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Effects of pharmacist-led counseling on pediatric antibiotic suspension reconstitution knowledge and technique among rural parents: A multicenter study in Malaysia

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ABSTRACT

This study aimed to evaluate the effects of pharmacist-led counseling on the rural parents' knowledge and technique of oral antibiotic suspension reconstitution, storage, and dose measurement. This was a multicenter interventional study involved 330 parents from four government health clinics in Sik, Malaysia. A checklist and infographic handout were developed for the counseling purpose. A questionnaire was used to evaluate parents' knowledge, and they were tasked with demonstrating their reconstitution and dose measurement techniques during the counseling session. The knowledge and technique were evaluated through scoring both before and after counseling sessions, and the comparison was performed using Wilcoxon signed rank test. The parents' median score of reconstitution knowledge improved significantly ($p < 0.001$) from 5 (pre-counseling) to a perfect score of 7 (post-counseling). Meanwhile, the antibiotic storage knowledge showed a similar trend of significant improvement ($p < 0.001$) from a median of 2 to a perfect score of 3. Significant improvement ($p < 0.001$) was found in the reconstitution technique with the median score increased from 3 to a perfect score of 7. After the counseling, majority of parents (96.4%) performed the correct dose measurement technique as compared to 37.7% at pre-counseling. In conclusion, the pharmacist-led counseling guided with checklist and visual handout was effective.

INTRODUCTION

In primary care settings, antibiotics are among the most prescribed drugs, especially among young children. Antimicrobial stewardship programs were launched to monitor the appropriate use of antibiotics among government healthcare settings in Malaysia, due to the high usage of antibiotics [1]. Antibiotics for pediatric are commonly formulated into dry powders for reconstitution. The formulation of dry powders is to prevent the hydrolytic degradation of the antibiotic in aqueous vehicle, ease of swallowing for children, and reduce the transportation cost [2–4].

The appropriate use of antibiotics suspensions involves the correct dispensing and administration indicators. The dispensing indicators include an appropriate choice of dose measuring tool and measurement technique. Meanwhile, the administration indicators are correct reconstitution and storage technique [5]. Errors from antibiotic reconstitution arise when the parents do not read or understand the manufacturer's instruction. Failure to shake the bottle to loosen the powder and a wrong volumetric measurement technique are among the common reconstitution errors. Besides, wrong steps for the addition of water and wrong choice of water commonly occurred among parents [6,7]. However, there is currently no study conducted in Malaysia to assess the technique of antibiotic suspension reconstitution among rural parents. It is possible that parents in rural areas lack exposure to counseling on antibiotic reconstitution, highlighting the need to address this issue.

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There are three main contributing factors to the incorrect antibiotic dose, which include inappropriate dose measuring tool, wrong interpretation of the dosing label, and wrong dose measurement technique. Studies showed that medicinal cup and low dose tip syringe with engraved dosing line are two common dose measurement tools for antibiotic suspensions [6,7]. However, dosing variation occurred between these two measuring tools which leads to either overdose or underdose. A previous study demonstrated that around 20% of the medicinal cup measurement exceeded 40% of the actual dose while approximately 40% were underdose [8]. Meanwhile, a study showed that the dosing variations were not significant between different types of syringes [9]. Therefore, syringe is a more suitable measuring tool particularly for small volume antibiotic dosing for pediatrics [9].

The storage of antibiotic suspension after reconstitution is important in preserving the efficacy of antibiotics throughout the treatment period [2]. The antibiotic dry powders should be stored in an enclosed bottle away from heat, light, and humidity. The storage of dry powders at room temperature is deemed suitable as the powders are stable at room temperature [4]. However, once reconstituted, the suspensions should be stored in the refrigerator to slow down the degradation of the antibiotic. The antibiotic suspension should not be reconstituted all at once but once at a time [10]. This is due to the chemical and physical instability of antibiotic particles in the aqueous vehicle once reconstituted. For instance, hydrolytic degradations may occur especially for penicillin which has the strain beta-lactam rings [2,4]. In some cases, the lack of a refrigerator in the household and the high temperature in tropical countries may speed up the degradation of the antibiotic suspensions [11]. Hence, there is a necessity to investigate the storage practices of antibiotic suspensions among rural parents in Malaysia. It remains unclear whether these parents appropriately store the reconstituted suspension in the refrigerator.

A structured pharmacist-led counseling intervention is among the strategies to address the parents' malpractices of antibiotic reconstitution. A previous study showed that face-to-face counseling between parents and pharmacist with a well-designed photographs-attached education aid was more effective in improving the parents' knowledge of antibiotic suspension [10]. Presently, there is a lack of standardized counseling guides and antibiotic reconstitution handouts designed to assist pharmacists, especially when interacting with rural parents in Malaysia. Additionally, the impact of pharmacist-led counseling on issues related to knowledge and techniques of antibiotic reconstitution remains unknown. Therefore, this study aimed to evaluate the effects of pharmacist-led counseling intervention on the rural parents' knowledge of antibiotic suspension reconstitution and storage. The parents' reconstitution and dose measurement technique pre- and post-counseling were also assessed. Besides, the parents' satisfactions toward the pharmacist counseling were assessed upon completion of the study. This study introduces novelty by designing an antibiotic reconstitution counseling handout specifically tailored for rural parents. The handout employs step-by-step infographics along with comprehensive instructions to assist parents in comprehending the reconstitution techniques.

MATERIALS AND METHODS

Study design, site, and duration

This was a multicenter interventional study conducted in all the government primary care health clinics in Sik district of Kedah, Malaysia. The health clinics involved in this study were Gulau Health Clinic, Jeniang Health Clinic, Kampung Betong Health Clinic and Teloi Timur Health Clinic. The data collection was conducted from 1st May 2020 to 31st December 2020. The study protocol was approved by the Medical Research and Ethics Committee, Ministry of Health Malaysia (approval number: NMRR-20-461-53881).

Development of counseling checklist and handout

A checklist for oral antibiotic suspension reconstitution and storage was specifically developed to guide the pharmacist counseling. An antibiotic suspensions reconstitution handout was also developed for the counseling purpose. The construction of the preliminary counseling checklist and handout started with the review of the literature and manufacturer's recommendations. The "Mixing Powdered Medication into Suspensions Leaflet" published by Ministry of Health Singapore was used as the tool in the content development of the counseling checklist and handout [12]. Besides, the feedback from the practicing pharmacists in the health clinics of the Sik district based on their working experiences were also considered in the counseling tools development.

Content of counseling checklist and handout

The counseling checklist consists of instructions on antibiotic suspension reconstitution steps. Information on the proper storage of reconstituted antibiotic was included in the checklist. Meanwhile, infographic presentation of the reconstitution steps and techniques were available in the counseling handout. The information on proper reconstituted antibiotic storage was also presented as infographic in the handout.

Validation of counseling checklist and handout

The counseling tools went through face and content validation by an expert panel. The expert panel consists of a family medicine specialist from Jeniang Health Clinic, two medical practitioners from Gulau Health Clinic, two practicing pharmacists (from Gulau Health Clinic and Sik Health District Office) and a pharmacist who is an academician from School of Pharmaceutical Sciences, Universiti Sains Malaysia. Content validation index (CVI) was calculated based on the expert panel's feedback on the contents of the counseling checklist and handout. The CVI was 0.89 and 0.88 respectively for the checklist and handout. After the validation, the checklist and handout went through forward-backward translation procedure to Malay language. The translation was done due to the widely used Malay language among the Malaysian parents. After the translation, a pilot study was conducted to verify the understanding of parents on both language versions of the counseling tools.

Study population

The study included parents who visited the government health clinics in Sik district. These clinics were located in different zones in the Sik district. The Sik district is a rural area with a population estimated at 43 persons per km^2 with more than 60% of the population involved in agricultural work. The inclusion criteria were the parents of pediatric patients who were prescribed oral antibiotic suspension. The parents must be able to understand either English or Malay language. Parents who illiterate in English and Malay language were excluded. The recruitment of the parents was done at the outpatient pharmacy department of the health clinics. The parents were approached by the investigator when they walked in filling the antibiotic suspension prescriptions at the pharmacy counter.

Sample size and sampling method

The sample size was calculated based on the primary study objective, which was the improvement in the parents' knowledge of oral antibiotic suspension reconstitution after the pharmacist counseling. A proportion of 74% of parents achieving perfect score of knowledge of oral antibiotic suspension reconstitution is considered acceptable. The target of 74% of parents was based on a previous study conducted among parents in Taiwan who received pharmacist counseling on antibiotic reconstitution [10]. The sample size was calculated by using the formula for the estimation of a single proportion with 95% confidence interval [13]. The calculated sample size was 296 parents. A total of 330 parents were targeted for this study allowing for an attrition rate of 10% due to dropout. The participants were recruited by systematic random sampling.

Data collection form

A data collection form consisting of four sections was developed. Section one assessed the socio-demographic data of the parents and pediatric patients. Section two consists of a questionnaire to assess the parents' knowledge of antibiotic reconstitution and storage. Assessment of parents' antibiotic reconstitution and dose measurement technique was done in the third section of the form. Meanwhile, the parents' satisfaction toward pharmacist counseling was assessed in section four.

The data collection form was designed based on the domains and contents in the developed counseling checklist. The manufacturer's instructions for oral dry powder antibiotic reconstitution and literature review on problems related to antibiotic suspension reconstitution and storage were also considered in the data collection form development. The data collection form was initially developed in the English language and went through face and content validation by the same expert panel for the counseling tools validation. Subsequently, the form was translated into Malay language using forward-backward translation procedure. Both language versions of the form were pilot tested by a total of 30 parents. The parents were required to answer the questionnaire twice within a 1-week interval. The reliability score (kappa value) for the questionnaire was 0.9893. The parents provided comments and explained the difficulties they encountered when answering the questions in the form. The questions in the form were further adjusted after the pilot study.

Data collection procedure

The data collection was performed through a face-to-face interview between the parents and pharmacists. A total of four practicing pharmacists from the health clinics were involved in the data collection and parents' counseling. The parents were asked to answer the questions in the data collection form in a counseling room. The pediatric patients were taken care of by the nursing staff to avoid disturbance from them. The questions were read out clearly and explained thoroughly to the parents. The parents' answers were transcribed verbatim and recorded into the data collecting form by the pharmacists.

A total of seven questions were used to assess the parents' knowledge of antibiotic reconstitution. Other three questions were focusing on the knowledge of antibiotic storage and one question of disposal knowledge. A score of one was given to each correctly answered question. The total score for the parents was a summation of the scores for all the correctly answered questions. Hence, the perfect score was seven and three, respectively, for the reconstitution and storage knowledge assessment. The knowledge assessment was performed pre- and post-pharmacist counseling.

The parents were asked to demonstrate the antibiotic suspension reconstitution technique using a demonstration kit consisting of an antibiotic suspension bottle with flour. The parents were also assessed on their dose measurement technique using a syringe. Scores were given to the reconstitution and dose measurement steps correctly demonstrated by the parents prior to the pharmacist counseling. A total score of seven was considered a good reconstitution and dose measurement technique. Errors made by the parents during the process will be noted and addressed during the subsequent counseling session. After counseling, the parents' reconstitution and dose measurement technique were re-evaluated. Scores were given again to the correct reconstitution and dose measurement steps and mistakes were corrected at the same time by the pharmacist.

Training of pharmacists

Prior to the study, training was given to the pharmacists who were involved in the data collection and parents' counseling. The training was conducted by the principal investigator of the study (the first author). Details reviews and explanations regarding the data collection were given during the training. Besides, the pharmacists were trained on the antibiotic reconstitution and dose measurement technique guided by the counseling checklist and handout. The pharmacists were allowed to asked questions if there was any ambiguity in the content of the counseling tools or questions in the data collection form. Lastly, all the pharmacists went through an assessment, and they should obtain perfect score before enrolled as data collectors in the study.

Data analysis

The data analysis was performed by using IBM SPSS® version 27. As the data were not normally distributed, Wilcoxon-signed rank test was used to determine the differences between the parents' scores of knowledge and technique of antibiotic suspension reconstitution pre- and post-pharmacist counseling.

A *p*-value of less than 0.05 was considered statistically significant.

RESULTS

Demographic characteristics of respondents

The responding parents were mostly aged between 32 and 40 years (44.2%) and were mothers (89.1%) to the pediatric patients. Majority of the parents' highest education level was secondary school (77.6%). During the study period, most of the clinic visit were due to upper respiratory tract infections such as tonsillitis (50.3%) and pharyngitis (27.0%). The pediatric patients were mainly prescribed with amoxicillin suspensions (60.6%) (Table 1).

Knowledge of antibiotic suspension reconstitution

Only 14.8% of the parents have experience in reconstitutions of antibiotic suspensions. Most of the parents chose the appropriate type of water for antibiotic reconstitutions, such as cooled boiled water (49.4%) and distilled water (26.7%). Following the counseling session, the percentage rose to 54.5% for cooled boiled water and 28.5% for distilled water, indicating an improvement in understanding among participants. Majority of parents (75.5%) accurately demonstrated their understanding of the instructions for using the marker on the antibiotic bottle to measure the volume of reconstitution water. The percentage of parents who acknowledged this practice has increased to 98.8% after the counseling (Table 2).

In evaluating the frequency of water addition for reconstitution, parents' responses varied, with 83.3% following a single step, 9.1% opting for two steps, and a minority (3.0%) resorting to unconventional practices like mixing a single spoonful of antibiotic powder with milk without reconstituting the entire bottle. The proportion of parents who correctly indicated two steps of adding water has increased to 93.0% after the counseling. Moreover, the majority of parents (69.4% pre-counseling and 95.5% post-counseling) correctly adhered to the practice of reconstituting one bottle of the antibiotic suspension at a time and proceeding to reconstitute the next bottle once the first one was finished (Table 2).

Before counseling, only 45.8% of parents engaged in the practice of shaking the antibiotic suspension bottle to loosen the powder, a figure that notably rose to 91.2% after counseling. Additionally, it is important to shake the suspension bottle once more after adding the water and before administering it to the child. The majority of parents were understood of these correct practices, with 98.8% and 92.1% respectively, even before the pharmacist counseling. Following the counseling, the understanding level further elevated to 100.0% and 99.7% respectively. (Table 2).

Knowledge of antibiotic storage and disposal

The parents mostly keep the antibiotic suspension dry powder in the kitchen (35.8%) and fridge (11.2%). A mere 29.4% of parents accurately recognized the appropriate storage location for the antibiotic as the medicine cabinet. The percentage of parents who answered correctly increased to 39.1% post-counseling (Table 2).

After reconstitution, the antibiotic suspension was mostly stored by the parents in the fridge (46.1%), which is a correct practice. Nevertheless, some parents wrongly keep the reconstituted suspension in the kitchen (20.3%). The proportion of parents who indicated the correct storage increased to 91.5% post-counseling. The duration of reconstituted antibiotic storage was assessed among the parents. Before counseling, only 32.1% of parents accurately reported the correct duration of 7 days, a figure that significantly increased to 93.9% following the counseling session (Table 2).

Considering the disposal method of the remaining suspensions, the majority of the parents will either throw the antibiotic into the sink (33.0%) or the toilet bowl (20.0%). Only 19.0% of parents indicated the correct disposal technique by returning the remaining antibiotic to the pharmacy. Interestingly, some parents will dispose of the remaining antibiotic into the river (10.0%), while 6.4% will bury it in the soil. After the counseling, the percentage of parents who demonstrated the correct understanding of the disposal technique increased to 46.7% (Table 2).

Table 1. Demographic characteristics of parents and pediatric patients.

Characteristics	*N* (%)	Characteristics	*N* (%)
Age of parent (year)		Gender of pediatric patient	
21–30	74 (22.4)	Male	146 (44.2)
32–40	146 (44.2)	Female	184 (55.8)
41–50	108 (32.7)	Health clinic	
≥51	2 (0.6)	Jeniang	111(33.6)
Gender of parents		Kampung Betong	89 (27.0)
Mother	294 (89.1)	Gulau	86 (26.1)
Father	36 (10.9)	Teloi Timur	44 (13.3)
Education level		Indications of antibiotics prescribed	
No formal education	21 (6.4)	Tonsilitis	116 (50.3)
Primary school	36 (10.9)	Pharyngitis	89 (27.0)
Secondary school	256 (77.6)	Soft tissue and skin infection	41 (12.4)
Pre-university	13 (3.9)	Pneumonia	11 (3.3)
University	4 (1.2)	Otitis media	9 (2.7)
Number of children		Acute bronchitis	8 (2.4)
1	71 (21.5)	Balanitis	6 (1.8)
2	135 (40.9)	Types of antibiotics prescribed	
3	96 (29.1)	Amoxicillin suspensions	200 (60.6%)
≥4	28 (8.4)	Phenoxymethylpenicillin suspensions	67 (20.3%)
Age of pediatric patient (year)		Cloxacillin suspensions	41 (12.4%)
<1	100 (30.3)	Erythromycin suspensions	22 (6.7)
1–3	123 (37.3)		
4–6	51 (15.5)		
7–9	23 (7.0)		
10–12	33 (10.0)		

Table 2. Assessment of parents' knowledge of antibiotic suspension reconstitution, storage and disposal.

Assessment		Parents' response	
		Pre-counseling *N* (%)	Post-counseling *N* (%)
1. Is this your first time reconstituting the antibiotic suspensions?	Yes	49 (14.8)	-
	No	267 (80.9)	
	I don't know	14 (4.2)	
Knowledge of antibiotic reconstitution			
1.What type of water to be used in the antibiotic suspension reconstitution?	Treated-tap water	46 (13.9)	7 (2.1)
	Distilled water	88 (26.7)	94 (28.5)
	Cooled boiled water	163 (49.4)	180 (54.5)
	Filtered water	20 (6.1)	46 (13.9)
	Others	3 (0.9)	1 (0.3)
	I don't know	10 (3.0)	2 (0.6)
2. How do you measure the volume of water needed for antibiotic suspensions reconstitution?	Using the mark on the bottle	249 (75.5)	326 (98.8)
	Syringe	15 (4.5)	2 (0.6)
	Medicinal cup	17 (5.2)	2 (0.6)
	Milk bottle	20 (6.1)	0 (0.0)
	Others	4 (1.2)	0 (0.0)
	I don't know	25 (7.6)	0 (0.0)
3. The water should be added either in a single step or in multiple steps?	Single step	275 (83.3)	13 (3.9)
	Two steps	30 (9.1)	307 (93.0)
	Multiple step	6 (1.8)	10 (3.0)
	Others	10 (3.0)	0 (0.0)
	I don't know	9 (2.7)	0 (0.0)
4. Should you reconstitute all the antibiotic suspensions at a time or only one bottle at a time and to reconstitute another after finishing the previous bottle?	All at one time	81 (24.5)	11 (3.3)
	Only one at a time	229 (69.4)	315 (95.5)
	I don't know	20 (6.1)	4 (1.2)
5. Should you shake the bottle before adding water?	Yes	151 (45.8)	301 (91.2)
	No	160 (48.5)	23 (7.0)
	I don't know	19 (5.8)	6 (1.8)
6. Should you shake the bottle well after adding water?	Yes	326 (98.8)	330 (100.0)
	No	2 (0.6)	0 (0.0)
	I don't know	2 (0.6)	0 (0.0)
7. Should you shake the bottle well before serving the antibiotic suspensions?	Yes	304 (92.1)	329 (99.7)
	No	16 (4.8)	1 (0.3)
	I don't know	10 (3.0)	0 (0.0)
Knowledge of antibiotic storage			
1. Where should the bottle of antibiotic powder be stored?	Kitchen	118 (35.8)	119 (36.1)
	Medicinal cabinet	97 (29.4)	129 (39.1)
	Refrigerator	37 (11.2)	12 (3.6)
	Dining room	34 (10.3)	43 (13.0)
	Above refrigerator	26 (7.9)	24 (7.3)
	I don't know	18 (5.5)	3 (0.9)

(Continued)

Assessment Pre-counseling *N* (%)		Parents' response	
		Post-counseling *N* (%)	
2. Where should the bottle of antibiotic suspensions be stored after reconstitution?	Refrigerator	152 (46.1)	302 (91.5)
	Kitchen	67 (20.3)	2 (0.6)
	Medicinal cabinet	55 (16.7)	18 (5.5)
	Dining room	19 (5.8)	7 (2.1)
	Above refrigerator	15 (4.5)	1 (0.3)
	I don't know	22 (6.7)	0 (0.0)
3. How long can the antibiotic suspensions be stored in the refrigerator after reconstitution?	7 days (correct duration)	106 (32.1)	310 (93.9)
	Wrong duration	153 (46.4)	16 (4.8)
	I don't know	71 (21.5)	4 (1.2)
Knowledge of antibiotic disposal			
1. How should you discard the expired or excess antibiotic suspensions after the treatment duration?	Into the sink	110 (33.3)	10 (3.0)
	Into the toilet bowl	67 (20.3)	10 (3.0)
	Pharmacy	60 (18.2)	154 (46.7)
	Into the river	33 (10.0)	3 (0.9)
	In the dustbin	24 (7.3)	146 (44.3)
	Bury in soil	21 (6.4)	6 (1.8)
	I don't know	15 (4.5)	1 (0.3)

Table 3. Assessment of parent's antibiotic suspensions reconstitution and dose measurement technique.

No.	Technique assessment Pre-counseling		Proportion of parents performed correctly, *N* (%)	
			Post-counseling	
1.	Invert and shake the bottle to loosen the antibiotic powder.		138 (41.8)	306 (92.7)
2.	Open the cap and add water (cold water or filtered water) till half the height below the mark on the bottle.		288 (87.2)	324 (98.2)
3.	Close the cap and shake vigorously to mix the suspensions. Continue shaking till the clumps disappeared.		330 (100.0)	330 (100.0)
4.	Leave the suspensions aside until the air bubbles disappear.		47 (14.2)	330 (100.0)
5.	Add water until it reached the mark on the bottle.		42 (12.7)	307 (93.0)
6.	Shake the bottle again to ensure the formation of a homogenous suspensions.		70 (21.2)	313 (94.8)
7.	Measure out the dose (in volume, ml) of antibiotic using a syringe at eye level.		125 (37.9)	318 (96.4)
8.	Dose measurement:	Correctly measured the dose	125 (37.9)	318 (96.4)
		Overdose	40 (12.1)	5 (1.5)
		Underdose	165 (50.0)	7 (2.1)

Technique of antibiotic suspension reconstitution and dose measurement

Before the pharmacist intervention, only 41.8% of the parents performed step 1 of reconstitution, which is inverting and shaking the bottle to loosen the antibiotic powder. Majority of the parents performed poorly in step 4 to step 6. Merely 14.2% of parents opted to set the suspensions aside after adding water for the first time (step 4). Moreover, 80.3% refrained from adding water again until reaching the designated mark on the bottle (step 5). Additionally, only 21.2% of parents took the extra step of shaking the bottle again to ensure the formation of a homogeneous suspension (step 6). After the pharmacist counseling, more than 90% of the parents were able to perform steps 1–6 of the reconstitution (Table 3).

Before the counseling, only 37.9% of the parents correctly measured the volume of antibiotic suspensions based on the medication label. A total of 12.1% of the parents were overdose, while 50.0% were underdose. Investigations were done and incorrect eye position at the meniscus was found to be the reason for incorrect volume measurement. The parents' eye positions were either above the meniscus which leads to underdose or under the meniscus which causes the overdose of the antibiotic. The percentage of parents accurately performing

Table 4. Comparison of parents' knowledge and techniques scores pre- and post-pharmacist counseling.

Assessment criteria	Median score (interquartile range, IQR)			Proportion of parents achieving perfect score, *N* (%)	
	Pre-counseling	Post-counseling	Wilcoxon signed ranks test	Pre-counseling	Post-counseling
Knowledge of antibiotic suspensions reconstitutions and storage					
Knowledge of antibiotic reconstitution (perfect score: 7)	5 (4–6)	7 (7–7)	$Z = -15.39$ $p < 0.001$	11 (3.3)	256 (77.6)
Knowledge of antibiotic storage (perfect score: 3)	2 (1–2)	3 (3–3)	$Z = -14.59$ $p < 0.001$	43 (13.0)	273 (82.7)
Techniques of antibiotic suspensions reconstitutions					
Antibiotic suspensions reconstitution techniques assessment (perfect score: 7)	3 (2–4)	7 (7–7)	$Z = -15.70$ $p < 0.001$	5 (1.5)	258 (78.2)

Table 5. Satisfaction of parents towards the pharmacist-led counseling on antibiotic suspension reconstitution and dose measurement.

Questions	Response	*N* (%)
1. How would you rate your understanding of antibiotic suspension reconstitution and storage after this counseling session?	Much worse than before counseling.	0 (0.0)
	Slightly worse than before counseling.	2 (0.6)
	Same as before counseling.	5 (1.5)
	Slightly better than before counseling.	11 (3.3)
	Much better than before counseling.	312 (94.5)
2. How would you rate your understanding of antibiotic suspension dose measurement after this counseling session?	Much worse than before counseling.	0 (0.0)
	Slightly worse than before counseling.	3 (0.9)
	Same as before counseling.	12 (3.6)
	Slightly better than before counseling.	10 (3.0)
	Much better than before counseling.	305 (92.4)
3. Does this pharmacist counseling meet your expectation for this study?	Poor.	0 (0.0)
	Fair.	0 (0.0)
	Satisfactory.	8 (2.4)
	Good.	12 (3.6)
	Excellent.	310 (93.9)
4. How useful was the counseling on antibiotic reconstitution provided by the pharmacist?	Extremely useless.	0 (0.0)
	Useless.	0 (0.0)
	No difference.	8 (2.4)
	Useful.	13 (3.9)
	Very useful.	309 (93.6)
5. Do you agree that the pharmacist should continue to conduct such counseling session on antibiotic reconstitution in the future?	Strongly disagree.	0 (0.0)
	Disagree.	0 (0.0)
	No comment.	6 (1.8)
	Agree.	16 (4.8)
	Strongly agree.	308 (93.3)
6. How would you rate the counseling session that was provided by the pharmacist to you in this study?	Poor.	0 (0.0)
	Fair.	0 (0.0)
	Satisfactory.	3 (0.9)
	Good.	13 (3.9)
	Excellent.	314 (95.2)

the measurement increased to 96.4% following the pharmacist counseling (Table 3).

Comparison of parents' knowledge and techniques scores pre- and post-pharmacist counseling

Overall, the parents showed significant improvement in their knowledge scores of antibiotic reconstitution and storage after receiving the pharmacist counseling. The percentage of parents achieving perfect scores surged from 3.3% to 77.6% for antibiotic reconstitution knowledge and from 13.0% to 82.7% for storage knowledge assessment. A similar trend occurred in the antibiotic reconstitution technique assessment whereby the parents' technique score improved significantly post-counseling. The majority of parents (78.2%) attained a perfect score post-counseling, a drastic increase compared to the mere 1.5% of parents with a perfect score before counseling (Table 4).

Satisfaction of parents towards the pharmacist-led counseling

The majority of the parents agreed that their understanding of antibiotic reconstitution and storage (94.5%) and dose measurement (92.4%) were much better after the pharmacist counseling. The parents mostly agreed that the pharmacist counseling met their expectation (93.9%) and were very useful (93.6%). Majority of them (93.3%) strongly agreed that pharmacist should continue conducting the counseling session in the future (Table 5).

DISCUSSION

Knowledge of antibiotic suspension reconstitution

Antibiotic dry powder requires clean reconstitution water to provide stability to the reconstituted suspensions [6]. Therefore, distilled water, cooled boiled water, and filtered water are the appropriate choices for reconstitution. These types of water does not have excessive minerals and bacteria which will affect the stability and shelf-life of the reconstituted antibiotic [11]. However, some parents in this study wrongly chose tap water as the choice for reconstitution. The presence of heavy metals and high acidity of tap water will cause hydrolytic degradation of the antibiotic suspensions [14]. Moreover, some parents opted for river water in the reconstitution of antibiotic suspensions. The choice of river water as a source for reconstitution might stem from the limited accessibility of treated drinking water for rural parents. The use of river water is inappropriate due to the concern of its heavy metals content and bacterial load [11,15,16]. In the present study, all the parents' misconceptions were corrected during the pharmacist counseling session.

The measuring tools for the volume of reconstitution water is crucial to ensure the correct concentration of antibiotic suspension. The mark printed on the antibiotic suspension bottle should be used to measure the amount of water to be added [6,12]. In the present study, the majority of the parents understood this practice and this finding was consistent with a previous study conducted among parents in Palestine [6]. Nevertheless, in the current study, a subset of parents expressed uncertainty regarding the proper method for measuring the volume of water for reconstitution. Therefore, it is essential to clarify this issue in the pharmacist counseling.

The frequency of adding water throughout the reconstitution steps will affect the concentration of the antibiotic suspensions [6]. There are reasons for addition of water in two steps. The water added during first step is to thoroughly mix the suspensions. Meanwhile, the second step aims to adjust the volume of the suspension until it reaches the mark on the bottle, ensuring the desired volume and concentration are achieved [6,17]. Majority of the parents in this study acknowledged wrong practice of either adding the water in a single step or in multiple steps. Addition of water in a single step will cause difficulty in mixing the lump of antibiotic powder. Besides, the water level was not adjusted after shaking and this may lead to overconcentration of the suspension [17]. Meanwhile, adding water in multiple steps may lead to errors in measuring the required water volume [6]. After the pharmacist counseling, the proportions of parents who chose the correct practice increase to 93.0%.

During the reconstitution, shaking of bottle prior to and after the addition of water carries a different reason. Shaking the bottle before adding water ensures that the lumps of antibiotic dry powder do not adhere to the bottom of the bottle [17]. Meanwhile, shaking the bottle after adding water is done to ensure the homogeneous mixing of antibiotic suspensions [10]. The parents in this study have a lack of understanding towards the shaking of the bottle before reconstitution and this issue should be emphasized in the pharmacist counseling. However, the majority of parents comprehended the necessity of shaking the bottle after adding water, and this observation aligns with findings from a previous study conducted in Taiwan [10].

Knowledge of antibiotic suspension storage

The antibiotic suspension consists of hygroscopic dry powder which is sensitive to surrounding moisture. The dry powder should be stored at room temperature with low humidity to maintain its shelf-life [11]. Some parents in the current study misunderstood that antibiotic dry powder showed be kept in the refrigerator, dining room or kitchen. Water droplets can form in the bottle of antibiotic dry powder as a result of the drastic temperature change when the fridge door is opened. These droplets may combine with the dry powder, potentially diminishing the antibiotic's shelf life [16,18]. Additionally, the storage of antibiotic dry powder in the kitchen or dining room will increase the rate of antibiotic degradation due to the high temperature and humidity [6]. The parents' misconceptions were rectified during the pharmacist counseling in this study.

After reconstitution, the antibiotic suspension should be stored in the fridge. The low temperature in the fridge will slow down the degradation of antibiotic suspensions [11]. This correct practice was acknowledged by approximately half of the parents in this study and this finding was in accordance with a study conducted among parents in Palestine [6]. Nonetheless, some of the parents preferred to keep the reconstituted suspension in locations at room temperature such as kitchen, dining room, and medicinal cabinet. This inappropriate storage will affect the stability of the antibiotic suspensions. The room

temperature will increase the risk of microbe growth inside the antibiotic suspensions due to the presence of sugar content [7]. Pharmacist education should be emphasized on this issue to ensure the correct storage of the reconstituted antibiotic suspensions.

In this study, the parents demonstrated a lack of understanding regarding the recommended storage duration for reconstituted antibiotic suspensions in the refrigerator. The parents might misunderstand that antibiotic suspension is stable at a low temperature of the fridge till the expiry dates stated on the bottle, and it can be kept for future use [17]. Hence, the parents tend to keep the suspensions longer than the recommended durations. The recommended duration of reconstituted antibiotic suspensions storage in the fridge is around seven to 10 days depends on the manufacturer's recommendations [7,10,17]. The antibiotic suspensions will reduce its stability and prone to degradation after mixing with water [11]. Hence, it is advisable to reconstitute one bottle of the suspension at a time and proceed to reconstitute the next bottle once the first one is finished. After the pharmacist counseling, 93.9% of the parents showed understanding of the storage duration, which was higher than the 80% found among the parents in Taiwan [10].

Knowledge of antibiotic suspension disposal

In this study, only 18.2% of the parents would return the expired or unused antibiotic suspensions to the pharmacy. This practice is appropriate for the populations in the rural area in which they were far away from the medication disposal center [17]. However, more than 60% of parents in this study will throw antibiotic suspensions into the sewage system such as sinks, toilet bowls, and rivers. This malpractice might lead to aquatic environment contamination [19]. A recent review highlighted that concentration of multiple types of antibiotics were detected in various types of aquatic environment [19]. Extensive counseling is required for rural parents as this study revealed that most of them inappropriately dispose of the antibiotic suspensions.

Antibiotic suspension reconstitution and dose measurement technique

This study found that the majority of the parents did not shake the bottle before reconstitution. Furthermore, they neglected to set the water bottle aside until the bubbles disappeared and failed to top up the water to the mark on the bottle. These errors are crucial as they have the potential to impact the homogeneous mixing of the suspensions, subsequently influencing the concentration of the preparation [4]. A study in Nigeria revealed similar mistakes made by the parents [7]. These errors were corrected during the pharmacist counseling session in the current study.

Dose measurement error is common among parents. A study by Olorukooba *et al.* [7] showed that more than half of the parents were unable to correctly measure the dose of the antibiotic suspensions using a syringe. Failure to identify the level of meniscus is the main reason for dosing error as the parents were not measuring the dose at eye level [9]. The present study showed that 50% of the parents measured the volume of the antibiotic suspensions above the plunger tip, which led to underdose. Whereas 12.1% of them measured the volume more than the required volume, which caused the overdosing of the antibiotic suspensions. These findings were consistent with the results from a Nigerian study [7].

Strength and limitation of study

The strengths of this study include the creation of a visual aid—a handout for antibiotic reconstitution specifically designed for pharmacist counseling. The results demonstrate the effectiveness of pharmacist counseling, supplemented by the visual handout, in significantly enhancing the understanding and practices of antibiotic reconstitution skills among rural parents. However, this study did not include the evaluation on the parent's long-term retainment of the knowledge and technique of the antibiotic reconstitution. Besides, this study was conducted only in a rural district of Kedah state. Hence, the findings might not be generalized to all the rural area in Malaysia.

CONCLUSION

Suboptimal knowledge and technique were found among the rural parents on antibiotic suspension reconstitution, storage, as well as dose measurement. Strategies should be carried out to minimize such medication errors in the future. The baseline data gathered in this study, along with the created counseling tools, can serve as a valuable resource for the Malaysian government in implementing a comprehensive national counseling program. This approach will enhance the capabilities of healthcare providers in effectively educating rural parents. Moreover, antibiotic manufacturers should create product leaflets containing infographics and step-by-step instructions in layman's terms to assist parents in the reconstitution process.

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AUTHOR CONTRIBUTIONS

All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agree to be accountable for all aspects of the work.

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CONFLICTS OF INTEREST

The authors declare that they have no conflict of interest.

ETHICAL APPROVAL

The study protocol was approved by the Medical Research and Ethics Committee, Ministry of Health Malaysia (approval number: NMRR-20-461-53881).

DATA AVAILABILITY

All data generated and analyzed are included in this research article.

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