

# Home Medication Readiness for Preschool Children With Asthma

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## abstract

**BACKGROUND:** Having a medication available in the home is a prerequisite to medication adherence. Our objectives with this study are to assess asthma medication readiness among low-income urban minority preschool-aged children, and the association between beliefs about medications and medication readiness.

**METHODS:** During a baseline assessment, a research assistant visited the home to administer a caregiver survey and observe 5 criteria in the medication readiness index: the physical presence and expiration status of medications, the counter status of metered-dose inhalers, and caregiver knowledge of medication type and dosing instructions.

**RESULTS:** Of 288 enrolled children (mean age 4.2 years [SD: 0.7], 92% African American, 60% boys), 277 (96%) of their caregivers reported a rescue medication, but only 79% had it in the home, and only 60% met all 5 of the medication readiness criteria. Among the 161 children prescribed a controller medication, only 79% had it in the home, and only 49% met all 5 readiness criteria. Fewer worries and concerns about medications were associated with higher odds of meeting all 5 readiness criteria for controller medications.

**CONCLUSIONS:** Inadequate availability of asthma medications in the home is a barrier to adherence among low-income urban preschoolers. Assessment of medication readiness should be incorporated into clinical care because this is an underrecognized barrier to adherence, and interventions are needed to improve medication management and knowledge to increase adherence.



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Dr Eakin conceptualized and designed the study, contributed to the analysis plan, and reviewed and revised the manuscript; Dr Callaghan-Koru contributed to the analysis plan, conducted the analysis, wrote the initial draft of the manuscript, and revised the manuscript; Drs Riekert and Rand contributed to the conceptualization and design of the study and reviewed and revised the manuscript; Ms Ruvalcaba contributed to the collection of data and to the interpretation of results and reviewed and revised the manuscript; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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**WHAT'S KNOWN ON THIS SUBJECT:** Adherence to daily medication regimens among young children with chronic conditions is suboptimal. The authors of previous research have identified individual, community, and health care system factors that influence medication adherence.

**WHAT THIS STUDY ADDS:** We assess medication readiness criteria including the physical presence in the home of prescribed asthma medications, a prerequisite to medication adherence. We find that only two-thirds of children's caregivers reporting a controller medication had it present in the home.

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Asthma is the most common chronic disease among children in the United States. Pediatric asthma is also recognized as a major contributor to health disparities, with 15.9% of African American non-Hispanic children reporting asthma as compared with 7% of white non-Hispanic children.<sup>1</sup> Many children are diagnosed with asthma early in the preschool years, and this age group is twice as likely to visit the emergency department and 3 times as likely to be hospitalized compared with older children.<sup>2</sup> Guideline-based medication regimens is a key strategy for controlling asthma symptoms in young children and preventing hospitalizations.<sup>3</sup> Despite their effectiveness, adherence to asthma medication regimens among children is often low,<sup>4</sup> particularly in urban African American populations at high risk for asthma morbidity.<sup>5</sup> Poor adherence to controller medications increases the risk of asthma morbidity and mortality.<sup>6,7</sup>

To reduce disparities in asthma morbidity, US agencies have committed to addressing barriers to adherence to prescribed medications.<sup>8,9</sup> Medication adherence is often described as a process with 3 components: initiation (patient receives the medication and takes first dose), implementation (patient takes medication according to prescribed dosing regimen), and persistence (length of time patient continues to take the medication).<sup>10</sup> For a patient to be adherent over time, they must have the medication available to administer. Authors of previous research have demonstrated that ~8% of adults with asthma never fill their first prescription for inhaled corticosteroids (ICSs), with African Americans being the most likely not to fill their prescription.<sup>11</sup>

Although the majority of childhood asthma adherence researchers have examined prescription-filling patterns<sup>12–14</sup> or self-reported adherence,<sup>13,15</sup> little is known about

whether families have prescribed asthma medications physically available in the home.<sup>8</sup> Caregivers of children with asthma have been shown to have limited knowledge about their children's medications, with only 63% able to identify their child's prescribed medicines.<sup>16</sup> Furthermore, medication beliefs such as worries and concerns about medicines, confidence in one's ability to correctly take medicines (self-efficacy), and outcome expectancies were associated with medication adherence in previous studies and may serve as mediators of the relation between race and adherence.<sup>13,17</sup>

In this study, we conceptualize medication readiness to include both the physical availability of medications (the presence in the home of a medication that is not expired and not empty) as well as knowledge of the medication's purpose and dosing. Our goals with this study are (1) to objectively assess asthma medication readiness for both controller and rescue medications among caregivers of low-income urban minority preschool-aged children and (2) to assess whether beliefs about medications are associated with medication readiness in this population.

## METHODS

### Design and Participants

This study is a cross-sectional analysis of baseline asthma medication readiness among the caregivers of preschool-aged children at the time of enrollment in the trial Asthma Basic Care Education in Head Start. Participants were recruited from Baltimore City Head Start programs from April 2011 to November 2016. Eligible caregivers had to be the parent or legal guardian of a child aged 2 to 6 years, who reported that a physician diagnosed their child with asthma, and who

spoke English. Study staff contacted eligible families who gave permission on screening forms completed at Head Start to confirm eligibility and schedule a home visit. During the home visit, research assistants (RAs) obtained written informed consent from the child's primary caregiver and conducted the baseline assessment. The Johns Hopkins School of Medicine Institutional Review Board reviewed and approved this study.

### Procedures

At a 2-hour home visit to the primary home of each child enrolled in the study, the RA conducted a structured interview with the child's caregiver. RAs asked caregivers to report all asthma medications the child had been prescribed and to assemble all of the child's asthma medications and devices that were currently in the home. RAs visually inspected the medications to assess the 5 readiness criteria for each reported medication. Caregivers also responded to questions on medication beliefs, controller medication adherence, and level of asthma control.<sup>18</sup>

### Measures

#### *Medication Readiness Index*

The medication readiness index includes 5 basic elements of medication availability and knowledge that we considered usual and necessary prerequisites to appropriate use of rescue medications and adherence to controller medications. The 3 availability criteria included whether the caregivers could locate each reported medication, including the nebulizer machine for nebulizer medications (criterion 1), whether each medication was not expired (criterion 2), and whether each medication with a counter had remaining doses (criterion 3). The 2 knowledge criteria included whether the caregiver could correctly identify whether the

medication was a rescue or controller medication (criterion 4) and could state any dosing instructions for the medication (criterion 5). The index was developed in consultation with a pediatrician, pediatric pulmonologist, pharmacist, and behavioral psychologist. Survey questions to measure items in the index were reviewed and revised to ensure that they objectively captured the essential components of medication availability and management that are prerequisites for adherence (Supplemental Table 5). We calculated dichotomous measures of “medication readiness,” defined as meeting all 5 criteria in the medication readiness index. Medical records were not available for confirming doctor-prescribed medications and dosing instructions.

#### *Pediatric Asthma Medication Beliefs*

Caregiver beliefs about medications were measured by using a 21-item scale, the Pediatric Asthma Medication Beliefs Assessment (PAMBA), which was previously validated in a similar minority urban population.<sup>19</sup> Caregivers rated their agreement with each statement about asthma controller medications on a 5-point Likert scale from “strongly agree” to “strongly disagree” (see Supplemental Table 6 for agreement with individual statements). The scale includes 3 subscales: symptom-based outcome expectancy (8 items), self-efficacy (7 items), and worries and concerns (6 items). Responses to negative statements were scored according to a 1-to-5 Likert scale, with “strongly agree” scored as 1 and “strongly disagree” scored as 5, whereas responses to positive statements were scored in reverse. Item scores were summed to create a total PAMBA score, with a maximum possible score of 105, as well as subscale scores for symptom-based outcome expectancy (maximum of 40), self-efficacy (maximum of 35), and worries and concerns (maximum of 30). Higher PAMBA and subscale

scores indicate more positive beliefs about asthma medications.

#### *Self-Reported Adherence*

For each controller medication reported, caregivers answered structured questions about how frequently the child took the controller medication in the past 2 weeks: “not at all,” “a few days (1–3 days),” “several days (4–7 days),” “most days (8–11 days),” “almost every single day (12–13 days),” or “every single day (14 days).” This measure is adapted from other single-item self-reported adherence measures that have been previously validated.<sup>20,21</sup> Caregivers who responded “almost every single day” or “every single day” for any controller were considered to have self-reported adherence in analysis, consistent with the common definition of adherence as taking 80% or more of prescribed doses.<sup>22</sup>

#### *Statistical Analyses*

Descriptive statistics for the medication readiness index criteria, self-reported adherence, and health beliefs were calculated for all children whose caregivers completed the medication readiness index assessment. Logistic regression was used to assess the relationship between medication readiness and PAMBA scores. Possible confounders for this relationship were also tested, including caregiver demographics and asthma control, but excluded from the presented models because they were not significant in bivariate analyses. Cross tabulations and the  $\chi^2$  test were used to assess associations between self-reported adherence and medication presence in the home. Two-sample tests of proportions were used to assess for differences between medication type (rescue or controller) and medication readiness index criteria. All analyses were conducted in Stata version 13 (Stata Corp, College Station, TX).

## **RESULTS**

A total of 288 caregivers of Baltimore City Head Start children with asthma completed the baseline surveys including medication readiness index assessments. The caregivers most commonly completing the survey were the birth mother (85%) or birth father of the child (7%; Table 1). Close to 40% of caregivers had not completed high school, 29% reported a high school diploma or general equivalency diploma as their highest educational attainment, and 33% had attended or graduated from college. The mean age of enrolled children at the time of the assessment was 4.2 years (SD = 0.7). The sample is predominantly African American (92%) and covered by state insurance (94%). Sixty percent of the children were boys, and 61% of the children had uncontrolled asthma.

#### *Medication Readiness*

Caregivers reported at least 1 rescue medication or controller medication for 277 (96%) and 161 (56%) children, respectively. The rescue medication most commonly reported was an albuterol metered-dose inhaler (MDI;  $n = 255$ , 89%); 58% were prescribed both an albuterol MDI and an albuterol nebulizer (Table 2). The most commonly reported controller medication was fluticasone MDI ( $n = 120$ , 42%). Caregivers reported 2 or more controller medications for 39 children (14%) and 2 rescue medications (albuterol MDI and nebulizer) for 168 children (58%).

Among children whose caregivers reported a rescue medication, only 60% had a rescue medication that met all 5 readiness index criteria (Fig 1). Medication readiness was lower for children whose caregivers reported a controller medication, with only 49% meeting all 5 readiness index criteria. Although the proportion of caregivers who were able to locate a rescue medication in the home was nearly identical

**TABLE 1** Description of the Sample (*N* = 288)

| Characteristic                           | Frequency  | %    |
|------------------------------------------|------------|------|
| <b>Characteristics of the children</b>   |            |      |
| Mean age in y (SD)                       | 4.2 (0.7)  | N/A  |
| Sex                                      |            |      |
| Male                                     | 174        | 60.4 |
| Female                                   | 114        | 39.6 |
| Race                                     |            |      |
| African American                         | 264        | 91.7 |
| White (non-Hispanic)                     | 9          | 3.1  |
| Hispanic                                 | 5          | 1.7  |
| Other                                    | 10         | 3.4  |
| Health insurance                         |            |      |
| Medical assistance                       | 270        | 93.6 |
| Private insurance                        | 6          | 2.1  |
| Don't know                               | 2          | 0.7  |
| Other                                    | 4          | 1.4  |
| Uncontrolled asthma                      | 175        | 60.8 |
| <b>Characteristics of the caregivers</b> |            |      |
| Mean age in y (SD)                       | 31.7 (8.3) | N/A  |
| Relationship to child                    |            |      |
| Birth mother                             | 246        | 85.4 |
| Birth father                             | 19         | 6.6  |
| Grandmother                              | 8          | 2.8  |
| Legal guardian                           | 8          | 2.8  |
| Other                                    | 7          | 2.4  |
| Education                                |            |      |
| Less than ninth grade                    | 51         | 17.7 |
| Some high school                         | 57         | 19.8 |
| High school graduate or GED              | 82         | 28.5 |
| Some college or trade school             | 63         | 21.9 |
| 4-y college graduate                     | 32         | 11.1 |

There are 6 missing values for insurance and 3 missing values for education. GED, general equivalency diploma; N/A, not applicable.

to that of those who were able to locate a controller medication (78%), caregivers were less likely to meet the knowledge criteria for controller medications, which includes stating any dosing instructions (81% for controller compared with 92% for rescue;  $P < .01$ ) and identifying the

type of medication (controller or rescue) correctly (78% compared with 94%;  $P < .01$ ).

Among the 2 rescue medications, only 52% of children with albuterol nebulizer prescriptions and 45% of children with albuterol MDIs

met all 5 readiness criteria for the respective medication (Table 2). For both albuterol MDI and albuterol nebulizer prescriptions, the criteria that was most likely to be met was caregiver identification of the medication as a rescue medication (93% and 92%, respectively), and the criteria least likely to be met was that the medication had not passed the expiration date (55% and 63%, respectively).

Among children with a controller medication, the proportion whose caregiver met all 5 medication readiness criteria was near or below half for all but 1 medication. For the most commonly reported controller medication, fluticasone MDI, only 44% of children met all 5 readiness criteria. Medication readiness was similar for budesonide nebulizers (48%) and montelukast (51%).

Some medication management patterns are apparent by medication type and mode of delivery. More caregivers correctly identified the purpose of rescue medications than control medications (92% compared with ~80%;  $P < .01$ ). For each of the 3 MDI rescue or controller medications, one-third of children actually had an empty canister in the home. Spacers, which are required for correct administration of MDIs, were present for 133 of the 187 children (71%) with any MDI

**TABLE 2** Home Medication Readiness for Rescue and Controller Medicines (*n* = 288)

|                                                         | Rescue Medications |                     |                                   | Controller Medications |                      |                                 |             |
|---------------------------------------------------------|--------------------|---------------------|-----------------------------------|------------------------|----------------------|---------------------------------|-------------|
|                                                         | Albuterol MDI      | Albuterol Nebulizer | Fluticasone and/or Salmeterol DPI | Fluticasone MDI        | Budesonide Nebulizer | Beclomethasone Dipropionate MDI | Montelukast |
| Reports doctor prescribed medication                    | 255                | 190                 | 6                                 | 120                    | 23                   | 18                              | 37          |
| Meets all 3 availability criteria, <i>n</i> (%)         | 136 (53.3)         | 109 (57.4)          | 4 (66.7)                          | 68 (56.7)              | 14 (60.8)            | 12 (66.7)                       | 23 (62.2)   |
| Located medication in the home                          | 178 (71.5)         | 129 (67.9)          | 5 (83.3)                          | 90 (75.0)              | 18 (78.2)            | 15 (83.3)                       | 25 (67.6)   |
| Medication not expired                                  | 157 (54.5)         | 119 (62.6)          | 4 (66.7)                          | 77 (64.2)              | 15 (65.2)            | 15 (83.3)                       | 24 (64.9)   |
| Counter not at 0                                        | 162 (63.5)         | N/A                 | 5 (83.3)                          | 80 (66.7)              | N/A                  | 12 (66.7)                       | N/A         |
| Meets all 2 knowledge criteria, <i>n</i> (%)            | 212 (83.1)         | 149 (78.4)          | 5 (83.3)                          | 78 (65.0)              | 15 (65.2)            | 6 (33.3)                        | 30 (81.1)   |
| States dosing instructions                              | 223 (87.5)         | 158 (83.2)          | 6 (100)                           | 96 (80.0)              | 18 (78.2)            | 9 (50.0)                        | 33 (89.2)   |
| Identifies if controller or rescue                      | 236 (92.5)         | 175 (92.1)          | 5 (83.3)                          | 89 (74.2)              | 16 (69.6)            | 13 (72.2)                       | 31 (83.8)   |
| Meets all 5 medication readiness criteria, <i>n</i> (%) | 114 (44.7)         | 99 (52.1)           | 4 (66.7)                          | 53 (44.2)              | 11 (47.8)            | 3 (16.7)                        | 19 (51.4)   |

Percentage of those who report doctor prescribed medicine. DPI, dry powder inhaler; N/A, not applicable.

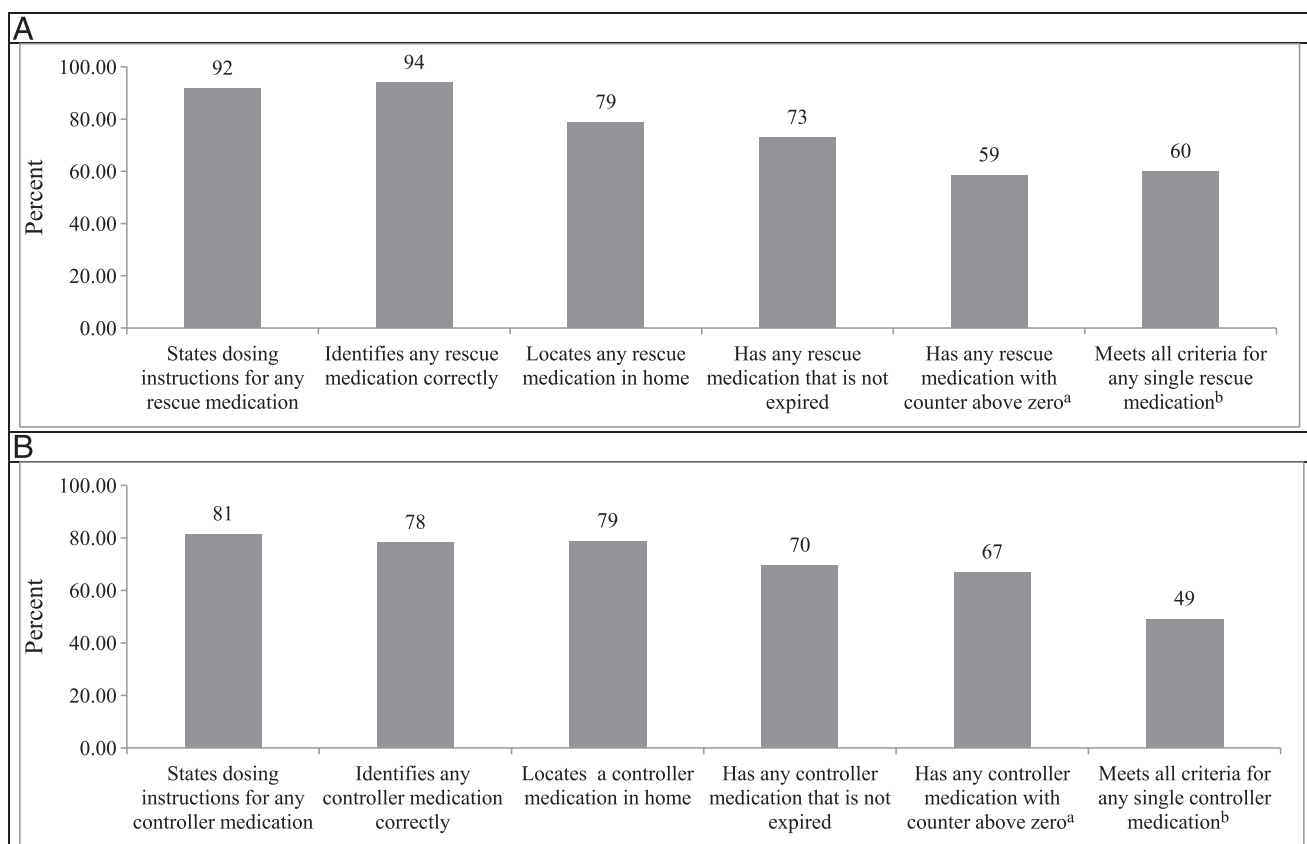


**FIGURE 1**

Proportion of children prescribed a medication who meet medication readiness criteria by medication type. A, Rescue medication adherence readiness ( $n = 277$ ). B, Controller medication adherence readiness ( $n = 161$ ). <sup>a</sup> Only calculated for MDI medications. <sup>b</sup> 5 criteria for MDI medications, 4 criteria for other medications.

medication in the home. Among the controller medications, the only oral medication, montelukast, was the least likely to be located in the home (68%).

### Caregiver-Reported Adherence to Controller Medication

Of the 161 children whose caregivers reported a controller medication, 153 also responded to questions measuring self-reported adherence. Slightly more than half of these caregivers (54%) reported that the child was adherent by taking the medication every day or nearly every day (Table 3). Although caregivers who were able to locate a controller medication in the home were statistically significantly more likely to report that the child was adherent (62% compared with 25%;  $P < .01$ ), it is worth noting that caregivers for

8 (10%) of the 83 children reported to be adherent could not locate a controller medication in the home. Among the 32 children whose caregivers reported a controller medication but were unable to physically locate one in the home at the time of the interview, 16 (50%) reported the child took a controller medication “most days” or more frequently.

### PAMBA Scores and Association With Medication Readiness

The mean overall PAMBA score was 79.9 (SD: 9.3). Subscale means and Cronbach’s  $\alpha$  are included in Supplemental Table 7. The association between caregivers’ medication beliefs as measured according to the PAMBA and meeting all 5 medication readiness criteria was tested for the overall PAMBA

score and the 3 subscales (Table 4). Higher scores on the PAMBA, indicating more positive beliefs about asthma medications, were associated with increased odds of meeting all 5 medication readiness criteria for controller medications (crude odds ratio: 1.04;  $P < .05$ ) but not rescue medications. A 1-point increase in the scale of worries and concerns, indicating the caregiver had fewer worries and concerns about asthma medication, was associated with 1.19 times the odds of controller medication availability in adjusted models ( $P < .05$ ).

When separate models were compared for the 3 availability criteria and the 2 knowledge criteria, the association between worries and concerns was significant for meeting the knowledge criteria for controller medications (adjusted odds ratio

**TABLE 3** Self-Reported Adherence to Controller Medications in Households With and Without Medication Present

| Caregiver Reported Frequency of Controller Use in Past 2 wk | Presence of Medication in the Home                         |                                                         |
|-------------------------------------------------------------|------------------------------------------------------------|---------------------------------------------------------|
|                                                             | Controller Medication Not Present in Home ( <i>n</i> = 32) | Controller Medication Present in Home ( <i>n</i> = 122) |
| Not at all                                                  | 10 (31.3)                                                  | 19 (15.6)                                               |
| A few d (1–3 d)                                             | 3 (9.4)                                                    | 5 (4.1)                                                 |
| Several d (4–7 d)                                           | 3 (9.4)                                                    | 8 (6.6)                                                 |
| Most d (8–11 d)                                             | 8 (25)                                                     | 15 (12.3)                                               |
| Almost every single d (12–13 d)                             | 0 (0)                                                      | 28 (23.0)                                               |
| Every single d (14 d)                                       | 8 (25)                                                     | 47 (38.5)                                               |

Caregivers for 11 children reporting a controller medication did not respond to the self-reported adherence questions.

**TABLE 4** Odds of Meeting Readiness Criteria for Rescue and Control Medications Based on Health Beliefs and Self-Reported Adherence to Control Medications

|                                      | Crude ORs               |                      |                | aORs                    |                      |                |
|--------------------------------------|-------------------------|----------------------|----------------|-------------------------|----------------------|----------------|
|                                      | 3 Availability Criteria | 2 Knowledge Criteria | All 5 criteria | 3 Availability Criteria | 2 Knowledge Criteria | All 5 criteria |
| Rescue medication ( <i>n</i> = 277)  |                         |                      |                |                         |                      |                |
| Health belief scale                  | 1.01                    | 1.03                 | 1.01           | —                       | —                    | —              |
| Subscales                            |                         |                      |                |                         |                      |                |
| Symptom-based outcome expectancy     | 1                       | 1.02                 | 1              | 0.99                    | 1                    | 0.99           |
| Self-efficacy                        | 1.03                    | 1.03                 | 1.03           | 1.02                    | 1                    | 1.03           |
| Worries and concerns                 | 1.03                    | 1.09                 | 1.03           | 1.01                    | 1.09                 | 1.02           |
| Control medication ( <i>n</i> = 153) |                         |                      |                |                         |                      |                |
| Health belief scale                  | 1.03                    | 1.06**               | 1.04*          | —                       | —                    | —              |
| Subscales                            |                         |                      |                |                         |                      |                |
| Symptom-based outcome expectancy     | 1.03                    | 1.09*                | 1.04           | 1.02                    | 1.05                 | 1              |
| Self-efficacy                        | 1.04                    | 1.07                 | 1.04           | 0.96                    | 1                    | 0.95           |
| Worries and concerns                 | 1.08                    | 1.16**               | 1.14**         | 1.11                    | 1.13*                | 1.19*          |
| Self-reported adherence              | 4.88**                  | 2.4*                 | 4.06**         | 5.2**                   | 2.51*                | 4.59**         |

Adjusted models include only the variables in the table. Possible confounding variables, including asthma control and caregiver characteristics, had no significant effect on medication readiness and were excluded from the model. OR, odds ratio; —, not applicable.

\*  $P < .05$ ;

\*\*  $P < .01$ .

[aOR]: 1.13;  $P < .05$ ) but not the availability criteria. The subscales for symptom-based outcome expectancy and self-efficacy had no significant association with meeting the medication readiness criteria. High self-reported adherence to controller medications (every single day or almost every single day) significantly increased the odds of meeting all 5 medication readiness criteria for controller medications (aOR: 4.59,  $P < .01$ ).

## DISCUSSION

Adherence to medication regimens for pediatric asthma control requires caregivers to complete a series of steps that precede actually taking the medication,

including filling the prescription, identifying and understanding how to take the medication, organizing storage of the medication, and monitoring medication expiration dates and counter status.<sup>23</sup> Among the population of low-income, predominantly African American households with preschool-aged children with asthma in this study, we observed major gaps in medication readiness, including low knowledge about medications and unavailability of medications. Gaps in the 3 availability criteria were similar for both controller and rescue medications, whereas more caregivers met the 2 knowledge criteria for rescue medications than controller medications. Overall, less than half

of children reporting controller medications are ready for daily adherence, and only 60% reporting rescue medications are ready to respond to an asthma exacerbation, by meeting all 5 medication readiness criteria for each class of medication. These findings suggest that poor medication readiness should be considered as an important and potentially modifiable contributor to home-based asthma management. The urban low-income population in this study experiences significantly higher rates of emergency department use and deaths because of asthma exacerbations,<sup>15</sup> and improving home medication readiness may help to improve these outcomes.

In this study, we objectively documented suboptimal home medication management among caregivers of young children with asthma and identified important gaps in medication availability and caregiver knowledge. We extend previous research using self-reported adherence<sup>8,10</sup> and prescription filling patterns<sup>12–14</sup> to document suboptimal adherence by identifying specific gaps in home medication management that prevent proper adherence. In 1 previous study, asthma medication availability in the home before any intervention was reported, but expiration dates and counter status were not assessed. The researchers reported physical presence of medications among a cohort of Hispanic children between the ages of 5 and 18 in Chicago with uncontrolled asthma.<sup>8</sup> Two-thirds of children in the Chicago sample (74%) had a rescue medication in the home, whereas only half (49%) had any controller.<sup>8</sup> Although the composition of our sample is younger, predominantly African American, and 40% of the children had controlled asthma, a similar proportion of households had rescue medications and controller medications physically present in the home (75% and 44%, respectively). Large gaps were also observed in the caregivers' ability to correctly identify controller medications (32%) but not rescue medications (84%) in the Chicago study.<sup>8</sup> Another study at the end of a trial to improve asthma management among school-aged children in Rochester, New York, revealed that only 46% of caregivers could accurately recall the name of the asthma medications present in the home but did not verify if the medication was in the home.<sup>24</sup> Our results reveal that empty canisters and expired medications also contribute substantially to reducing medication readiness and should be routinely assessed in both research and clinical settings.

The association between a caregiver's reported worries and concerns about asthma medications and their level of controller medication knowledge and overall medication readiness in our study is similar to associations between beliefs and adherence reported in other studies among different populations of adults<sup>25–28</sup> and children with asthma.<sup>13,17,29</sup> Researchers for previous studies have reported an association between ICS necessity beliefs, concerns about ICS, and medication refills.<sup>27</sup> Negative health beliefs about asthma medications may be a particular concern for minority populations in the United States. Research by Le et al<sup>26</sup> among adults with asthma suggests that higher rates of negative health beliefs among minority populations mediates the relationship between minority race and lower adherence. Our findings extend our understanding about the role of medication beliefs and adherence beyond medication taking behavior by demonstrating that worries and concerns about controller medications predict medication readiness.

Our findings about limited medication availability in the home, as well as the association between health beliefs and medication knowledge, indicate an important intervention point in medication adherence.<sup>23</sup> The caregivers in this study reported low educational attainment, which likely contributes to low medication knowledge scores. Another factor that may be contributing to both negative medication beliefs and knowledge gaps is inadequate or ineffective medication counseling from health providers. Although routine asthma care, such as having a nonurgent asthma visit and an asthma action plan, have been associated with improved adherence,<sup>30</sup> the majority of surveyed pediatric patients with asthma report that they not are

receiving guideline-based care, such as counseling on proper preventive medication use and developing asthma action plans.<sup>24</sup> Interventions to improve asthma education can effectively increase adherence and improve outcomes.<sup>31</sup> Our results suggest that such interventions, particularly when delivered to urban minority populations, should specifically address worries and concerns about medications as well as barriers to maintaining medications in the home. Providing appropriate education will be an important component of efforts to reduce asthma disparities.<sup>9,32</sup>

These results suggest that including home asthma medication readiness in adherence interventions may increase their ability to reduce asthma-related morbidity and mortality. A child whose medication is expired or empty, or whose caregiver cannot locate the medication in the home, is by definition not able to adhere to their controller medication regimen, putting them at greater risk for asthma morbidity and mortality.<sup>6,7</sup> Barriers to filling prescriptions for caregivers of low-income urban children with asthma may include gaps in insurance coverage, difficulties with previous authorization requirements, and competing time demands for meeting other basic household needs.<sup>33</sup> Among children in preschool programs that require a new rescue medication for enrollment, such as Head Start, insurance reimbursement policies that limit refills may require caregivers to go without a medication at home until a new refill is allowed.<sup>34</sup> Many families in our sample also divide caregiving responsibilities between multiple caregivers and/or households, and medications may not be present in every home where children spend significant time.<sup>34</sup>

A major strength of this study is the in-home objective measurement of rescue and controller medication availability. The majority of studies in which pediatric medication adherence is assessed rely on self-reported measures or pharmacy fill data, which provide an incomplete picture of the actual medication availability required for children to be ready to adhere to their regimens. However, the cross-sectional nature of this study did not allow us to examine the effects of poor medication readiness on asthma control and health care utilization. Additional research is needed to examine this relationship

as well as to understand the factors contributing to poor medication readiness. Furthermore, we did not confirm the parent-reported regimen against medical records.

## CONCLUSIONS

A striking proportion of low-income urban children with asthma do not have medications readily available in the home. This gap leaves children unable to appropriately adhere to their treatment plan or respond to an exacerbation with a rescue medication, which previous research has revealed increases the risk for

asthma morbidity and mortality. Assessment of medication readiness should be incorporated into the care of children with chronic conditions, and interventions are needed to improve medication management.

## ABBREVIATIONS

aOR: adjusted odds ratio  
ICS: inhaled corticosteroid  
MDI: metered-dose inhaler  
PAMBA: Pediatric Asthma Medication Beliefs Assessment  
RA: research assistant

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# Supplemental Information

**SUPPLEMENTAL TABLE 5** Medication Readiness Index Questions From Caregiver Survey

| No. | Question/Instructions                                                                                                                                          | Response Options                                                                                                                                                                                                                                       |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | I am going to ask you to show me how you manage your child's asthma. Please check all asthma medications that your child is currently prescribed. <sup>a</sup> | Advair diskus/HFA<br>Albuterol/ProAir/Proventil/Ventolin MDI<br>Albuterol/ProAir/Proventil/Ventolin nebulizer<br>Atrovent MDI<br>Flovent MDI<br>Pulmicort/budesonide nebulizer<br>Qvar MDI<br>Singulair/Montelukast<br>Xopenex MDI<br>Other medication |
| 2   | Reports [medication name] prescribed <sup>b</sup>                                                                                                              | Yes<br>No                                                                                                                                                                                                                                              |
| 3   | Knows dosing instructions                                                                                                                                      | Yes<br>No                                                                                                                                                                                                                                              |
| 4   | Locates medication in the home                                                                                                                                 | Yes<br>No                                                                                                                                                                                                                                              |
| 5   | Identifies if controller or rescue                                                                                                                             | Yes<br>No                                                                                                                                                                                                                                              |
| 6   | Medication expired                                                                                                                                             | Yes<br>No                                                                                                                                                                                                                                              |
| 7   | Counter at 0 <sup>c</sup>                                                                                                                                      | Yes<br>No                                                                                                                                                                                                                                              |

HFA, hydrofluoroalkane.

<sup>a</sup> Medication types are reported in the article by using generic names, but caregivers were asked about medication types according to brand names for easy identification by caregivers.

<sup>b</sup> Questions 2 through 7 repeat for each medication option in question 1.

<sup>c</sup> For MDIs only.

**SUPPLEMENTAL TABLE 6** Agreement With Statements in the PAMBA (*n* = 288)

| Statements                                                                                                                                                                | Mean (SD)    |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| Symptom-based outcome expectancy subscale                                                                                                                                 | 28.77 (4.62) |
| Even if my child takes asthma medicines, he or she will have asthma symptoms                                                                                              | 1.61 (1.13)  |
| Taking asthma medicines makes my child hyperactive                                                                                                                        | 1.79 (1.09)  |
| There is nothing I can do to stop an asthma attack from getting worse                                                                                                     | 2.25 (0.92)  |
| Taking asthma medicines keeps my child from getting sicker [R]                                                                                                            | 1.11 (1.05)  |
| Taking asthma medicines helps my child not miss school or daycare [R]                                                                                                     | 1.12 (1.07)  |
| Taking asthma medicines helps my child sleep through the night without waking up coughing or wheezing [R]                                                                 | 1.2 (1.15)   |
| Taking asthma medicines keeps my child from having to go to the hospital [R]                                                                                              | 1.23 (1.16)  |
| Taking asthma medicines helps my child play and exercise more [R]                                                                                                         | 1.54 (1.25)  |
| Self-efficacy subscale                                                                                                                                                    | 28.70 (4.10) |
| It is hard to know when my child's inhaler is empty                                                                                                                       | 2.41 (0.63)  |
| It is hard for me to remember to get refills for my child's asthma medicine before it runs out                                                                            | 2.32 (0.73)  |
| It is difficult for me to help my child take asthma medicines exactly the way the doctor said to                                                                          | 2.22 (0.84)  |
| Getting my child to take medicine when we're out in public is hard                                                                                                        | 2.29 (0.84)  |
| It is hard to make my child take medicine when he or she feels fine                                                                                                       | 2.02 (1.0)   |
| I am sure that I can help my child take his or her medicine exactly the way the doctor said to [R]                                                                        | 0.60 (0.69)  |
| Even when there are things my child would rather be doing, I am sure that I can get him or her to take his or her asthma medicines exactly the way the doctor said to [R] | 0.75 (0.87)  |
| Worries and concerns subscale                                                                                                                                             | 22.4 (3.89)  |
| The side effects of asthma medications are bad enough that I do not want my child to take them                                                                            | 2.38 (0.68)  |
| Taking asthma medications every day will make them not work as well when my child really needs them                                                                       | 2.21 (0.91)  |
| Even when they feel well, children with asthma should limit how much they play or exercise                                                                                | 1.64 (1.15)  |
| Taking medications makes me worry more about my child's asthma                                                                                                            | 2.08 (0.80)  |
| My child will become addicted to asthma meds if he or she takes them every d                                                                                              | 2.38 (0.82)  |
| The benefits that come from my child taking asthma medications make the side effects worth it [R]                                                                         | 1.51 (1.29)  |
| Total PAMBA score                                                                                                                                                         | 79.9 (9.29)  |

Responses were scored according to a 1-to-5 Likert scale, with "strongly agree" scored as 1 and "strongly disagree" scored as 5. [R] indicates positive statements that were reverse-coded in the scale. Missing values: 2 missing for statements 5, 14, and 19; 1 missing for statements 9, 11, 12, 16, 17, and 21.

**SUPPLEMENTAL TABLE 7** Health Belief Subscale Means, Correlations, and Cronbach's  $\alpha$  for Scale Items Among Children Prescribed a Controller Medication (*n* = 161)

| Subscale                                   | Mean (SD)  | Correlations ( $\alpha$ ) |                                  |                      |
|--------------------------------------------|------------|---------------------------|----------------------------------|----------------------|
|                                            |            | Self-Efficacy             | Symptom-Based Outcome Expectancy | Worries and Concerns |
| Self-efficacy (7 items)                    | 28.9 (4.1) | (0.69)                    | —                                | —                    |
| Symptom-based outcome expectancy (8 items) | 28.4 (4.8) | 0.24                      | (0.57)                           | —                    |
| Worries and concerns (6 items)             | 22.8 (3.8) | 0.44                      | 0.32                             | (0.64)               |

Responses to negative statements were scored according to a 1-to-5 Likert scale, with "strongly agree" scored as 1 and "strongly disagree" scored as 5 and responses to positive statements scored in reverse. Higher scores indicate more positive beliefs about asthma medications. Cronbach's  $\alpha$  was calculated to assess agreement between items in each subscale, and correlations were calculated between subscales. —, not applicable.