Pill School: Maximising access to medicines for children within the NHS

By: Asia Rashed

With: David Terry, Andy Fox, and Stephen Tomlin

PROJECT DETAILS
PRUK-2016-PG3-2-A
02/01/2018 to 01/07/2021
£59,568

FUNDING STATEMENT
This final report presents research funded by Pharmacy Research UK (**PRUK-2016-PG3-2-A**). The views expressed in this report are those of the authors and do not necessarily represent the views of the funder.

Describe any changes to the study plan (200 words max)
Please outline any changes made to the conduct or protocol of the research since submission of the original application for funding.

Three changes were made to the original study proposal as the project progressed. These are summarised below:

- A slight change in the method was made. Following the discussion and feedback from parents and their children as well as healthcare professionals during the development phase of the pill school (PS), the follow-up phone call frequency was changed to 2 days post-discharged home, then 1 and 6 months later instead of what was initially proposed (at 1, 6 and 8 months).

- The HRA Ethics Committee requested a slight change in the PS training process; once the child is trained on how to swallow tablets successfully, the study team should observe them for the next 24hrs while they are in hospital to prove to the team that they are able to adhere to swallowing their actual pills before being discharged home.

- Following opening the study for recruitment, it was found that the wording of the eligibility criteria needed to be slightly modified to increase the chance of capturing more eligible children (minor-ethics-amendment request). Also, the condition (observing trained child for 24 hrs – mentioned above) imposed by the HRA ethics committee proved to be a huge barrier to recruitment. Hence substantial ethics-amendment request was submitted, resulting in pausing participants' recruitment until approval was granted.

Outline any extension requests granted by PRUK (200 words max)
This section should outline any extension requests that were approved (extensions to the study duration or additional monies) and the reasons for the extension.

1. No-cost extension request: Extension for another year, from 01/07/2019 to 30/06/2020.
Reasons

- Initial delay in submitting and obtaining ethical approval, due to contract variation between PRUK, KCL and GSTT (as reported in the first progress report).
- Delays in the recruitment process because of submitting a substantial ethics amendment request, as mentioned above.

2. Costed extension request
The project was intended to end on 1 July 2020, however, due to COVID-19 pandemic, the final stage in the project evaluation process was put on hold. This was because doctors, nurses, and pharmacists were not able to attend non-COVID research-related activities, during the lockdown. Also, because of the pandemic, the local R&D department paused all clinical research activities, apart from COVID-related research. Hence, it wasn't feasible to continue working on the Pill School project. Therefore, an extension of 12 months period starting from 02/07/2020 to 01/07/2021 was requested and granted.

Background (1500 words max)
This section should outline the existing literature available and a background to the research conducted.

Medicines for children should be safe, well tolerated, easy to use (palatable and requiring minimal manipulation), transportable, easily produced, cost effective, commercially viable, and with minimal impact on children's lifestyle (Salunke et al., 2013; EMA, 2011).

Oral liquid forms of medicines are often considered the most appropriate formulation for children as they are easy to swallow (Salunke et al., 2013; Nunn & Williams, 2005; Schim et al., 2003). Liquids have disadvantages including poor stability; unpleasant taste; potentially inappropriate excipients for children, low transportability and lack of controlled release formulations resulting in multiple doses being needed throughout the day (EMA, 2006; WHO, 2009; Lopez et al., 2015). Liquid formulations are often costly, e.g. warfarin 1mg/1mL suspension 150mL may cost £124, compared to <£2 for 28 tablets of any strength (BNFc, 2021). Moreover, liquid medicines for children are often unlicensed/off-label, and often prepared extemporaneously, thereby reducing the quality assurance of the preparation due to manipulating the licensed product (Nunn & Williams, 2005).
Carers commonly misunderstand dosage instructions and volume calculations for liquid medicines which can result in wrong doses being administered, compromising patient safety (Tomlin, 2015; Winnick et al., 2005; Bailey et al., 2009; Yin & Mendelsohn, 2010).
Dose volume is another risk; large volumes may be a barrier to children and very small volumes cannot be measured accurately even if the most suitable measuring device is used (Sam et al., 2012; Liu et al., 2014). Parents/carers usually remember the dosage volume (mL) but not necessarily the dosage in units (mg), so a supply of different strengths can lead to dosing errors when the same volume is administered (Tomlin, 2015; Wong et al., 2006). For example, spironolactone suspension is available in strengths between 5mg to 100mg/5mL (BNFc, 2021).
Solid dosage forms (tablet/capsule) have several advantages over liquid forms, e.g. stability, easy dose selection, easy storage and transportability and may indirectly improve compliance (Baguley et al., 2012; Stoltenberg et al., 2010; Lajoine et al., 2014). Tablets/capsules are usually much less costly than liquid forms. A study by a team at Birmingham Children's Hospital showed that 90% of liquid medicines are available as solid forms and 80% of these liquids could be substituted with a solid form for children aged above 2 years. They also estimated that three-quarters of the current medicines' expenditure may be saved if solid formulations were substituted for liquids (Lajoine et al., 2014). Despite these significant advantages, there is a lack of strong evidence regarding their acceptability to children and the child's ability to swallow tablets/capsules.

The age from which children are prescribed solid dosage formulations over liquids is believed to be subjective based on the judgment and experience of the prescriber. The World Health Organisation (WHO) advises that young children be treated with oral solid medicines where possible (WHO, 2009). The European Medicines Agency (EMA) suggests 6 years as the age from which solid dosage forms may be considered suitable for children and advises that adequate training could improve tablet acceptability in children (EMA, 2006). In the UK, a retrospective medical record review in one paediatric hospital found that the average age of conversion from liquid to solid antiretroviral formulations was 7 years (Yeung et al., 2005).

Previous studies have shown that pill swallowing training has the potential to overcome swallowing barriers (Patel et al., 2015; Jagani et al., 2016). However, those reports focused on either one swallowing technique or a specific swallowing aid, certain diseases or only children who have swallowing difficulties. Other studies (with larger sample sizes) have shown a positive effect of tablet-swallowing training and demonstrated that children as young as 3 years, who have chronic conditions, e.g. human immunodeficiency virus (HIV) and attention deficit hyperactivity disorder (ADHD), easily gain the skills when trained (Hommel et al., 2010; Czyzewski et al., 2000; Ghuman et al., 2004; Kaplan et al., 2010).

There is no formal guidance (national/international) for paediatric prescribers to consider pills instead of oral liquids for children and/or refer them to pill swallowing training sessions. No evidence was found of any swallowing training service established and implemented as an integrated service within routine healthcare services, which provides swallowing training sessions for children on a daily basis as part of routine practice, considering various techniques for a wide

range of children of different ages based on the principle 'whatever works for the individual child is the best technique for them'
In summary, the extensive use of liquid medicines, whilst understandable, confers several disadvantages and potential risks, some of which can be mitigated by the use of solid dosage forms. Change in practice can only be achieved by understanding the perceptions of stakeholders, including children and their parents/carers. Thus, this project focused on improving the health care provided to paediatric patients by supporting the use of marketed solid dosage forms that can be safely prescribed to children, providing swallowing training sessions within clinical settings, analysing the opinions of children and their carers concerning the administration of solid formulations.

Aims & Objectives (500 words max)
Please outline the aims and objectives of the research.

Aims
This project aimed to assess the feasibility of introducing swallowing training session (called Pill School, PS), within a UK hospital setting, to train children how to swallow pills; to identify the proportion of children at the study site who can, with training, be swapped from liquid medicines to tablets/capsules; and to assess opinions of the child and their parents/carer and of healthcare professionals, of the PS intervention.

Objectives
1. Develop a structured programme of different swallowing training techniques (called Pill School).
2. Train PS teachers (nurse, pharmacist) on how to deliver swallowing training sessions.
3. Identify the proportion of inpatient children (and their parents/carers), at the study site, who are recruited and received the intervention (PS swallowing training).
4. Identify the proportion of children (and their parents/carers), at the study site, who agreed to swap to tablets/capsules after receiving the intervention (PS swallowing training).
5. Follow-up with children and their parents/carers 2 days post-discharge, then after 1 and 6 months, to identify their opinions regarding the provided training.
6. Identify the experiences, opinions and recommendations of healthcare professionals involved in the feasibility study regarding the proposed PS intervention.

Method (1000 words max)
Please describe the methodologies employed on this proposal, including any other relevant assessments conducted.

Design and setting

A prospective feasibility study was carried out at the Evelina London Children's Hospital (ELCH). The PS training sessions were conducted on paediatric wards; at bedside or play area, depending on child and parents' preference.

The swallowing training techniques were collated from literature (Patel et al., 2015) and from a previous information booklet designed for clinicians use at ELCH. The PS teachers, a research pharmacist and a research nurse were trained by an established PS trainer and were also trained in Basic Paediatric Life Support, to be able to treat potential choking, which was considered to be extremely low risk.

Participants' recruitment

Eligible children were identified by ward pharmacists. Inclusion criteria were: age 3-18 years; taking oral-liquid and/or manipulated solid medicines (e.g. crush and dissolve a tablet); their medication regimen assessed by a clinical pharmacist as having a suitable oral tablet/capsule as an alternative, where the dose can be given by tablet either whole, halved or quartered (if tablets are scored and clinically appropriate); the ability of children (as appropriate) and their parents to understand spoken and written English.

Children with significant developmental delay, e.g. visual, hearing, motor or learning disabilities; diagnosed with clinical swallowing difficulties; and children not eating or drinking via oral route were excluded.

Recruited participants (children and their parents) received parent and age-appropriate participant information sheets and were required to sign an informed consent form. Participants were offered a single PS training session on the same day of enrolment or before being discharged home.

Pill School training session

The training session was conducted in the presence of parents/carers. The PS teacher ensured that parents were engaged in the session and understood the swallowing technique taught to their children to support continuity after discharge. The ward pharmacist was present during the training session to take notes and to answer any questions the parent/child may have about the medication.

Training sessions were delivered using hard sweets of different shapes and sizes (Appendix-Table 1), starting from the smallest size (cake decoration silver & gold balls) and gradually increasing the size of the sweet. At the start of the session, information about the sweets was made available to participants, in case a child had any issues with certain sweets (e.g. allergies, religious beliefs or dietary requirements). The training session lasted up to 30 minutes. It was a facilitated learning session where the children and their parents/carers were asked to describe their experiences when taking liquid dosage forms and whether they have attempted to swallow solid dosage forms before. Children were taught techniques according to individual circumstances using the principle that 'whatever works for the individual child is the best technique for them'.

The training session started by asking the child to swallow water in different head positions (head centred face forward, head turned to the left, head turned to the right, head tilted backward, and head slightly tilted down toward chest). This was done to help the child find the best head position where they felt comfortable in swallowing. Then the PS teacher explained to the child (and their parents) how to swallow a sweet by asking them to place a sweet on the back or middle of the tongue, drink water or juice and swallow using their preferred head position. Different swallowing aids were used during the training session as per the child's preference, e.g. sports cap bottle (Appendix-Table 1). When the child had swallowed a sweet, they moved to the next larger size sweet. The child was praised each time they were successful in swallowing a sweet. Those who were unsuccessful were also praised for trying and were encouraged by the teacher and parents to try

again with the same sweet size. The training session was terminated when a child had successfully swallowed a sweet approximately equivalent or larger in size to their current medication in solid form during the training session. Then, if the patient and their parent were happy to switch from oral liquid medicines to pills, the prescriber was asked to change their inpatient medications and to write their discharge medications in solid forms. A child's ability to swallow pills was confirmed by taking one dose of their actual solid medication while they were in the hospital.

As there is evidence that a single short training session can enable children to make the switch from liquids to pills (Patel et al., 2015), only one training session was delivered to each child. Participating children were provided with a certificate of attendance (stickers for younger children) as a reward and encouragement at the end of the training session.

Evaluation of the Intervention

A. Follow-up phone call with participants

Trained children were followed-up after discharge home by a phone call at + 2 days, + 1 month, then + 6 months post-discharge, by the PS teacher. Follow-up calls were conducted using a short semi-structured questionnaire. The questionnaire included items such as: has the child's confidence in pill swallowing changed since receiving training; have they received their repeat prescription or bought any over-the-counter medicines in solid forms and are there any ongoing administration or medication access issues. The phone call was conducted mainly with parent/carer, unless a child was happy to speak to the PS teacher on the phone.

B. Focus group with healthcare professionals (HCPs)

A virtual focus group (FG) with HCPs (doctors, nurses and pharmacists) was conducted in January 2021. HCPs who were looking after trained children at ELCH were invited by email via the Trust's email system along with the participant information sheet. The general practitioners (GPs), who were sent electronic letters notifying them about the PS training and the change in medication formulations for their patients, were also invited via email.

The FG was conducted after completing the follow-up phone calls with all trained children. The FG discussed HCPs' views on the PS role in children's medicine, issues or barriers that occurred or might prevent a child from taking part in the PS; and what could be improved. The FG was audio-recorded and transcribed verbatim.

Sample size

Based on a previous study where 80% of trained children were able to successfully swallow pills and switch to solid dosage form after training (34), a sample of 30 recruited patients would provide a 95% confidence interval for the true mean rate of success 65.7% to 94.3%. This study aimed to recruit 30 paediatric patients to receive training and to assess the feasibility outcomes measures.

Outcome measures:

- Proportion of patients agreeing to participate in the PS training session; retained and not lost for follow-up.
- Change in the child's ability to swallow a tablet/capsule after receiving a swallowing training session at the PS – measured by the child's success in swallowing a sweet that is approximately equivalent in size and shape to their medicine (smallest size if on several medicines).
- Acceptance by the child and their parent/carer to switch to solid form following successful PS training – measured by the number of oral liquid prescriptions changed to solid forms at discharge time.

- Success and satisfaction in maintaining swallowing skills - measured using a follow-up questionnaire administered by the PS teacher.

Data analysis

Only anonymised data was recorded electronically, using an excel spreadsheet (MS Excel v2017) and analysed. Descriptive analysis of the obtained data was done using Stata15 software. Descriptive data has been presented as mean (SD), frequency and percentages, unless otherwise specified. Chi-squared tests were used to assess the impact of age, in groups, on the success of learning pill swallowing. Statistical significance was considered at a p-value of <0.05.

An anonymised transcript of the focus group and relevant field notes (such as child and their parent's description of their experience with swallowing liquid or solid forms) collected during the PS training session and follow-up were analysed using content analysis to identify issues pertinent to the research question, using NVivo 12 software.

Ethical approval

This study was approved by the Health Research Authority and Care Research Wales (Reference number 18/SC/0285) on 19th July 2018.

Results (1000 words max)

Please describe the main results of the research and an outline of the analyses conducted to produce the results.

Pill School training session

Overall, 50 patients were deemed eligible to take part in the PS training session; of these, 40% (20/50) refused to take part. In total 30 children (and their parents) agreed and were included in the study (mean age 7.8 ± 3.3 years, range 3.5 - 14 years); 60.0% (18/30) were male (Table 1).

The PS training sessions were conducted over eight months in 2019 (February – September) at ELCH. Overall, 86.7% (26/30) of children successfully learned how to swallow pills after receiving a single PS training session (mean duration time 14.5 ± 5.8 minutes, range 8-30 minutes) during their hospital stays. One child aged 4 years managed to master the swallowing skills in just 8 minutes and was moved onto pills. On average, five different sweet sizes (range 3-7) were swallowed per child. The remaining four children, who were not successful in mastering the swallowing skills during the training session, were discharged on oral liquids medicines and were advised to keep practising using sweets as demonstrated to them during the training session.

Many children preferred to swallow with their head slightly tilted back (50%, 15/30) or with their head centred looking straightforward (46.7%, 14/30), (Appendix - Table 2). More than half (56.7%, 17/30) of children preferred to drink plain water in an everyday cup followed by sports-cap-bottle (16.7%, 5/30), (Appendix - Table 2). None of the children wanted to use the special-pill-cup when offered to them.

Table 1 Children characteristics

Parameter	Value	Range
Age (y), mean ± SD	7.8 ± 3.3	3 - 14
Number of children by age group; n (%)		
3-5 y	12 (40)	
6-11 y	13 (43.3)	
12-18 y	5 (16.7)	
Gender; n (%)		
Female	12 (40)	
Male	18 (60)	
Weight (kg), mean ± SD	28.9 ± 13.6	13.2 - 65
Condition; n (%)		
Congenital heart disease	3 (10.0)	
Fracture of lower leg; ankle, fibula	3 (10.0)	
Cerebral palsy - orthopaedic surgery	2 (6.7)	
Appendectomy	2 (6.7)	
Acute disseminated encephalomyelitis	2 (6.7)	
Lower respiratory tract infection	2 (6.7)	
adolescent idiopathic scoliosis	2 (6.7)	
Kawasaki disease - joints pain and fever	1 (3.3)	
End-stage renal failure: T-cell-mediated rejection	1 (3.3)	
Tight calf muscles and hamstrings	1 (3.3)	
Transient ischaemic attack	1 (3.3)	
Chest pain - Balloon dilation of right ventricular outflow tract	1 (3.3)	
Chronic constipation	1 (3.3)	
Elective cholecystectomy	1 (3.3)	
Fever, abdominal pain and weight loss	1 (3.3)	
Gastroenteritis	1 (3.3)	
Periorbital cellulitis, chickenpox	1 (3.3)	
Severe cellulitis of the right flank secondary to VZV	1 (3.3)	
Sickle cell disease HbSS crisis	1 (3.3)	
Sore throat and fever	1 (3.3)	
Toxic shock syndrome	1 (3.3)	

n: number of patients; VZV: varicella-zoster virus; HbSS: sickle cell anaemia where a patient with sickle cell disease inherits two sickle cell genes "S", one from each parent. Hb: Haemoglobin

Most children who succeeded in learning to swallow pills (sweets) were from the age group 6-11 years (46.1%, 12/26), followed by age group 3-5 years (34.6%, 9/26), and only 5 (19.2%) patients were from age group 12-18 years. There were no statistically significant differences between the age groups in their ability to master swallowing skills. However, younger children were found to be more enthusiastic about the training and were less concerned about the increment in the sweet size, where the largest sweets were swallowed by those aged 3-5 and 6-11 years (Table 2).

Of the 26 children, 92.3% (24/26) were discharged on pills. In the cases of the remaining two children, the parents of one refused to allow their child to be discharged on pills despite being successful in the training and was able to swallow their in-patient medications as pills. However, they admitted that their child struggled with the taste of some liquid medications *"Sometimes she doesn't like the taste, but she gets on with it"* [parent of 5.8-year-old child]. Parents thought that

the child was not ready to start taking pills at their age *"We want to keep her on liquids for now."* [parent of 5.8-year-old child].
The other child (7 years – swallowed Tic Tac with soft food, disliked liquid amoxicillin), was unable to swallow 500 mg amoxicillin capsules.

Table 2 Frequency of different sweet sizes used by age groups

Sweet	**3-5 years n (% out of 12)***	**6-11 years n (% out of 13)***	**12-18 years n (% out of 5)***
Popping candy (Cake angels®) (approx. 1.0 cm)	2 (16.7)	7 (53.8)	2 (40.0)
Gold balls cake decoration (approx. 0.3 cm)	9 (75.0)	12 (92.3)	5 (100.0)
Jelly Belly beans® (approx. 1.7 x 0.9 cm)	2 (16.7)	6 (46.1)	-
Mike & Ike® candy fruits (approx. 2.3 x 0.9 cm)	1 (8.3)	3 (23.1)	-
Millions® (approx. 0.7 cm)	5 (41.7)	7 (53.8)	1 (20.0)
Nerds® candies (approx. 0.3 x 0.7 cm)	2 (16.7)	3 (23.1)	1 (20.0)
Silver balls cake decoration (approx. 0.5 cm)	9 (75.0)	12 (92.3)	5 (100.0)
Tic Tac® (approx. 0.6 x 1.0 cm)	8 (66.7)	11 (84.6)	3 (60.0)
Wacky Monkey® candies (approx. 0.3 x 0.6 cm)	5 (41.7)	4 (30.8)	4 (80.0)

*n=number of children in each age group. The numbers of children do not add up as one child swallowed more than one sweet.

The total number of prescribed oral liquid medications during admission was 103, median of 4 (IQR 3-5) medications per patient. Of these, 72.8% (75/103) were deemed suitable for switching to solid dosage, and 89.3% (67/75) were switched after a successful PS training session, median 3 (IQR 2-5) medications per child, (Table 3).

Table 3 List of medications switched to solid dosage forms post successful PS training session

Medication	**Frequency (% out of 67)**
Paracetamol 500 mg tab	17 (25.4)
Ibuprofen 200 mg tab	7 (10.4)
Omeprazole 20 mg Cap	5 (7.5)
Aspirin 75 mg tab	4 (6.0)
Ondansetron 4 mg tab	4 (6.0)
Morphine sulphate 10 mg immediate-release tab	4 (6.0)
Prednisolone tab 25 mg	1 (1.5)
Prednisolone tab 5 mg	3 (4.5)
Senna 7.5 mg tab	2 (3.0)
Chlorphenamine maleate 2 mg tab	2 (3.0)
Clonidine HCL 100 mcg tab	2 (3.0)
Ibuprofen 400 mg tab	2 (3.0)
Dihydrocodeine 30 mg tab	2 (3.0)
Lisinopril 2.5 mg tab	2 (3.0)
Bisacodyl 5 mg tab	1 (1.5)
Cetirizine tab 10 mg	1 (.5)
Ciprofloxacin 500 mg tab	1 (1.5)
Clarithromycin 250 mg tab	2 (3.0)
Co-amoxiclav tab 250 mg/125mg	1 (1.5)
Furosemide 20 mg tab	1 (1.5)
Lisinopril 5 mg tab	1 (1.5)
Phenoxymethylpenicillin 250 mg tab	1 (1.5)
Tacrolimus cap (Adoport) 0.5 mg	1 (1.5)

During the PS training session, participants (child and parent) reported their experience with administering oral liquids (Figure 1). The majority of them (76.7%, 23/30) referred to the taste as the main issue they faced when taking/given oral liquids *"… she doesn't like strawberry taste…says [it] tastes like "poo"* [a parent of 4.5-year-old child].

Most parents (86.7%, 26/30) said that they did not know that they could start their child on pills from a young age (table 4). Only four parents reported that they had tried to teach their children to swallow tablets at home, but were not successful, with one saying that *"…he spat it [tablet] out"*.

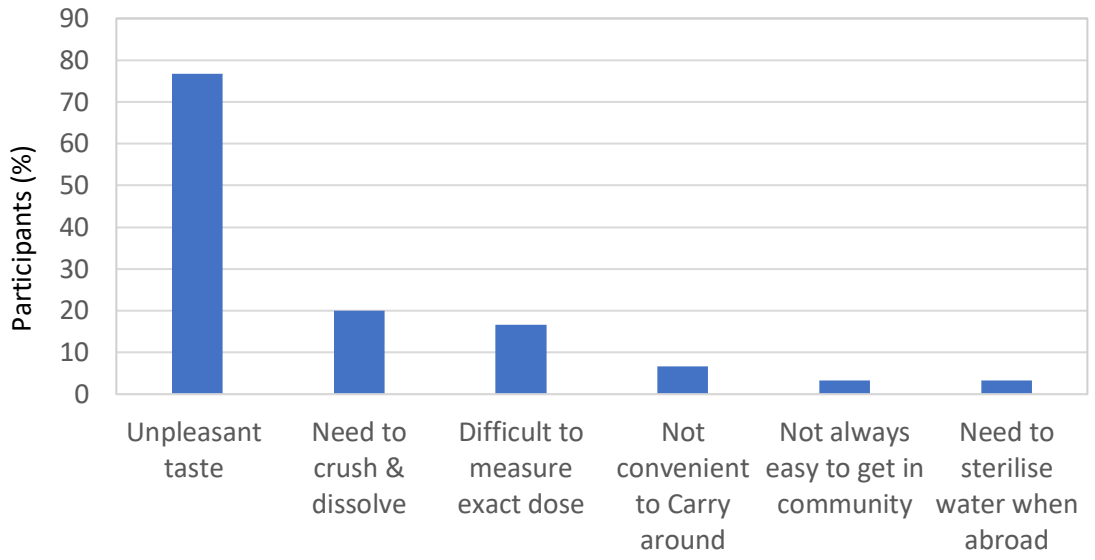

Figure 1 Issues regarding oral liquid medicines reported by participants during the PS training session

Evaluation of the intervention

A. Follow-up phone call with participants

Table 4 presents all the themes and subthemes that were identified from the training session and follow-up phone calls at 2 days, 1- and 6-months post-discharge.

All parents of children who moved onto pills reported that medication-taking activity had become easier post-PS training. All trained children remained on pills post-discharge.

Table 4 Themes and subthemes identified during the PS training session and the follow-up phone calls*

Theme	Subtheme	Example quote
Swallowing training provided by a third party	Child acceptance of training by a healthcare staff vs parent	*"The way you [are] saying it in oppose to mother...they take it differently"* [parent of 13-year-old child]
The age of a child to start on tablet	- Parent perception - Lack of endorsement from HCP	*"It is quite interesting to know that…nobody told me I can give her tablet at this age"* [parent of 4.5-year-old child]
Confidence gained	- Child confidence - Parent confidence	*"The GP gave her vitamin D and she told him; I need tablet, I don't want syrup…she asked for it herself"* [parent of 8-year-old child] *"I bought him [paracetamol] tablet instead of Calpol…he asked for tablet"* [parent of 9-year-old child]
Changes to medication-taking time experience	- Easier post-PS training - No crush and dissolve - No administration issues	*"It helps me a lot. I don't need to chase him…it is easier now"* [parent of 8-year-old child] *"I am more relaxed administering his medicines. Not to have to crush and dissolve table made a difference to both of us"* [parent of 5-year-old child]
Obtaining pills in the community	- Issues in getting repeat prescriptions from GP and local pharmacy - Buying OTC products in solid dosage form	*"We received his repeat prescription from GP, one bottle…liquid [of Pen V]…delivery. I had to go and ask them again to change it to tablet"* [parent of 8-year-old child] *"I requested his lisinopril repeat from our regular pharmacy to give us tab, but pharmacy asked for a prescription from heart consultant because I asked to change from liquid to tablet".* [parent of 3.8-year-old tab]

Pen V = Phenoxymethylpenicillin; *Follow-up phone calls at 2 days, 1- & 6-months post-discharge.

All parents reported that providing their children with the PS training by healthcare staff at the hospital was a "great" opportunity for them as they would not try the training by themselves at home.

The majority of parents whose children were discharged on pills (87.5%, 21/24) reported that PS training improved their child's confidence in taking their medications in pill forms. Knowing that

their children could swallow pills, parents became more confident in buying OTC medications in solid forms from community pharmacies, as reported by 41.7% (10/24).

For one child, providing a PS training session helped their parent to understand their child's ability to swallow oral medication. The child was on suppositories because he refused to take any oral liquid. Following attending a PS training session, the parent realised, for the first time, that their child has anxiety when taking any oral medications. This resulted in asking for a referral to a psychologist. After 6 months, the parent reported that their child had overcome the fear of taking oral medication. *"Psychologist explained to him that taking medication is to help him, not to hurt him"* [parent]. The child moved from suppositories to oral liquids which was "a big achievement for him" and started ill swallowing training as per the PS teacher's instructions, according to the parent.

B. Healthcare professionals' focus group

In total eight HCPs attended the virtual focus group that took place on 29th January 2021; seven were from a secondary care setting [hospital doctors (2); ward nurses (3); pharmacists (2)] and one from a primary care setting (GP).

Three main themes were identified: 1) impact of PS training sessions; (2) Barriers preventing PS from working; (3) Suggestions to overcome barriers. These themes and subthemes are summarised in Appendix-Table 3.

All participants were unanimously supportive and in total agreement on the direct impact the PS might have on a child's health outcomes, such as overcoming taste issues associated with oral liquids, improving a child's adherence to their medication, improving safety in terms of administrating the right dose of medication, overcoming the large volumes of multiple oral liquids, and improving the quality of life of children and their families.

> *"I've got a patient on fifteen medications and taking tablets is obviously essential for her…they come out with suitcases in order to fill up with liquid preparations…um…it just shows how important it is to be able to get some of those children to be able to take tablets."* [Paediatric Renal Consultant, FG1]

Participants also identified potential barriers that might prevent PS from working effectively in practice and the strategies to overcome those barriers (Appendix-Table 3). For example, one recommendation to overcome potential resistance from some parents/carers or children especially those on long-term medication is to make PS part of normal admission assessment (i.e. normalising that tablet is normal)

> *"If you have a child coming in… "is your child taking tablets yet?...No. Well, we have this support for children". So, normalising that tablet is normal, not that medicine is the normal."* [General Practitioner, FG1]

Discussion (1500 words max)

Please use this section to analyse the findings of your research and link it back to the original hypothesis.

This feasibility study achieved the stated outcomes. It demonstrates that children can acquire the ability to swallow pills from as young as 3 years, with appropriate training. The training sessions proved to be effective. The rate of success in acquiring pill swallowing skills following attending a single PS session was recorded in this study, with over 90% of children discharged on pills and none of them switched back to liquids during the follow-up periods.

The age of participating children in this study ranged from 3 – 14 years. Younger children (3-11 years) were found to be more enthusiastic to learn and acquired the swallowing skill easily. Previous studies have reported that children as young as 3 years easily gained the skills when trained (Ghuman et al., 2000; Kaplan et al., 2010).

Many parents expressed surprise at their child's ability to swallow pills. Parents (and children) are only likely to know about available dosage forms of medication and when to start taking/giving tablets from healthcare professionals. Ensuring that they are aware that young children can take pills is therefore of importance to clinical practice. Where appropriate parents' beliefs about the appropriate age to take pills may be usefully challenged by clinical staff.
The engagement of the parents during the PS training session not only provided support to their children, but it also helped them in gaining the confidence and assurance that their child can swallow pills. This is particularly important as it has been reported that parents can influence the choice of a dosage form and their child's adherence to their medications (Venables et al., 2015).
A previous study showed that parents of children with HIV reported that it was easier to administer medication in tablet form than a large volume of liquid (Jagani et al., 2016). In this present study, parents reported that switching their children to pills made the medication-taking time an easier activity for both children and their parents (Table 4).

Increasing a child's confidence in swallowing pills enables them to become more in control of their treatment and supports independence. This may improve their adherence to medication. Though this was not assessed in our study, previous studies have reported that taking tablets instead of oral liquids improved children's adherence to their medications (Patel et al., 2015).

Parental engagement during the PS training session was considered important to confirm their acceptance of the child's ability to swallow pills and support medication choice in the future. The study showed that following the PS intervention, parents gained confidence in buying OTC medications for their children in pills from a community pharmacy.
The effectiveness and the potential direct impact the PS might have on the health outcomes of children, and consequently on their and their family's quality of life, was appreciated by all the HCPs who participated in the focus group. A change in practice in favour of pills may improve safety as it would reduce or even eliminate the need for parents/caregivers to measure small-dose volumes, hence reducing the potential for dose administration errors (Bailey et al., 2009; Yin et al., 2010).
For one case an unexpected outcome of the PS training session showed that the reason behind a child's refusal to take any oral medication was anxiety rather than a dislike for the liquid taste as previously assumed. This was successfully addressed with psychologist intervention.

This study was designed to prove the concept of the feasibility of providing PS training for children within UK hospitals and no cost analysis was conducted. However, if we consider the hospital costs for the prescribed drugs identified in this study, swapping the 67 liquids medicines to pills for the 24 participating children on discharge would result in a potential saving of £31,133 each year (89% reduction in medication costs). The cost saving could even be higher in the community as hospital prescribing behaviours, sources of liquid medicines and costs are different to those in the community. Similar costs saving resulted from switching to pills have also been reported previously (Tse et al., 2019).

Limitations (500 words max)
Address where your research could have been further improved.

This study had limitations that need to be considered when interpreting the findings. Firstly, there is a lack of data on the cost-saving resulting from switching children from oral liquid medications to pills. However, this study was designed to prove the feasibility of using PS for children within UK hospitals. Future research is needed to identify the cost implications. Pills are generally far cheaper than liquids and there are potentially large cost savings for the health economy (Lajoinie et al., 2014).

Secondly, the impact of PS training on medication adherence, particularly for those on long-term medications, was not investigated.

Lastly, in this study sweets of various sizes were used rather than placebo as children may be less concerned about swallowing a sweet than a tablet. However, this served to demonstrate to the child that they can swallow a solid dosage form. The short-term risk of the sugar content is considered negligible. However, this meant that children with diabetes or those on restricted diets were excluded. This should be considered in future research and when implementing PS within routine clinical practice.

Conclusion (500 words max)
Please provide a succinct conclusion to the report and provide the key take-home message for the reader to understand.

The high success rate of pill swallowing (92.3%) demonstrates the utility of providing children with a single swallowing training session as part of routine clinical care. The study showed that children can be prescribed pills from the age of 3 years if they are provided with a PS training session. The Pill School initiative was acceptable to children and parents. The Pill School has influenced the confidence of both children and parents positively in regard to taking/administering pills. Integrating Pill School training sessions into routine paediatric care would increase children's access to medications by both increasing the availability of solid formulations and avoidance of unpalatable liquid formulations. Consequently, medication adherence may improve.

Take-home messages

- The Children's Pill School initiative providing a single short swallowing training session was effective and acceptable to children and their parents who participated in this study.
- Children as young as three years were able to learn the swallowing skills and switched to pills.
- A high percentage (89%) of liquid medications included in the study were switched successfully to pills, which, based on the medications taken by the 24 participating children, could result in an estimated medication cost saving of over £31,000 per year.
- Children's Pill School service could be implemented in clinical settings to offer training to children and their parents before prescribing oral liquids.

Summary of outputs (500 words max)
Please include a list of dissemination activities carried out during the life of the project, in addition to future activities planned.

Dissemination activities:

- A paper on the findings of the Pill School training session was commissioned and published by Arch Dis Childhood (Rashed et al., 2021, Arch Dos Child, doi: 10.1136/archdischild-2020-319154).
- The findings were also presented to the local HCPs (nurses, doctors, pharmacists) at two paediatric hospitals (Evelina London Children's Hospital and Great Ormond Street Hospital) ahead of introducing a new NHS service called "Pill School" for patients at these two hospitals.

Future activities:

- The second paper presenting the findings of the focus group with healthcare professionals' is currently under preparation and will be submitted as a short report or letter to the Arch Dis Childhood journal.
- Presenting at the 26th European Association of Hospital Pharmacists Congress, 23-25 March 2022, Vienna.

Recommendations for future research (500 words max)
Discuss the impact of your research more generally, whether it is towards a particular patient group or for further research.

Implication for clinical practice

Although future research (as described below) is warranted, given the high success rate of this feasibility study and the high number of requests for Pill School (PS) training for children since the completion of the study at ELCH, implementing PS as routine care, and providing PS training to all children taking long-term oral medication (with no physical swallowing difficulties) is recommended. Adopting the Pill School concept in clinical settings and supporting children to make the switch from oral liquid medicines to pills will result in optimising children's medicines. This is likely to include: expanding access to routinely available medicines, reduced use of 'specials', reduced reliance on hospital pharmacy services after discharge, reduced risk of dosage errors, improved compliance, reduced waste and reduced drug costs. PS has the potential to improve the quality of life of children taking long-term oral medications and their families.

Currently, the project team is implementing Pill School in different clinical areas (inpatients and outpatients) across two paediatric hospitals: Evelina London children's Hospital and Great Ormond Street Hospital. Expansion to other NHS organisations is under consideration.

Future research recommendations

Future research should focus on evaluating long-term sustainability and the cost implications of pill school to the NHS settings as well as the impact of pill school training on the adherence of children to their medications, particularly those on long-term medications. Funding resources are being investigated to enable future research.

The project team is currently in discussion with the national pharmacy team at Health Education England for wide-scale testing and implementation of Pill School in different sites (30 sites) in England with a view for wider scaling and the integration of pill school into commissioning. The potential integration of pill school training into education and training programmes for healthcare professionals (pharmacy, nursing, and medicines education) is also being considered.

References

Please use the Harvard referencing format.

Baguley, D., et al. (2012) Prescribing for children – taste and palatability affect adherence to antibiotics: a review. *Archives of Disease Childhood*, 97(3), 293–297.

Bailey, S.C., et al. (2009) Predictors of misunderstanding pediatric liquid medication instructions. *Family Medicine*, 41(10), 715-721.

British National Formulary Children (BNFc). Available at: https://bnfc.nice.org.uk/ (Accessed 5 October 2021).

Czyzewski, D., et al. (2000) Teaching and maintaining pill swallowing in HIV-infected children. *The AIDS Reader*, 10(2), 88–94.

EMA Committee for Medicinal Products for Human use (CHMP). (2006) Reflection paper on formulations of choice for the paediatric population. Available at: http://www.ema.europa.eu/docs/en_GB/document_library/Scientific_guideline/2009/09/WC500003782.pdf. Accessed 05 May 2020 (Accessed 5 October 2021).

Ghuman, J.K., et al. (2004) Behavioural training for pill-swallowing difficulties in young children with autistic disorder. *Journal of Child and Adolescent Psychopharmacology*, 14(4), 601–611.

Hommel, K.A. and Baldassano, R.N. (2010) Brief report: barriers to treatment adherence in pediatric inflammatory bowel disease. *Journal of Pediatric Psychology*, 35(9), 1005–1010.

Jagani, M., et al. (2016) Can a flavoured spray (Pill Glide) help children swallow their medicines? A pilot study. *Pediatrics*, 138(6), e20160680.

Kaplan, B.J., et al. (2010) Successful treatment of pill-swallowing difficulties with head posture practice. *Paediatrics & Child Health*, 15(5), e1–5.

Lajoinie, A., et al. (2014) Solid dosage forms availability in children: a cost saving investigation. *British Journal of Clinical Pharmacology*, 78(5), 1080-1089.

Liu, F., et al. (2014) Patient-centred pharmaceutical design to improve acceptability of medicines: similarities and differences in paediatric and geriatric populations. *Drugs*, 74(16), 1871-1889.

Lopez, F.L., et al. (2015) Formulation approaches to pediatric oral drug delivery: benefits and limitations of current platforms. *Expert Opinion on Drug Delivery*, 12(11):1727-1740.

Nordenmalm, S., et al. (2019) Children's views on taking medicines and participating in clinical trials. *Archives of Disease Childhood*, 104(9):900-905.

Nunn, T. and Williams J. (2005) Formulation of medicines for children. *British Journal of Clinical Pharmacology*, 6(59), 674–676.

Patel, A., et al. (2015) Effectiveness of Pediatric Pill Swallowing Interventions: A systematic review. *Pediatrics*, 135 (5), 884-889.

Salunke, S., et al. (2013) The STEP (Safety and Toxicity of Excipients for Paediatrics) database: part 2 - the pilot version. *International Journal of Pharmaceutics*, 457(1), 310-322.

Sam, T., et al. (2012) A benefit/risk approach towards selecting appropriate pharmaceutical dosage forms – an application for paediatric dosage form selection. *International Journal of Pharmaceutics*, 435(2), 115–123.

Stoltenberg, I., Winzenburg, G., Breitkreutz, J. (2010) Solid oral dosage forms for children–formulations, excipients and acceptance issues. *Journal of Applied Therapeutic Research*, 7(4), 41-6.

Tomlin, S. (2015) Medicine doses in children: it's not child's play. *Nursing Prescribing*, 13(7), 352-356.

Tse, Y., et al. (2019) The KidzMed project: teaching children to swallow tablet medication. *Archives of Disease in Childhood*, 0, 1-3.

Venables, R., et al. (2015) Problems with oral formulations prescribed to children: a focus group study of healthcare professionals. *International Journal of Clinical Pharmacy*, 37(6), 1057-1067.

Walsh, J., et al. (2014) Playing hide and seek with poorly tasting paediatric medicines: do not forget the excipients. *Advanced drug delivery reviews*, 73, 14-33.

Winnick, S., et al. (2005) How do you improve compliance? *Pediatrics*, 115(6), e718–724.

Wong, I.C., et al. (2006) Supply problems of unlicensed and off-label medicines after discharge. *Archives of Disease Childhood*, 91(8), 686–688.
World Health Organization (WHO). (2009) Report of the informal expert meeting on dosage forms of medicines for children. Geneva, Switzerland: WHO Headquarters.
Yeung, V.W. and Wong, I.C. (2005) When do children convert from liquid antiretroviral to solid formulations? *Pharm World & Science*, 27(5), 399–402.
Yin, H.S., et al. (2010) Parents' medication administration errors: role of dosing instruments and health literacy. *Archives of Pediatrics & Adolescent Medicine*, 164(2), 181–6.

Appendices

Appendix-Table 1 List of sweets and aids used in the swallowing training sessions

Sweet/description		Aids
Gold balls for cake decoration	Spherical gold ball cake decoration (approx. 0.3 cm)	Everyday cup
Silver balls for cake decoration	Spherical silver ball cake decoration (approx. 0.5 cm)	Water
Popping candy (Cake Angels®)	Spherical multicolour candies (approx. 1.0 cm)	Juice (e.g. squash)
Tic Tac®	Capsule-shaped candies (approx. 0.6 x 1.0 cm)	Soft food (e.g. yoghurt)
Wacky Monkey®	Multicolour capsule-shaped candies (approx. 0.3 x 0.6 cm)	Sports cap bottle
Nerds® candies	Different shapes and sizes; spherical/capsule-shaped candy (approx. 0.3 x 0.7 cm)	Straw
Millions®	Spherical candies (approx. 0.7 cm)	Special pill cup (Pilgo®)*
Jelly Belly beans®	Bean-shaped candies resemble capsule-shape (approx. 1.7 x 0.9 cm)	
Mike & Ike® candy fruits	Capsule-shaped candies (approx. 2.0 x 0.9 cm)	
Sugar-coated chocolate beans	Different shapes; Round/spherical-shaped candies (approx. 0.9 x 0.7 cm)	
Smarties®	Tablet-shaped candies (approx. 0.7 x 1.0 cm)	
M&Ms®	Round tablet-shaped candies, different sizes; mini – to regular (~ 1.04 cm)	

*https://www.dosego.co.uk/pilgo-pill-swallowing-cup.html

Appendix-Table 2 Head positions and aids used during PS training sessions

Variable	Frequency (% out of 30)
Head position:	
Head slightly tilted back	15 (50.0)
Head centred straightforward	14 (46.7)
Head turned to the right	4 (13.3)
head turned to the left	5 (16.7)
Aids*	
(Everyday) cup of plain water	20 (66.7)
Water in sports-cap-bottle	7 (23.3)
(Everyday) cup of Juice (squash)	4 (13.3)
Use of straw	4 (13.3)
Soft food	2 (6.7)

* Frequency of aids doesn't add up to 30 as some children used more than one

Appendix-Table 3 Summary of topic themes and subthemes identified from the focus group with HCPs

Theme	Subtheme
Impact of PS	A whole list of benefits to taking tablets instead of liquid: • Easier to carry • Overcome taste issues of liquid • Preferred formulations • Tablet easier to manage • Overcome large volumes of multiple liquids • Improve medication adherence/compliance • Easier to get prescribed tablet from GP (avoid interface issues around specials) • Increase safety in terms of administration of medicines • Improve quality of life and mental wellbeing of children and their families • Teach a child a life skill
Barriers preventing PS from working	• Child, Parents/carers' perception/resistance, especially those of children with a long-term condition. • Clinic overload for some patients • Time constraints: time pressures in clinics/the timing of conducting PS session • Manpower resources
Recommendations to overcome barriers	• Making PS part of normal admission assessment (normalising that taking pills is normal) • Running a PS educational classroom in outpatient clinics – helps children encouraging and supporting each other • An external person to run the PS session • Provide a list (crib sheet) of sized pills that liquids come in to help HCPs prescribing pills • Use of online material for parents • Interactive PS virtual class (e.g. on Zoom) • Introduce a PS application • Recorded session (e.g. YouTube)

HCP: Healthcare professionals; PS: Pill School; GP: General Practitioner