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REGULAR ARTICLE

Heterogeneity of emergency treatment practices in wheezing preschool children

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Abstract

Aim: Our aim was to survey treatment practices used for preschool children with wheezing in emergency rooms (ER) focussing on inhalation device choice and handling, face mask use, salbutamol dosing and written instructions. We sought to assess whether current protocols are in line with published evidence and guidelines.

Methods: This is a cross-sectional survey done in paediatric ER units located in Finnish municipalities with more than 10 000 inhabitants.

Results: Of the 100 units contacted, 50% responded. More than 50% of the units used nebulisers. Only 13% of the units administered salbutamol in single puffs. More than 30% of the units lacked criteria on face mask use. Poor co-operation had no effect on the dose of salbutamol in 62% of the units. Ensuring tight mask-to-face seal was included in the training in 20% of the units. A written action plan was provided to the caregivers in 28% of the units.

Conclusion: ER treatment guidelines for preschool children with wheezing are poorly endorsed. Research is needed to identify approaches to guideline implementation that are specific for primary care. Clinical research should focus on strengthening recommendations that are currently not embraced. ER treatment protocols need to be updated and adherence to guidelines should be re-evaluated.

KEYWORDS
acute management, asthma, bronchodilators, drug delivery emergency treatment, guidelines, inhalation therapy, preschool children, spacer, valved holding chambers, wheezing

1 | INTRODUCTION

International and national clinical guidelines have summarised important factors to be considered in the clinical management of wheezing in preschool children.[1-5] Most guidelines recommend the use of pressurised metered dose inhalers (pMDI) with valved holding chambers (VHC) rather than nebulisers.[1-6] Drug delivery is most reliable when each puff is given into the pMDI separately.[2-5,7-9] The use of face mask is recommended in children younger than 3 years.[1-5] Furthermore, the face mask should fit well to ensure reliable aerosol delivery.[10-13] Crying and poor co-operation decrease pulmonary drug delivery.[3,14] Most guidelines recommend that families should

Abbreviations: ABS, acrylonitrile butadiene styrene; ER, Emergency room; PIFR, Peak inspiratory flow rate; pMDI, Pressurised metered dose inhalers; RR, Respiratory rate; VHC, Valved holding chambers; Vt, Tidal volume.

receive a written action plan in case of exacerbations.[1,2,4,6] Finally, previously published data indicate that drug delivery via VHCs is device-dependent and recommended inhaled bronchodilator doses may have to be adjusted according to the properties of each pMDI + VHC combination.[8-10,15-18]

In clinical practice, the adherence to clinical guidelines may vary markedly and influence the clinical effectiveness of the treatment of wheezing in preschool children. Adherence to guidelines should be regularly evaluated to identify factors that need to be improved.

The objective of this study was to survey treatment practices used for preschool children with wheezing in Finnish emergency rooms (ER). We especially focussed on factors that potentially effect successful drug delivery, such as choice and handling of inhalation device, application of face mask and co-operation during drug delivery. In addition, we sought to assess weather current protocols are in line with published evidence and guidelines.

Key notes

- Clinical practice guidelines improve management of acute wheezing, and adherence to guidelines needs to be evaluated regularly.
- In Finland, emergency room treatment protocols for preschool children with wheezing are not in harmony with current care guidelines.
- The best methods to implement guidelines in paediatric primary care units need to be identified, and clinical research should focus on strengthening the recommendations that are currently not embraced.

2 | MATERIALS AND METHODS

Finland has 310 municipalities in 19 regions within five large university hospital districts. In Finland, paediatric emergency care outside office hours is concentrated to large healthcare centres and hospitals. For this reason, we sent the questionnaire to all municipalities that provide acute paediatric emergency room (ER) services and have a population over 10 000 inhabitants. The Swedish speaking sovereign Åland region was excluded from our study (population less than 30 000 inhabitants and only one municipality with over 10 000 inhabitants). Population data were derived from Statistics Finland, the Finnish public authority that produces official statistics in Finland.

To inquire about the ER treatment protocols used for an acutely wheezing child, an electronic questionnaire was sent via e-mail to chief physicians responsible for emergency care in all identified municipalities (Table S1). Three reminder e-mails were sent during a 3 month period. Those not responding to the questionnaire were contacted by telephone. The questionnaire was designed in a way that blank answers were not possible.

3 | RESULTS

One hundred questionnaires were sent to the healthcare units with a catchment area covering 84% of the total population in Finland (Table 1). Four sets of e-mails (altogether 343) and 76 phone calls were made. Altogether, 50municipalities answered the questionnaire yielding a response rate of 50% representing 60% of the whole population (3,329,201/5,513,130 inhabitants) (Table 1). Response rate in different regions of Finland varied from 14% to 100% (Table 1). The questionnaire was answered by the chief physician and/or the head nurse of the unit. There were no missing data among those who returned the questionnaire. In case of ambiguous answer, the responder was contacted by phone to clarify the question.

Four units reported that pMDI with VHCs were never used in preschool children. More than 50% of the units used nebulisers in preschool children. At the time of the survey, there were six types of VHCs available in Finland (Table S2). Babyhaler was the most frequently used VHC (Table 2). For children older than 3 years of age, 28% of the units used facemask each time and 65% sometimes (Table 2). More than 30% of the units lacked defined criteria when to use face mask (Table 2). For the healthcare staff, a predefined written instruction for salbutamol use and dosing was available in 41 (82%) units; 27 (54%) based on weight and 12 (24%) on age. The most frequent (42%) dosing scheme was six puffs (0.6 mg) of salbutamol (0.1 mg/puff) for children <25 kg and 8 puffs (0.8 mg) for children >25 kg to be repeated 3 to 4 times with 20 min interval. The salbutamol dose protocol varied from two puffs (0.2 mg) at a time repeated with 2–4 h interval to 8 puffs 3 times during 1 h.

In the units using pMDI + VHCs (n = 46), salbutamol was administered one puff at a time in 6 (6/46 = 13%) units, 2 puffs at a time in 35 (76.1%) units and more than 2 puffs in two (4.3%) units. In three (6.5%) units, there was no instruction for how to administer the puffs.

In case the child was crying or was otherwise not cooperating during inhalation, 62% of the units continued to administer salbutamol without changing the dose or treatment regimen (Table 3). In 80% of the units, the staff was not systematically trained to ensure tight mask-to-face seal during bronchodilator inhalation (Table 3).

Most units maintained the VHCs using a washer disinfector (40/46 = 87%). One unit (2.2%) used a dishwasher, two units (4.3%) washed the VHCs by hand, two units provided no information about device care, and one unit adopted the single patient use protocol. Antistatic treatment was routinely used only by two units (2/46 = 4.3%). A written action plan was provided to the caregivers in 28% of the emergency care units.

4 | DISCUSSION

The present Finnish national survey indicates that current care guidelines for wheezing in preschool children are inadequately

TABLE 1 Population and response rate by regions

Region*	Population in the region	Number of approached municipalities	Population in approached municipalities	Ratio of inhabitants in approached municipalities per region	Number of responder municipalities in the region	Population in responder municipalities	Ratio of inhabitants in responder municipalities per region	Response rate of municipalities in the region
Uusimaa	1 655 624	17	1 609 854	97%	10	1 152 085	70%	59%
Pirkanmaa	512 081	11	455 136	89%	7	367 593	72%	64%
Southwest-Finland	477 677	10	396 666	83%	5	277 681	58%	50%
North Ostrobothnia	411 856	8	308 447	75%	2	226 811	55%	25%
Central Finland	276 031	5	209 284	76%	4	190 306	69%	80%
North Savo	246 653	4	182 660	74%	2	139 848	57%	50%
Satakunta	220 398	6	171 146	78%	3	106 379	48%	50%
Päijät-Häme	201 228	4	178 704	89%	1	119 573	59%	25%
South Ostrobothnia	190 910	7	152 179	80%	1	62 676	33%	14%
Ostrobothnia	180 945	4	117 239	65%	1	67 392	37%	25%
Lapland	179 223	3	105 604	59%	2	83 676	47%	67%
Kymeenlaakso	175 511	3	158 228	90%	1	53 539	31%	33%
Kanta-Häme	172 720	4	130 475	76%	3	113 290	66%	75%
North Karelia	162 986	5	124 830	77%	1	76 067	47%	20%
South Savo	147 194	3	107 145	73%	3	107 145	73%	100%
South Karelia	129 865	3	100 178	77%	2	100 178	77%	67%
Kainuu	73 959	2	47 662	64%	1	37 239	50%	50%
Central Ostrobothnia	68 780	1	47 723	69%	1	47 723	69%	100%
All	**5 483 641**	**100**	**4 603 160**	**84%**	**50**	**3 329 201**	**61%**	**50%**

*The sovereign state of Åland region was excluded from the study (population less than 30,000 inhabitants). In some regions, most of the municipalities have less than 10 000 inhabitants. Total population in Finland at the time of the study was 5,513,130.

endorsed in clinical practice. In particular, poor adherence to VHC use, single puff administration, appropriate mask unitisation and provision of written action plan were noted (Tables 2 and 3).

The frequent use of nebulisers during the time of our survey cannot be attributed to lack of evidence.[1,2] Potential barriers to switching from nebulisers to pMDI + VHCs have been identified in previous studies. These include concerns regarding costs, effectiveness, safety, infection control, parental expectations, lack of a physician leadership and changes in workload of nurses.[19,20] In Finland, most ER units used a VHC model (Babyhaler) with very low output. This might lead to suboptimal therapeutic effect and hence hinder the switch from nebulisers to pMDI + VHC. On the other hand, it has been shown that by systematic training and education of the nurses and physicians the transition from nebulisers to pMDI + VHCs can be achieved successfully.[21]

In accordance with the Finnish[1] as well as other guidelines,[2-6,22] face mask was used for children younger than 3 years in most units. However, the mask was often applied also in older children, possible because the criterion for face mask use was not well defined in most ERs. Using face mask in older children increases the risk of poor fit, especially in models (eg Babyhaler) where only one size is available.

We observed that confirming good face mask fit and seal was instructed only in few ER units. This might be due to lack of awareness about the key elements that influence inhaled drug delivery in preschool children. Although several *in vitro* studies have shown that poor mask-to-face seal has a marked impact on aerosol delivery,[10-13] only some guidelines remark the importance of good face mask fit.[2,3,5] As soon as the child can hold the VHC mouthpiece properly between the lips, omitting the facemask improves drug delivery.[10,11]

The importance of calming the child to ensure reliable drug delivery is mostly lacking from the guidelines, apart from the Australian one.[3] In fact, it is often erroneously thought that gasping during crying ensures adequate influx of air into the lungs when in effect inhaled drug is mostly impacted in the oral cavity, pharynx and then swallowed into the gastrointestinal tract.[14,23] Lack of knowledge and time might explain why in more than 60% of the ERs poor cooperation did not influence treatment scheme.

Salbutamol dosing was mostly in line with GINA[2] as well as Finnish[1] guidelines. Some units administered salbutamol in every 2–4 h, which is less efficient during acute wheezing compared to the recommended 20 min intervals.[2] As opposed to most guidelines,[2-5] when pMDI + VHC was used, only 13% of the units gave salbutamol one puff at a time. The Finnish guideline—that is currently under revision—does not give recommendation on how many puffs should be delivered into the VHC at a time.[1]

In our survey, one single VHC brand (Babyhaler, 350 mL volume, one size mask) was remarkably popular, despite the lack of evidence

TABLE 2 Treatment practices regarding inhaler devices in 50 Finnish emergency room (ER) units surveyed

	Age <3 years n (%)	Age 3 –7 years n (%)	Recommendations in the guidelines (references)
	(n=50)	**(n=50)**	
Nebuliser is never used	23 (46.0)	24 (48.0)	Guidelines favour the use of VHCs instead of nebulisers.[1-6] The Finnish guidelines recommend using VHCs instead of nebulisers in the paediatric ER.[1]
Nebuliser is also used	27 (54.0)	26 (52.0)	
pMDI with VHC is never used	4 (8.0)	4 (8.0)	
VHC model used	**(n=46)**	**(n=46)**	The GINA guideline indicates that young children can use spacers of all sizes, but a lower volume spacer (<350 mL) is advantageous in very young children.[2] None of the guidelines have specific recommendations concerning the choice of VHC brand or model.[1-6]
Aerochamber plus	1 (2.2)	1 (2.2)	
Babyhaler	43 (93.5)	37 (80.4)	
Volumatic	1 (2.2)	7 (15.2)	
Vortex	1 (2.2)	1 (2.2)	
Face mask use with VHC	**(n=46)**	**(n=46)**	Guidelines recommend the use of face mask for children under 3–4 years.[2-6] The Finnish guidelines recommend that a face mask should be used for children under 3 years.[1]
never	2 (4.3)	3 (6)	
always	43 (93.5)	13 (28.3)	
sometimes	1 (2.2)	30 (65.2)	
Criteria for face mask use with VHC	**(n=46)**	**(n=46)**	Face mask should be used for children under 3–4 years and for those who are unable to use mouthpiece.[2,3,5] The Finnish guidelines do not advise on specific conditions when face mask should be used in children above 3 years of age.
no predefined criteria	18 (39.1)	1 (30.4)	
criteria based on age	10 (21.7)	27 (58.7)	
only in case the child is unable to use mouthpiece*	10 (21.7)	5 (10.9)	
mask is always used	8 (17.4)	0	

*In case the child is not capable to hold the mouthpiece between the lips and teeth.

TABLE 3 Protocols in relation to bronchodilator administration in 50 Finnish emergency room (ER) units surveyed

Protocol used in case of crying or poor co-operation during inhalation therapy	n (%)	Recommendations in the guidelines (references)
Salbutamol inhalation is continued despite poor co-operation, no change in salbutamol dose	31 (62.0)	Some guideless remark that babies are unlikely to inhale enough medicine while crying and there should be extra effort to calm the children down in order to ensure adequate therapeutic effect[3] Most guidelines, including the Finnish, have no specific notes on the effect of co-operation during inhalation therapy.[1,2,4-6]
Salbutamol inhalation is continued when the child is more co-operative	15 (30.0)	
Inhalation is continued despite poor co-operation with higher dose of salbutamol	1 (2.0)	
There is no instruction how to deal with poor co-operation	2 (4.0)	
If the inhalation is not successful with VHC, salbutamol is given via nebuliser	1 (2.0)	
Written instructions available about the face mask fit and seal in the unit		
No written instructions	40 (80.0)	Most guidelines recommend using tightly fitting face mask.[2,3,5] The Finnish guidelines have no recommendation concerning face mask fit or seal.[1]
Written instructions are available	6 (12.0)	
No written instructions, but the importance of face mask seal has been discussed during training	4 (8.0)	
Written action plan given to the caregivers after discharge		
There is no written action plan provided by the unit	36 (72.0)	Most guidelines, including the Finnish, recommend that patients should receive written personalised asthma action plans.[1,2,4,6]
A written plan is always handed out	7 (14.0)	
There is a written action plan, but it is not always provided	7 (14.0)	

of its superiority compared to other VHCs.[9,10,15] Previously published data indicate that similar devices from different brands may have up to 20-fold differences in drug delivery capacity in experimental *in vitro* models[10,11] and larger volume VHCs may result in a lower salbutamol output compared to smaller VHCs.[10,15] In addition, shallow and rapid respiration during bronchoconstriction may have pronounced negative effect on the drug delivery for some VHCs.[10,24-27] The GINA guideline indicates that young children can use spacers of all sizes, but a lower volume spacer (ie <350 mL) is advantageous in very young children.[2] None of the guidelines have specific recommendations concerning the choice of VHC brand or model.[1-6] However, antistatic VHCs with well-fitting face mask and having published efficacy data in paediatric population should be used.[7-18,24-26] VHCs that has been shown to have low output (eg Babyhaler) should not be used. Without specific guidelines, factors such as local traditions or marketing schemes may have unjustifiable influence on clinical practice.

Manufacturers use several different terms to describe their VHC product: antistatic, non-electrostatic or reduced static charge. However, all non-conductive materials (such as ABS, polycarbonate, and cardboard) are prone to accumulate electrostatic charge. Antistatic treatment of the VHC was rarely done in the surveyed units. Although some guidelines address the issue of VHC static charge,[2,3,5] there are no specific recommendations in any of the guidelines as to how and with which detergent should the VHCs be pre-treated.

Most guidelines, including the Finnish guideline, state that patients should be provided with personalised asthma action plan including self-management of exacerbations.[1,2,4-6] Our survey indicates that this is seldom the case in real-life practice. Only 30% of the units provided written action plans for the caregivers upon discharge.

The strength of the present study is that it was designed to provide a representable national sample of ER units covering most paediatric patients. The 50% response rate of healthcare units is comparable or even better than in other surveys.[28,29] In addition, there were no missing data among the responders.

There are several limitations to our study. The response rate varied from 14% to 100% in different regions of the country. The reason for not responding and for this regional difference on response rate is not known. However, this poses a potential selection bias. Our study did not evaluate the actual treatment given over time; rather our data are based on the answers provided by the chief physician and/or the head nurse of the unit. Hence, our data do not provide detailed information on individual patient level, but reflects the protocols usually employed. The questionnaire used is designed for this study, and it was not validated previously. We aimed to increase the accuracy of data by clarifying possible ambiguous answers by contacting the responders by phone. The phone calls were made each time by the same study physician. Lastly, our survey did not inquire about the perceived usefulness of guideline recommendations.

Our survey indicates that ER treatment protocols for preschool children with wheezing are not in harmony with current care guidelines. Thus, despite available evidence, a significant proportion of patients may receive suboptimal treatment. The dissemination of published evidence is rarely enough by itself to

improve healthcare. Time constraints, clinical inertia and workflow barriers may explain the low rate of guideline endorsement. Clinical practice guidelines are possible to use successfully in the ER to improve management and treatment approach to acute exacerbations of childhood asthma.[30] However, more research is needed to identify approaches to implementation that are specific for paediatric primary care and focus clinical research on strengthening recommendations that are currently not embraced. In addition, ER treatment protocols need to be updated, implementation methods should be improved, and adherence to guidelines should be re-evaluated.

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CONFLICT OF INTERESTS

Dr. Csonka reports personal fees for lectures, consultations and advisory board memberships from ALK and Thermo Fisher Scientific. Dr. Lehtimäki reports personal fees for lectures, consultations and advisory board memberships from ALK, AstraZeneca, Boehringer Ingelheim, Chiesi, Circassia, GSK, Novartis, Mundipharma, OrionPharma, Sanofi and Teva. Dr. Tapiainen declares no conflict of interest. Dr. Mäkelä declares no conflict of interest.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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