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Research paper

Putting children first: Understanding caregivers' and children's perspectives on the usability of oral and respiratory administration devices for paediatric medication☆

Elisa Alessandrini [a,*], Jennifer Walsh [b], Esmerald Hermans [c], Smita Salunke [a]

[a] University College London School of Pharmacy, London, UK
[b] Jenny Walsh Consulting Ltd., East Midlands Chamber, 8 Experian Way, ng2 Business Park, Nottingham NG1 1EP, UK
[c] Janssen Pharmaceutica NV, Belgium

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ABSTRACT

A multi-national online survey was developed to obtain feedback on users' experiences of administration devices for oral and inhaled paediatric medicines. The questionnaire was divided into two identical parts: 1) for caregivers looking after children aged 0–18 years, and 2) for children aged 10 years and above, with parental consent. Each part of the questionnaire consisted of a section regarding oral devices and the other about respiratory devices. All data were anonymous and handled and stored in compliance with GDPR. Ethics approval (REC4612-016) was obtained.

The study involved eight countries: Albania, Italy, Israel, the Netherlands, Romania, Spain, UK, and USA. A total of 206 adults and 43 children agreed to take part in the survey. Oral dosage forms were more used than inhaled medicines. For oral liquid medicines, oral syringe was the device mostly used by European and Israeli participants. Measuring spoon was the second most common device used, and was also often used in the USA. For respiratory devices, manually actuated and breath actuated metered dose inhalers were the most common everywhere. All devices were deemed easy to use by most of respondents and instructions clear. However, a recurrent suggestion was to simplify device instructions by adding explanatory images and to summarise or highlight key points. Moreover, respondents proposed other improvements related to device appearance and design that would make the device more acceptable for them to use.

Understanding paediatric patients and caregivers' experiences about oral and respiratory devices is key to provide industry with information that can help improve the use and acceptability of administration devices. Aspects that device suppliers and healthcare professionals would need to prioritise are the provision of simpler instructions in the form of images and key summaries, and to provide adequate training on device use. These improvements are essential to ensure that children and caregivers are able to use the device appropriately.

1. Introduction

The patient acceptability of a medicinal drug product is a well-recognised attribute that should be an integral part of pharmaceutical development, especially when developing medicines for paediatric patients. When designing a paediatric drug product, in addition to considering aspects such as palatability, complexity of preparation, dose and dosing frequency, it is important to consider how the medication will be administered and the need for an administration device [1,2]. Medication errors have been reported to occur as a result of incorrect device use, especially by parents or caregivers in a home setting [3–5]. Hence, the selected device should be easy to use for the intended end-user, with the provision of clear instructions, to reduce the potential risk of mis-dosing.

Understanding administration device users' experiences is an important step towards identifying ways in which erroneous device use may be addressed. A pilot survey was conducted in the United Kingdom (UK) among children and their caregivers to gain an understanding of their views and experiences regarding oral and respiratory devices, and to help determine potential challenges associated with their use [6]. A

☆ On behalf of European Paediatric Formulation Initiative (EuPFI) Devices workstream.

* Corresponding author at: 29-39 Brunswick Square, London WC1N 1AX, UK.
E-mail address: elisa.alessandrini@ucl.ac.uk (E. Alessandrini).

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secondary aim of the pilot study was to inform the design and execution of wider studies in paediatric patients and their caregivers.

Building on feedback and learnings from the United Kingdom (UK) pilot study, the aim of this study was to conduct a wider survey in paediatric patients and their caregivers in Europe, Israel and the United States of America (USA), regarding their use of, and experiences with oral and respiratory medicine administration devices.

2. Methods

2.1. Study design

An online cross-sectional survey was conducted. The study received approval from the University College London Research Ethics Committee, Approval No. 11675/002.

2.2. Participants and setting

Parents/guardians/carers completed the survey on behalf of children/young people aged from birth to 18 years. They were considered eligible to participate in the survey if they: (a) were aged more than 18 years old; b) had at least one child aged under 18 years. Children and young people were considered eligible to participate if they were aged between 10 years and 18 years. This online study used targeted email advertising as the primary recruitment strategy, in addition to advertising the study on relevant online platforms and social media and through EPTRI (European Paediatric Translational Research Infrastructure) and iCAN (International Children's Advisory Network) between November 2020 and July 2021.

2.3. Sample size

Although a sample size of approximately 100 has been used in previous survey studies [7], since this survey was to be shared with participants across several countries, it was aimed to gather as many responses as possible (parents/caregivers and children) to enable the analysis and comparison of responses according to geographical location. In addition, it was hoped to be able to compare responses according to the age of the child and also between caregivers and children themselves. The proposed sample included 100 parents/ carers and children together. It was aimed to reach a range of 100 – 1000 participants to acquire 100 responses, assuming only 10 % of participants completed the survey.

2.4. Questionnaire development and pre-testing

The questionnaire was developed using a computerised questionnaire software (Qualtrics, Provo, UT, version 2022) in order to address the aims of the study and was focused on oral (by mouth) and respiratory devices (e.g., spoons and inhalers respectively), as these are commonly used by children. The survey was divided into two parts (part one and part two) and each part in three sections, and it is available as supplementary data (S1). Part one of the survey was aimed at parents/caregivers, whilst children aged 10 years and above were given the opportunity to answer questions themselves in the second part, after completion of part one by their caregivers and if parental consent had been given. For children under 10 years, caregivers completed part one of the survey only.

Part one and part two were further divided into three sections. The first section captured general demographic information of the participant (such as age, country and type of medicine). Section two was focused on oral (by mouth) administration devices (e.g., spoons, oral syringes) and section three was focused on pulmonary (inhaled) devices (e.g. inhalers). Participants were only required to complete the section (s) that was relevant to them, depending on the medication they or their child had recently taken or were currently taking. The questions focused on the type of devices used by parents or children, opinions on their ease of use and difficulties encountered, together with opinions on how the devices and their instructions for use may be improved. A variety of question types were included: list - where the respondent was offered a list of items and could select more than one item, and category - where only one response could be selected. In addition, some open questions were included to allow respondents to add their comments. Forced response validation was adopted for key questions: participants were required to answer the key questions before submitting each question of the survey to reduce missing data. The questions were assessed by the European Paediatric Formulation Initiative (EuPFI) devices workstream members who are experienced with device human factors studies. The definitive list of questions used in the survey was the result of an unanimous agreement reached by the EuPFI devices workstream members on the accuracy of content, words, and structure of sentences. In addition, the questionnaire and information pages and consent/ assent forms were reviewed by three European Young Person's Advisory Groups (YPAG) through EPTRI (https://www.cvbf.net/eptri/), KIDS1 Barcelona, KIDS Bari, and KIDS Albania. The KIDS groups provided feedback on the questions and layout of the survey. Moreover, the feedback received from the UK pilot study (REC4612-016) was considered [6] and questions were revised accordingly using language that is appropriate and understandable for child participants. The survey was designed to be completed in an average time of 15—20 min to improve the response rate.

2.5. Survey procedure

This multinational, cross-sectional survey was conducted in 6 European countries: Albania, Italy, Romania, the Netherlands, Spain, and the United Kingdom; and in two non-European countries: United States of America, and Israel. The survey was translated from English into the native languages of the non-English speaking countries. The survey was administered between November 2020 and July 2021. This survey was predominantly conducted using an electronic self-administered questionnaire as this appeared to be the most feasible approach for reaching the wide and geographically disperse target audience for the study. Information about the survey and an online survey link were circulated through advisory groups such as YPAGs and the International Children's Advisory Network (iCAN) via their websites, newsletters, and events. In addition, the survey was shared via email to professional and personal contacts and various social media sites. The advertisement and information sheet explained the purpose of the study. Information about the purpose of the study was also available on the first page of the survey. Participation in the study was voluntary and no incentives were offered. As for the UK pilot survey [6], all the participants were asked to read the participant information sheet and provide consent prior to participation in the survey to confirm their agreement to participate in this research study. Access was only provided to those who gave consent. Children aged 10 years and above were given the opportunity to complete the survey themselves if appropriate consent from the responsible adult was obtained. All consent and assent forms were embedded in the survey. The participants were asked to give their age before any answers to the survey questions were requested. If the age was given as over 18, the participant was directed to the parent/carer survey questions. However, if the age given was less than 18, then the child was excluded from giving further information until the appropriate consent from the responsible adult was obtained. Participants were provided with the option to leave the survey at any time if they did not feel comfortable in answering the questions.

2.6. Data analysis

Questionnaires containing coarse errors were excluded from the analysis. The data analysis was performed independently for each individual question, thus questionnaires partially completed, where the

participants had skipped one or more questions, were included.

Descriptive statistics such as frequency of distribution and central tendency (the mode) were used to analyse the data. The statistical analysis was performed using Microsoft Excel, figures were produced in Flourish Studio (Canva UK Operations Ltd).

3. Results

3.1. Demographics

The survey was conducted in 6 European countries: Albania, Italy, Romania, the Netherlands, Spain, and the UK; and in two non-European countries: USA, and Israel.

As mentioned previously, since some participants did not provide responses to all the questions, the analysis was performed per question and the results are reported accordingly.

A total of 374 adults and 43 children accessed the survey, of which, 206 adults and 43 children agreed to take part, Table 1. In the second part of the survey, only children and adolescents that were aged 10 to 18 years were allowed to participate. These children accounted for 58 % of the paediatric population in the study. The remaining 42% of the children were younger than 10 years, 5% of whom were younger than 12 months, 4 % were 12 to 23 months old, 13 % were 2 to 5 years old and 20 % were 6 to 9 years old, Fig. 1. The number of children per age-group in each country is shown in Figure S1.

Most adults taking the survey were parents (52%, n = 108/206), some were other relatives such as siblings, aunt, or uncle (7%, n = 15/206), or grandparents (2%, n = 3/206), a few were guardians (1%, n = 2/206). Others had no direct relationship with the child (9%, n = 18/206), and these included nurses or other professionals. However, almost a third of participants (29%, n = 60/206) did not answer this question.

3.2. Type of medicine used

When asked about what type of medicine the child recently took, almost half of the caregivers (n = 96/201) stated that their child had not taken any medicine recently, i.e., neither oral nor inhaled. Thus, for these participants the survey was automatically terminated. Among those who recently gave a medicine to the child in their care, 65 % (n = 68/105) administered an oral medicine, 12 % (n = 13/105) an inhaled medicine, and 23 % (n = 24/105) both an oral and an inhaled medicine. As regards to children, 4 of them stated that they did not take any medicine recently, and so the survey was terminated for them. Of the remaining 38 paediatric participants, 66 % (n = 25/38) indicated they had used oral medicines, 18 % (n = 7/38) an inhaled medicine, and 16 % (n = 6/38) both oral and inhaled medicines, Fig. 2.

3.3. Oral dosage forms and administration devices

Among the 92 caregivers who had administered an oral medicine to their child, 85% (n = 78/92) specified the type of oral dosage form used, whilst 87% (n = 27/31) of the children indicated the type of oral dosage form they had taken.

The most commonly taken oral dosage form in all the countries except for the Netherlands and the USA emerged to be liquid dosage forms such as a syrup, suspension, or drops; these were selected by 58% (n = 45/78) of adult participants. In contrast, in the USA solid dosage forms, i.e., tablets, were frequently taken. Overall, tablets were selected by 36% (n = 28/78) of participants, capsules by 2% (n = 2/78) of participants, and granules by 2% (n = 2/78) of participants. Results from the children's part of the survey showed a similar number of children taking liquid (48%, n = 13/27) and solid medicines (52%, n = 14/27). Fig. 3 shows the type of oral doage forms used by the caregiver-child pair in each country.

The evaluation of responses from the adult part of the survey (n = 69) according to country and age-group showed the following results.

In Albania, liquid formulations such as syrups and suspensions (77%, n = 10/13), were largely used by the entire paediatric population. Tablets were used in the 2–5 years, 6–9 years and 10–18 years age groups but less frequently (23%, n = 3/13) than liquid medicines.

In Spain, data for children in the youngest age groups (i.e., less than 12 months and 12–23 months) were not available. However, in the remaining age groups, a variety of liquid medicines were used. Liquid dosage forms (58%, n = 7/12) were used more than solid medicines such as tablets (25%, n = 3/12), a trend also seen in the responses from the 10–18 years old group.

In Romania, the only age-groups represented were the 6–9 years and the 10–18 years age groups. In analogy with the previous two countries, liquid formulations were predominantly used (70%, n = 7/10), compared to solid dosage forms, i.e., tablets (30%, n = 3/10).

Liquid medicines were also largely used in Italy (75%, n = 9/12). Drops were selected in both the 2–5 years and the 6–9 years age-groups (4/12). The use of solid dosage forms was reported only in the 10–18 years age-group, and these were tablets (8%, n = 1/12) and granules (8%, n = 1/12).

In the UK, liquid formulations emerged to be used more than solid dosage forms in the youngest age groups, i.e., 12–23 months and in the 6–9 years old groups (75%, n = 3/4), whilst tablets were used more than liquids (67%, n = 4/6) in the 10–18 years old group.

In the Netherlands, data was available only for the age-group 10–18 years, where the use of capsules was reported (n = 1/1). In Israel, liquid dosage forms (drops) were used in the youngest age-groups; less than 12 months, and 2–5 years (67%, n = 2/3), and tablets were used in the 10–18 years group (33%, n = 1/3), data from the 6–9 years age-group were not available.

Finally, in the USA only responses for the 6–9- and 10–18 years old groups were represented, and they tended to use solid dosage forms, (i.e., tablets), much more than liquid dosage forms (75%, n = 6/8).

Oral medicines were usually taken for short periods of time, such as less than a week or for 1 to 2 weeks (55%, n = 42/77). Nonetheless, some participants indicated to have used oral medicines for more than three weeks (14%, n = 11/77) and some (13%, n = 10/77) participants for over a year. Finally, 14/77 (18%) participants did not know. The frequency of medication use varied from once a day up to three times a day, with a few having to take/administer oral medicines four times a day.

When asked about which device they used to administer the medicine to the child in their care, a total of 72 answers were provided by the

Table 1
Number of adults and children 10 years or older who accessed the survey.

	Albania	Spain	Romania	Italy	United Kingdom	Netherlands	Israel	United States	Total
Adult participants									
Accessing survey	76	53	30	78	54	19	20	44	374
Agreeing to take part	54	27	22	32	21	5	9	36	206
Participation rate	71%	51%	73%	41%	39%	26%	45%	82%	55%
Paediatric participants*									
Parents' consent	3	5	6	6	5	1	5	16	47
Child's assent	3	5	6	5	4	1	5	14	43

*This includes children 10 years or older only.

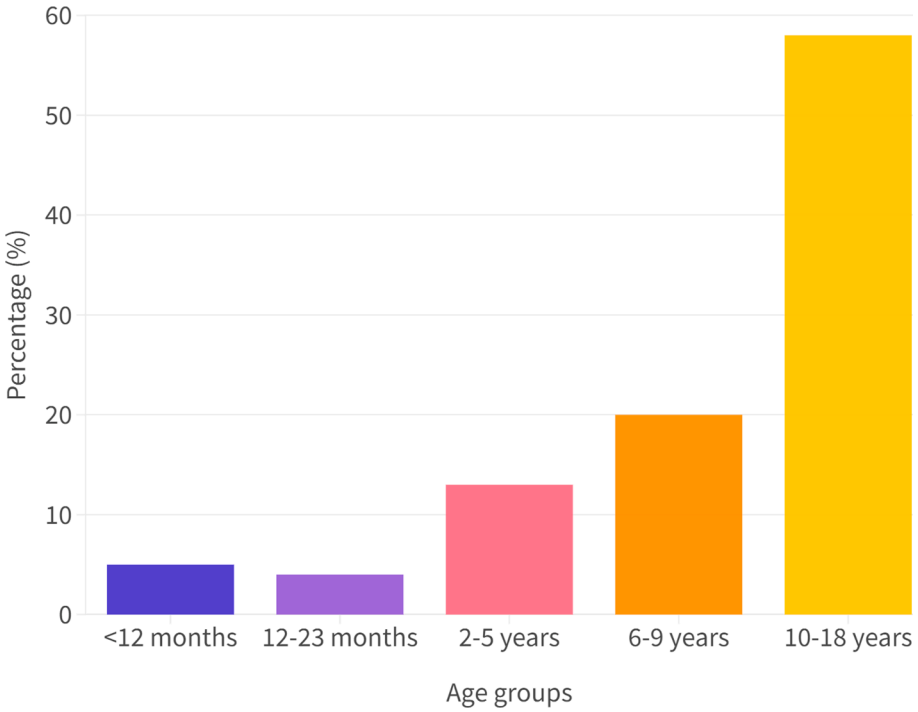

Fig. 1. Percentage of children per each age-group..

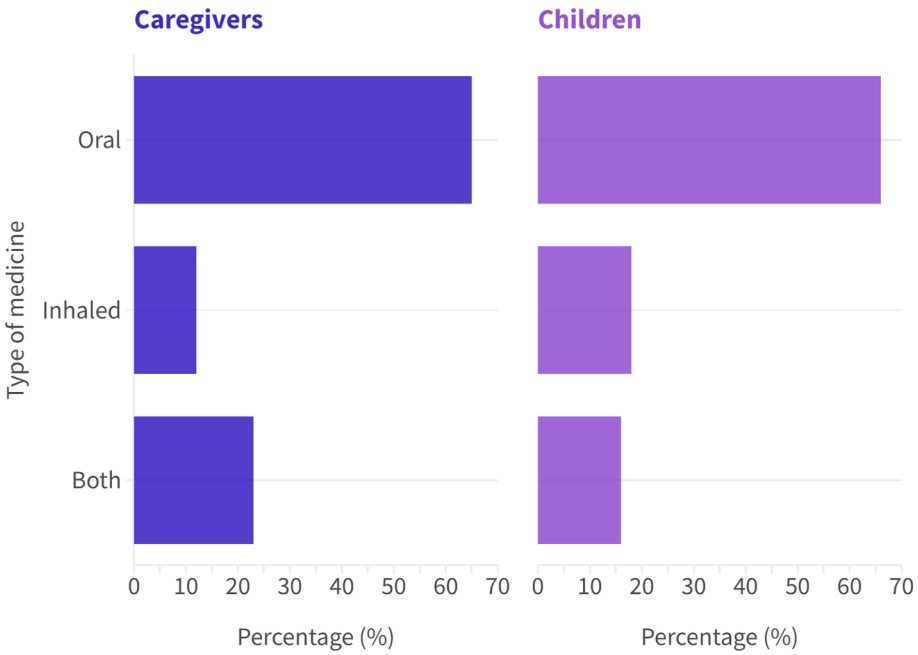

Fig. 2. Type of medicine administered to / used by the children according to caregivers and children respectively.

caregivers. Overall, the device selected most often to administer liquid medicines appeared to be the oral syringe, followed by measuring spoon, household spoon, measuring cup, and dropper. It should be noted that the measuring cup was also used for solid dosage forms. Devices used varied among the countries (Fig. 4) and age-groups (Fig. 5), and the evaluation of data from the adult part of the survey (n = 67) by country and age-group showed the following results. In Albania, a measuring spoon was used in various age groups (less than 12 months (8%, n = 1/13), 2–5 years (15%, n = 2/13), 6–9 years (8%, n = 1/13), and 10–18 years (15%, n = 2/13)), an oral syringe was reported to be used in the 6–9 years age-group (23%, n = 3/13), as was a household spoon (8%, n = 1/13). In the age group 2–5 years, measuring cup (8%, n = 1/13) and dropper (8%, n = 1/13) were selected, although no drops were reported to being used among Albanian participants; there was one participant who selected other, but no explanation was given. In Spain, the oral syringe emerged to be the device most often used to administer liquid medicines in the age-groups reported (49%, n = 6/12). In the 10–18 years group, measuring spoon was also used (17%, n = 2/12), one person selected other, reporting to have used a balance. Participants from Romania reported to have used a variety of administration devices with their liquid medicines, including measuring spoons (30%, n = 3/10), oral syringes (20%, n = 2/10), droppers (10%, n = 1/10), and

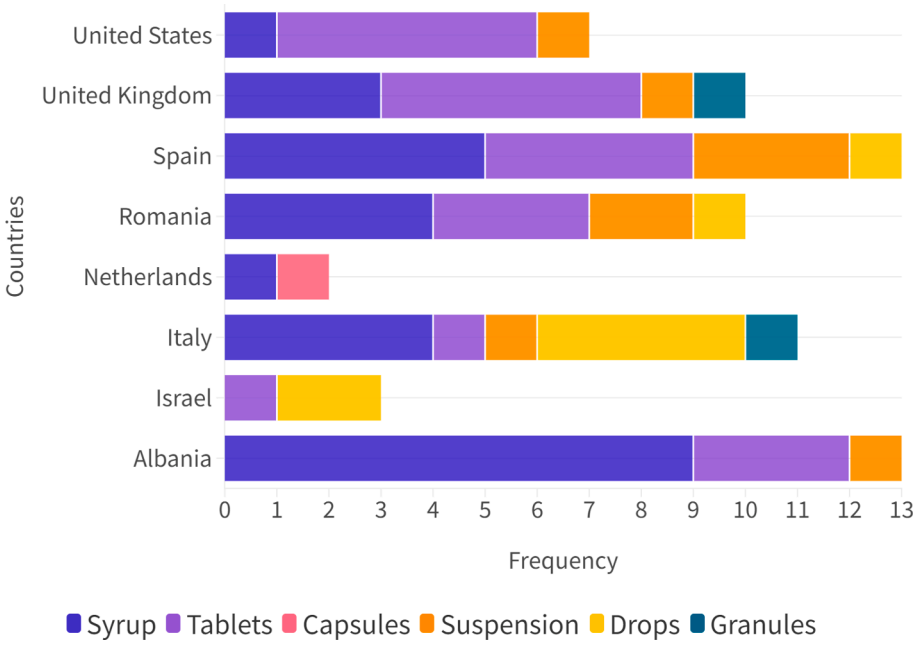

Fig. 3. Type of oral dosage forms used by the caregiver-child pairs in each country.

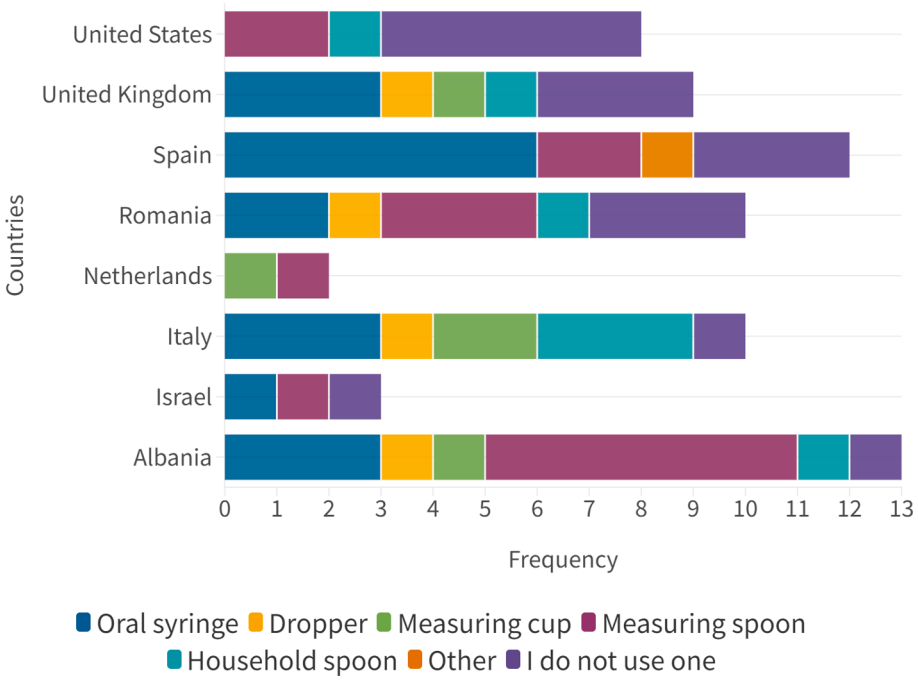

Fig. 4. Type of oral administration device used in each country according to each caregiver-child pair.

household spoons (10%, n = 1/10). In Italy, droppers were used to administer drops (10%, n = 1/10); however, oral syringes (30%, n = 3/10) and household spoons (30%, n = 3/10) were frequently used. Measuring cups were only reported to be used by the 10–18-year-old group (20%, n = 2/10). On the contrary, in the UK, measuring cups emerged to be used in both young (12–23 months) and old age groups (10–18 years) (20%, n = 2/10). Oral syringes were widely used as well (30%, n = 3/10), and one participant indicated the use of a dropper, despite drops were not being selected among the dosage forms of this country. One participant indicated the use of a household spoon. In the Netherlands, a measuring cup was used to administer capsules. In Israel, the oral syringe was the device selected for use in the less than 12 months group (33%, n = 1/3), and household spoon was the device used in the 2–5 years group (33%, n = 1/3). Lastly, in the USA, devices used to administer liquid dosage forms were measuring spoons only (25%, n = 2/8).

All participants who had taken tablets declared to not have used any administration device (n = 21/72).

Responses from the children's part of the survey were broadly consistent with the results above except for the use of the household spoon that appeared to be used in different countries from those indicated in the adult part (UK and USA). Moreover, two children selected that they were using other devices than those listed in the survey, and one specified the use of a balance (child was using liquid and tablets).

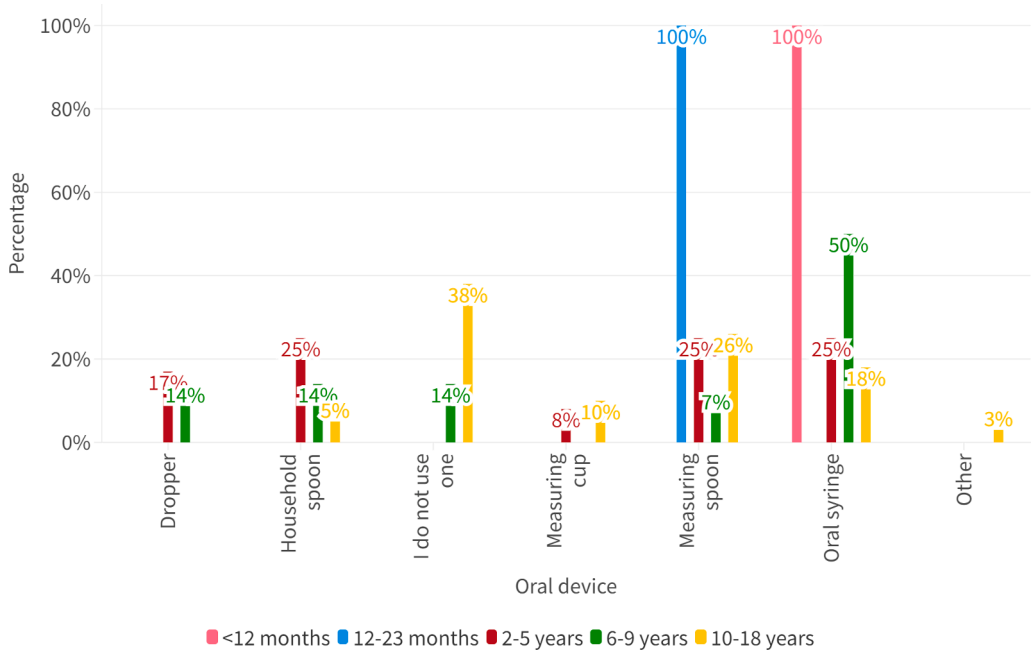

Fig. 5. Percentage of children using each oral device divided by age groups.

When asked about device ease of use, the majority of adults and children in all countries stated that the device was easy to use, Fig. 6 (mode of the dataset = easy; 79%, n = 45/57 adults and 63%, n = 10/16 children). In contrast, 16% (n = 9/57) of adults and 25% (n = 4/16) of children found the device neither easy nor difficult to use, and 5% (n = 3/57) of adults (one in Spain, one in the UK, and one in the Netherlands) and 13% (n = 2/16) of children (one in Romania and one in the UK) thought the device was difficult to use. A similar level of usability emerged among the various devices, although the oral syringe emerged to be slightly more difficult to use compared to the other devices.

Instructions on how to use the device correctly were provided to 55% of caregivers (n = 31/56) and 50% of the children (n = 8/16), whilst 39% of caregivers (n = 22/56) and 25% of the children (n = 4/16) stated they had not received any instruction, and 5% of caregivers (n = 3/56), and 25% of the children (n = 4/16) did not know. In Romania, Italy, the Netherlands, and Israel, there were more adult participants that did not receive any instruction than those receiving them. However, for the children, only in the UK was the number of children not receiving instructions higher than those receiving them, whilst in the USA the number of children not receiving instructions equalled those who received some.

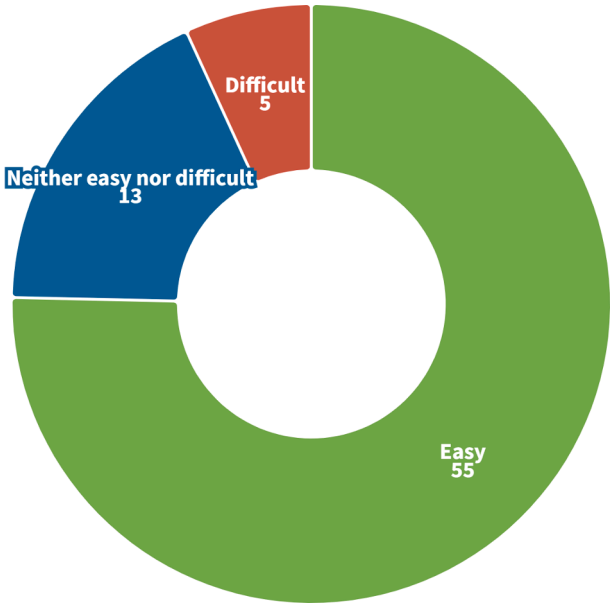

Fig. 6. Ease of oral device use according to caregivers and children (N = 73).

Instructions provided to the caregivers were usually those found in the patient information leaflet (PIL) or on the label (44%, n = 17/39) or given by a pharmacist (26%, n = 10/39), a doctor (20%, n = 8/39) or a nurse (10%, n = 4/39). On the other hand, children usually received instructions from their parents (59%, n = 7/12) and less frequently from a doctor (17%, n = 2/12), a nurse (8%, n = 1/12) (in Italy), a pharmacist (8%, n = 1/12) (in Albania), or by reading the Patient Information Leaflet (PIL)/label (8%, n = 1/12), Fig. 7. In the caregivers' part of the survey no responses were collected from the Dutch participants, whilst no responses were collected by participants of the UK, the Netherlands, or Israel in the children's part of the survey.

In all countries, instructions provided were deemed to be clear by most of the caregivers (93%, n = 28/30) except for the Netherlands where answers were missing for this question. Two adults found instructions not clear; one participant was from Spain and the other from the UK. All the children (100%, n = 9/9) thought instructions given were clear, although no answers were provided by children from the Netherlands, Israel, and the USA.

Finally, an open question allowed participants to provide their suggestions about what suppliers could do to make oral administration devices more user-friendly and/or fit-for-purpose. Several ideas were provided by caregivers and children. All the suggestions were classified into three themes: i) improvement of device instructions, ii) suggestions about device appearance/design, and iii) proposal of alternative devices, Table 2.

3.4. Inhaled medicines and administration devices

The number of children in the survey who were reported to be using inhaled medicines was smaller than those using oral dosage forms. A total of 37 caregivers and 13 children had administered or used an inhaled medicine recently. However, only 26 adults and 6 children answered the question about the type of inhaler device used. The

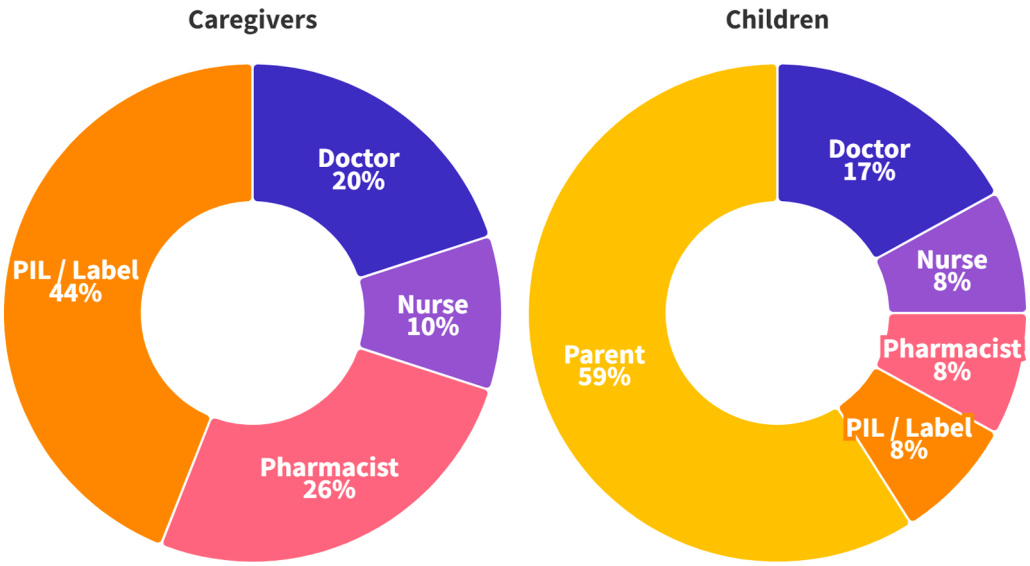

Fig. 7. Instruction providers that gave instructions on how to use an oral device to the caregivers and the children.

Table 2
Suggestions provided by caregivers and children about how to improve oral administration devices.

Themes of suggestions	Suggestions provided by caregivers and children
Device instructions	To add illustrations, use "visual instructions" or add "explanatory drawings, as the visual is always the simplest and easiest" way to understand
	Make instructions more summarised or add a summary
	To "highlight key parts of the instructions"
	To "make the font size bigger"
	To add instructions directly on the bottle of medicine
Device appearance/ design	To "use attractive shapes and colours" when designing oral devices for children
	"Insert a measuring device in the box of the medicine"
For droppers	To "change the design of the drip system"
For measuring spoons	Make soft spoon suitable for babies
	Add graduation lines for volume on the measuring spoon
For oral syringes	Possibility to withdraw all liquid in the bottle
	"Use rubber piston instead of plastic"
	"Make graduation units more visible, e.g. in different colours or colour band rather than transparent as they are difficult to see"
	Make them "easier to wash"
	Make them "easier to push"
Alternative devices	"Create a device that gives dose per day only with locking system"

manually actuated metered dose inhaler (MDI) with or without spacer was the device used the most (caregivers 50%, n = 13/26, children 33%, n = 2/6), followed by the breath-actuated MDI (caregivers 27%, n = 7/26, children 33%, n = 2/6). These devices were used heterogeneously across the countries. Nebulisers with and without facemask were used less frequently (caregivers 15%, n = 4/26, children 17%, n = 1/6), and similarly, mist inhalers (caregivers 4%, n = 1/26, children 17%, n = 1/6) and dry-powder inhalers (caregivers 4%, n = 1/26, children 0%, n = 0/6), were used less often, Fig. 8. In the paediatric part of the survey, no responses were collected from participants of Albania, Spain, UK, and Israel.

Inhaled medicines were used for different treatment durations and frequencies, although most respondents did not know these details.

When asked about the ease of device use, half of the adult respondents (n = 10/20) stated that the device was easy to use, 30 % (n = 6/20) declared it was neither easy nor difficult, and 20 % (n = 4/20) reported that it was difficult to use, Fig. 9. No responses were recorded from the UK respondents. Half of the paediatric participants found the device easy to use (n = 3/6) and the other half neither easy nor difficult (n = 3/6). However, participants from Albania, Spain, and Israel did not provide any response.

The devices that emerged to be the easiest to use were the manually-actuated and the breath-actuated MDI. However, the addition of a spacer seemed to complicate their use. Nebulisers appeared more difficult to use than MDIs, however the use of a facemask seemed to make their use easier, information for the other devices was not available.

Instructions on correct device use were usually provided to the caregivers (70%, n = 14/20), with two adults stating to have not received instructions (10%, n = 2/20) and some did not know (20%, n = 4/20). No responses were recorded from participants from the UK. Among the children, 33% (n = 2/6) received instructions on correct device use, 50% (n = 3/6) did not receive any instruction, and 17% (n = 1/6) did not know. No responses were provided by participants from Albania, Spain, UK, and Israel.

When instructions were provided, these were usually given by a doctor (caregivers 40%, n = 6/15, children 33%, n = 1/3), a nurse (caregivers 27%, n = 4/15), or a pharmacist (caregivers 20%, n = 3/15). Less frequently participants referred to instructions provided on the label or PIL (caregivers 13%, n = 2/15). No responses were recorded by participants from Albania and the UK. Children usually received instructions from their parents (67%, n = 2/3), Fig. 10. However, these responses were collected only by participants from Romania and the USA.

Instructions provided were deemed clear by the children answering this question (n = 2/2), they were from Romania and the USA. Also, most adults (n = 10/11) found instructions clear, except for one Spanish participant who thought instructions provided were not clear. Responses were missing from participants from the UK and Albania.

Suggestions provided by participants about what suppliers could do to make respiratory devices more user-friendly and/or fit-for-purpose were classified into three themes: i) improvement of device instructions, ii) suggestions about device appearance/design, and iii) proposal of alternative devices, Table 3. Suggestions were provided by the caregivers only, whereas children did not provide any suggestions.

4. Discussion

The results from this survey provide insights about children's and caregivers' experiences with oral and respiratory administration devices across various European and non-European countries. The findings

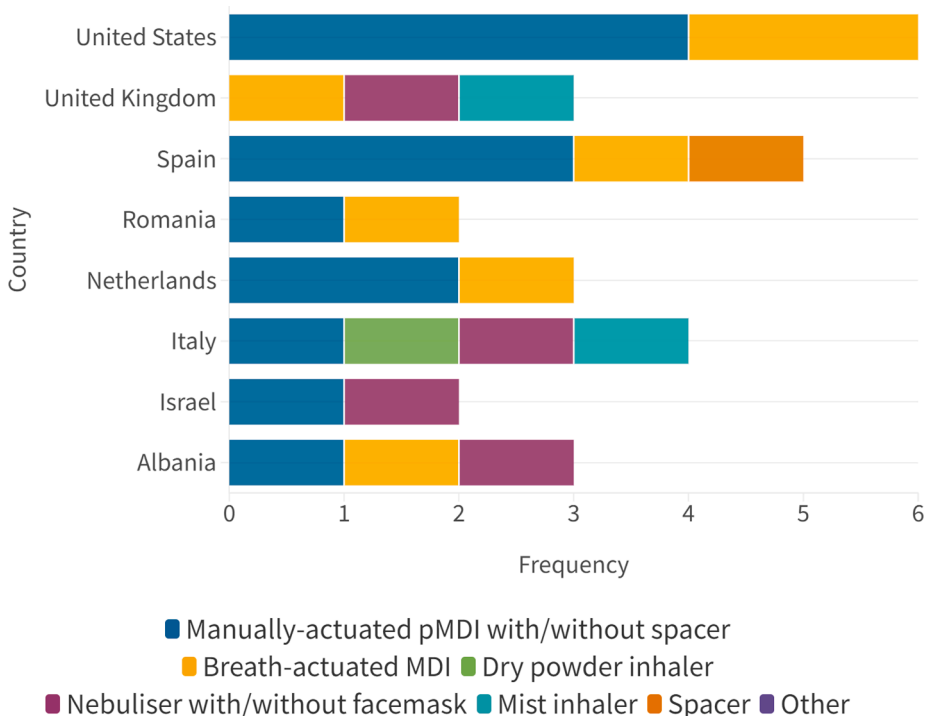

Fig. 8. Type of inhaled administration devices used in each country according to each caregiver-child pair.

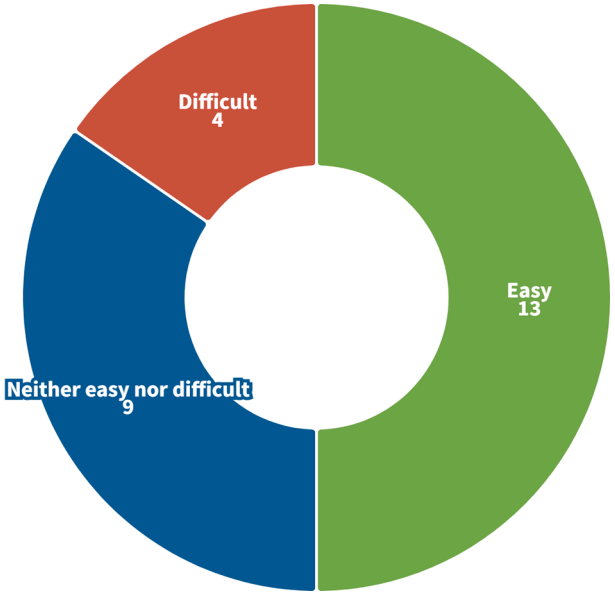

Fig. 9. Ease of inhaled device use according to caregivers and children (N = 26).

indicate that different perspectives emerge at the country level, and insights also differ depending on the surveyed person's own experience with the device used.

This study follows a smaller paper-based survey conducted in the UK [6] that was aimed at piloting the design and execution of this international survey.

As expected, results showed that overall oral medicines are used much more than inhaled medicines in the paediatric population. In fact, the oral route is extensively used for administering medicines treating minor conditions as well as chronic diseases. Whereas inhaled medicines are generally prescribed to children suffering from airways diseases, a smaller proportion of the entire population.

Among the oral dosage forms, liquid medicines were widely used across all age-groups and countries, except for the USA, where solid dosage forms were predominant. This wide use of solid dosage forms in the USA can partly be explained by the fact that this country had a large proportion of children aged 10–18 years completing the survey (77%). However, a similar fraction of children of the same age group was registered in other countries such as Spain (77%), where instead liquid dosage forms were preferred. This suggests that the age of the child is not the only component affecting the use of a dosage form.

Overall, similar trends were observed across various countries in terms of dosage forms used. Albania, Spain, Romania, and Italy predominantly used liquid dosage forms across all paediatric age groups. The USA seemed to use solid oral dosage forms, whereas in the UK and Israel oral liquid dosage forms appeared to be used in young children, and solid oral dosage forms in older children (6–9 years and 10–18 years). Data from the Netherlands were insufficient to draw any conclusions. These variations in dosage form use across countries are known to be related to market availability as well as different cultural preferences of healthcare professionals, caregivers, or end-users [8]. For instance, a similar study performed in India reported the preference for liquid medicines in both younger and older children [9] showing analogy with our results from some of the European countries. Whereas a study in Japan reported that solid dosage forms such as powders are the dosage forms mostly prescribed to children of all ages [10].

The most common liquid formulations used were syrup and suspensions, whereas drops appeared to be used in Italy and Israel only. Among solid dosage forms, tablets emerged to be the most common. Tablets were used most frequently by older children and adolescents (10–18 years) compared to all the other age groups, which is not unexpected since tablets are generally considered to be acceptable for this age group, and may be preferred by them over other oral dosage forms [11–13]. In particular, the 10–18-year-old groups of UK, USA, and Israel tended to use more tablets than liquid medicines compared to participants of the other European countries [3].

To administer liquid medicines, various administration devices were used. Although a variation in device use was observed across the countries, some trends could be drawn from these results.

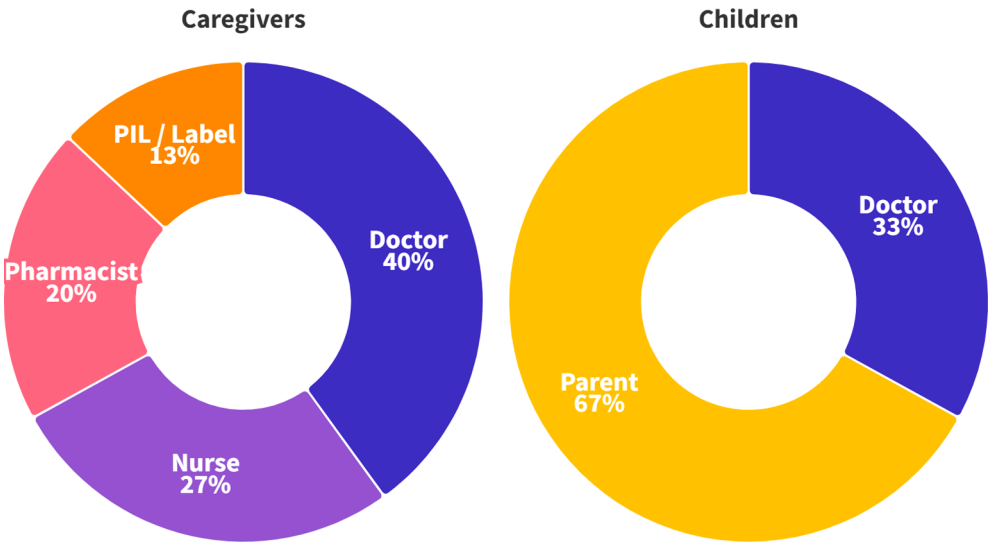

Fig. 10. Instruction providers that gave instructions about inhaled device use to the caregivers and the children.

Table 3
Suggestions provided by caregivers about how to improve inhaled devices.

Themes of suggestions	Suggestions provided by caregivers
Device instructions	"Use images to explain how the device works" "Clearly describe the dose based on the age of the child and the severity of the disease" To add instructions on the side of the inhaler "Give specific instructions on how to operate a breath-actuated inhaler"
Device appearance/ design	[The device] "could have a better mechanism to prevent it from accidentally blowing out puffs of medicine"
Alternative devices	"Invent an adjustable steam pipe that also stays in place".

The oral syringe appeared to be the device most frequently used overall. Its use was recorded everywhere except in the Netherlands and in the USA. Oral syringes are considered the measuring device providing the highest dosing accuracy and uniformity [14,15], hence its widespread use. Despite being considered suitable for the administration of medicines to younger children [16], our results and similarly results from the pilot study [6] have proved that this device is largely used also in school-age children and adolescents between 6 and 18 years in many countries.

Two studies from Japan and India respectively, showed that oral syringes are used infrequently to administer liquid medicines in favour of other devices such as measuring cups or household spoons [17,18]. Interestingly, our results showed that in the USA oral syringes were not commonly used to administer liquid medicines. This shows that there appears to be different trends across worldwide countries in terms of oral devices dispensed or supplied with medication.

Instead of oral syringes, in the USA, measuring spoons appeared to be frequently used for the administration of liquid medicines. It has been reported that if calibrated, measuring spoons can provide accurate dosing, although a small variance in dosing is only reached with an oral syringe [16,19]. Measuring spoons were also used in Albania, in Romania, and in Spain, whilst they were not commonly used in Italy, UK, and Israel.

On the other hand, measuring cups were reported to be used in Italy and the UK. This device is known to be less accurate than oral syringes and measuring spoons to administer liquid medicines, and may thus be more prone to dosing errors [16,20,21]. Interestingly, in the Netherlands a measuring cup was used to administer capsules. Overall, swallowing aids such as "pill swallowing cups" [14] were not used for the administration of tablets, as all participants taking this dosage form declared to not have used any device.

Droppers were not frequently used and similarly to measuring cups, these devices do not provide good dosing accuracy [22]. Droppers were used in Italy and Romania, however, their use was also reported in countries that did not indicate the use of drops such as the UK and Albania. Conversely, Spain and Israel that had both indicated the use of drops, did not report using droppers. We can assume that other administration devices, such as a household spoon, were used instead to give this dosage form to the children.

Despite being associated with increased risks of dosing inaccuracies [23], household spoons seem to still be widely used for administering liquid medicines to the children. In our study, their use was reported in 5 out of the 8 countries (Albania, Romania, Italy, UK and Israel). Their widespread use has been reported also in India [8] and Japan [18], although in Japan they are usually used to administer pre-defined quantities of powders from sachets [9]. It is important that healthcare professionals discourage end-users to use households spoons for administering medicines to their children, in favour of an appropriate device. This highlights the importance to supply the administration device with the medicine or to make sure that a healthcare professional provides the correct device to the patient [8,12,13].

As regards respiratory devices, manually actuated MDIs with and without spacer were the most used, followed by the breath-actuated MDIs. The manually actuated MDIs are considered adequate for the whole paediatric population, used with a spacer in young children and thus frequently prescribed by doctors [16]. These devices were used in all countries except for the Netherlands. As for the breath-actuated MDI, this appeared to be used in all the countries except for Israel. Breath-actuated devices are considered suitable for children 5 years and older, and their mechanism is aimed at overcoming the difficulties with coordination of inhaler actuation and inspiration [24]. The use of nebulisers was also, frequently reported, being used in Italy, Albania, Israel and the Netherlands. Nebulisers are one of the oldest types of devices. They can be useful for the management of children unable to use an inhaler with a spacer or those with coordination problems [24]. Mist inhalers were less commonly used, their use was reported in two countries only, Italy and the Netherlands. Similarly a dry-powder inhaler was used in Italy only. Dry powder inhalers (DPI) require the user to generate a sufficient airflow to being effectively used. Thus, they are deemed suitable for children aged 5 years and older [25].

Nebulisers and manually / breath actuated MDIs were also the devices most commonly used in India [9], suggesting similar global trends

in inhaled devices use in the paediatric population. This is further corroborated by findings from the HCP survey that indicated MDIs are the respiratory devices most frequently supplied, whereas DPIs the least frequently supplied by healthcare professionals [16].

When asked about the usability of administration devices, both oral and inhaled devices were deemed easy to use by the majority of participants, with only 5% of adults and 10% of children declaring oral devices difficult to use and a 20% of caregivers and none of the children declaring inhaled devices difficult to use, although data were not available for all the countries. For oral devices, a similar level of usability emerged among the various devices, although the oral syringe seemed to be slightly more difficult to use compared to the other devices. Patients' difficulties in identifying and/or measuring the correct dose with oral syringes has been reported previously [16]. As for the respiratory devices, the manually-actuated and the breath-actuated MDIs emerged to be easier to use than the nebulisers, however the use of a facemask seemed to make the use of the nebuliser easier.

From our findings, it emerged that instructions on how to operate the device were not always provided to participants. For oral devices, several adult participants from Italy, Israel, the Netherlands, and Romania and some children from the UK and the USA declared to not have received instructions.

When provided, device instructions for both oral and inhaled devices were deemed clear by study participants.

It is not possible to ascertain from results of our survey whether this apparent ease of device use and clarity of instructions corresponded to correct device use. Although end users may believe they are using a device correctly, this may not always be the case. Several studies have demonstrated the importance of adequate training and repeated follow-up checks to make sure the correct technique is adopted and to minimise errors [26–30]. These findings should raise awareness among healthcare professionals of the importance to provide comprehensive instructions on device use when dispensing the medicine to their patients to make sure the device is used correctly, even for devices deemed easy to use.

The percentage of adults receiving instructions on how to use an administration device was slightly higher for the inhaled devices compared to the oral devices, however, 50% of the paediatric respondents declared to not have received them. This difference between oral and inhaled devices may be because oral devices are considered easier to use than respiratory devices, and thus many healthcare professionals deem unnecessary to instruct end users on their use [16]. In our study, many caregivers using oral devices stated to have learned how to use a device by reading the PIL/leaflet rather than being shown by a healthcare professional. In contrast, for inhaled devices, instructions from the PIL only accounted for 13% of the total, with most of the participants being instructed by a healthhare professional such as a doctor, nurse, or pharmacist.

As for the children, they were usually instructed by their parents rather than a healthcare professional for the use of both oral and inhaled devices. Only one child, using an oral medicine, declared to have used a PIL.

Since caregivers are frequently those explaining to the child in their care how to use an administration device, it is vital that they receive adequate support for being able to train their children on correct device use. This also suggests the importance to make leaflets / PIL more accessible to children.

The need to simplify device instructions was a recurrent theme highlighted in the comments left by respondents when asked about how to improve device use. This simplification can consist of the addition of images or pictograms to the leaflet visually explaining how to use the device as suggested by some participants: "use visual instructions", "[add] explanatory drawings, as the visual is always the simplest and easiest [way to understand]". Previous studies have demonstrated the effectiveness of using pictograms to minimise medication administration errors [4,31]. Furthermore, although not suggested by participants, the creation of animated cartoons or videos showing how to use an administration device could be another good solution that manufacturers or healthcare professionals should implement for improving understanding of device instructions. Another suggestion provided by participants was to "make instructions more summarised or add a summary" of the main steps of the instructions, or to make the key parts of the instructions more visible, for example by "highlighting key parts". Furthermore, it appears that adding "instructions directly on the bottle of the medicine" or "on the side of the inhaler" could be useful to the end-users. These additions could increase the readability, understanding, and compliance with device instructions also of those with a poor health literacy as well as of children.

It has been reported that the level of health literacy can affect the ability of a patient to use the device correctly [5,28]. This aspect was not enquired in our study but it should be considered when prescribing or supplying an administration device. The ability to use a device appropriately is key to maximise therapeutic benefit and prevent administration errors [16]. Thus, appropriate patient training by a healthcare professional on device use and a simplification of instructions are the two most important aspects that would need to be prioritised to make sure administration devices are used correctly by all [29]. Healthcare professionals prescribing or dispensing a medication requiring an administraton device should be educated on or reminded of the importance of providing adequate training on device use, and be given sufficient time to provide this support to patients. The training could consist in a practical demonstration with the end-user on how the device works, to make sure the patient is able to use the device correctly once at home. Moreover, healthcare professionals should provide adequate training material to their patients, such as leaflets with iconic representations of the steps required to use a specific device or videos accessible via QR codes.

Further suggestions provided by the children and their carers concerned the device appearance and design. An overall suggestion was to "use attractive shapes and colour when designing devices for children". Moreover, for oral devices it was suggested that the measuring device is inserted in the box of the medicine, as this could reduce the use of household spoons or incorrect devices that may lead to dosing errors. There were also suggestions for specific devices, although most were for oral syringes. For droppers one participant proposed to "change the design of the drip system", for measuring spoons some participants suggested to "make soft spoon suitable for babies" and to "add graduation lines on the measuring spoon for [measuring the correct] volume". For oral syringes, participants suggested the "use of rubber piston instead of plastic", and to make them "easier to wash" and "to push". Moreover, some participants proposed to "make graduation units more visible, e.g., in different colours or colour band rather than transparent as they are difficult to read". Difficulty in identifying the correct dose on oral syringes has been reported previously, and marking or colour-coding the required dose on the device has been proposed to reduce this issue [6,32]. Finally, for inhaled devices, one participant suggested that the device should "have a better mechanism to prevent it from accidentally blowing out puffs of medicine". Acknowledging these suggestions from the end-users is important to make devices that are patient-friendly and acceptable.

Our study had the following limitations. Firstly, although we targeted various paediatric advisory groups and other interested parties, the number of responses collected in each country was smaller than expected. This resulted in insufficient responses to perform statistical comparisons across countries, and the ability to only identify trends. This emerged to be a challenge for data analysis, especially for inhaled devices as the number of participants completing this part of the survey was low and some questions lacked responses from participants of some countries. Prior to the start of the distribution of the questionnaire, we investigated the possibility of conducting the survey in hospitals. However, unfortunately due to both logistical and funding challenges, this option was not possible and therefore not pursued.

It was noted that many participants left the survey before the end or

skipped several questions. Reasons for this could be survey fatigue that resulted in the early drop out of some participants. Moreover, we can hypothesise that some respondents skipped those question that they found too complicated, irrelevant, or simply they did not know the answer. Because of the anonymity of the survey and the channels used for its distribution, it was not possible to follow up participants or obtain their feedback. This is a common problem of online surveys. However, during the development of the survey, the questions and the structure of the questionnaire were assessed and deemed appropriate by the EuPFI devices workstream members and by a European Young Person's Advisory Group (YPAG). Furthermore, the same questionnaire was piloted in a group of UK school children and caregivers [6]. However, in the pilot study, the questionnaire was delivered in person and children were guided through the survey questions preventing large dropouts to happen.

Compared to the pilot study, the number of responses collected from the children's part was much lower than that of the caregivers'. This was due to several reasons: firstly, only children aged 10 years or above could complete the second part of the survey; secondly, some parents left their survey incomplete thus preventing their children to access their part of the survey. Finally, some parents did not give consent to their children to take part in the survey.

The number of responses from caregivers looking after infants and very young children (age groups less than 12 months and between 12 and 23 months) was very limited and missing in various countries. This could be related to the channels used to distribute the survey predominantly reaching children and their caregivers belonging to older age groups.

Another limitation of our study was the impossibility to assess the reliability of responses given. This is common to all survey-based studies. Thus we recognise the possibility that some respondents might have given inaccurate answers. However, when looking at responses given by the caregivers and their children for two of the key questions of our survey, i.e. type of dosage forms used, and device used, a good correlation (around 82%) emerged, suggesting a good reliability of responses between the caregivers and children.

Finally, we did not include any question about participants' background, such as educational status of the caregiver. We acknowledge the possibility that among all those who received the link to the survey, our respondents might have belonged to specific population groups, e.g., people with higher educational level or those interested in medical research, leading to some bias in our results. This is an issue faced with all voluntary surveys.

However, the benefits associated with the use of an online survey are the ease to reach respondents living in different geographical regions, and limited costs. An in-loco study of the same scale would have been costly and impractical to conduct. This study follows a smaller paper-based survey conducted in the UK [6] that was aimed at piloting the design and execution of this international survey. The main changes adopted in this study compared to the pilot edition were the use of an online survey rather than a paper-based that enabled a larger number of participants across several countries to be reached. Moreover, the use of a computer-based questionnaire permitted the number of response options each participant could select for each question to be controlled, and to make some of the key questions mandatory.

5. Conclusion

Results from this survey have provided new and valuable insights about the oral and respiratory administration devices used by paediatric end users across various European and non-European countries. Moreover, our results provide useful information about end users' experiences and the usability of these devices. The findings indicate device use tends to vary from country to country, however some trends emerged across countries. The oral syringe was the device mostly used particularly in the European countries, followed by the measuring spoon, which was instead used as primary device for administering liquid medicine in the USA. As for inhaled devices, the most common devices were manually actuated and breath actuated MDIs followed by nebulisers. Despite the apparent general clarity and ease of device use declared by the majority of participants for all devices, from the participants' suggestions, the need to simplify device instructions by either reporting visual instructions, or by summarising or highlighting the key points were noted. Moreover, it emerged that frequently patients do not receive any instruction on correct device use. Appropriate patient training by a healthcare professional on device use and a simplification of instructions are the two most important aspects that would need to be prioritised to ensure administration devices are used correctly by all. Moreover, the implementation of some of the suggestions provided by participants about device appearance and design could make administration devices more user friendly and acceptable.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ejpb.2023.07.006.

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