

Medication Errors in Adolescents Using Asthma Controller Medications

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Abstract

The purpose of this study was to describe the number and types of errors that adolescents and caregivers report making when using asthma controller medications. A total of 319 adolescents ages 11 to 17 with persistent asthma and their caregivers participated in this cross-sectional study. Adolescent and caregiver reports of asthma medication use were compared to the prescribed directions in the medical record. An error was defined as discrepancies between reported use and the prescribed directions. About 38% of adolescents reported 1 error in using asthma controller medications, 16% reported 2 errors, and 5% reported 3 or more errors. About 42% of caregivers reported 1 error in adolescents using asthma controller medications, 14% reported 2 errors, while 6% reported 3 or more errors. The type of error most frequently reported by both was not taking the medication at all. Providers should ask open-ended questions of adolescents with asthma during visits so they can detect and educate families on how to overcome errors in taking controller medication use.

Keywords

asthma, adolescents, medication error

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Introduction

An estimated 6 million children in the United States are diagnosed with asthma, making it one of the most common chronic illnesses among adolescents.¹ Asthma is characterized by chronic airway inflammation, leading to airflow obstruction and bronchial hyperresponsiveness.² This causes clinical symptoms including shortness of breath, chest tightness, coughing, wheezing, and difficulty breathing.² These asthma symptoms can have a large impact on adolescent's quality of life by limiting school, social, and physical activities.³ Management of this chronic illness often requires repeated physician visits and is associated with increased emergency department visits.⁴

Standard of care for patients with persistent asthma includes long term control medications that reduce airway inflammation, relieve symptoms, and prevent exacerbations.^{3,5} According to the National Heart, Lung, and Blood Institute asthma practice guidelines, the preferred treatment for persistent asthma consists of low dose inhaled corticosteroids (ICS), with step up therapy increasing ICS dose or adding additional agents (long acting beta agonist, montelukast, or oral

corticosteroids). Oral tablets including cromolyn or montelukast can be used as alternative treatment.^{1,5}

Medication errors can be defined as preventable events that lead to inappropriate medication use.⁶ These errors are highly prevalent among the adolescent population in a variety of medication classes.^{7,8} Previous research focuses on over-the-counter acetaminophen and chemotherapy medication, leading to toxicity and hospitalization.⁷⁻¹¹ However, little research has been performed regarding the types of errors that adolescents make in using asthma controller medications.

Caregiver involvement in asthma care has been studied in adolescent populations, with increased involvement associated with better patient outcomes.¹² Excessive patient self-care autonomy at very young ages has also been associated with decreased medication

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adherence in the adolescent population.¹³ Additionally, adolescents with asthma experience increased emergency department (ED) visits when their caregivers suffer from psychological health illnesses such as depression.¹⁴ By analyzing both adolescent self-reported medication use and caregiver reporting of medication use and comparing it to actual provider instructions for use, this study aims to help health care providers better understand the types of errors that adolescents make when using asthma medications.

Previous research has studied the misuse of inhalers in the adult chronic obstructive pulmonary disease (COPD) and asthma populations. A cross-sectional study analyzing errors in the outpatient respiratory care setting found at least 1 incorrect step in 48.2% of patient inhalation demonstrations while using COPD controller inhalers.¹⁵ Melani et al¹⁶ analyzed medication errors associated with controller inhalers in both adult COPD and asthma populations, finding errors in metered dose inhalers (MDI), dry powder inhalers (DPI), and Turbohalers (12%, 35%, and 44%, respectively). A study in the *European Respiratory Journal* found similar results in the adult COPD population, with less than 40% of patients able to perform appropriate inhalation technique compared to package insert instructions leading to increased exacerbations in past 3 months.¹⁷ Despite the extensive body of research reporting medication errors in the adult asthma and COPD population, there is a lack of evidence concerning medication errors in regard to the pediatric asthma population. The purpose of this study is to determine the number and types of errors adolescents make when using asthma controller medications.

Methods

Procedures

This study was approved by the University of North Carolina Institutional Review Board (14-2628). The principal investigator visited the 4 practices in person and obtained provider consent. Forty-six providers from 4 pediatric primary care practices in North Carolina agreed to participate in the study. The primary care practices included 1 academic practice and 3 private practices. Participants in the study were enrolled over an 18-month period from June 2015 to November 2016. Staff from each practice explained the study to families attending the primary care practice for asthma management in adolescent patients. Families interested in the study were then referred to a research assistant to learn more. Research assistants explained the study to families during the pre-visit wait time where they obtained adolescent assent and caregiver consent. Caregivers completed Health Insurance

Portability and Accountability Act (HIPAA) forms which gave us permission to review their medical records. Research assistants then administered eligibility screeners for the study.

Adolescents were eligible if they met the following inclusion criteria: ages 11 to 17 years old, spoke and read English or Spanish, had persistent asthma, were present for an acute or follow-up asthma visit or a well-child visit, and had previously visited the clinic at least once for asthma. Persistent asthma was defined using the National Health Lung and Blood Institute Guidelines—experiencing asthma-related daytime symptoms more than twice a week, asthma-related nighttime symptoms more than twice a month or receiving 1 or more long-term controller therapies for asthma.¹ Caregivers were eligible if they were greater than 18 years of age, spoke and read English or Spanish, and were legal guardian of the adolescent.

Adolescents were interviewed after their medical visits while caregivers completed questionnaires. Adolescents and caregivers were both provided \$25 for their time.

Measurement

Patient sociodemographic factors. Caregivers reported the primary language spoken at home, race, total annual household income, and adolescent's health insurance type. Adolescent age was extracted from medical record and measured as continuous variable. Adolescent and caregiver gender were measured dichotomously (male/female). Language spoken at home was measured as a dichotomous variable (English or Spanish). Adolescent race/ethnicity was organized as 5 categories: White, African American, Native American/American Indian, Hispanic, other. Caregiver race was measured dichotomously (white or non-white). Total self-reported household income was categorized into 6 categories: less than \$10 000, \$10 000 to \$19 999, \$20 000 to \$29 999, \$30 000 to \$49 999, \$50 000 to \$69 999, and \$70 000 or more. Type of health insurance was measured as a dichotomous variable (Medicaid or other). Asthma severity was measured as a dichotomous variable, classified as mild persistent vs. moderate/severe persistent according to the National Heart Lung and Blood Institute's guidelines.¹

Controller asthma medications reported by caregivers and adolescents included: Montelukast, QVAR Redihaler[®], ProAir[®] HFA, Proventil[®] HFA, Ventolin[®] HFA, Advair, Symbicort[®], Xopenex[®] HFA, and Pulmicort Flexhaler[®].

Types of adolescent and caregiver reported medication errors. When interviewed after the medical visits, adolescents were asked the following questions regarding the use of their asthma controller medications:

Table 1. Typology of Asthma Medication Errors.

Type of error	Error definition
Extra single administration doses	Two puffs (or more) instead of one puff per administration
Too few single administration doses	One puff instead of two puffs per administration
Taking too frequently per day	Twice daily (or more) administration instead of prescribed once daily administration
Not taking enough times per day	Once daily administration instead of prescribed twice daily administration
Missing 1 to 3 doses per week	Missing three doses or less in a 7-day period
Missing three or more doses per week	Missing more than three doses in a 7-day period
Not taking at all	Does not report taking medication although listed on medical record
Does not know names of all medication	Reports medication with descriptive factors instead of name (ie, red inhaler, tablet, etc.)

(a) Medication name?, (b) How many days did you (adolescent) use it in the past week?, (c) How many times per day did you (adolescent) use it?, (d) How many pills or puffs did you (adolescent) use each time?, and (e) How many times did you (adolescent) miss taking it? Caregivers were asked the same questions regarding their adolescent's asthma medication use stated above in the questionnaires they completed after visits.

Each adolescent's medical record had information abstracted for a period of twelve months before the baseline visit. Information extracted from the medical record included the intended administration schedule of each prescribed asthma controller medication. All medications prescribed for asthma control use were extracted and included in the study. Any additional medication not prescribed for an asthma diagnosis was omitted.

Information from the adolescent interviews and caregiver questionnaires was extracted and compared to the adolescent's medical record. The study team reviewed the comparisons and created a typology of medication errors similar to the methods used by Walsh in the pediatric cancer area.^{7,8}

Table 1 demonstrates the typology of errors created comparing adolescent and caregiver reported use to the prescribed administration instructions in the adolescent's medical record. The typology of errors included: extra single administration doses, too few single administration doses, taking too frequently per day, not taking enough times per day, missing 1 to 3 doses per week, missing 3 or more doses per week, not taking at all, or does not know names of all medications. We computed the number of errors reported by adolescents and caregivers and measured them as continuous variables.

Data Analysis

Our analyses included all youth who were on 1 or more controller medications, which was 319 out of 359 participating adolescents. All analyses were conducted

using IBM SPSS Statistics version 26. Descriptive statistics were computed for the number and types of errors that were reported by both adolescents and caregivers. Descriptive statistics were computed for the adolescent and caregiver sociodemographic characteristics and number and type of errors reported by adolescents and caregivers. We examined the bivariate relationships between adolescent and caregiver sociodemographic characteristics and the number *and type* of errors reported using Pearson chi-square, t-tests, or Pearson correlation coefficients. For the bivariate analyses, we recoded adolescent and caregiver race into dichotomous variables (Caucasian vs. non-Caucasian).

Results

Three hundred and fifty-nine of 469 screened youth and their caregivers were eligible and enrolled. A total of 110 did not meet inclusion criteria. Of these 53 refused to participate (87% participation rate). About 319 youth out of the 359 enrolled patients were on 1 or more controller medications.

Table 2 demonstrates the youth and caregiver demographic characteristics. Fifty-seven percent of patients were male. The average adolescent age was 13.2 years old (SD 1.9). About 36% of adolescents were White, 37.2% were African American, 13% were Hispanic, and 11% were Native American. Ninety-one percent of adolescents reported English as their primary language at home, while 9% reported Spanish.

Table 3 demonstrates the number of errors for adolescents and caregivers by comparing their reported medication use to the medication directions in the medical record. Many errors were detected for both adolescents and caregivers, 58% and 61%, respectively. Thirty-eight percent of adolescents reported 1 error, 16% reported 2 errors, and 5% reported 3 or more errors. About 42% of caregivers reported 1 error, 14% reported 2 errors, and 6% reported 3 or more errors.

Table 2. Youth and Caregiver Demographic and Youth Asthma-Related Characteristics (N=359).

Characteristics	Percent (N)
Youth gender	
Male	57.1 (205)
Female	42.9 (154)
Youth race/ethnicity	
Caucasian	36.2 (130)
African American	37.2 (134)
Hispanic	12.5 (45)
Native American	11.4 (41)
Other	2.5 (9)
Asthma severity	
Mild	46.8 (168)
Moderate/severe	53.2 (191)
Caregiver gender	
Male	13.6 (49)
Female	86.4 (310)
Caregiver race	
Caucasian	43.7 (157)
African American	34.9 (125)
Hispanic	9.2 (33)
Native American	10.3 (37)
Other	1.9 (7)
On controller medication	
Yes	88.9 (319)
No	11.1 (40)
Primary language spoken at home	
English	91.5 (292)
Spanish	8.5 (27)
Reason for visit	
Asthma	66.6 (239)
Other	33.4 (120)
Household total annual income	
Less than \$10000	16.4 (59)
\$10000 to \$19999	15.3 (55)
\$20000 to \$29999	18.7 (67)
\$30000 to \$49999	13.1 (47)
\$50000 to \$69999	13.1 (47)
\$70000 or more	23.4 (84)
Has medicaid as health insurance	
Yes	54.6 (196)
No	45.4 (163)
	Mean (SD), range
Youth age	13.2 (1.9), 11-17
Years living with asthma	9.5 (4.1), 1-17
Caregiver age	42.6 (8.6), 19-76
Caregiver education (in years)	13.6 (3.3), 4-26

None of the socio-demographic characteristics were significantly associated with the number of errors reported by adolescents and caregivers.

Table 4 demonstrates the types of errors reported by adolescents and caregivers. The 3 most commonly reported errors by adolescents were not taking the

Table 3. Number of Errors Reported by Adolescents and Caregivers (N=319).

Reported errors	Adolescents reporting errors percent (N=319)	Caregivers reporting errors percent (N=319)
0	42.0 (134)	38.6 (123)
1	37.6 (120)	41.7 (133)
2	15.7 (50)	13.5 (43)
3+	4.7 (15)	6.3 (20)

medication at all, missing 3 or more doses per week, and not taking the medication enough times per day. About 32% of adolescents reported not taking the medication at all. Fifteen percent of adolescents reported missing 3 or more doses per week. About 10% of patients reported not taking the medication enough times per day. The 3 most commonly reported errors caregivers reported for adolescents were not taking the medication at all, missing 3 or more doses per week, and missing 1 to 3 doses per week. Twenty-nine percent of caregivers reported the adolescent not taking the medication at all. About 14% of caregivers reported missing 3 or more doses per week. About 9% of caregivers reported missing 1 to 3 doses per week. The least commonly reported errors for both adolescents and caregivers was taking doses too frequently per day, 4% and 3%, respectively. None of the socio-demographic characteristics were significantly associated with the types of errors reported by adolescents and caregivers.

Discussion

A large percentage of both caregivers and adolescents reported errors in taking asthma medications (61.4% of caregivers and 58% of adolescents). When adolescents and caregivers report errors, the most common reported error across both groups is not taking the medication at all. The second most commonly reported error was missing 3 or more doses per week. Future research needs to explore in more detail why adolescents are taking their control medications so differently from what their provider prescribed. It is especially concerning that the most common error that both adolescents and caregivers reported was not taking the control medication at all.

Health care providers can utilize the information from this study when communicating with pediatric asthma patients to reduce medication errors. Providers could ask simple open-ended questions such as "How are you using your controller medication?" or "Tell me how you are using your controller medication" so that they can assess how the adolescent's use of the medication might differ from what was prescribed. They could ask open-ended questions such as "What fears or concerns do you have about taking controller

Table 4. Types of Errors Reported by Adolescents and Caregivers (N=319).

Error type	Adolescent reporting errors percent (N)	Caregiver reporting errors percent (N)
Not taking at all	31.9 (102)	28.8 (92)
Missing 3 or more doses per week	15.4 (49)	14.4 (46)
Not taking enough times per day	9.4 (30)	7.5 (24)
Missing 1 to 3 doses per week	8.8 (28)	9.1 (29)
Does not know names of all medication	8.8 (28)	6.6 (21)
Too few single administration doses	3.8 (12)	5.6 (18)
Extra single administration doses	3.1 (10)	4.1 (13)
Taking too frequently per day	2.5 (8)	3.4 (11)

medications?” or “What barriers do you have to using controller medications?” to better understand why families might not be using their asthma medications as they were instructed.

None of the adolescent or caregiver socio-demographic characteristics were significantly associated with the number or types of errors that adolescents or caregivers reported. Therefore, health care providers should work with adolescents from all backgrounds to ensure that they and their caregivers understand how to appropriately use asthma controller medications.

Previous research has analyzed medication errors in the adolescent cancer population. Walsh et al⁷ reported 17% of patients reported non-adherence in the adolescent population, while 13% of patients reported missing doses in the last 7 days for any medicine used in the cancer treatment, both chemotherapy and supportive medications. Similar to asthma controller medication, chemotherapy and supportive medications may have difficult administration techniques and instructions for adolescents. This creates opportunity for both adolescents and caregivers to misinterpret appropriate administration schedule and/or instructions, leading to errors in the population. Our study found similar information in regard to the errors that were reported. Medications that had strict administration schedules had more errors reported than as needed medication.

There is a current gap in knowledge regarding misuse of medications in the adolescent population, particularly in using asthma controller medications. The results of this study can be used to improve the communication between health care providers and patients regarding using asthma controller medications. By understanding the types of errors that adolescents and caregivers make, health care providers can address relevant concerns in follow up visits regarding chronic asthma management. Health care providers can utilize this information to ensure that both adolescent patients and caregivers are appropriately educated on asthma controller medications in order to decrease unnecessary follow up visits and improve patient outcomes.

The pharmacist’s role in healthcare includes providing patients with information on how to take their medications appropriately. Pharmacists in the community setting can use the findings from this study to cater their patient education in order to maximize patient care in the adolescent asthma population. Emphasizing the importance of adherence in the adolescent patient population while using scheduled controller medication can decrease need for rescue inhalers.

There are various limitations that exist within this study. One limitation is that providers may not accurately report how patients should be using the medication in the medical record or may not update the medical record as instructions change for the patient over time. This may falsely increase the number of errors reported when comparing patient use to an incorrect medical record. The patients included in this study were attending pediatric clinics instead of specifically pulmonology clinics, which may have limited generalizability to those with severe asthma diagnosis. The patients in this study were only in North Carolina, which limits generalizability. We created and used a medication error typology used methods similar to those used by Walsh et al^{7,8} in the pediatric cancer area. Not all researchers might agree that not taking the medication at all is a medication error. However, we do believe that not taking an asthma medication at all is an error. Despite the limitations, our results illustrate a need for physicians, nurses, and pharmacists to work with adolescents so that they can better understand how to properly use their asthma controller medications.

Future research should be performed to assess if provider and pharmacist interventions can reduce the number of medication errors that adolescents and caregivers make when using asthma controller medications. Future research could analyze the number and types of errors reported before and after pharmacist counseling interventions on the adolescent asthma population. Community pharmacists could potentially reduce the number of medication errors among adolescents with asthma who are on control medications.

Author Contributions

HC: contributed to conception and design; contributed to acquisition, analysis, and interpretation; drafted manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy.

DC: contributed to conception; contributed to acquisition, analysis, and interpretation; critically revised manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy.

KW: contributed to conception; contributed to interpretation; critically revised manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy.

SAD: contributed to conception and design; contributed to analysis and interpretation; critically revised manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy.

NG: contributed to conception and design; contributed to acquisition, analysis, and interpretation; critically revised manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy.

BS: contributed to conception and design; contributed to acquisition, analysis, and interpretation; drafted manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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