Accuracy of Oral Liquid Measuring Devices Used Among Caregivers at Hospital Dungun

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ABSTRACT

Oral liquid medications are common type of dosage form prescribed to children. Caregiver responsible to choose appropriate measuring device to measure intended dose and minimize dosing error. Objectives of this study were 1) To identify types of measuring devices used at home; 2) To determine dose error deviation across all the measuring devices. This cross-sectional study involved caregivers visiting outpatient pharmacy with oral liquid prescription that fulfilled inclusion and exclusion criteria. The caregivers were instructed to measure 4.8ml and 15.0ml liquid by using suitable devices provided, which were 4 types of syringes and 2 types of dosing cups. The measured liquid was read by investigator and any dose error deviation was calculated and reported as percentages. Data was analyzed descriptively using SPSS version 21. Out of 120 caregivers involved, 60% were female (n=72), aged between 31-40 years old (49.1%, n=59), and employed (62.5%, n=75). 82 caregivers (68.3%) received secondary education level. Most caregivers use standardized measuring devices at home, particularly syringes and dosing cups. For smaller dose, less dose error was detected if using syringe (13.3%) as compared to dosing cup (39.3%); while for larger dose, both syringe and dosing cups are acceptable (11.7% and 7.4% respectively). Syringe shows less dose error as compared to dosing cup for smaller dose. Pharmacist should participate in decision making of choosing right measuring device to improve accuracy of medication administration.

Keywords: Caregiver, liquid medication, measuring devices, rate of dose deviation.

Introduction

Oral liquid medications are commonly prescribed to children. There are many measuring devices often used to measure oral liquid medications, such as cups, droppers, household spoons, and syringes. All of these devices are used with varying levels of accuracy. At Hospital Dungun, the commonly used measuring devices are syringe and cup.

Previous studies found that a considerable proportion of caregivers
make errors when dosing oral liquid medications with different measuring devices (Yin et al., 2016 & Ryu et al., 2012). There were also caregivers who frequently ask the pharmacist on how to read the meniscus of the measuring device provided. In addition, caregivers tend to use various types of measuring devices with unknown accuracy to measure their children’s liquid medications at home. Unsuitable use measuring devices leads to sub-therapeutic dose or overdose.

Ryu et al., 2012 found only 34 cases (11.3%) had dose errors greater than 10%, and only 6 cases (2.0%) had a variance of more than 20% from the 5 mL target volume. Large dose error was more common for the etched dosing cup (47.1%), the dosing spoon (50.0%), and the printed dosing cup (30.8%).

Yin et al., 2016 stated that 84.4% of caregivers made ≥1 dosing error with more errors were seen when using cups compared to syringes (adjusted odds ratio = 4.6; 95% confidence interval, 4.2–5.1) across different health literacy and language groups (p < .001). The percentages of parents dosing accurately (within 20% of the recommended dose) were 30.5% using cup with printed markings and 50.2% using cup with etched markings, while more than 85% dosed accurately with the remaining instruments. Large dosing errors (>40% deviation) were made by 25.8% of parents using the cup with printed markings and 23.3% with etched markings.

Thus, caregivers must choose an appropriate measuring device to ensure the intended dose was given to their children. This study was conducted to identify types of measuring devices used at home and determine dose error deviation across all the measuring devices.

Research Method

This cross sectional involved of consented caregivers; age >18 years old; and able to understand Malay or English; whom visit outpatient pharmacy Hospital Dungun with oral liquid prescription for children age <12 years old from July to October 2020. Caregivers with auditory or visual impairment was excluded from the study. Sample size was estimated involved of prescription with oral liquid for children and calculated using Krejcie and Morgan’s formula. The estimated sample size was 120 after considering 20% dropout. This study was conducted in one dedicated room and involved of 2 trained investigators which are Pharmacist. The caregivers were instructed by an investigators to select one of their preferred measuring devices from 4 alternatives syringes (1 mL syringe, 3 mL syringe, 5 mL syringe and 10 mL syringe) and another one from 2 alternatives cups (20 mL etched-calibration dosing cup, 15 mL etched-calibration dosing cup). After that, they were asked to measure 4.8 ml and 15.0 ml dose of tap water using the device of their choice. Quantity of 4.8 ml and 15ml were chosen as a measured quantity.
because to determine whether the caregivers able and understand to measure whole value as 15mL and also the volume that has one decimal place like 4.8 mL. The investigators then read the measured volume and any dose error variation was calculated as percentage. Data was analyzed descriptively using SPSS version 21 including caregivers sosiodemographic characteristics which were gender, age, education level and job status as well as dose error variation.

Results and Discussion

As shown in Table 1, majority of the caregivers were female (60%, n=72), aged between 31-40 years old (49.1%, n=59), employed (62.5%, n=75) and secondary education level (68.3%, n=82). Based on Table 2, most commonly used devices at home are syringe 5mL and etched dosing cup. Interestingly, about 42 caregivers preferred to use teaspoon and tablespoon which according to them much more convenient than others.

According to FDA, syringe is classified as gold standard for measuring liquid medication. Use of non-standardized measuring devices may lead to dosing error due to no calibration markings while measuring (Ryu & Lee, 2012). The variation in selection of measuring devices among caregivers might be due to poor knowledge on accuracy of each measuring devices; unclear dose instruction in mL, mg or teaspoon; or no standard measuring devices available at that time they want to use it. There were caregivers who beliefs that dosing cups were best for accuracy because they may be influenced by the fact that most over-the-counter (OTC) liquid medications were packaged with dosing cups (William TA et al, 2019). Study done by Yin et al, 2016 found that labels on bottle or packaging of medications with ‘tsp’ or ‘teaspoon’ were associated with an increased likelihood of caregivers choosing non-standardized kitchen spoon as compared to when mL units were used.

American Academy of Paediatric Committee (AAPC), 2015 advice all caregivers to avoid using teaspoon and tablespoon instead encourage them to use standardized measuring devices with metric markings to support accurate dosing, preferably oral syringes. However, in view of some caregivers still employing teaspoon in administered their liquid medication, US Pharmacopeia states that the teaspoon may be regarded as 5mL. However, caregivers need to be cautioned on the accuracy of the spoon for measuring medications due to the variation in size of manufacturing.

From Table 3, majority of caregivers (81.7%, n=98) used 5ml syringe to measure 4.8ml liquid which were appropriate with only 13.3% dose error; whereas, 85.8%, n=103, of them used 10ml syringe to measure 15ml liquid measurement with only 11.7% dose error. There were 3 caregivers (2.5%) who chose 3ml syringe to measure 15ml liquid which given 100% dose error.
Table 1. Sociodemographic characteristics

| Sociodemographic characteristics (N=120) | n, (%) |
|-----------------------------------------|--------|
| Gender                                  |        |
| Male                                     | 48 (40.0) |
| Female                                   | 72 (60.0) |
| Age (years)                              |        |
| 18-30                                    | 35 (29.2) |
| 31-40                                    | 59 (49.1) |
| >41                                      | 26 (21.7) |
| Employment status                        |        |
| Employed                                 | 75 (62.5) |
| Not employed                             | 45 (37.5) |
| Education level                          |        |
| Primary                                  | 9 (7.5)  |
| Secondary                                | 82 (68.3) |
| Tertiary                                 | 29 (24.2) |

Table 2. Types of measuring devices used at home

| Measuring devices          | Frequency, n |
|----------------------------|--------------|
| Syringe 1mL                | 13           |
| Syringe 3mL                | 51           |
| Syringe 5mL                | 95           |
| Syringe 10mL               | 51           |
| Printed dosing cup         | 23           |
| Regular (etched) dosing cup| 61           |
| Teaspoon                   | 21           |
| Tablespoon                 | 21           |

Furthermore, there were few caregivers who used inappropriate syringe which were 1ml (1.7%), 3ml (0.8%) and 10ml (15.8%) to measure 4.8ml liquid which resulted in more than 50% larger dose error except for 10ml syringe which only caused 36.8% larger dose error. From this study, we can justify that chose syringe near to the intended volume was more accurate and lead to less dose error. This was similar to finding in the study done by Yin et al, 2017 where they found greatest reduction in errors were seen when using dosing tool more closely matched the prescribed dose volume because caregivers no need to measure multiple instrument-full for a single dose.

As shown in Table 3 also, measuring cup regardless of small or large interval scale contributed to large error to measure small liquid volume with decimal point (4.8ml) which reflected by 54.3% from Cup B (1ml interval) and 39.3% from Cup A (5ml interval). This was due to the difficulty of the caregivers to adjust liquid volume correctly. This was parallel with the study done by Sobhani et al, 2016 found that 66.7% of caregivers measured an acceptable smaller dose with the oral syringe versus 14.6% with the measuring cup for. Study done by Ryu and Lee 2012 also found high rates of accurate dosing using syringe in small dose as compared to measuring cup.
Table 3. Dose error deviation across all the measuring devices

| Devices (Syringe/ Cup) | No. of caregivers n (%) | 4.8ml Error ± >10% n (%) | No. of caregivers n (%) | 15.0ml Error ± >10% n (%) |
|------------------------|-------------------------|--------------------------|-------------------------|--------------------------|
| 1ml                    | 2 (1.7)                 | 1 (50.0)                 | 0                       | 0                        |
| 3ml                    | 1 (0.8)                 | 1 (100.0)                | 3 (2.5)                 | 3 (100)                  |
| 5ml                    | 98 (81.7)               | 13 (13.3)                | 14 (11.7)               | 2 (14.3)                 |
| 10ml                   | 19 (15.8)               | 7 (36.8)                 | 103 (85.8)              | 12 (11.7)                |
| Total                  | 120                     |                          | 120                     |                          |
| Cup A (with 5ml interval) | 28 (23.3)             | 11 (39.3)                | 66 (55.0)               | 18 (27.3)                |
| Cup B (with 1ml interval) | 92 (76.7)             | 50 (54.3)                | 54 (45.0)               | 4 (7.4)                  |
| Total                  | 120                     |                          | 120                     |                          |

Error ± >10% indicated large error

On the other hand, most caregivers (45%, n=54) were able to measure 15ml correctly with less dose error using both measuring cups compared to 4.8ml with percentage of larger error for Cup A and B were only 27.3% and 7.4% respectively. By comparing with the 10ml syringe to measure 15ml liquid, measuring cup with 1ml interval scale shown less dose error. These indicated that both syringe with larger capacity and dosing cups were acceptable in measuring large volume of medication. Study done by William TA et al, 2019 also found that using of dosing cup to measure specific absolute amount and larger dose amount had less error as compared to small dose amount.

There were various definition and cut off point for dose error. According to US Pharmacopeia volume error incurred in measuring 5mL of liquid medication ‘should not greater than 10% of the indicated amount’. According to Ryu and Lee 2012, liquid medication dose error rates were classified as less than 5%, 6-10%, 11-20%, and more than 20%. Less than 10% error was classified as small dose error while greater than 10% was classified as large dose error.

On the other hand, Sobhani et al. 2016 defined acceptable dose as within 10% of the indicated amount. For the purpose of this study, we categorized the error as large dose error if the error was ± >10%.

Conclusion

Most commonly used devices at home are syringe 5mL and etched dosing cup. Syringes were more accurate compared to measuring cups for small volume whereas both syringe with larger capacity and dosing cups were acceptable in measuring large volume of medication. Pharmacist involvement in decision making of choosing appropriate measuring device may help better outcome of liquid medication administration.
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