

Albuterol off-label use in the management of hyperkalemia and students survey

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Abstract

This study aimed to explore the evidence in the off-label use of albuterol in the acute management of hyperkalemia. It also aims to explore the knowledge and opinion of first-year pharmacy students related to this topic. Based on the literature survey, it shows a lack of awareness among first-year pharmacy students regarding albuterol, hyperkalemia, and the use of albuterol for hyperkalemia. Demographic factors, such as income and years of work experience, were shown to influence students' understanding of the topic. Regarding the survey, a total of forty participants completed an online survey, providing information on demographic factors such as age, gender, residency state, employment status, income, education, and work experience. Results revealed a predominantly female and younger student population, with diverse geographic representation and varied employment and income levels. Most participants selected the wrong answer to questions related to albuterol and hyperkalemia, suggesting potential knowledge gaps in this area. These findings highlight the need for targeted educational interventions to enhance student understanding and clinical decision-making skills in pharmacotherapy-related concepts. Further research could evaluate the effectiveness of such interventions in improving student knowledge and patient care outcomes.

Keywords: Albuterol; Hyperkalemia; Survey; Pharmacy; Students

1 Introduction

Hyperkalemia, characterized by elevated serum potassium levels, is the second most common electrolyte imbalance and is a major risk for patients with renal failure ^{1,2}. Albuterol, a selective long-acting β_2 -adrenergic agonist, is a bronchodilator that is primarily indicated for reversible obstructive airway diseases such as asthma, chronic obstructive pulmonary disease (COPD), and exercise-induced bronchospasms ^{3,4}. Available formulations include metered-dose inhalers or nebulizer solutions, oral tablets, extended-release tablets, and injectable solutions. Albuterol has been investigated for its effect on lowering serum potassium and is particularly useful in renal failure patients undergoing hemodialysis. Previous studies have demonstrated that intravenous and nebulized albuterol rapidly reduce serum potassium levels, offering a promising therapeutic approach for the management of acute hyperkalemia ^{5,6}. Albuterol treats hyperkalemia via activation of the Na-K-ATPase pump in skeletal muscle, which induces intracellular potassium uptake and rapidly decreases serum potassium concentrations ^{1,2}.

For centuries, studies have examined the use of albuterol for hyperkalemia. One of the earliest clinical studies found that albuterol alleviates hyperkalemic paralysis caused by exercise or ingestion of potassium ⁷. Another study found that 1,200 μ g of inhaled albuterol consistently reduced serum potassium levels in renal failure patients within 3 to 5 minutes following delivery ⁸. Currently, the first-line management for acute hyperkalemia is IV regular insulin and glucose ⁹. However, multiple guidelines recommend high-dose albuterol as an adjunct therapy ^{9,10}. Despite the transient tachycardia and the paradoxical hyperkalemia observed with albuterol administration ⁸ it is generally well tolerated, effective, and has minimal adverse effects³.

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There are limited studies that assess healthcare professionals' knowledge of medications and their use for specific indications. Existing studies have only utilized surveys to assess the knowledge, attitude, and practice of pharmacists in regard to the pathology of asthma, asthma treatment, and metered-dose inhaler counseling^{11,23,13}. To our knowledge, this is the first study to assess pharmacy students' knowledge of albuterol and hyperkalemia. This study aims to bridge this gap by surveying first-year pharmacy students' knowledge of albuterol and its use in hyperkalemia management, while also investigating potential demographic influences on their understanding of the topic.

2 Methodology

2.1 Study Design

This study utilized a cross-sectional survey design to collect data from 40 first-year pharmacy students regarding their demographic information and knowledge about albuterol/hyperkalemia. *Participant Recruitment*: Participants were recruited through convenience sampling from first-year pharmacy student cohorts at Howard University College of Pharmacy. Participation was voluntary, and students were informed about the purpose of the survey and their rights as participants. *Survey Instrument*: The survey was administered electronically using an online survey platform. Participants were provided with a link to access the survey, which they could complete at their convenience. They were instructed to answer all questions honestly and to the best of their knowledge. *Data Collection*: The survey consisted of two sections: demographic information followed by 7 knowledge-based questions and 4 opinion-based questions about the albuterol and hyperkalemia. Each question asked students to respond by selecting how strongly they agree/disagree with statements. The answer choices were: "Strongly Agree, Agree, Disagree, and Strongly Disagree".

2.2 Data Analysis

Data obtained from the survey were analyzed using IBM SPSS (Statistical Package for the Social Sciences, Version 28.0.1.1 14). Descriptive statistics, including frequency tables and cross-tabulations, were generated to summarize the demographic characteristics of the participants and their knowledge about albuterol and hyperkalemia.

3 Results

Analysis of the responses shows varying levels of agreement or disagreement among students. However, for all questions, most students disagreed with the statements (50% to 83.8%). The following trends in demographic factors (Table 1, Table 2) were also observed:

The demographic characteristics of the participants in the study reveal a predominantly female composition, with females comprising 59% of the sample. The majority of students (80%) fell within the 18 to 24 years old bracket. Interestingly, no participants were reported to be between 25 and 34 years old. In terms of geographic representation, the data shows that a significant proportion of participants come from states other than Maryland and Virginia, accounting for 51.3% of the total. Maryland and Virginia followed, with 25.6% and 17.9% representation, respectively. (87.2%).

Table 1 Participant Demographic Data

Demographic Category	N	Frequency (%)
Gender (n = 39):		
Male	16	41%
Female	23	59%
Age (n = 40):		
18-24	32	80%
≥35	7	17.5%
State (n = 39): "State you have lived just before accepting admission to Howard."		
Washington	2	5.1%
Maryland	10	25.6%

Virginia	7	17.9%
Other	20	51.3%
Income (n = 36): "Annual income from your Job if you have worked."		
<\$10,000	12	33.3%
\$10,000-\$19,999	2	5.6%
\$20,000 - \$29,999	5	13.9%
\$30,000 - \$39,999	7	19.4%
\$40,000 - \$49,999	4	11.1%
> \$49,999	6	16.7%

The income distribution varies with most earning less than \$10,000 (33.3%), working in pharmacy or health-care related roles (39.4%), entering school with 1-3 years of work experience (54.3%), and having a 4-year degree (74.4%).

Table 2 Participants Work & Education Experience

Experience Category	N	Frequency (%)
Work Status (n = 39): "Have you worked or had a job before coming to Howard University pharmacy program?"		
Yes	34	87.2%
No	5	12.8%
Work Years (n = 35): "If you worked prior to coming to HU, how many years have you worked (in years)?"		
< 1 year	3	8.6%
1-3 years	19	54.3%
4-5 years	2	5.7%
>5 years	11	31.4%
Work Type (n = 33):		
Pharmacy or health care related.	13	39.4%
Pharmacy related.	8	24.2%
Not pharmacy or health care related	12	36.4%
Education (n = 39): "Highest education attended before coming to Howard Pharmacy School"		
Some college	4	10.3%
2-year degree	3	7.7%
4-year degree	29	74.4%
Professional degree	3	7.7%

Participants' responses to the knowledge-based questions are shown below (Table 3). Participants generally disagreed with all of the questions. When asked if it is advised for patients to drink lots of fluid if they are given albuterol (Q1), 31 students (83.8%) correctly disagreed compared to 6 students (15.0%) who agreed. Albuterol does not directly affect hydration levels or kidney function, so there is typically no need for patients solely taking albuterol to increase water intake. Students were assessed on whether they believed albuterol should be limited to use its approved indications (Q5), with 30 disagreeing (83.3%) and 6 (16.7%) agreeing. For this question, the correct answer was to disagree, as albuterol is used off-label for acute hyperkalemia. Notably, most students disagreed with the facts that: tachycardia is a major side effect of albuterol (Q7, N= 32, 86.5%), hyperkalemia is primarily caused by a shift in intra-extracellular potassium concentrations (Q8, N=31, 83.8%), the first-line treatment combination for hyperkalemia (Q9, N=26, 70.3%),

and that albuterol comes in tablet form (Q11, N= 22, 59.5%). The majority correctly disagreed that albuterol is approved for the treatment of respiratory bacterial infections (Q10, N=22, 59.5%); however, there was a general trend in student's disagreeing with all of the knowledge-based questions. The widespread selection of "Strongly disagree/Disagree" even when the answer was "Strongly Agree/Agree" suggests a lack of awareness about albuterol and hyperkalemia in this sample.

Table 3 Results of knowledge-based questions

Knowledge-based Question:	S. Agree / Agree N (%)	S. Disagree/Disagree N (%)
Q1. Patients should be advised to drink lots of fluid if they are given albuterol. (Answer: Disagree)	6 (15.0%)	31 (83.8%)
Q5 = Due to its ability to cause serious adverse effects, albuterol should be limited to its approved indications. (Answer: Disagree)	6 (16.7%)	30 (83.3%)
Q7 = One of the major side effects of albuterol is tachycardia. (Answer: Agree)	5 (13.5%)	32 (86.5%)
Q8 = One of the primary causes of hyperkalemia is a shift in the intra-extracellular concentrations of potassium. (Answer: Agree)	6 (16.2%).	31 (83.8%)
Q9 = Insulin plus dextrose IV infusions and β_2 -adrenergic agonists are the major combination to treat hyperkalemia. (Answer: Agree)	11 (29.7%)	26 (70.3%)
Q10 = Albuterol is approved for the treatment of respiratory bacterial infections. (Answer: Disagree)	15 (40.5%)	22 (59.5%)
Q11 = Albuterol also comes in tablet form. (Answer: Agree)	15 (40.5%)	22 (59.5%)

A significant majority of participants disagreed with infusing albuterol outside of its approved indication (Q2), with 28 participants (75.7%) expressing disagreement compared to 9 (24.3%) who agreed (Table 4). Similarly, the majority disagreed with the notion that some illnesses may interact with albuterol and do not support its use outside its indications (Q3), with 28 participants (75.7%) disagreeing compared to 9 (24.3%) who agreed. Regarding personal familiarity with albuterol, responses were evenly split, with 18 participants (50%) indicating knowing someone who had taken or been dispensed albuterol in the past (Q6). In contrast, when asked about using a non-approved drug for managing hyperkalemia (Q4), a smaller proportion, 10 participants (27%), expressed discomfort, while the majority, 27 participants (73%), disagreed with this statement.

Table 4 Results of the opinion-based questions

Opinion-Based Question	S. Agree/Agree N (%)	Disagree/S. Disagree N (%)
Q2 = I do not believe in infusing albuterol outside of its approved indication since the drug is given by inhalation.	9 (24.3%)	28 (75.7%)
Q3 = I believe some illnesses may interact with albuterol and do not support its use outside its indications	9 (24.3%)	28 (75.7%)
Q6 = I know someone taking or dispensed albuterol in the past.	18 (50%)	18 (50%)
4. Q4 = Hyperkalemia is an emergency, and I am not comfortable in using a non-approved drug to manage it. (n=37)	10 (27%)	27 (73%)

Gender was found to have a significant association with the correctness of responses to Question 11, with more females (n=23) selecting the correct answer (Table 5). State of residence also exhibited a significant correlation, as evidenced by Question 4, where more participants from other states (n=19) chose the correct answer. Furthermore, participants' income levels impacted their responses to Question 6, with a higher proportion of those earning between \$30,000-\$49,999 reporting not knowing someone taking or dispensed albuterol. Conversely, in Question 8, participants earning \$10,000-\$19,999 showed a higher likelihood of selecting the correct answer, whereas those earning less than \$10,000,

\$20,000-\$39,000, and >\$49,000 tended to select the wrong answer. Interestingly, age, work type, and education did not exhibit any statistically significant differences in responses. However, work experience demonstrated notable associations, with participants working for less than one year showing a higher likelihood of selecting the correct answer for Question 3, while those with longer work durations tended to choose the wrong answer. Similarly, for Question 7, participants with more than five years of work experience consistently selected the wrong answer, contrasting with those with less experience, who tended to choose the correct answer. This trend continued in Question 9, where participants with less than one year of work experience were more likely to select the correct answer compared to those with longer work durations.

Table 5 Cross-Tabulation Results of Demographic Factors v. Knowledge of Albuterol ($p \leq 0.05$)

Factor	Result
GENDER	Question 11: More females (n=23) chose the correct answer.
AGE	No statistically significant difference.
STATE	Question 4: More participants that were from other states (n = 19) chose the correct answer. Question 6: More participants from other states did not know someone taking or dispensed albuterol in the past.
WORK	No statistically significant difference.
INCOME	Question 6: More participants making between \$30,000-\$49,999 did not know someone that was taking or dispensed albuterol. Whereas most participants of the other income categories knew someone taking or dispensed albuterol Question 8: More participants making \$10,000-\$19,999 (n = 2) selected the correct answer. Most participants making less than \$10,000, \$20,000-\$39,000, and >\$49,000 selected the wrong answer
WORKTYPE	No statistically significant difference.
WORKYEARS	Question 3: All participants that worked for less than 1 year selected the correct answer. All who worked for 4-5 years chose the wrong answer. Most participants in other work year ranges (1-3 years, >5 years) selected the wrong answer. Question 7: All participants who worked >5 years selected the wrong answer. Most who worked 1-3 years selected the wrong answer. And all who worked <1 year selected the correct answer. Question 9: All participants who worked <1 year selected the correct answer. Most of those who worked 1-3 years or >5 years chose the wrong answer. Those who worked 4-5 years all selected the wrong answer.
EDUCATION	No statistically significant difference.

4 Discussion

The demographic characteristics of the participants in this study provide valuable insights into the profile of first-year pharmacy students. The majority of participants were female, consistent with the trend of increasing female enrollment in pharmacy programs in recent years. Additionally, most participants were in the younger age group of 18-24 years old, reflecting the typical age range of students entering pharmacy school directly from undergraduate studies.

Regarding residency state, a significant proportion of participants came from states other than Maryland and Virginia, indicating a diverse geographic representation within the sample. This diversity could potentially influence the perspectives and experiences of the participants, contributing to the richness of the data obtained. The employment status of participants revealed that a high percentage were employed, reflecting the common scenario of students balancing work commitments with academic responsibilities. Furthermore, the distribution of income varied widely among participants, highlighting the financial diversity within the student population. In terms of education and work experience, most participants possessed a 4-year degree and had 1-3 years of work experience. This suggests that many students enter pharmacy school with prior educational and professional backgrounds, which could influence their perspectives and knowledge base.

In analyzing survey responses, it is evident that despite differing levels of agreement or disagreement, the majority of students tended to disagree with statements regarding albuterol and hyperkalemia, even when the correct answer was

to agree. This discrepancy suggests a potential lack of awareness or understanding among first-year pharmacy students regarding this therapeutic approach. Cross-tabulation results reveal that factors such as gender, state of residence, income level, and years of work experience may influence first-year students' knowledge of albuterol. However, age, employment status, work type, and previous education level do not significantly influence their knowledge of albuterol.

There were a few observed trends that are worth examining further. Interestingly, students with less years of work experience consistently selected the correct answers compared to those with longer work durations. This can be attributed to several factors. Firstly, students with less work experience may still be in the early stages of their pharmacy education and training, where they are actively engaged in learning and absorbing new information. As a result, they may be more up-to-date and aligned with pharmacy information. Another trend was that students earning \$10,000-\$19,999 were more likely to select the correct answer about the cause of hyperkalemia compared to those earning higher or lower incomes. This could be influenced by factors such as cultural background, previous experiences, and individual learning styles. These factors may interact with income level in complex ways, contributing to variations in participants' knowledge and understanding of hyperkalemia.

Overall, these trends emphasize the importance of ongoing education and training for pharmacy professionals, regardless of their level of experience, and suggest a need to consider students' socioeconomic factors in healthcare education and training.

Study limitations

The study is subject to several limitations that should be acknowledged. Firstly, the recruitment of participants relied on convenience sampling from a student cohort, potentially introducing selection bias. Additionally, the use of self-reported data in an online survey format may have led to social desirability bias, recall bias, and measurement bias, potentially influencing the accuracy of responses. In regards to the diversity of the cohort, the majority hailed from states other than Maryland or Virginia. However, being that Howard University is a historically black university, there is little racial diversity of the cohort. Furthermore, the study's focus on a single university limits its external validity, and the absence of control for confounding variables may impact the robustness of the results. Therefore, while the study provides valuable insights into participants' demographic characteristics and knowledge about albuterol and hyperkalemia, these limitations should be considered when interpreting the findings.

5 Conclusion

The findings of this study underscore existing literature evidence on the use of albuterol in managing hyperkalemia, and the importance of targeted educational interventions to enhance student understanding of albuterol and hyperkalemia. While current guidelines primarily recommend IV regular insulin and glucose for acute hyperkalemia, high-dose albuterol is increasingly recognized as an adjunct therapy. Albuterol remains generally well-tolerated and effective, with minimal adverse effects reported. However, there is a paucity of large-scale studies assessing healthcare professionals' knowledge of albuterol's indications and use.

The secondary findings of the study reveal intriguing insights into participants' demographic characteristics. The sample of Howard University College of Pharmacy first-year students is predominantly female, with the majority falling within the 18-24 age bracket. Notably, there were no participants aged 25-34, indicating a narrower age range among first-year pharmacy students. Geographically, the study reflects a diverse representation, with a significant proportion hailing from states other than Maryland and Virginia. This geographic diversity may enrich the perspectives and experiences of participants, contributing to the depth of the study's findings. Additionally, the employment status and income distribution among participants underscore the financial diversity within the student population, highlighting potential socioeconomic influences on knowledge acquisition. Furthermore, the educational and professional backgrounds of participants suggest varied prior experiences that may shape their perspectives and knowledge base regarding albuterol and hyperkalemia.

This study underscores the imperative for tailored educational initiatives aimed at enriching students' comprehension of pharmacotherapy-related principles. Addressing the identified knowledge gaps is pivotal for equipping pharmacy educators to effectively nurture students' competence in delivering optimal patient care across various clinical contexts. Future investigations could delve into assessing the efficacy of educational interventions in augmenting student knowledge and refining their clinical decision-making abilities in this realm.

Ethical Considerations: Participants were assured of the confidentiality and anonymity of their responses, and informed consent was obtained from each participant before they commenced the survey.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare no conflict of interest. The survey was approved by Howard University IRB as part of a Drug Information course.

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