

Quality Improvement to Engage General Pediatrics in Reducing Inaccurate Penicillin Allergy Labels



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ABSTRACT

OBJECTIVE: To remove inaccurate penicillin allergy labels in the general pediatric clinic setting.

METHODS: From October 2017 through December 2021, this collaborative, quality improvement project used education, feedback, electronic health record alerts, and the introduction of oral amoxicillin challenges in a general pediatric clinic setting with the primary aim of decreasing the proportion of penicillin allergy labeled patients. Control charts were used to track the relationship between interventions and improvements in referral rates to allergy clinic, removal of the allergy label at clinic visits and the overall proportion of clinic patients labeled as PCN allergic.

RESULTS: Referral rates to allergy clinic for penicillin allergy labeled patients increased from a baseline mean of 1.9% to 20.4%. The proportion of PCN allergy labeled patients who had the label removed during a pediatric clinic visit increased

from a baseline of 1.1% to 6.6%. The overall proportion of penicillin allergy labeled clinic patients decreased from a baseline of 3.4% to 2.2%.

CONCLUSION: With adequate education and collaboration with allergists, general pediatric practitioners can play a significant role in removing inaccurate penicillin allergy labels. Pediatricians can remove some of the burden placed on allergists by evaluating low risk patients in the primary care setting while referring higher risk patients to the specialist.

KEYWORDS: pediatrics; penicillin allergy label; quality improvement

ACADEMIC PEDIATRICS 2022;22:1175–1183

WHAT'S NEW

We demonstrate that a general pediatric clinic, using quality improvement tools, can reduce the proportion of inaccurate patient penicillin allergy labels.

PENICILLIN (PCN) AND aminopenicillins are the most widely used antibiotics in pediatrics and the most common drug allergy in the medical record.^{1,2} These allergy labels are often acquired by age 3 years and frequently persist into adulthood.^{3,4} An estimated 10% of patients have a documented penicillin allergy, but when properly evaluated, 90%–98% will tolerate the medication due to either waning sensitivity over time or erroneous attribution of symptoms as an allergic reaction.^{2,5,6} Inaccurate antibiotic allergy labels lead to overuse of broader spectrum antibiotics, increased antibiotic resistance, and increased healthcare expense.⁷ To the individual patient, an inaccurate allergy label can lead to treatment with a less effective and sometimes more expensive antibiotic.

Internationally, professional allergy societies recommend evaluation of all patients with a suspected penicillin allergy including a multidisciplinary approach.^{6,8–10}

Relying solely on allergists to evaluate all patients with an inaccurate penicillin allergy may not be efficient or even feasible.³ Successful efforts at de-labeling low-risk patients have already occurred in several settings outside of the allergy clinic including the emergency room, outpatient internal medicine, pharmacy, military basic training, and the inpatient setting.^{11–14} Multiple studies have demonstrated successful de-labeling through improved screening, testing, electronic alerts, and provider education.^{12,15,16} Given the volume of patients labeled as penicillin allergic and the limited number of allergists compared to primary care providers, primary care clinics can be valuable in de-labeling more efficiently.

We developed a collaborative quality improvement (QI) project involving primary care and the allergy division at a major pediatric academic center. Recognizing the wide spectrum of reported reactions, varying knowledge and comfort level of clinicians, and time constraints, we sequentially integrated multiple interventions aimed at reducing the proportion of patients labeled as penicillin allergic and followed outcomes over a 4-year period.

The prevalence of true penicillin allergies is estimated to be 1% or less, but 3.4% of our primary care clinic

patients are labeled as allergic to penicillin, amoxicillin, or amoxicillin clavulanate. This proportion of labeled patients had remained unchanged over the year prior to our project. Based on data from our electronic health record (EHR), only 1.9% of our patients with a penicillin allergy label were referred to our institution's allergy clinic for further evaluation in the year prior to the start of the project. We implemented a QI project with the aim of reducing the proportion of penicillin allergy labeled patients in our clinic to 2% through education, increased referral rates to allergy clinic, deletion of inaccurate labels in clinic and introduction of single dose drug provocation tests (DPT) in the primary care setting.

METHODS

CONTEXT

This QI project was conducted from October 2017 through December 2021 in a single pediatric primary care clinic that is part of a 12-site primary care network affiliated with an academic pediatric tertiary care center. The clinic is staffed by 5 pediatricians and has up to 25 pediatric residents each year for continuity clinic. In 2021, the clinic had 8600 patient visits. The clinic's EHR is Epic Software (Epic Systems Corporation, Verona, Wisconsin). This project included patients from birth through age 17 years with an allergy to penicillin, amoxicillin, or amoxicillin clavulanate listed in the EHR.

INTERVENTIONS

We followed the Institute for Healthcare Improvement principles.¹⁷ We established a multidisciplinary QI team

including a pediatrician at the study site, 3 pediatric resident physicians, 2 clinic nurses, and a clinic administrator with experience in QI. Throughout the process we consulted and received feedback from members of our institution's division of allergy and immunology, pharmacy, and information technology (IT). The QI team used group brainstorming and results from a department wide penicillin allergy knowledge survey to develop a key driver diagram (KDD). The survey measured both physician and nursing antibiotic allergy knowledge as well as comfort with adding/deleting allergies in the medical record. The KDD addressed 4 specific drivers regarding penicillin allergy de-labeling: staff knowledge of true penicillin allergy symptoms, family understanding of true penicillin allergy symptoms, accurate communication and documentation in the electronic health record and an efficient and consistent referral process (Fig. 1).

The initial intervention in October 2017 focused on staff and patient family education. Clinic staff meetings provided education for physicians and nurses about signs and symptoms of allergic drug reactions and common misconceptions. These sessions provided guidance about identifying allergy labels that could be deleted without need for referral to the allergy clinic (eg, labels based on family history alone, subsequent use of the antibiotic without reaction, and symptoms consistent with a medication side effect rather than an allergy). If clinicians or families were uncertain or uncomfortable removing the label, a referral to the allergy clinic was recommended.

The initial educational intervention also included a change in EHR documentation. As part of the standard patient check-in process, nurses asked families about interest in an allergy clinic referral if their child had an

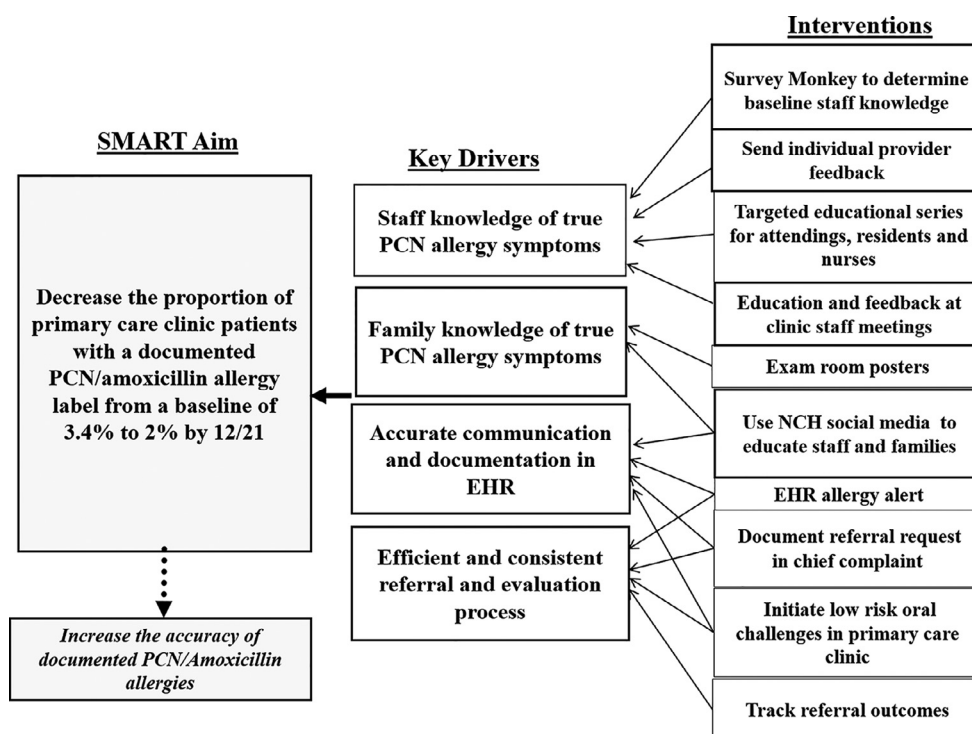


Figure 1. Key driver diagram.

allergy to penicillin, amoxicillin, or amoxicillin clavulanate listed in the EHR. If there was interest, “referral request” was documented as a secondary reason for the visit to alert the physician to have further discussion with the family and place a referral if appropriate. The specific nurse asking the intake questions was not tracked.

Patient and family education was provided by a poster in each clinic exam room explaining common myths about drug allergies as well as how to request further evaluation. With assistance of the media department of our home institution, digital signage, a blog post, a patient handout, and on-hold phone messaging provided family-level knowledge about penicillin allergy as well as encouragement for further evaluation.

Beginning in March 2018, a second intervention started. A penicillin allergy teaching module was developed, and completion was required for all pediatric residents during their one-month pediatric primary care rotation. After 12 months, a checklist confirmed completion of the module by all 25 residents assigned to the clinic site.

Individual provider allergy clinic referral data was provided as feedback. Additional staff meetings provided reinforcement of educational material, ongoing outcome data, and opportunities to ask questions or provide feedback on the process.

In August 2019, a 2-tiered electronic alert called a best practice alert (BPA) was created for our EHR. During check in, if the nurse added a new penicillin allergy label to a patient chart, an alert prompted the completion of 4 additional questions about the nature and timing of the reaction. Based on the responses in the nursing alert, the physician received an alert suggesting an intervention such as referral to the allergy clinic or removal of the allergy from the medical record. The alert did not create a hard stop in workflow and could be ignored. A link within the BPA allowed immediate feedback (like/dislike) about the alert (Fig. 2). The alert was suppressed if a referral to Allergy had been placed in the previous 90 days. The 4

nursing questions also appeared if the patient had a pre-existing penicillin allergy label, but there was not a reminder alert. The alert was revised in May 2020 to include patients with a pre-existing allergy label.

The final intervention started in August 2020. With oversight from our institution’s allergy division, we developed a screening algorithm and oral amoxicillin challenge algorithm for use in the primary care setting (Figs. 3, 4). Based on previous literature, these algorithms enabled single-dose oral amoxicillin challenges followed by 60 minutes of observation on low-risk patients in our primary care clinic.^{6,12,14,18,19} The process could be conducted concurrently with other visit types such as routine well care. The clinic had readily available epinephrine, antihistamine, supplemental oxygen, and nebulized beta agonist in case of severe reactions. An allergic reaction treatment protocol was created in collaboration with the allergy division.

MEASURES

The specific, measurable, achievable, realistic, and time-bound (SMART) aim was to reduce the proportion of pediatric clinic patients with a penicillin/amoxicillin/amoxicillin clavulanate label from a baseline of 3.4% to 2% by December 2021. The proportion was calculated at the end of each month with the numerator representing the total number of patients registered to our clinic with a PCN allergy label and the denominator representing the total number of patients registered to our clinic.

We tracked 2 process measures. The first measure tracked monthly referrals to allergy clinic for drug allergy evaluation. The percentage was calculated by using the total number of allergy referrals for patients with a PCN allergy label in one month for the numerator and using the total number of visits by patients with a PCN allergy label in one month for the denominator. Patients referred to allergy clinic in the previous 90 days were excluded from the monthly calculation and were not considered a missed

Allergy Removal Candidate

@FNAME@ has a self-reported Penicillin/Beta-lactam Allergy based solely on a **family history** of allergy.

Please discuss with family and if confirmed @FNAME@ has not had any personal exposure/reactions to this antibiotic, this allergy can be removed.

[Click to Remove Allergy](#)
[Click to View Screening Questions](#)

Acknowledge Reason

Give the Epic Team Feedback on this Alert

Figure 2. Example of penicillin allergy computer alert.

Based on patient/family interview or chart review:

Did one of the following symptoms occur < 2 hours after the first or second dose?

Difficulty breathing/wheezing

Urticaria/itchiness/angioedema/swelling

Dizziness/fainting

{YES NO NOT SURE:17989}

Did the symptoms include?

Need for hospitalization

Mucous membrane involvement

Arthritis/arthralgias

Ongoing unexplained fevers

Skin desquamation

Liver/kidney involvement

{YES NO NOT SURE:17989}

If both of the above answers are "no" then patient is eligible for an oral dose challenge in clinic.

If "yes" or "not sure" to either of the above questions, referral to Allergy clinic recommended.

Keep amoxicillin/penicillin allergy label.

The family agreed to the referral {YES NO:17494}

The benefits include possible removal of the amoxicillin/penicillin allergy label that will allow future use of the medication and possible avoidance of less effective, more costly antibiotics.

The risk of the procedure includes an allergic reaction, although based on the above history, the risk is considered low.

I have explained the process of the oral amoxicillin/penicillin challenge including risks and benefits, allowed the family time to ask questions and obtained verbal consent. {YES

NO:17494}

Figure 3. Algorithm screening questions for low risk penicillin allergy patients.

opportunity. Referral comments were reviewed to exclude any allergy referrals unrelated to a penicillin allergy.

The second process measure tracked the removal of a PCN allergy label during a pediatric clinic visit without a referral to allergy clinic. The label could be removed by a successful oral amoxicillin challenge or by deletion without testing if based on an inaccuracy such as family history alone or side effect. Quarterly percentages were calculated using the quarterly total number of patients who had their allergy label deleted the day of the visit as the numerator and the quarterly total number of visits by patients with a documented PCN allergy label as the denominator.

Quarterly referral outcome tracking helped identify inefficiencies in the referral process and served as a balancing measure by identifying potentially inappropriate referrals.

STATISTICAL ANALYSIS

Statistical process control was used to monitor these measures over time. We looked for signals of special

cause variation utilizing Nelson's rules and American Society for Quality rules.²⁰ Control charts were annotated to show relationships between key interventions and improvements in the system. Monthly referral rates and the monthly proportion of PCN allergy labeled patients were plotted on separate charts with control limits representing 3 standard deviations from the mean baseline. The rate of allergy labels deleted at a primary care visit was plotted quarterly on a similar chart.

RESULTS

The process measure of tracking referrals to allergy clinic had a baseline process stage mean referral rate of 1.9% (Fig. 5). After our initial educational intervention in October 2017, the process stage mean shifted upward to 33.5%. The year prior to the start of our project, a total of 4 patients were referred for further evaluation of their drug allergy. A year after the start of the project, 93 patients had been referred. The second intervention, a resident teaching module, did not alter the baseline mean of 33.5% after being introduced in March 2018. A downward

Amoxicillin Oral Dose Challenges for Primary Care Clinic

1. Determine if low risk at beginning of visit using .pccamoxicillinchallenge in Epic.
2. Document verbal consent. It is helpful to explain that it is unlikely the child has a true allergy and the benefits of potentially removing the allergy label from Epic.
3. Order a single weight-based dose of amoxicillin. 500 mg is OK for older children and adolescents (going above 500 mg is not necessary for the purpose of a challenge).
4. Observe for 60 minutes. If no reaction in first 30 minutes, it's OK for patient to be moved to the lobby for final 30 minutes. Family should notify front desk if new symptoms develop. Physician or nurse should evaluate at the end of 60 minutes.
5. If no reaction, *first* add a statement about successful oral challenge in the comment section of the allergy *then* delete the allergy.
6. Use. pccnegativeamoxchallenge in A/P.
7. Family should call the clinic or on call provider if new symptoms, such as rash, appear in the week following the challenge.

Any reactions during the oral challenge should be managed as outlined in the adverse reaction algorithm.

Figure 4. Algorithm for screening and documentation of oral amoxicillin challenge in primary care clinic.

shift in the baseline referral rate to 20.4% occurred around January 2019. This baseline referral rate stabilized with the introduction of the electronic health alert in August 2019 and its revision in May 2020. This referral rate of 20.4% has been stable over the past 2 years and represents a 10-fold increase in referrals to allergy clinic compared to the rate prior to our study.

The second process measure, which tracked the proportion of patients that had their PCN allergy label removed in the primary care clinic based on history or a successful oral challenge, had a baseline mean of 1.1% prior to the beginning of our study. The baseline mean shifted to 6.6% at the first quarter of 2019 (Fig. 6) This was preceded by our initial educational intervention in October

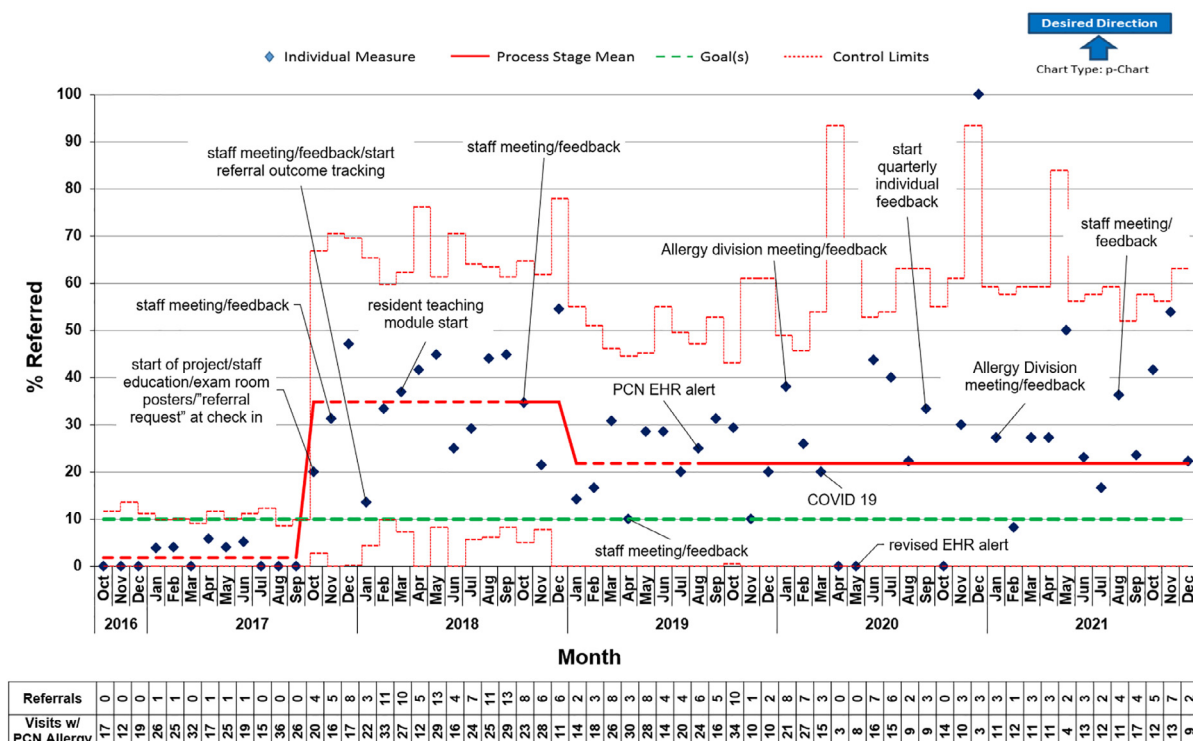


Figure 5. Monthly percentage of primary care clinic visits with a referral to allergy clinic for penicillin (PCN) allergy.

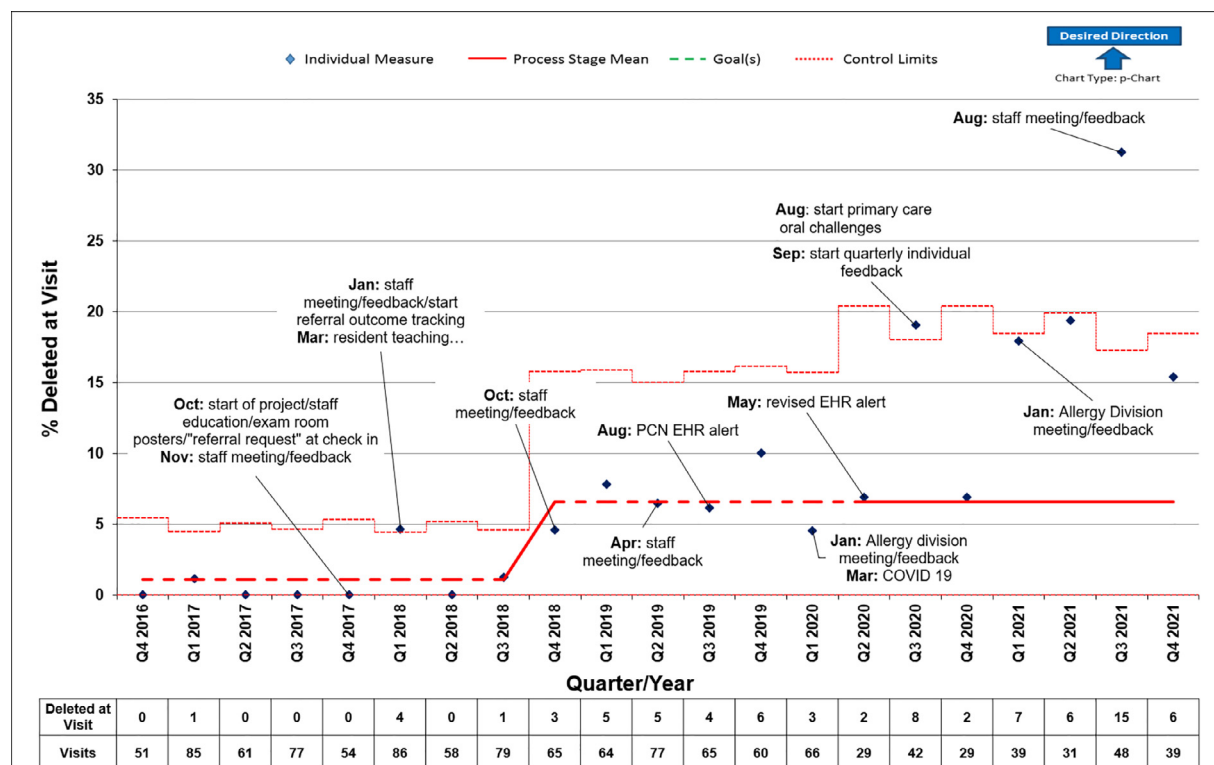


Figure 6. Percentage of patients with penicillin (PCN) allergy deleted at primary care visit based on history alone or oral challenge.

2017, resident physician education starting in March 2018 and 3 staff feedback sessions. After introduction of oral amoxicillin challenges in August 2020, four out of the last 5 most recent quarters of data have had a rate >15%, but the process has not been stable long enough to cause another shift in the baseline mean. Prior to the start of this project, no oral amoxicillin challenges had ever been attempted in our primary care clinic. From August 2020 through December 2021, twenty low-risk patients ranging in age from 3 to 18 years passed a single dose oral amoxicillin challenge in our clinic. None experienced an adverse reaction, and all were de-labeled of their amoxicillin/penicillin allergy.

Our outcome measure, which tracked the proportion of pediatric clinic patients with a PCN allergy label, had a baseline mean of 3.4% prior to the start of the study. By August 2018, there was a downward shift in process stage mean to 3.3% following initial educational efforts and the previously noted upward shift in the referral rate to allergy clinic. By September 2019 the proportion of PCN allergy labeled patients shifted down to 2.9% as the EHR was introduced and referral rates to allergy clinic continued to be above baseline. By July 2020, there was third downward shift in the process stage mean to 2.4% following a revision to the EHR that captured all PCN allergy labeled patients. The proportion of labeled patients continued to trend downward with the introduction of oral amoxicillin challenges in primary care clinic in August 2020 with most current month of data showing the proportion of penicillin allergy labeled patients as <2% (Fig. 7).

Our results were potentially affected by float nurses and clinicians who were covering for regular staff who may have been ill or on vacation. These staff members would not have as much familiarity with the project and interventions. In addition, the COVID-19 pandemic affected clinic volumes, visit types, and availability of allergy clinic appointments starting in March 2020. Our primary care clinic changed to only non-sick visits and replaced some in person visits with telehealth visits for several months. Our referral allergy clinic was restricted to only telehealth appointments from March through June 2020 thus removing the ability for testing for a 4-month period.

As our data collection method was established prior to the COVID-19 pandemic, telehealth visits, which started in March 2020, and any Allergy referrals generated during those visits, would not appear in our subsequent data.

DISCUSSION

This study successfully used a multi-interventional approach to achieve our aim of reducing the number of PCN allergy-labeled patients in the general pediatric setting. The referral rate for penicillin allergy-labeled clinic patients increased more than 10-fold while the proportion of penicillin allergy labeled patients decreased more than 30% from baseline. Currently <2% of our clinic population is labeled as penicillin allergic compared to nationally reported rates of 10%. The most recent 9 months of data show that greater than 15% of patients had their allergy label removed without requiring referral to an

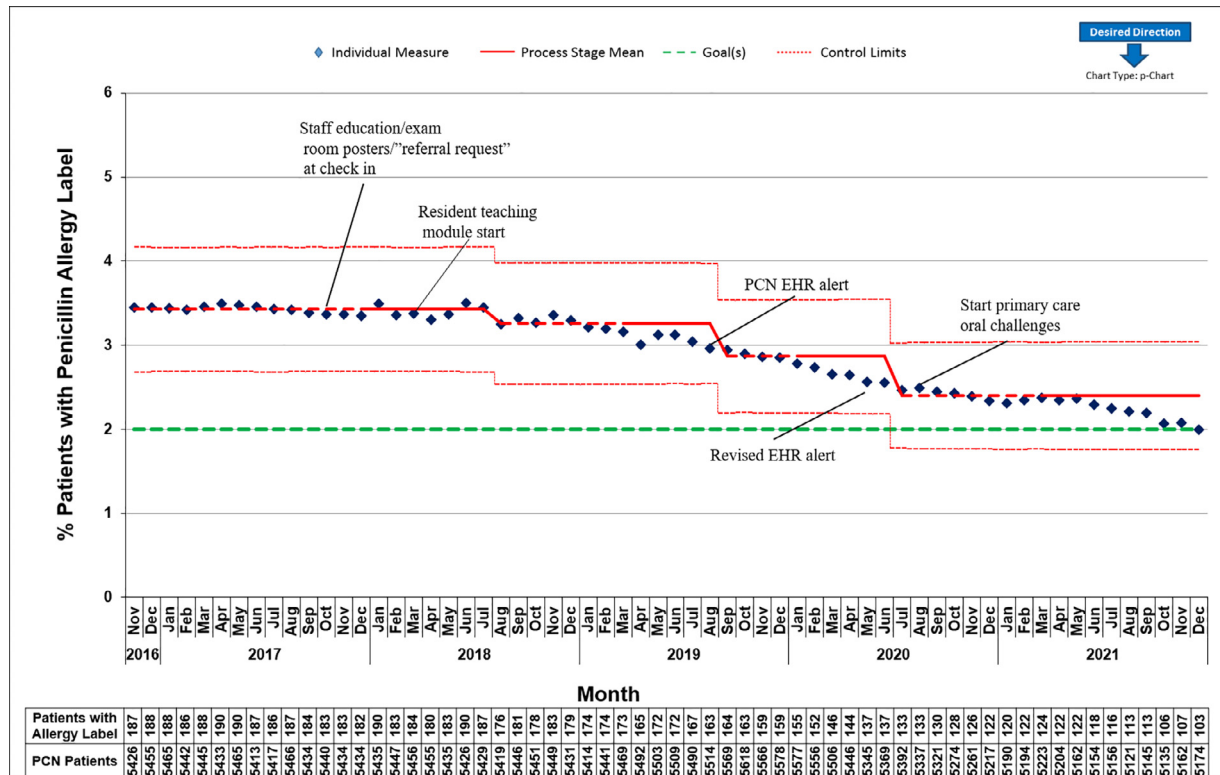


Figure 7. Monthly proportion of primary care clinic patients with a penicillin (PCN) allergy label.

allergist. By the end of our study period, greater than 1 out of every 4 patients presenting to our clinic with a penicillin allergy label was referred to allergy clinic for evaluation, had the allergy deleted based on history alone, or passed an oral amoxicillin challenge. The baseline referral rate to allergy clinic has remained stable over the past 3 years, but the proportion of penicillin allergy labeled patients continues to decline. These findings most likely represent referred patients continuing to work their way through the allergy clinic evaluation process, the elimination of some allergy labels based on medical history alone, and the introduction of oral challenges in primary care.

A strength of this study is using a multi-interventional approach to achieve our aim. While referring to allergy clinic is the mainstay of de-labeling high-risk patients, having the tools and understanding to remove inaccurate labels in primary care provides a needed alternative pathway. The successful adaptation and implementation of single dose oral amoxicillin challenges in the pediatric clinic as well as the multiyear nature of the study showing sustained success in removing labels were also strengths.

Our educational efforts directed toward clinic staff helped increase referral rates to allergy clinic. Previous studies have demonstrated the effectiveness of educational interventions targeted at understanding drug allergies and their management, although our study integrated education as part of a multi-intervention study unique to the outpatient pediatric clinic setting.^{12,15,21} Our improved referral rate was similar to previous QI results in the pediatric clinic setting but showed sustainability over 3 years and demonstrated the desired reduction in the proportion

of PCN allergy-labeled patients.¹⁶ Periodic provider feedback at clinic staff meeting reinforced education and frequently, but not always, boosted referral rates.

The impact of our EHR alert was less clear. Although the baseline referral rate did not improve with the alert, the rate had decreased from 30.5% to 20.4% prior to the alert being released. With the release of the alert, the referral rate stabilized at 20.4% through the end of the study. In addition, the introduction of oral amoxicillin challenges in clinic could possibly impact the referral rate as these patients no longer required a referral but opted to be evaluated and subsequently de-labeled in the pediatric clinic. A prior pediatric clinic study showed a successful increase in allergy clinic referral rate using an EHR alert but was the sole alert in the system.¹⁶ Our alert was one of several in our primary care setting competing for the provider's attention and possibly limiting its impact.

Multidisciplinary efforts and algorithm development in the inpatient pediatric setting have successfully reduced inaccurate penicillin allergy labels.¹² We had success with a similar approach but adapted it to the outpatient clinic setting in which time with the patient is more limited. Sharing outcome data with the allergy division helped identify problem areas in the referral and testing process. Based on referral outcome tracking, >50% of referred patients either did not show up for their allergy clinic appointment or were never able to be scheduled. The start of oral amoxicillin challenges at our primary care clinic reduced the need for some referrals while circumventing issues with cancellations and no-show appointments at the allergy clinic for our lowest risk

patients. Outpatient pharmacy assisted in getting amoxicillin on the shelf at our primary care clinic site, eliminating the need for families to bring a prescription with them. Nursing staff were able to integrate administration of the challenge medication into their workflow without need for additional staffing.

The introduction of oral amoxicillin challenges was effective in continuing to reduce the proportion of PCN allergy-labeled patients in our clinic. Emerging evidence over the past several years shows the safety and efficacy of oral drug challenges in low-risk pediatric patients such as those presenting with delayed onset benign rashes.^{22–25} Oral challenges have been successfully applied outside the allergy clinic setting, but there is little information on a similar approach in the general pediatric clinic setting.^{12–14} Our 20 successful oral challenges in low-risk patients demonstrate a feasible intervention in the pediatric clinic setting that eliminates the need for an allergy referral. In addition, almost all challenges were conducted simultaneously with other routine pediatric care eliminating the need for an additional appointment. With the amoxicillin being administered at the start of the appointment, the added time commitment of the family ended up being less than 60 minutes when combined with other care.

Our findings have the potential to be replicated and to influence healthcare systems through improved antibiotic stewardship and improved efficiency in removing inaccurate drug allergy labels. Education of clinicians and nurses about drug allergy symptoms and timing of different types of reactions is key to any future efforts to improve the accuracy of penicillin allergy labels in the medical record. Previous studies have noted that nonallergists may have a lack of knowledge or comfort managing drug allergies.^{15,26,27}

Introducing oral amoxicillin challenges in the general pediatric clinic settings holds great promise to reduce the large volume of patients inaccurately labeled as penicillin allergic while removing some of the burden on allergists who could focus on evaluating higher risk patients. The ability to de-label a low-risk patient is a benefit to families who can complete the process during visits for other health care needs and eliminates the need for a future allergy clinic visit. Expanding oral challenges to other primary care sites would require the use of reliable screening questions and an algorithm developed in collaboration with an allergist and ideally embedded within an EHR to ensure consistency. Screening questions need to ensure that only low risk patients would be challenged outside of the allergy clinic setting. The most efficient process involves having amoxicillin stocked at the clinic, but it also could be brought by the family using an outpatient prescription. In addition, clinicians could identify low risk patients at one visit, then conduct the challenge at a future visit if constrained by time. Many pediatric visits such as well care, ADHD, asthma and weight management require follow up. These visits would all present an opportunity to challenge the patient without requiring an additional appointment. Drug challenges represent a potential

opportunity cost to primary care staff who would need to invest additional time to carry out the procedure although that time was primarily limited to asking screening questions and administering the amoxicillin. We did not require any additional staffing to conduct the challenges. We realize low risk oral challenges in the busy pediatric clinic setting may not be achievable on a daily basis, but pediatricians doing a few challenges in a month could have a significant impact given that there are 60,000 practicing pediatricians in the United States alone.²⁸ This model could be adopted on a larger scale but would require collaboration with a pediatric allergy specialist, education of staff and the ability to treat an allergic reaction.

STRENGTHS AND LIMITATIONS

Being conducted at a single pediatric clinic site is a limitation of our study. At baseline, our clinic already had a lower proportion of penicillin allergic labeled patients (3.4%) than reported in the general literature (10%). Generalizability on a larger scale could present challenges with time constraints, education, access to resources, adherence to protocol, feedback, and oversight. In addition, our study did not address the addition of new penicillin allergy labels during our study period. We do not know if our educational efforts helped reduce the number of new allergy labels being added. Penicillin allergy labels could have been added or removed at sites in our healthcare system other than our clinic and the allergy clinic. In addition, identifying the precise number of patients de-labeled during the study period was potentially limited by patients disenrolling from our clinic during the study period. Patients who were not de-labeled or referred at the time of their visit did not always represent a missed opportunity by clinicians, but rather the family's choice not to proceed with further evaluation.

FUTURE DIRECTIONS

Given that penicillin allergy labels are usually acquired early in life, are frequently inaccurate, and tend to persist into adulthood, our findings suggest plausible ways to reduce the number of patients inaccurately labeled as penicillin allergic and potentially prevent these inaccuracies from being carried into adulthood. Success will require an integrated effort by pediatricians, allergists, nurses, pharmacists, and information technology specialists. Success will also require primary care providers to adopt a multi-interventional approach as it is not feasible, or even necessary, for all PCN allergy labels to be removed by an allergist. General pediatricians well-educated in the signs and symptoms of antibiotic drug reactions can help eliminate many of these labels by referring high risk patients to an allergist but also by performing in-office oral challenges for low-risk patients or deleting labels based on symptoms not consistent with an allergic reaction.

CLINICAL TRIAL REGISTRATION

NA.

ACKNOWLEDGMENTS

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

REFERENCES

- King LM, Bartoces M, Fleming-Dutra KE, et al. Changes in US outpatient antibiotic prescriptions from 2011-2016. *Clin Infect Dis*. 2020;70:370-377.
- Castells M, Khan DA, Phillips EJ. Penicillin allergy. *N Engl J Med*. 2019;381:2338-2351.
- Staicu ML, Vyles D, Shenoy ES, et al. Penicillin allergy delabeling: a multidisciplinary opportunity. *J Allergy Clin Immunol Pract*. 2020;8:2858-2868.e2816.
- Vyles D, Chiu A, Simpson P, et al. Parent-reported penicillin allergy symptoms in the pediatric emergency department. *Acad Pediatr*. 2017;17:251-255.
- Abrams EM, Wakeman A, Gerstner TV, et al. Prevalence of beta-lactam allergy: a retrospective chart review of drug allergy assessment in a predominantly pediatric population. *Allergy Asthma Clin Immunol*. 2016;12:59.
- Jeimy S, Ben-Shoshan M, Abrams EM, et al. Practical guide for evaluation and management of beta-lactam allergy: position statement from the Canadian Society of Allergy and Clinical Immunology. *Allergy Asthma Clin Immunol*. 2020;16:95.
- Stone Jr. CA, Trubiano J, Coleman DT, et al. The challenge of delabeling penicillin allergy. *Allergy*. 2020;75:273-288.
- Penicillin allergy in antibiotic resistance W. penicillin allergy testing should be performed routinely in patients with self-reported penicillin allergy. *J Allergy Clin Immunol Pract*. 2017;5:333-334.
- Mirakian R, Leech SC, Krishna MT, et al. Management of allergy to penicillins and other beta-lactams. *Clin Exp Allergy*. 2015;45:300-327.
- Broyles AD, Banerji A, Barmettler S, et al. Practical guidance for the evaluation and management of drug hypersensitivity: specific drugs. *J Allergy Clin Immunol Pract*. 2020;8:S16-S116.
- Ham Y, Sukerman ES, Lewis 2nd JS, et al. Safety and efficacy of direct two-step penicillin challenges with an inpatient pharmacist-driven allergy evaluation. *Allergy Asthma Proc*. 2021;42:153-159.
- Bauer ME, MacBrayne C, Stein A, et al. A multidisciplinary quality improvement initiative to facilitate penicillin allergy delabeling among hospitalized pediatric patients. *Hosp Pediatr*. 2021;11:427-434.
- Tucker MH, Lomas CM, Ramchandrar N, et al. Amoxicillin challenge without penicillin skin testing in evaluation of penicillin allergy in a cohort of Marine recruits. *J Allergy Clin Immunol Pract*. 2017;5:813-815.
- Vyles D, Chiu A, Routes J, et al. Oral amoxicillin challenges in low-risk children during a pediatric emergency department visit. *J Allergy Clin Immunol Pract*. 2020;8:1126-1128.e1121.
- Blumenthal KG, Shenoy ES, Hurwitz S, et al. Effect of a drug allergy educational program and antibiotic prescribing guideline on inpatient clinical providers' antibiotic prescribing knowledge. *J Allergy Clin Immunol Pract*. 2014;2:407-413.
- Wang H, Kozman M, Pierce H, et al. A quality improvement initiative to improve primary care referral rates for penicillin allergy delabeling. *Ann Allergy Asthma Immunol*. 2021.
- How to Improve*. Boston, Massachusetts: Institute for Healthcare Improvement. (Available on www.IHI.org) Last accessed January 2022.
- Prieto A, Munoz C, Bogas G, et al. Single-dose prolonged drug provocation test, without previous skin testing, is safe for diagnosing children with mild non-immediate reactions to beta-lactams. *Allergy*. 2021;76:2544-2554.
- Li J, Cvetanovski V, Fernando S. Single-step direct drug provocation testing is safe for delabelling selected non-low-risk penicillin allergy labels. *Ann Allergy Asthma Immunol*. 2021;127:232-235.
- Langley GL MR, Nolan KM, Nolan TW, et al. *The Improvement Guide: A Practical Approach to Enhancing Organizational Performance*. 2nd Edition San Francisco, CA: Jossey-Bass; 2009.
- Berger RE, Singh HK, Loo AS, et al. Improving antibiotic stewardship for inpatients with reported beta-lactam allergies and limited access to penicillin skin testing. *Jt Comm J Qual Patient Saf*. 2022;48:147-153.
- Exius R, Gabrielli S, Abrams EM, et al. Establishing amoxicillin allergy in children through Direct Graded Oral Challenge (GOC): evaluating risk factors for positive challenges, safety, and risk of cross-reactivity to cephalosporines. *J Allergy Clin Immunol Pract*. 2021;9:4060-4066.
- Torres MJ, Adkinson Jr. NF, Caubet JC, et al. Controversies in drug allergy: beta-lactam hypersensitivity testing. *J Allergy Clin Immunol Pract*. 2019;7:40-45.
- Nguyen M, Parashar S, Lee BR, et al. Twenty-year comparison of de-labeling penicillin allergic pediatric patients with and without prior skin testing. *Ann Allergy Asthma Immunol*. 2022.
- Dona I, Caubet JC, Brockow K, et al. An EAACI task force report: recognising the potential of the primary care physician in the diagnosis and management of drug hypersensitivity. *Clin Transl Allergy*. 2018;8:16.
- Vyles D, Mistry RD, Heffner V, et al. Reported knowledge and management of potential penicillin allergy in children. *Acad Pediatr*. 2019;19:684-690.
- Wanat M, Anthierens S, Butler CC, et al. Management of penicillin allergy in primary care: a qualitative study with patients and primary care physicians. *BMC Fam Pract*. 2021;22:112.
- Association AM. *Number of People per Active Physician by Specialty, 2019*. Association of American Medical Colleges; 2019. <https://www.aamc.org/what-we-do/mission-areas/health-care/workforce-studies/interactive-data/number-people-active-physician-specialty-2019>.