Parent Medication Administration Errors: 
*Role of Dosing Instruments and Health Literacy*

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M Kline, MA, BP Dreyer, MD
Medication Administration Errors in Children

- Outpatient medication administration errors are frequent
  - >50% caregivers give an incorrect dose of liquid medicine (Frush 2004; Li 2000; Simon 1997; McMahon 1997)

- Medication administration errors account for 70% of preventable pediatric outpatient ADEs (Zandieh 2008)
Dosing Instruments and Medication Errors

• Parent choice of measuring device important for dosing accuracy

• Non-standardized kitchen spoons inaccurate

• Standardized dosing instruments
  – Many types, variability
  – Oral syringes used by health professionals for maximal accuracy
  – Few studies have examined parent ability to dose with the range of available instruments
Health Literacy & Medication Errors

• In adults, low health literacy has been linked to
  – poor comprehension of Rx labels (Davis 2006)
  – non-adherence (Osborn 2007; Gazmararian 2006; Kalichman 1999)

• Few studies have assessed the role of parent health literacy and medication errors in children
  – Parent ability to use dosing instruments accurately
Study Objective

• To assess rates of parent dosing error by instrument type

• To examine the role of parent health literacy in the accurate use of dosing instruments
Study Design

• Experimental study

• Urban public hospital pediatric outpatient clinic

• Eligibility criteria
  – Parent / legal guardian
    • Responsible for administering medication to child
    • English / Spanish language
Predictor Variables

• Two predictor variables
  – Dosing Instrument Type
  – Caregiver Health Literacy (HL)
"Let’s pretend your child is 3 years old, and has a fever. You find out that the right dose for your child is 1 teaspoon or 5 mL. Please measure this amount using each dosing instrument."
Predictor Variable: *Dosing Instrument Type*

Parents asked to dose “1 teaspoon or 5 mL” using 4 types of instruments

- Order of dosing with each instrument randomized

![Images of dosing instruments: DOSING CUP #1, DOSING CUP #2, DOSING SPOON, DROPPER, ORAL SYRINGE]
Parents asked to dose “1 teaspoon or 5 mL” using 4 types of instruments
– Order of dosing with each instrument randomized

DROPPER

Predictor Variable: Dosing Instrument Type

ORAL SYRINGE
+ PRESS-IN BOTTLE ADAPTER

DOSING CUP #1

DOSING CUP #2

DOSING SPOON

DROPPER

ORAL SYRINGE
Predictor Variable: Health Literacy

- Caregiver Health Literacy (HL)
  - Newest Vital Sign (NVS)
    - Food label
      - 6 accompanying questions
  - Validated in English and Spanish
  - Categorization
    - Adequate Literacy
    - Possible Limited Literacy
    - Limited Literacy

Score Sheet for the Newest Vital Sign Questions and Answers

READ TO SUBJECT: This Information is on the back of a container of a pint of ice cream.

1. If you eat the entire container, how many calories will you eat?
   Answer: 1,000 is the only correct answer.

2. If you are allowed to eat 60 grams of carbohydrates as a snack, how much ice cream could you have?
   Answer: Any of the following is correct: 1 cup (or any amount up to 1 cup), half the container. Note: If patient answers "two servings," ask "How much ice cream would that be if you were to measure it into a bowl?"

3. Your doctor advises you to reduce the amount of saturated fat in your diet.
Outcome Variable: 
**Observed Dosing Accuracy**

- Standard bottle of children’s acetaminophen suspension
- % Deviation From Dose
  - Parent Measured Dose Wt compared to Reference Measured Dose Wt
  - Reference Measured Dose Wt = Average Measured Dose Weight of 5mL for 5 pediatricians using the oral syringe

**Measured Dose Weight** =  
Wt of Instrument Containing Measured Dose  
minus  
Pre-assessment Empty Instrument Weight
Outcome Variable: 
**Observed Dosing Accuracy**

- Standard bottle of children’s acetaminophen suspension

- **Measured Dose Wt** =

  - % Deviation From Dose
    - Parent Measured Dose Wt compared to Reference Measured Dose Wt
      - Reference Measured Dose Wt = Average Measured Dose Weight of 5mL for 5 pediatricians using the oral syringe
Outcome Variable: 
*Observed Dosing Accuracy* (cont’d)

- Parent dose considered accurate if within 20% of reference dose (Yin 2008; Kozer 2002; Simon 1997)
  - Small error
    - Deviation of >20-40% from dose
  - Large error
    - Deviation of >40% from dose

- Conservative, compared to USP
  - USP: Standard volumetric error should be within 10% for dosing instruments
Potential Confounders

- **Caregiver**
  - Age
  - Relationship to child
  - Language
  - Ethnicity
  - Country of birth
  - SES

- **Child**
  - Presence of child <8y in household
  - # of children
  - Presence of child in household with chronic illness
Statistical Analysis

• Unadjusted analyses
  – Chi square
  – Fisher’s exact test

• Multivariate logistic regression analyses
  – Generalized estimating equations
Results: Descriptive Data (n=302)

CHILD-RELATED
Presence of child < age 8 in home 86%
# of children (mean (SD)) 2.1 (1.2)
Presence of child with chronic disease 32%

CAREGIVER-RELATED
Caregiver Age (yrs, mean (SD)) 31.1 (8.6)
Relationship to Child: Mother 95%
Caregiver Ethnicity Latino 80%
Caregiver non-US born 76%
Hollingshead SES Level 4 or 5 81%
Results: Descriptive Data (cont’d)

- Adequate Literacy: 22%
- Limited Literacy: 41%
- Possible Limited Literacy: 37%

Parent Health Literacy
**Results: Dosing Errors by Instrument Type**

- **Large Error (>40%)**
- **Small Error (>20-40%)**
- **No Error (within 20%)**

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Large Error (%)</th>
<th>Small Error (%)</th>
<th>No Error (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dosing Cup #1</td>
<td>26</td>
<td>44</td>
<td>30</td>
</tr>
<tr>
<td>Dosing Cup #2</td>
<td>23</td>
<td>27</td>
<td>50</td>
</tr>
<tr>
<td>Dosing Spoon</td>
<td>2</td>
<td>12</td>
<td>86</td>
</tr>
<tr>
<td>Dropper</td>
<td>2</td>
<td>4</td>
<td>94</td>
</tr>
<tr>
<td>Oral Syringe</td>
<td>5</td>
<td>4</td>
<td>91</td>
</tr>
<tr>
<td>Oral Syringe + Adapter</td>
<td>4</td>
<td>5</td>
<td>91</td>
</tr>
</tbody>
</table>

*p<0.001*
Results:
Dosing Accuracy – Dosing Cups

% Subjects

% Deviation From Dose

Below recommended dose
Above recommended dose

DOSING CUP #1

DOSING CUP #2
Results:
Dosing Accuracy – Dosing Cups

Accurate = Within 20%

DOSING CUP #1

DOSING CUP #2

% Subjects

% Deviation From Dose

Below recommended dose  Above recommended dose
**Results:**

Dosing Accuracy – Dosing Cups

- **DOSING CUP #1**
  - Small Underdose: 0.3%, 2%, 28%, 2%, 18%, 4%
  - Small Overdose: 20%

- **DOSING CUP #2**
  - Small Underdose: 0.3%, 11%, 39%, 9%, 7%
  - Small Overdose: 20%

% DeVIation From Dose

- Below recommended dose
- Above recommended dose
Results:
Dosing Accuracy – Dosing Cups

Results:
Dosing Accuracy – Dosing Cups

- **Dosing Cup #1**
  - Large Underdose: 0.3%, 2%, 28%, 44%, 18%
  - Large Overdose: 4%, 3%

- **Dosing Cup #2**
  - Large Underdose: 0.3%, 11%, 39%, 27%, 9%
  - Large Overdose: 1%, 7%, 3%

% Subjects vs. % Deviation From Dose

- Below recommended dose
- Above recommended dose
Results:
Dosing Accuracy – Dosing Cups

<table>
<thead>
<tr>
<th>% Subjects</th>
<th>% Deviation From Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>&lt;0-20</td>
</tr>
<tr>
<td>0</td>
<td>&gt;20-40</td>
</tr>
<tr>
<td>0</td>
<td>&gt;40-60</td>
</tr>
<tr>
<td>0</td>
<td>&gt;60-80</td>
</tr>
<tr>
<td>0</td>
<td>&gt;80-100</td>
</tr>
<tr>
<td>0</td>
<td>&gt;100-200</td>
</tr>
<tr>
<td>0</td>
<td>&gt;200-300</td>
</tr>
<tr>
<td>0</td>
<td>&gt;300-400</td>
</tr>
</tbody>
</table>

DOSING CUP #1
Large Underdose: 0.3%, 2%, 11%, 39%, 39%, 44%, 18%, 4%
Large Overdose: 3%, 1%

DOSING CUP #2
Large Underdose: 0.3%, 2%, 11%, 39%, 39%, 44%, 18%, 4%
Large Overdose: 3%, 1%, 7%, 3%, 3%, 1%
Results:
Dosing Accuracy – Dosing Cups

<table>
<thead>
<tr>
<th>% Deviation From Dose</th>
<th>DOSING CUP #1</th>
<th>DOSING CUP #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below recommended dose</td>
<td>0.3%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Above recommended dose</td>
<td>2%</td>
<td>11%</td>
</tr>
<tr>
<td>20-40</td>
<td>28%</td>
<td>39%</td>
</tr>
<tr>
<td>40-60</td>
<td>44%</td>
<td>27%</td>
</tr>
<tr>
<td>60-80</td>
<td>18%</td>
<td>9%</td>
</tr>
<tr>
<td>80-100</td>
<td>4%</td>
<td>1%</td>
</tr>
<tr>
<td>&gt;100</td>
<td>1%</td>
<td>7%</td>
</tr>
<tr>
<td>&gt;200</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>&gt;300</td>
<td>1%</td>
<td>1%</td>
</tr>
</tbody>
</table>

% Subjects
Results:
Dosing Accuracy – Dosing Cups

- Large Underdose
- Small Underdose
- Accurate
- Small Overdose
- Large Overdose

DOSING CUP #1

- 0.3% in 0-20
- 2% in >20-40
- 28% in >40
- 44% in >60

DOSING CUP #2

- 11% in 0-20
- 39% in >20-40
- 27% in >40
- 9% in >60

% Subjects vs. % Deviation From Dose

- Below recommended dose
- Above recommended dose

Results:
Dosing Accuracy – Dosing Cups

- DOSING CUP #1
  - Accurate
  - Large Underdose
  - Small Underdose
  - Small Overdose
  - Large Overdose

- DOSING CUP #2
  - Accurate
  - Large Underdose
  - Small Underdose
  - Small Overdose
  - Large Overdose

% Subjects vs. % Deviation From Dose
Results:
Dosing Accuracy - Dropper & Dosing Spoon

Accurate = Within 20%

- Above recommended dose:
  - Dropper: 78%
  - Spoon: 11%

- Below recommended dose:
  - Dropper: 1%
  - Spoon: 8%

% Subjects vs. % Deviation From Dose
Results:
Dosing Accuracy - Syringes

Accurate = Within 20%

% Subjects

% Deviation From Dose

Below recommended dose

Above recommended dose
Results:
Parent Dosing Accuracy

ORAL SYRINGE

DOSING CUP #1

DOSING CUP #2

DROPPER

DOSING SPOON

% Subjects

% Deviation From Recommended Dose

Below rec. dose  Above rec. dose  Below rec. dose  Above rec. dose
**Results:**

Parent Dosing Accuracy

- Multivariate Analysis -

Dosing Error Defined as **>20% Deviation** from Dose

<table>
<thead>
<tr>
<th></th>
<th>AOR†</th>
<th>95% CI</th>
<th>p</th>
</tr>
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<tbody>
<tr>
<td>Dosing Cup #1</td>
<td>26.3</td>
<td>16.5-41.9</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Dosing Cup #2</td>
<td>10.9</td>
<td>7.1-16.6</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Dosing Spoon</td>
<td>1.7</td>
<td>1.1-2.7</td>
<td>0.02</td>
</tr>
<tr>
<td>Dropper</td>
<td>0.6</td>
<td>0.4-1.0</td>
<td>0.1</td>
</tr>
<tr>
<td>Syringe+Adapter</td>
<td>1.1</td>
<td>0.7-1.6</td>
<td>0.7</td>
</tr>
<tr>
<td>Oral Syringe</td>
<td>1.0</td>
<td>***</td>
<td>***</td>
</tr>
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Results: Parent Dosing Accuracy
- Multivariate Analysis -

Dosing Error Defined as >20% Deviation from Dose

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## Results: Parent Dosing Accuracy

- Multivariate Analysis -

Dosing Error Defined as **bolded >20% Deviation** from Dose

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Results: Parent Dosing Accuracy

- Multivariate Analysis -

Large Dosing Error of **>40% Deviation** from Dose

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<td>Dropper</td>
<td>0.9</td>
<td>0.5-1.5</td>
<td>0.6</td>
</tr>
<tr>
<td>Syringe+Adapter</td>
<td>0.8</td>
<td>0.5-1.5</td>
<td>0.6</td>
</tr>
<tr>
<td>Oral Syringe</td>
<td>1.0</td>
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Results: Parent Dosing Accuracy

- Multivariate Analysis -

Large Dosing Error of >40% Deviation from Dose

<table>
<thead>
<tr>
<th>Dosing Method</th>
<th>AOR†</th>
<th>95% CI</th>
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<td>Syringe+Adapter</td>
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Results: Parent Dosing Accuracy

- Multivariate Analysis -

Large Dosing Error of **>40% Deviation** from Dose

<table>
<thead>
<tr>
<th>Tool</th>
<th>AOR†</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dosing Cup #1</td>
<td>7.3</td>
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# Results:
**Accuracy with Standardized Instruments**

## Exploratory Analyses: Dosing Cups & Eye Level Verification

<table>
<thead>
<tr>
<th></th>
<th>No Error</th>
<th>Small Error</th>
<th>Large Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye Level</td>
<td>57%</td>
<td>30%</td>
<td>14%</td>
</tr>
<tr>
<td>Not Eye Level</td>
<td>33%</td>
<td>38%</td>
<td>30%</td>
</tr>
</tbody>
</table>

- **Eye level verification** (n=59)
  - Dosing Cup #1: 25%
  - Dosing Cup #2: 38%
  - \( p = 0.15 \)
### Results: Parent Dosing Accuracy

- Role of Health Literacy -

<table>
<thead>
<tr>
<th></th>
<th>AOR†</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Any Dosing Error</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limited HL</td>
<td>1.7</td>
<td>1.1-2.7</td>
<td>0.03</td>
</tr>
<tr>
<td>Possible Limited HL</td>
<td>1.6</td>
<td>0.98-2.5</td>
<td>0.06</td>
</tr>
<tr>
<td>Adequate HL</td>
<td>1.0</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>Large Dosing Errors</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limited HL</td>
<td>2.3</td>
<td>1.2-4.4</td>
<td>0.02</td>
</tr>
<tr>
<td>Possible Limited HL</td>
<td>1.8</td>
<td>0.9-3.6</td>
<td>0.08</td>
</tr>
<tr>
<td>Adequate HL</td>
<td>1.0</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

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### Results: Parent Dosing Accuracy

**- Role of Health Literacy -**

#### Any Dosing Error

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<td>Adequate HL</td>
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#### Large Dosing Errors

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</tbody>
</table>

† Adjusting for instrument, caregiver age, ethnicity, language, country of birth, SES, rel. to children, # of children, child age, child with chronic disease
Results:
Dosing Errors and Parent Health Literacy by Instrument Type

- **DOSING CUP #1**
  - *p=0.01
  - % Subjects
    - Adequate HL: 53
    - Poss. Lim. HL: 50
    - Limited HL: 34
  - Categories:
    - Green: No Error (within 20%)
    - Orange: Small Error (>20-40%)
    - Red: Large Error (>40%)

- **DOSING CUP #2**
  - *p=0.02
  - % Subjects
    - Adequate HL: 68
    - Poss. Lim. HL: 46
    - Limited HL: 45

- **DOSING SPOON**
  - *p=0.01
  - % Subjects
    - Adequate HL: 95
    - Poss. Lim. HL: 87
    - Limited HL: 80
Results:
Dosing Errors and Parent Health Literacy by Instrument Type

**ORAL SYRINGE**

- **DROPPER**
- **ORAL SYRINGE + ADAPTER**

Legend:
- Large Error (>40%)
- Small Error (>20-40%)
- No Error (within 20%)

p-values:
- p=0.4
- p=0.1
Role of Health Literacy in Dosing Errors By Instrument Type

• Statistically significant
  – Dosing cup #1
  – Dosing cup #2
  – Dosing spoon

• Trend
  – Dropper
  – Oral syringe + adapter

• No significance
  – Oral syringe
Summary

- Parent dosing accuracy varies by instrument
  - Fewer errors with droppers, dosing spoons, and syringes
  - Dosing cups associated with the most errors; primarily overdosing

- Parent health literacy also found to be associated with dosing accuracy
  - Greatest association seen for the two dosing cups and the dosing spoon
Limitations

- Dosing assessment performed under experimental conditions, may not reflect caregiver’s true ability to dose at home
- Representative sample of instruments chosen; all dosing instrument variations could not be tested
- The degree to which the dosing errors found would be associated with adverse clinical outcomes unclear
  - Multiple cutpoints utilized
Implications

• Strategies to decrease medication dosing errors in children should address
  – Accurate dosing instrument use
  – Parent health literacy skills

• Additional study needed to better understand the factors which relate instrument type to error
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