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Authors	Marshall, Sarah;Fleming, Aoife;Moore, Anne C.;Sahm, Laura J.
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Acceptability of microneedle-patch vaccines: a qualitative analysis of the opinions of parents

S. Marshall[1], , A. Fleming[1, 2], AC. Moore[1, 3], LJ. Sahm[1, 2]

[1] School of Pharmacy, University College Cork, Cork, Ireland.

[2]. Department of Pharmacy, Mercy University Hospital, Cork, Ireland.

[3] Department of Pharmacology and Therapeutics, University College Cork, Cork, Ireland

Keywords

Microneedle, microneedle-patch, vaccine, acceptability, qualitative, focus group.

Abstract

Introduction

Vaccines incorporated into microneedle-based patch platforms offer advantages over conventional hypodermic injections. However, the success and clinical utility of these platforms will depend on its acceptance among stakeholders. Minimal focus has been placed on detpermining parents' acceptability of microneedle-patch vaccines intended for paediatric use. This qualitative study probes the perceived acceptability of microneedle technology for paediatric vaccination in a parent population.

Research Design and Methodology

Focus groups (n = 6) were convened through purposive sampling of Cork city primary schools. Discussions were audio-recorded, transcribed verbatim, anonymised, independently verified and analysed by thematic analysis, with constant comparison method applied throughout.

Results

The opinions of 32 parents were included. All participants declared that their children were fully vaccinated. Five core themes were identified and defined as: (i) concern, (ii) suitability for paediatric use, (iii) potential for parental administration, (iv) the role of the healthcare professional and (v) special populations. Drivers for acceptance include; concerns with current vaccines and vaccination programmes; attributes of microneedle-patch (reduced pain, bleeding, fear and increased convenience) and endorsement by a healthcare professional. Barriers to acceptance include; lack of familiarity, concerns regarding feasibility and suitability in paediatrics, allergic potential, inability to confirm delivery and potential reduction in vaccine coverage.

Conclusion

This is the first study to explore parental acceptance of microneedle-patch vaccines. Capturing the opinions of parents, the ultimate decision makers in paediatric vaccination, is crucial in the understanding of the eventual uptake of microneedle technology and therefore adds to literature currently available. This study has revealed that even "vaccine-acceptors"; parents who agree with, or do not question vaccination, will question the safety and efficacy of this novel method. Participants in this study remained tentative. However, the study has also revealed that healthcare professional endorsement could reduce this tentativeness, thereby identifying the role of healthcare professionals in disseminating information and providing support to parents. An increased awareness of developments in microneedle technology is needed to permit informed decision-making by parents.

Introduction

Microneedles are micron-sized needles, designed to achieve the efficacy of the conventional hypodermic injection with the simplicity of a skin patch (1, 2). Incorporating vaccines into microneedle-based patch platforms offer the possibility of reducing costs associated with current vaccination programmes: (i) their thermostability eliminates cold-chain transportation requirements, thereby reducing distribution costs (3-5); (ii) their potential for self-administration would reduce reliance on trained personnel, reducing administration costs (1, 6-8) and (iii) their potential dose-sparing characteristics would permit a reduction in vaccine antigen per dose, reducing production costs (9-11). In addition, microneedles may be fabricated using dissolving polymers, eliminating the biohazardous sharps waste associated with conventional vaccination methods (7, 12). These dissolving microneedle-patches have been developed to successfully incorporate vaccines *in vivo* for multiple disease indications (13). The ability to penetrate the skin with minimal trauma, in the absence of pain and bleeding (1) has been identified by healthcare users as an important factor in their eventual clinical use (14, 15).

Despite these desirable characteristics for healthcare professionals and vaccinees, the success and commercial viability of this technology will depend on its acceptance among these stakeholders. It is widely accepted that obtaining and evaluating public opinion on developing scientific, technological and medical innovation and policy is important (16, 17). The European Medicines Agency (EMA) recommends that evaluation of patient acceptability should be an integral component of pharmaceutical and clinical development (18). In their exploratory research study, Birchall *et al.*, captured the perceived advantages of, and concerns with, microneedles, through the convening of focus groups comprising public participants and healthcare professionals (19). A high percentage of participants suggested that microneedles would be ‘ideal’ for the administration of medicines to children (19). In another study, children expressed a favourable viewpoint, suggesting that microneedle-based blood monitoring could offer an attractive alternative to conventional methods (20). This research was expanded to include parental perception of microneedle-mediated blood monitoring of their infants and, once again, support for the microneedle was evident (21). Research thus far has focussed on demonstrating safety and efficacy of microneedle-mediated delivery and assessing the acceptability of microneedle technology in general, with minimal focus on determining the acceptability of microneedle-patch vaccine delivery, in particular those intended for paediatric use. Therefore, to address this knowledge gap, this qualitative study probes the perceived acceptability of microneedle technology for paediatric vaccination in a population of parents.

Methodology

Focus groups

The acceptability of microneedle-patch vaccines was explored through a series of focus groups. Focus groups were chosen as they can provide insights into attitudes and beliefs that underlie behaviour and give context and perspective that enable experiences to be understood more holistically (22). These attitudes, feelings and beliefs may be partially independent of a group or its social setting but are more likely to be revealed via the social gathering and the interactions entailed within a focus group.

A list of primary schools in Cork city, Ireland (n=50), detailing address, Principal name and contact details was compiled using information freely available from the Irish Department of Education and Skills (23). A recruitment poster, a copy of the informed consent form and a cover letter detailing study overview, addressed to each Principal, were sent via post. A follow-up email detailing the same information was sent one week later. With the permission of the Principal, contact was made with the Parent Association of those schools that expressed willingness to participate and focus group participants were recruited, using purposive sampling. Inclusion criteria included self-declared satisfactory English language and parent or guardian of a child or children less than 12 years of age, with no limitation placed on age or gender of participant. Focus groups took place within the grounds of the school, often coinciding with pre-arranged Parent Association meetings, to enhance convenience for participants. Written informed consent to take part in the study and to be audio-recorded was obtained from participants prior to each focus group. Information detailing gender, age, highest level of education achieved (according to International Standard Classification of Education (ISCED) (24)), number of children less than 12 years of age in their care and the vaccination status of their children was obtained for each participant.

A brief description of microneedle-patch vaccines, explaining their ability to disrupt the outer skin barrier layer and deliver a vaccine, without impinging on the underlying pain receptors and blood vessels, was provided by the moderator. This was considered necessary given the likely unfamiliarity of participants with microneedle technology. However, to mitigate against risk of introduction of bias, information relayed was of a factual nature only. A research prototype, placebo microneedle-patch was passed around the groups and a magnifying glass was provided, to permit visualisation of the individual microneedles, to act as a focussing exercise to stimulate discussion and to reduce bias by enabling the independent formation of opinions (Figure 1). A topic guide with a semi-structured design was used during each focus group, constructed based on a comprehensive literature search (25), providing general probes in an open-questioning style (Table 1). Ethical approval was obtained from the Social Research Ethics Committee, University College Cork. The authors declare that they have no competing interests.

Figure 1 Prototype, placebo microneedle-patch & magnifying glass given to participants at the outset of focus groups

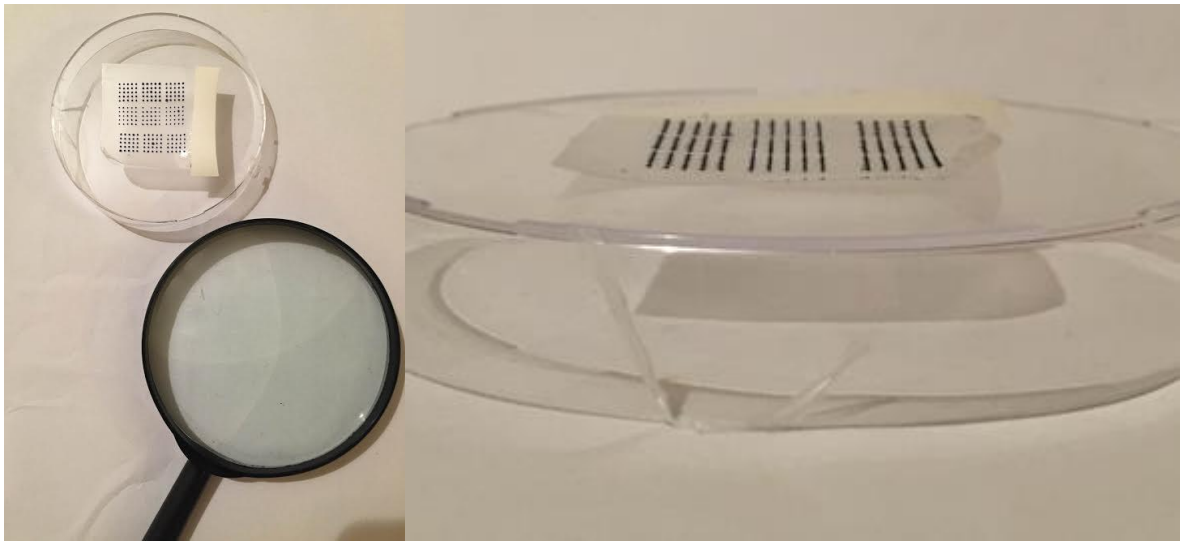


Table 1 Focus group topic guide

Opinions of vaccines
What are your opinions on current paediatric vaccination programmes?
Do you agree with current paediatric vaccination programmes?
What are the benefits of vaccination programmes?
What are your concerns about vaccination programmes?
What are the problems with current vaccination programmes?
Are you happy for your children to be vaccinated?
Do you have any issues with current vaccination methods?
Do you think cost is a major consideration with vaccination programmes?
Opinions of microneedle-patch vaccines
Before today, had you ever heard of a microneedle-patch vaccine?
What is your initial opinion of the microneedle-patch vaccine?
Do you believe that the microneedle-patch vaccine is as effective as other vaccination methods?
Would you trust this vaccination method?
Do you think there are any advantages of the microneedle-patch vaccine?
What do you like about the microneedle-patch vaccine?
Do you think there are any disadvantages of the microneedle-patch vaccine?
What do you dislike about the microneedle-patch vaccine?
Would you have any concerns in relation to the use of a microneedle-patch vaccine?
Would you allow your child or a child in your care to be vaccinated using a microneedle-patch vaccine?
Do you think the microneedle-patch vaccine could change opinions of vaccination?
What would children think of the microneedle-patch vaccine?
Do you think people would be nervous of the microneedle-patch vaccine?
If given a choice, which method of vaccination would you prefer?
Who do you think should administer the microneedle-patch vaccine?
Do you think you would be able to self-administer the microneedle-patch vaccine?
Would you be willing to administer the microneedle-patch vaccine to your child or a child in your care?
Would you be comfortable with administering the microneedle-patch vaccine to your child or a child in your care?
Is there any way you think the microneedle-patch vaccine could be improved?
What do you think of the design of the microneedle-patch vaccine?
Is there any way you think the design of the microneedle-patch vaccine could be improved?
Do you think the Health Service Executive (HSE) should endorse and invest in the microneedle-patch vaccine?

Focus group analysis

Audio-recorded sessions, using a Dictaphone (OLYMPUS Digital Voice Recorder VN-731PC), were fully transcribed verbatim within one week of each focus group. Data were entered into QSR International's NVivo V.11 software to assist analysis. Each participant was assigned an anonymised identifier; for example, the first participant of the first focus group was assigned FG1P1. Transcripts were verified against audio-recordings with a random sample verified by an independent researcher. Focus groups transcripts were independently coded by co-investigators. Disparities were identified

and resolved through discussion. Data were analysed by thematic analysis, with constant comparison method applied throughout.

Results

Focus Group Participants

Six focus groups were completed from 3rd November 2015 to 12th January 2016, representing an uptake rate of 12%. The opinions of 32 participants (29 female) were compiled. The most commonly reported age range was 30-39 years (46.88%), highest education level was Higher Education (ISCED level ≥ 4) (68.75%) and the number of child(ren) under 12 years in their care was two (46.88%). All participants declared that their children were fully vaccinated, to the best of their knowledge. A summary of participant demographics, including their anonymised identifier is provided in Table 2.

Table 2 Participant demographics

Identifier	Gender	Age category (years)	*Highest education level	Children under 12
FG1P1	Female	50-59	ISCED level 3	1
FG1P2	Female	40-49	ISCED level 3	2
FG1P3	Female	30-39	ISCED level ≥4	2
FG1P4	Female	40-49	ISCED level ≥4	3
FG2P1	Female	40-49	ISCED level ≥4	1
FG2P2	Female	40-49	ISCED level ≥4	4
FG2P3	Female	30-39	ISCED level ≥4	3
FG2P4	Female	50-59	ISCED level ≥4	2
FG2P5	Female	40-49	ISCED level ≥4	1
FG3P1	Female	30-39	ISCED level 3	3
FG3P2	Male	30-39	ISCED level 2	3
FG3P3	Female	40-49	ISCED level ≥4	1
FG3P4	Female	40-49	ISCED level ≥4	2
FG3P5	Female	30-39	ISCED level ≥4	1
FG3P6	Female	20-29	ISCED level 2	3
FG4P1	Female	40-49	ISCED level 3	2
FG4P2	Female	30-39	ISCED level ≥4	2
FG4P3	Female	30-39	ISCED level ≥4	3
FG4P4	Female	30-39	ISCED level ≥4	2
FG4P5	Female	20-29	ISCED level 3	1
FG5P1	Female	40-49	ISCED level ≥4	2
FG5P2	Female	30-39	ISCED level 3	2
FG5P3	Female	30-39	ISCED level ≥4	1
FG5P4	Female	40-49	ISCED level ≥4	2
FG5P5	Female	30-39	ISCED level ≥4	2
FG6P1	Male	40-49	Unknown	3
FG6P2	Female	30-39	ISCED level ≥4	1
FG6P3	Female	30-39	ISCED level ≥4	2
FG6P4	Male	40-49	ISCED level ≥4	2
FG6P5	Female	30-39	ISCED level 3	2
FG6P6	Female	30-39	ISCED level ≥4	2
FG6P7	Female	40-49	ISCED level ≥4	1

***Highest education level**

- ISCED level 1: Primary education, equivalent to 8 years official State education
- ISCED level 2: Lower secondary education: Irish Junior/Inter Certificate, equivalent to 11 years official State education
- ISCED level 3: Upper secondary education: Irish Leaving Certificate, equivalent to 14 years official State education

ISCED level ≥4: Higher Education including post-secondary non-tertiary education, short-cycle tertiary education, Bachelor (or equivalent), Master (or equivalent) and Doctoral (or equivalent)

Two of the six participating schools were included in the Delivering Equality of Opportunity in Schools (DEIS) programme, that is part of the Department of Education and Skills action plan which focusses on addressing and prioritising the educational needs of children from disadvantaged communities. Focus group duration ranged from 27 to 42 minutes (Table 3).

Table 3 Focus groups: DEIS status, gender breakdown and duration

	DEIS*	Male (n)	Female (n)	Duration (mins)
FG1	No	0	4	33
FG2	Yes	0	5	42
FG3	Yes	1	5	37
FG4	No	0	5	27
FG5	No	0	5	29
FG6	No	2	5	33
***DEIS: Delivering Equality of Opportunity in Schools**				

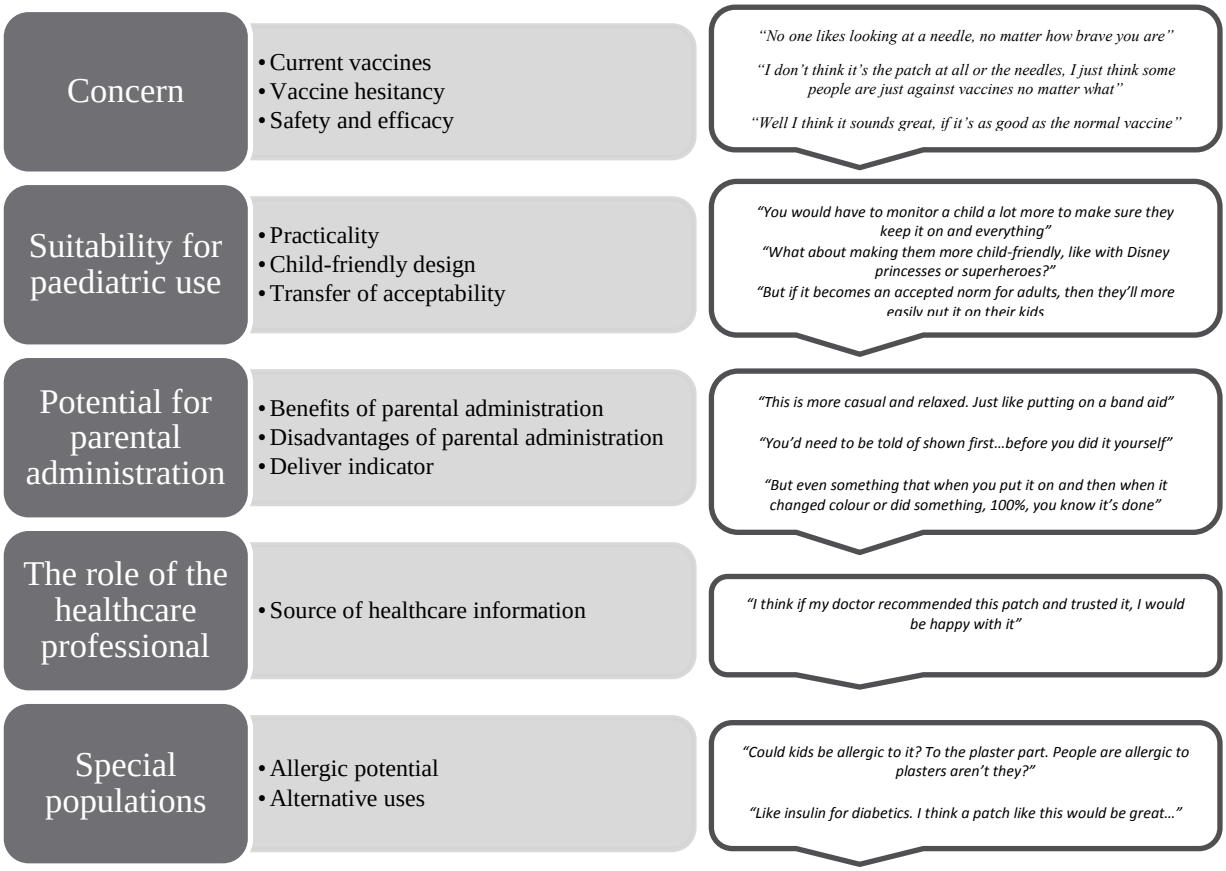
Focus group analysis

Focus groups transcripts were analysed by thematic analysis, with constant comparison method applied throughout. Five core themes were identified and defined as: (i) concern, (ii) suitability for paediatric use, (iii) potential for parental administration, (iv) the role of the healthcare professional and (v) special populations (Table 4). A pictorial representation of these themes, sub-themes and associated exemplar quotes is seen in Figure 2.

Table 4 Themes and sub-themes and their occurrence in each focus group

	Focus group					
Themes and sub-themes	**FG1**	**FG2**	**FG3**	**FG4**	**FG5**	**FG6**
i. Concern						
Current vaccines	✓	✓	✓	✓	✓	✓
Vaccine hesitancy			✓		✓	✓
Safety & efficacy	✓	✓	✓	✓	✓	✓
ii. Suitability for paediatric use						
Practicality	✓	✓	✓	✓	✓	✓
Child-friendly design	✓		✓	✓	✓	✓
Transfer of acceptability	✓	✓	✓	✓	✓	
iii. Potential for parental administration						
Benefits of parental administration	✓		✓	✓		✓
Disadvantages of parental administration	✓	✓	✓	✓	✓	✓
Delivery indicator		✓		✓		✓
iv. The role of the healthcare professional						
Source of healthcare information	✓	✓	✓	✓	✓	✓
v. Special populations						
Allergic potential	✓	✓	✓	✓	✓	✓
Alternative uses		✓	✓	✓	✓	✓

Figure 2 Themes, sub-themes and associated exemplar quotes



i. Concern

Concern emerged as a theme in all focus groups. Participants expressed concerns regarding current vaccination methods and programmes, such as unattractive visual appearance and hysteria associated with in-school programmes. In addition, participants discussed personal negative experiences with vaccines such as fear, parental and paediatric trauma, pain and side effects:

FG6P6 *"No one likes looking at a needle, no matter how brave you are"*

FG6P4 *"Mass fainting, hysterical crying, nightmare to deal with. This is why I'm not sure these in-school vaccine sessions are a good idea. I think it creates chaos"*

Some participants alluded to the behavioural phenomenon of vaccine hesitancy, despite declaring that all children in their care were fully vaccinated.

FG3P2 *"Is it still as important today as it was 10 years ago to get these vaccinations?...if you listen to some media, people have gotten sicker because of these vaccinations and some people blame these vaccinations…my small one is after having the mumps even after getting the vaccine…is it really important to get them when you say it prevents these things but it's still not preventing them"*

FG3P2 *"I don't think it's the patch at all or the needles, I just think some people are just against vaccines no matter what"*

Evidence of safety and efficacy was of paramount importance to parents, with all focus groups requiring reassurance that microneedle-patch vaccines would be as safe and efficacious as conventional vaccines.

FG1P3 *"So they have done controls comparing with injection with needle and syringe to the patch?"*

FG2P3 *"I actually, I love the idea of it in theory being able to give it but at the same time, before I'd give it to my child I'd want it to be tested in hundreds of thousands of people across the world for ideally at least 10 years"*

FG6P7 *"Well I think it sounds great, if it's as good as the normal vaccine"*

FG6P5 *"It's hard to believe the needles are big enough to give the vaccine, I mean, they're tiny"*

FG6P6 *"By creating loads of holes in your skin are you not increasing the risk of picking up an infection?"*

ii. Suitability for paediatric use

Focus groups participants acknowledged the advantages of microneedle-patch vaccines for paediatric use. These included a reduction in pain and bleeding and an attractive visual appearance. However,

the practicality and feasibility of using a patch delivery system in a paediatric population was explored:

FG1P4 *"If the child finds something on their arm, they will take it off"*

FG2P5 *"You would have to monitor a child a lot more to make sure they keep it on and everything"*

FG2P3 *"I'm just thinking of the practicality though you know…if you're using the thigh and what if they have an explosive nappy?"*

In addition, the current design of the patch was challenged and suggestions were offered to make the delivery system more 'child-friendly':

FG1P4 *"If they are designing those and especially for children, they would want to make them child friendly, in other words put some type of funny face or something on the patch so that the child would keep them on"*

FG1P4 *"Make it completely invisible so the child doesn't notice it"*

FG3P4 *"What about making them more child-friendly, like with Disney princesses or superheroes or something?"*

Focus groups discussed that acceptability for use in a paediatric population would be increased by an initial period of use in an adult population, permitting familiarisation with the microneedle technology:

FG1P1 *"But if it becomes an accepted norm for adults, then they'll more easily put it on their kids"*

FG2P3 *"If it was in widespread use as a technology for adults that we were more comfortable with it, familiar with it, you know that you'd be a bit more open to extending what's normal for an adult to a child"*

iii. Potential for parental administration

Participants acknowledged the potential benefits of parental administration, including convenience and a reduction in fear for the child:

FG1P1 *"Avoids the hassle of having to go"*

FG3P2 *"It would be a lot easier, as parents to put them on ourselves because bringing any child to a doctor is going to put fear in them anyway so doing it ourselves, it takes the fear factor completely out of it"*

FG6P4 *"This is more casual and relaxed. Just like putting on a band aid"*

However, a large number of parents indicated a level of discomfort with administration to their own children. Many participants believed that healthcare professionals ought to administer the vaccine, regardless of the delivery system, while others recognised the benefits of parental administration but would prefer medical supervision and reassurance should they be administering the vaccine to their own child. Participants discussed the need for reassurance that the patches would be easy to use, with minimal guidance or training.

FG1P2 *"You'd need to be told or shown first…before you did it yourself"*

FG2P3 *"How hard would you need to push, would you be literally ramming it against the skin?...my child I guarantee would end up with a bruised arm I'd be pushing so hard"*

FG3P2 *"Like I presume there's no danger with us putting them on ourselves, you know, there's no special way to put them on or anything like that"*

In addition, participants raised concerns regarding the potential elimination of current vaccine surveillance and monitoring systems and reduced traceability that may be associated with wide-spread parental administration, suggesting that convenience may result in a level of complacency and /or non-compliance:

FG1P4 *"The HSE will send you out a letter to tell you your vaccination is due. If you don't go, they will keep contacting you with letters…I know I would be quite lackadaisical, knowing it's there and I can do it any time, I won't do it"*

FG3P5 *"People could genuinely forget, leave it in the cupboard and say I'll do it later"*

FG1P1 *"We'd have to put something in place or else we would have no idea who was vaccinated"*

Many groups discussed how the inclusion of a delivery indicator would be necessary to provide reassurance that the appropriate dose had been administered, with participants offering suggested alterations to the current patch system.

FG2P1 *"But even something that when you put it on and then when it changed colour or did something, 100%, you know it's done"*

FG4P1 *"Is there any way you could tell they got the full amount? Like if it just fell off or something when it was done dissolving"*

FG6P2 *"It would be great if it changed colour or something, like change to green when it's time to take it off and stay red when it's dissolving or whatever. That could almost turn into a game and encourage the child to leave it on"*

iv. The role of the healthcare professional

The pivotal role played by healthcare professionals, such as doctors, nurses and pharmacists, in guiding healthcare decisions and supervising and providing medical care was revealed.

FG4P5 *"When the doctor told me to come in for the jabs, I just did"*

FG6P1 *"I think if my doctor recommended this patch and trusted it, I would be happy with it. I have to rely on them for information because if you gave me all the clinical study information or whatever in the world, I would not understand it"*

FG1P3 *"Even if the pharmacist would administer it. At least there's some kind of monitoring then"*

v. Special populations

Participants identified the potential for allergy associated with microneedle-patch vaccines, suggesting that this technology may be unsuitable for hypersensitive individuals.

FG2P4 *"Would you not expect reactions to occur, if dissolving in the skin, like allergy?"*

FG4P3 *"Could kids be allergic to it? To the plaster part. People are allergic to plasters aren't they?"*

FG5P3 *"Or what if a child has very sensitive skin, would the patch irritate it?"*

Focus group participants discussed alternative uses for the microneedle-patch, without prompt. It was highlighted that because a microneedle-patch would cause less pain on administration, the technology could provide an attractive alternative in the treatment of a variety of conditions, where a needle and syringe are conventionally required. This was deemed particularly useful in situations where multiple, repeated injections are required.

FG3P4 *"You know people are on monthly injections of immune suppressants and stuff, maybe it could replace those…and diabetics as well, poor things have to inject loads of times per day"*

FG4P2 *"My nephew is diabetic and has to give himself insulin all the time. He's 15 you know and poor fella hates being different and kind of, standing out. Wouldn't it be great if he could just stick on the patch instead? No one would even see it"*

FG5P1 *"Wouldn't they be great for babies in neonatal? The 'preemies' or even the sick babies and children that need to get lots of daily injections?"*

FG6P2 *"Like insulin for diabetics. I think a patch like this would be great and they'd be checking their sugars anyway so they'd be sure it was working"*

Discussion

The aim of this qualitative study was to determine the acceptability of microneedle technology for paediatric vaccination in a population of Cork city parents. According to the Health Service Executive (HSE) in Ireland, the target vaccine uptake rate for childhood immunisations is ≥95%. In their most recently available data, the Health Protection and Surveillance Centre (HPSC) reports that only the 6-in-1 vaccine (D_3, T_3, P_3, Hib_3, $Polio_3$ and $HepB_3$) administered to children at 24 months of age in 2015 had reached the target uptake rate of 95% (26). Therefore, there is scope for improving vaccine uptake, potentially through the introduction of novel immunisation methods, such as microneedle technology, as explored in this study. Whilst many sub-themes emerged, the five dominant themes that were revealed by thematic analysis were: (i) concern, (ii) suitability for paediatric use, (iii) potential for parental administration, (iv) the role of the healthcare professional and (v) special populations. Capturing the opinions of parents: the ultimate decision makers in paediatric vaccination, is crucial in the understanding of the eventual uptake of microneedle technology and therefore adds to literature currently available.

Six focus groups compiled the opinions of 32 participants (29 female). Such a gender imbalance is not unusual: mothers are found to be more likely to participate in clinical research (21). Parental concern emerged as an overarching theme in this qualitative study. Participants alluded to established issues associated with conventional hypodermic needles, including phobias, pain, side effects and paediatric and parental anxiety (27-29). In addition, some parents expressed concern regarding school vaccination programmes and their potential to cause hysteria, particularly in association with the administration of adolescent vaccines (30, 31). These concerns may act as drivers for the acceptance of an alternative vaccine delivery system, such as microneedle technology. However, before a novel vaccine delivery system can be considered for acceptance, an effort must be made to address current vaccine concerns. Despite declaring that their children were fully vaccinated, one participant in this study (FG3P2) expressed opinions which questioned the safety and efficacy of vaccines. Benin *et al* would categorise this participant as "vaccine-hesitant", accepting vaccination in spite of significant concerns (32, 33). Vaccine hesitancy presents a significant challenge, requiring a multidisciplinary approach (34). Many studies have shown that increasing knowledge alone will not change behaviour and reduce vaccine hesitancy (35). Efforts focussed on determining how parents make decisions regarding vaccination, how their attitudes and beliefs develop, and where they obtain information, should contribute to better understanding of vaccine hesitancy (34, 36). This study revealed that even "vaccine-acceptors", those who agree with or do not question vaccination (32), will question the safety and efficacy of novel immunisation methods (37). In agreement with published literature, our results suggest that lack of familiarity may act as a barrier to acceptance (19-21). However this barrier may be diminished by highlighting the advantages of microneedle-patch vaccines over conventional vaccination, by administering adult vaccines, such as influenza, using microneedle technology before

progressing to paediatric use (6, 9, 38) and by securing healthcare professional endorsement (37). In addition, it is likely that parents would benefit from educational programmes that highlight the manner in which safety and efficacy assessments are conducted prior to licensure (37).

Microneedle technology has been identified as ideal for paediatric use (19-21). However, this is the first study which asked participants to specifically consider a patch delivery system and this resulted in both the suitability and feasibility being challenged. Whilst participants recognised and acknowledged the benefits of the technology, concern was expressed regarding the wear-time required. Vaccinees must wait for the required periods of time for the microneedles to detach from the backing layer or dissolve into the skin before the patch can be removed. Participants expressed concern that paediatric tolerance of such a requirement would be low. In agreement with previous research, it was suggested that by creating a child-friendly version of the delivery system, children may be encouraged to leave the patch in place for the required amount of time (20). Various approaches have been developed to overcome the issue of prolonged wear-time (39). Two layered dissolving microneedles and arrowhead microneedles, consisting of a therapeutic polymer layer and a shaft, respectively, have been designed to deliver with greater efficiency (40, 41). Alternatively, a soft lithography approach based on a water soluble patch system has been introduced to increase delivery efficency by dissolving the patch after microneedle application (42). Given the parental concerns expressed, these approaches may warrant further investigation for the delivery of paediatric vaccines.

A well-documented advantage of microneedle-patch vaccines is the potential for self-administration (1, 6-8, 19, 20). One US study which examined the usability and acceptability of microneedle patches for self-vaccination against influenza reported that when given self-administration options, intent to be immunised increased significantly, suggesting that microneedle technology could increase vaccine coverage (6). Of those participants who expressed a preference for microneedle-mediated immunisation, 72% preferred self-administration at home, 12% preferred self-administration in the presence of a healthcare professional and 16% preferred administration by a healthcare professional (6). While self-administration of paediatric vaccines is not feasible, participants were asked to consider the acceptability of parental administration. The majority of participants in our study preferred vaccine administration by a healthcare professional, contradicting research by Birchall *et al*, who reported that 80% of participants disagreed with the statement *"I don't think I would want to administer microneedles to a child in my care"* (19). In agreement with previous research, participants suggested that the inclusion of a delivery indicator would be a desirable augmentation of the current design (19, 20). A colour change was also suggested, combining dual benefits of increasing paediatric appeal and confirming delivery. Participants expressed concern that widespread parental administration could result in an intentional or unintentional reduction in immunisation rates and a decrease in population vaccine coverage overall. The national childhood immunisation programme, which recommends the administration of 15 vaccines from birth to approximately five

years of age, is currently co-ordinated by general physicians (GP) and a series of Local Health Offices (23). The introduction of parental administration of vaccines would warrant the development of a National Immunisation Database, which would facilitate self-reporting of immunisation status and ensure vaccine traceability.

The purpose of this study was to determine the acceptability of vaccine delivery by microneedle technology. However, similar to previous research, participants discussed alternative uses of this technology, particularly in the management of conditions where repeated injections are warranted, such as insulin in the management of diabetes, analgesics in the management of chronic pain, anti-rheumatic agents in the management of arthritis and chemotherapeutic agents in the treatment of cancer (19). The clinical assessment of microneedle-mediated delivery of many drugs and macromolecules is already established (2, 43-47). Parental enthusiasm for microneedle-patch technology was increased by the exploration of alternative uses other than vaccination. It may be suggested that on-going monitoring in conditions such as diabetes is routine, thus providing continuous confirmation of efficacy, unlike vaccination, where confirmation of immunity is not routinely performed. By introducing microneedle technology for the management and treatment of these identified conditions, familiarity would be increased; there would be a tangible demonstration of safety and efficacy; and parental acceptance of microneedle-patch vaccines could be increased. In agreement with previous research, parents compared the delivery system to a sticking plaster and therefore expressed concern regarding the allergenic potential of microneedle-patch vaccines (19-21). It has been reported that the materials used in the fabrication of patch systems can cause skin irritation and allergic reactions (48). Similar to transdermal patch products, the use of a hypoallergenic system to ensure more widespread suitability and to reduce allergy potential would be necessary.

Healthcare professionals including doctors, nurses and pharmacists will play a crucial role in the clinical success of microneedle-patch vaccines. Parent interactions with healthcare professionals are a key factor shaping parental attitudes to vaccination (49). An effective interaction can alleviate concerns of vaccine supportive parents and motivate a hesitant parent towards acceptance (50, 51). These parental concerns are likely to escalate with increased complexity of vaccination schedules, increased access to information sources of variable reliability (52) and the emergence of novel immunisation methods, such as microneedle technology. Healthcare professional endorsement of a novel technology is critical to its success. Previous research has reported a positive response to microneedle technology by healthcare professionals (6, 19). Continuous professional development (CPD) could facilitate training in this technology and in parent engagement, according to proposed recommendations (53-55). Guided by parental concerns expressed in relation to parental and self-administration, it is likely healthcare professionals will retain the responsibility of vaccination, ensuring traceability and appropriate clinical management. . Limitations of this study include small

sample size (n=32), participant self-selection and the necessary provision of factual information by the moderator.

Conclusion

This is the first study to explore parental acceptance of microneedle-patch vaccines. While participants in this study remained tentative regarding microneedle technology, it was revealed that this tentativeness could be reduced by healthcare professional endorsement. Therefore, this study has identified the role of healthcare professionals in disseminating information and providing support to parents. An increased awareness of developments in microneedle technology is needed to permit informed decision-making by parents.

References

1. Prausnitz MR, Mikszta JA, Cormier M, Andrianov AK. Microneedle-based vaccines. Vaccines for Pandemic Influenza: Springer; 2009. p. 369-93.
2. Kim Y-C, Park J-H, Prausnitz MR. Microneedles for drug and vaccine delivery. Advanced drug delivery reviews. 2012;64(14):1547-68.
3. Mistilis MJ, Bommarius AS, Prausnitz MR. Development of a thermostable microneedle patch for influenza vaccination. Journal of pharmaceutical sciences. 2015;104(2):740-9.
4. Choi H-J, Yoo D-G, Bondy BJ, Quan F-S, Compans RW, Kang S-M, et al. Stability of influenza vaccine coated onto microneedles. Biomaterials. 2012;33(14):3756-69.
5. Chen X, Fernando GJ, Crichton ML, Flaim C, Yukiko SR, Fairmaid EJ, et al. Improving the reach of vaccines to low-resource regions, with a needle-free vaccine delivery device and long-term thermostabilization. Journal of controlled release. 2011;152(3):349-55.
6. Norman JJ, Arya JM, McClain MA, Frew PM, Meltzer MI, Prausnitz MR. Microneedle patches: usability and acceptability for self-vaccination against influenza. Vaccine. 2014;32(16):1856-62.
7. Sullivan SP, Koutsonanos DG, del Pilar Martin M, Lee JW, Zarnitsyn V, Choi S-O, et al. Dissolving polymer microneedle patches for influenza vaccination. Nature medicine. 2010;16(8):915-20.
8. Kim Y-C, Quan F-S, Yoo D-G, Compans RW, Kang S-M, Prausnitz MR. Improved influenza vaccination in the skin using vaccine coated microneedles. Vaccine. 2009;27(49):6932-8.
9. Van Damme P, Oosterhuis-Kafeja F, Van der Wielen M, Almagor Y, Sharon O, Levin Y. Safety and efficacy of a novel microneedle device for dose sparing intradermal influenza vaccination in healthy adults. Vaccine. 2009;27(3):454-9.
10. Quan F-S, Kim Y-C, Compans RW, Prausnitz MR, Kang S-M. Dose sparing enabled by skin immunization with influenza virus-like particle vaccine using microneedles. Journal of controlled release. 2010;147(3):326-32.
11. Moon S, Wang Y, Edens C, Gentsch JR, Prausnitz MR, Jiang B. Dose sparing and enhanced immunogenicity of inactivated rotavirus vaccine administered by skin vaccination using a microneedle patch. Vaccine. 2013;31(34):3396-402.
12. Naito S, Ito Y, Kiyohara T, Kataoka M, Ochiai M, Takada K. Antigen-loaded dissolving microneedle array as a novel tool for percutaneous vaccination. Vaccine. 2012;30(6):1191-7.
13. Marshall S, Sahm LJ, Moore AC. The success of microneedle-mediated vaccine delivery into skin. Human vaccines & immunotherapeutics. 2016(just-accepted):00-.
14. Kaushik S, Hord AH, Denson DD, McAllister DV, Smitra S, Allen MG, et al. Lack of pain associated with microfabricated microneedles. Anesthesia & Analgesia. 2001;92(2):502-4.

15. Haq M, Smith E, John D, Kalavala M, Edwards C, Anstey A, et al. Clinical administration of microneedles: skin puncture, pain and sensation. Biomedical microdevices. 2009;11(1):35-47.
16. Abelson J, Forest P-G, Eyles J, Smith P, Martin E, Gauvin F-P. Deliberations about deliberative methods: issues in the design and evaluation of public participation processes. Social science & medicine. 2003;57(2):239-51.
17. Calnan M, Montaner D, Horne R. How acceptable are innovative health-care technologies? A survey of public beliefs and attitudes in England and Wales. Social Science & Medicine. 2005;60(9):1937-48.
18. Agency EM. Guideline on pharmaceutical development of medicines for paediatric use. In: (CHMP) CfMPfHU, editor. 2013.
19. Birchall JC, Clemo R, Anstey A, John DN. Microneedles in clinical practice–an exploratory study into the opinions of healthcare professionals and the public. Pharmaceutical research. 2011;28(1):95-106.
20. Mooney K, McElnay JC, Donnelly RF. Children's views on microneedle use as an alternative to blood sampling for patient monitoring. International Journal of Pharmacy Practice. 2014;22(5):335-44.
21. Mooney K, McElnay JC, Donnelly RF. Parents' perceptions of microneedle-mediated monitoring as an alternative to blood sampling in the monitoring of their infants. International Journal of Pharmacy Practice. 2015;23(6):429-38.
22. Carey MA, Asbury J-E. Focus group research: Routledge; 2016.
23. Skills DoEa. Find-a-school. Available from: http://www.education.ie/en/find-a-school.
24. International Standard Classification of Education ISCED 2011. United Nations Educational, Scientific and Cultural Organization, 2011.
25. Marshall S, Sahm LJ, Moore AC. Microneedle technology for immunisation: Perception, acceptability and suitability for paediatric use. Vaccine. 2016;34(6):723-34.
26. Immunisation Uptake Statistics 2015 [updated January 2017; cited 2017 7th March]. Available from: http://www.hpsc.ie/A-Z/VaccinePreventable/Vaccination/ImmunisationUptakeStatistics/Immunisationuptakestatisticsat12and24monthsofage/.
27. Ayala ES, Meuret AE, Ritz T. Treatments for blood-injury-injection phobia: a critical review of current evidence. Journal of psychiatric research. 2009;43(15):1235-42.
28. Hamilton JG. Needle phobia: a neglected diagnosis. Journal of Family Practice. 1995;41(2):169-76.
29. Kleinknecht RA. Acquisition of blood, injury, and needle fears and phobias. Behaviour research and Therapy. 1994;32(8):817-23.
30. Bartholomew RE, Rickard B. Mass Hysteria in Schools: A Worldwide History Since 1566: McFarland, Incorporated Publishers; 2013.
31. Yasamy M, Bahramnezhad A, Ziaaddini H. Postvaccination mass psychogenic illness in an Iranian rural school. 1999.
32. Benin AL, Wisler-Scher DJ, Colson E, Shapiro ED, Holmboe ES. Qualitative analysis of mothers' decision-making about vaccines for infants: the importance of trust. Pediatrics. 2006;117(5):1532-41.
33. SAGE Working Group on Vaccine Hesitancy [cited 2016 6th December]. Available from: http://www.who.int/immunization/sage/sage_wg_vaccine_hesitancy_apr12/en/.
34. Kestenbaum LA, Feemster KA. Identifying and addressing vaccine hesitancy. Pediatric annals. 2015;44(4):e71-e5.
35. Dubé E, Vivion M, MacDonald NE. Vaccine hesitancy, vaccine refusal and the anti-vaccine movement: influence, impact and implications. Expert review of vaccines. 2015;14(1):99-117.
36. Leask J, Willaby HW, Kaufman J. The big picture in addressing vaccine hesitancy. Human vaccines & immunotherapeutics. 2014;10(9):2600-2.

37. Freed GL, Clark SJ, Butchart AT, Singer DC, Davis MM. Parental vaccine safety concerns in 2009. Pediatrics. 2010;125(4):654-9.
38. Arnou R, Frank M, Hagel T, Prébet A. Willingness to vaccinate or get vaccinated with an intradermal seasonal influenza vaccine: a survey of general practitioners and the general public in France and Germany. Advances in therapy. 2011;28(7):555-65.
39. Lahiji SF, Dangol M, Jung H. A patchless dissolving microneedle delivery system enabling rapid and efficient transdermal drug delivery. Scientific reports. 2015;5.
40. Chu LY, Prausnitz MR. Separable arrowhead microneedles. Journal of controlled release. 2011;149(3):242-9.
41. Chen M-C, Huang S-F, Lai K-Y, Ling M-H. Fully embeddable chitosan microneedles as a sustained release depot for intradermal vaccination. Biomaterials. 2013;34(12):3077-86.
42. Moga KA, Bickford LR, Geil RD, Dunn SS, Pandya AA, Wang Y, et al. Rapidly–dissolvable microneedle patches via a highly scalable and reproducible soft lithography approach. Advanced Materials. 2013;25(36):5060-6.
43. So J-W, Park H-H, Lee SS, Kim D-C, Shin S-C, Cho C-W. Effect of microneedle on the pharmacokinetics of ketoprofen from its transdermal formulations. Drug delivery. 2009;16(1):52-6.
44. Cormier M, Johnson B, Ameri M, Nyam K, Libiran L, Zhang DD, et al. Transdermal delivery of desmopressin using a coated microneedle array patch system. Journal of controlled release. 2004;97(3):503-11.
45. Gupta J, Felner EI, Prausnitz MR. Minimally invasive insulin delivery in subjects with type 1 diabetes using hollow microneedles. Diabetes technology & therapeutics. 2009;11(6):329-37.
46. Nordquist L, Roxhed N, Griss P, Stemme G. Novel microneedle patches for active insulin delivery are efficient in maintaining glycaemic control: an initial comparison with subcutaneous administration. Pharmaceutical research. 2007;24(7):1381-8.
47. Zhang Y, Brown K, Siebenaler K, Determan A, Dohmeier D, Hansen K. Development of lidocaine-coated microneedle product for rapid, safe, and prolonged local analgesic action. Pharmaceutical research. 2012;29(1):170-7.
48. Trookman NS, Rizer RL, Weber T. Irritation and allergy patch test analysis of topical treatments commonly used in wound care: Evaluation on normal and compromised skin. Journal of the American Academy of Dermatology. 2011;64(3):S16-S22.
49. Leask J, Kinnersley P, Jackson C, Cheater F, Bedford H, Rowles G. Communicating with parents about vaccination: a framework for health professionals. BMC pediatrics. 2012;12(1):1.
50. Gust DA, Darling N, Kennedy A, Schwartz B. Parents with doubts about vaccines: which vaccines and reasons why. Pediatrics. 2008;122(4):718-25.
51. Kennedy A, LaVail K, Nowak G, Basket M, Landry S. Confidence about vaccines in the United States: understanding parents' perceptions. Health Affairs. 2011;30(6):1151-9.
52. Betsch C, Brewer NT, Brocard P, Davies P, Gaissmaier W, Haase N, et al. Opportunities and challenges of Web 2.0 for vaccination decisions. Vaccine. 2012;30(25):3727-33.
53. Sturm LA, Zimet GD, Klausmeier T. Talking with concerned parents about immunization. Zero to Three (J). 2010;30(5):11-8.
54. Tenrreiro KN. Time-efficient strategies to ensure vaccine risk/benefit communication. Journal of pediatric nursing. 2005;20(6):469-76.
55. Healy CM, Pickering LK. How to communicate with vaccine-hesitant parents. Pediatrics. 2011;127(Supplement 1):S127-S33.