20674-D04 D14 Market Analysis Report

20674 COSMO@Home – Preparing Children at Home for MR Scanning; a COSMOnautic Virtual Reality Fairy Tale

EIT Health

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Contents

Executive Summary

This report summarizes the results of stakeholder analysis for the EIT-COSMO@home project. This analysis consisted of three steps:

- First, relevant stakeholders were identified, distinguishing between users (e.g., patients, child life specialists) and decision-making units (DMUs, e.g., radiology managers) in three levels: the target group, primary influencers, and secondary influencers.
- Next, we engaged with stakeholders from the target group and primary influencers (pediatric patients & their parents, MR Technologists, Radiologists, heads of (pediatric) radiology, C-suite members, Child Life Specialists, and referring physicians). We did this through conversations, workshops, conferences, and studies. Because there was limited geographical diversity in the stakeholders we initially engaged with, we also gave eight workshops to Global Application Specialists from different markets (incl. South East Asia, Latin America, the Middle East, and Japan). We administered questionnaires to gauge the interest, needs & willingness to pay in these markets.
- Finally, we conducted an extensive literature review and created a competitor overview to understand better how our proposed solution compares to existing solutions. Based on this analysis, we conclude that there is a need for an interactive app to reduce anesthesia rates in pediatric MRI. Stakeholders indicate a need for a solution that is accessible (e.g., available in multiple languages; adaptive to patients with different developmental ages), engaging, and gamified. Various stakeholders highlight other rationalizations for using the app, but their needs largely converge. From the analysis, two clear themes emerged: the need for accessibility of the app (e.g., in terms of language & costs) and the need for interactivity/serious gamification. Implications for further development/productization are discussed,

Introduction

Report outline

Undergoing an MRI-exam can be a stressful experience for pediatric patients and their parents/ caregivers. The COSMO@home project develops a COSMO@Home app that prepares pediatric patients for their MRI-exam so they know what to expect and, hopefully, can be scanned without anesthesia/sedation the future. The current report aims to summarize the results of an analysis of the needs of intended users and customers of the COSMO@home app. This report starts by outlining the target group & primary/secondary influencers of the target group. Next, we summarize a stakeholder analysis. After this, alternatives to the COSMO@home app are reported, both from academic literature and existing commercial/non-commercial solutions. We conclude by summarizing what this analysis

means for the COSMO@home project and how the features of the COSMO@home app relate to stakeholder needs.

Stakeholder mapping

When identifying stakeholders, there are different levels of stakeholders that can be identified. Figure 1 displays a stakeholder map outlining these various stakeholders (target group, primary influencers, and secondary influencers). The different levels of stakeholders can be divided into people how are deciding when implementing new technology (Decision Making Unit (DMU)) and people who will apply the technology (Main users). In the diagram, this is visualized by showing at the left-hand part the Decision Making Units (who make/influence purchasing decisions) and on the right-hand part the users. This diagram was used during an internal Philips workshop, including people from marketing, MRI technologists, application specialists, and clinical scientists.

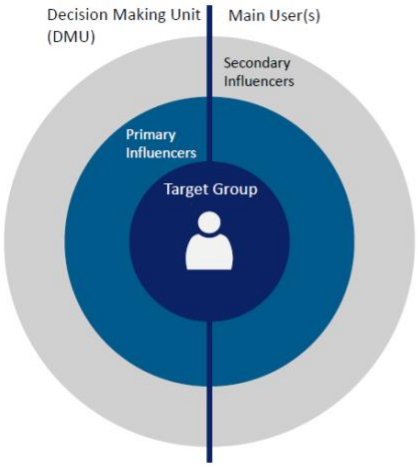


Figure 1. Stakeholder map

As displayed in Figure 1, the following levels of stakeholders can be distinguished:

1. The target group (in dark blue), consisting of a) the Decision Making Units (DMUs), who are in charge of deciding to purchase the intended solution; and b) the Main users (the people who will be using the conscious solution).
2. The primary influencers (in light blue): these are people who have a stake in the solution but are not intensely using it and are not in charge of making a purchasing decision. They can exert influence on the decision making process (DMUs) and/or users.
3. The secondary influencer (in grey): they may exert influence on the primary influencers and/or may impact the target group, but this effect is less direct than the impact of the primary influencer.

As part of the workshop outcome, the stakeholders can be defined as follows for the Cosmo@home app:

Target group

DMU	Main User(s)
Head of radiology	Patient
C-suite	Patient's parents/caregivers
	MR Technologist
	Child Life Specialist

Primary influencers

DMU	Main User(s)
Child Life specialist	Referring physician
MR Technologist	

Secondary influencers

DMU	Main User(s)
Anesthesiologist	Media/public opinion
Health insurance companies	Patient organizations
Professional organizations (e.g., Association for Child Life Specialists)	
Media/public opinion	

These stakeholders all have a role to play in the successful adoption of COSMO@home app, but the influence of the Target group & primary influencers is the largest. As such, we focused most of our effort on analyzing the needs of these groups.

Stakeholder analysis

Insights from workshops, interviews, customer visits & conferences

Through several channels, we tried to interact with as many stakeholders as possible. These discussions took place throughout 2019 and 2020: after the onset of the COVID-epidemic, the number of face-to-face meetings reduced drastically, and we were forced to have more limited online interactions. Because many conferences were moved, canceled, or held online, interaction possibilities were more limited in Q2-Q4 of 2020 than for Q1 2020 and 2019.

Project members (or their colleagues) discussed the proposition with radiologists, heads of (paediatric) radiology, C-suite members, MR technologists, and Child Life Specialists at several conferences (incl. The European Society for Pediatric Radiology, Society for MR Radiographers & Technologists/International Society for Magnetic Resonance in Medicine, Society for Pediatric Radiology and Radiology Society North America). During these conferences, the solution was presented via slide deck on a display/tablet to interested health care providers (HCPs), and in some instances, short demos of the app were given (e.g., of the introduction video used in the app and overview of possible components). The length and

content of these interactions varied, depending on practical considerations; some discussions lasted for mere minutes while others stayed for more than an hour.

In addition, project members visited several hospitals prior to COVID19, amongst others in Germany, Belgium, The Netherlands, and Spain, to have in-depth conversations onsite. Workshops were organized in Germany (for radiologists/heads of radiology) and Leuven (for radiologists and pediatricians, who are often the referring physicians for pediatric MRI scans).

In addition, UZ Leuven tested the COSMO@Home app in clinical practice and received feedback from pediatric patients & their parents. To obtain additional input to gauge parents' & patients' needs in another geography, Philips initiated another study at a hospital in the US (Cincinnatti Hospital & Medical Center) and received in-depth feedback from 28 pediatric MRI-patients (aged 5 to 9) and their parents.

The consortium interacted with stakeholders from the target group and primary influencers as described in the introduction. Many of the needs stakeholders voiced converged, albeit sometimes for different reasons. For example, although many stakeholders indicated that they wished to reduce the need for anesthesia, their reasoning differed. For instance, whereas parents told that anesthesia was unpractical because it increased the time their child had to spend at the hospital, highlighted the difficulty of keeping their child sober before the MRI exam or discussed their child's fear of a needle procedure to induce anesthesia, other stakeholders voiced different reasoning to reduce anesthesia rates. For example, one head of radiology highlighted safety concerns, while a C-suite member we talked to mentioned a need to improve patient satisfaction rates in her hospital.

As such, different stakeholders discussed different needs and concerns, but these mostly led to similar requirements. Although most of the stakeholders were highly positive about the proposed solution, several radiologists and MR Technologist mentioned that changing to a sedation-free workflow is challenging and will not be achievable for all patients. Additionally, several Child Life Specialists in the North America-market highlighted the need to include many different languages in the app to make it accessible to different patients and their parents. They also highlighted a need to complement the app with non-digital material (books, information leaflets or other information sources) to make it accessible to parents who may not have unlimited internet access. Finally, they highlighted that the app needs to be free for patients & their parents: otherwise, the children who may need it most may not have access. Several Child Life Specialists highlighted that this is a matter of equity, fairness, and effectiveness.

Several parents, child life specialists, and MR technologists highlighted the need for interactivity, adaptivity, and serious gaming. Child life specialists indicated that, for pediatric patients, calendar age and developmental age might differ, making it challenging to create age categories for an app. Fun, interactive, gamified content was regarded as essential to keep kids motivated to play the app. Moreover, child life specialists indicated that children do not learn passively: making sure the app teaches kids about MRI in different ways, with a lot of repetition and playfulness, ensures that kids master the required learning goals.

One final thing that was mentioned by several heads of radiology was pricing. Everyone agreed that patients should not have to pay for the app; instead, the hospital should cover costs. Several heads of radiology indicated that they would be unwilling to purchase an app if the price was too high. All of them suggested that the app should be free to use for patients. To investigate further, we asked 10 (heads of) radiology/radiologists to indicate if they would be willing to pay for a pediatric app if the

app's price was comparable to the price of a new coil. 7/10 said they would be willing to pay; 1 said only if the price was <5k: the other 2 showed no willingness to pay.

Insights from Global Application Specialists

The interactions mentioned above mostly focused on stakeholders in Europe and North America. We wanted to get a broader view of the potential needs/willingness to pay for customers in other markets. To gain insight into those markets that Philips operates in, in Q1 2020, project members gave eight workshops for global Philips MRI application specialists who work in hospitals across the globe. After the workshops, in which we showed (parts of) the proposed solution, we used a questionnaire to learn more about the needs/potential hurdles in different markets. Given that application specialists often work in multiple hospitals (e.g., traveling between sites) and interact with healthcare providers daily, global application specialists can help us gain much insight into possible acceptance of new solutions, user/customer needs, and market-specific needs/concerns.

Through the questionnaires, we received information from 74 application specialists from different regions (incl. amongst others: Japan, India, Latin America, Central/Eastern Europe, North America, Middle East/Turkey, Russia/Central Asia, Australia, India, and Southeast Asia). Attachment 2 contains more information about the markets that were covered, as well as detailed answers. In general, respondents indicated that they thought the hospitals they work in would be highly interested in an app to prepare pediatric patients, reporting slightly higher interest in a simple, generic app (M = 4.42 on a 5-point scale) than in a version that is tailored to the hospital (M = 4.32) or fully connected to the EMR (M = 4.19). Willingness to pay was rated as a bit lower, ranging from 3.51 for a connected version to 3.32 for a simple, generic version of an app. Many respondents indicated that a one-time sales model would be preferred over a pay-per-use/pay-per-moth model. Respondents from mature markets indicated higher acceptance of novel business models (such as pay-per-use) compared to emerging markets.

In addition to these quantitative data, applicant specialists gave detailed comments on all aspects of the proposed app, including the character (Ollie), offered games, and videos. This feedback helped us gauge the cultural acceptability of the proposed app to accommodate market-specific concerns and sensitivities. Many application specialists highlighted the need to ensure that the app is available in different languages and that it can be downloaded on both iPhone and Android phones. Several respondents indicated that, in their market, multiple languages are spoken besides the primary (official) language, ensuring availability in these languages (e.g., Spanish for the US; Russian for some countries in Central/Eastern Europe) increases the accessibility of the app to all patients. Moreover, many respondents highlighted the need to ensure that the app is fun/gamified, so kids are motivated to play it, and parents do not need to spend too much time helping their child.

Overview of existing solutions

Literature overview

We conducted a literature review to identify alternatives to the COSMO@home app by looking at literature on interventions geared towards anxiety-reduction and/or anesthesia reduction in pediatric MRI. Attachment 1 contains a full overview of our literature analysis, including relevant references. Based on the current literature, MRI preparation seems beneficial and worth pursuing: however, there seem to be relatively few high-quality randomized clinical trials (RCTs) looking at the effects of comprehensive interactive, at-home serious gaming preparation.

Competitor overview

To get more insight into existing competitor solutions, we conducted a comprehensive search of existing mobile applications and other preparation solutions (including books, toys, and movies). These solutions are depicted in Figure 2. Mobile applications are depicted in green: other solutions in blue. Availability is defined for apps based on the app's availability in both the Apple App Store and Google Play Store, and availability in multiple languages. Furthermore, we distinguished between apps launched by a commercial party (c) and apps launched by none governmental organization (NGO), university hospital, non-academic hospital, or other non-commercial entity (NC). We also analyzed if each app is based on a theoretical framework/theory or not.

Based on this analysis, we can conclude that all mobile applications except the Siemens MRI experience has limited availability, meaning that these apps are available in either the Apple App Store or on Google Play Store and are only available in specific geographies and/or in 1 or 2 languages. Most apps have been created for a particular hospital and are available in that language (e.g., Scankids is available in Spanish; Pingunautentrainer in German, etc.). The Siemens Scan Experience is available on Apple App Store for iPad, not for iPhone. It is not a dedicated app for children. Most information is in complex texts and contains little gamification.

Of the existing app, Rumble in MRI (Denmark) and Pingunautentrainer (Germany) are based on a solid theoretical framework; Okee (Australia) and Pingunautentrainer (Germany) contain strong, serious gaming elements. There is no existing app with high availability, multilanguage, strong gamification, a clear theoretical framework.

Alternative preparation solutions consist of videos/books that can be used for at-home preparation and toys often used in the hospital. There are many small-scale initiatives geared toward specific hospitals or departments. Solutions with wider availability include Lego toy scanners, the Siemens toy scanner, Philips Kitten Scanner, and Le Petit Prince toy scanner. These solutions can be complementary to at-home preparation.

Figure 2. Overview of existing solutions to prepare pediatric patienst for their MRI scan.

Conclusion

Several sources of information were used for this stakeholder analysis, including interviews/customer interactions, workshops, questionnaires, and literature study. Based on these data, we conclude a clear need for an interactive, serious gaming app with high accessibility, and such a solution is currently not available in the market. Even though different stakeholders highlight different needs and sometimes provide different reasoning to come to those needs, many overlapping requirements were found from the analysis. Two main themes emerged from this analysis:

1. **Accessibility**
   The feedback from different stakeholders indicates that the solution needs to be accessible. This means that it should be available in different languages so that children in different countries can use and understand the app, and the app is available in languages other than the official language of a country for minorities. It also means that the app needs to be available for iPhone and Android devices. Finally, several stakeholders indicated that the app should be free-of-charge for patients & their parents/caregivers to ensure optimal accessibility.

2. **Interactivity & serious gaming**
   Different data sources indicated that the app needs to be fun to play for kids and needs to be interactive, gamified, and repeat content in various ways to ensure that as many children as possible grasp the learning goals after playing the app.

These themes are an essential input for further business case development. Moreover, they provide clear information about the requirements for converting the app from a prototype to a product, e.g., indicating the importance of adding multiple languages and making the app widely available. These recommendations will be taken into account in the further development of the app.

Attachment 1: MRI preparation for pediatric patients – scientific literature overview

Review method

This review summarizes the literature on MRI preparation for children. This overview aims to present both the current status quo in the literature and innovations going beyond it, based on recent and recently discussed publications. Literature was gathered using PubMed and Google Scholar. Scanning literature broadly was followed by a more narrow systematic search. An Initial Google Scholar query with the keywords 'review pediatric MRI preparation' limited to 2019 yielded current literature reviews on the topic (Janos et al, 2019; Dong et al, 2019), and recent original research publications with representative or innovative approaches. They were included and summarized. Papers referenced in these articles were then, in turn, read and summarized themselves if they met the criteria. This way, many articles were included through references from current literature reviews and articles from the initial Google Scholar query. A review on awake pediatric radiotherapy (RT) found this way (O'Connor & Halkett, 2018) had a strong systematic approach and lead to the inclusion of several articles on pediatric preparation for RT without anesthesia. As soon as scanning references failed to provide more suitable publications, systematic PubMed queries were used to find more literature. The terms MRI, MR, scan, and radiology, were combined with search terms associated with awake scanning (unsedated, non-sedated, awake); pediatric patient groups (pediatric, child, adolescent); preparation (preparation, supportive); and psychology-based interventions (psychological, psychosocial).

Results were then checked against more narrowly defined criteria to ensure they were relevant. Papers from this systematic search needed to be published between November 2017 and November 2019. They were more likely to be included if they covered the age group 3-11; were prospective, randomized, controlled or had more than 60 study subjects; provided less common measures for parent and child satisfaction, like in depth interviews or physiological assessments; had an intervention that was not a child-life specialists, mock scanner training, or a preparatory video; or had results with great statistical significance. More articles were included based on this search. Lastly, articles discussing effects of anesthesia on children were found through the references of papers on MRI preparation. All reviews and most interventional studies motivate pediatric MRI preparation with adverse effects of anesthesia on children, and thus quote literature on the topic. Among many publications on the issue, four recent ones were included that make strong cases or demonstrate what the discourse and literature on this hotly contested issue is like.

Papers were included based on either being detailed accounts of common preparation approaches or novel and well-executed in terms of their intervention or methods. Papers describing common approaches with little detail were excluded. For instance, Grissom et al (2015) provides great detail on child life specialist interventions. Other publications on the topic provided less detail and were thus not summarized. If articles published before 2017 are included, they had particular approaches not replicated later or were mentioned positively in current review papers.

Further, the overview contains articles that were part of a previous internal literature overview on this topic from 2017. This is thus a comprehensive overview up to this point. Papers that were also included in this earlier review are marked as such. Some papers discussing preparation for awake pediatric radiotherapy (RT) are included alongside MRI publications. This is because professionals administering RT to children have very similar concerns and similar research interventions than those performing MRI. While RT and MRI are different in many ways, both require patients to lie motionless for a successful procedure and often require anesthesia to achieve good outcomes for pediatric patients.

Review results

Interventions differ between studies, but there are commonalities. Most publications in the area are case studies reporting on a single-center intervention to facilitate scans without anesthesia. The interventions for preparing children for MRI scanning that were found most frequently in the literature are:

1. hiring a child life specialist;
2. preparatory training with a (mock) MRI scanner;
3. audiovisual preparation materials like movies or VR experiences;
4. child-friendly MRI suites

Additionally, MRI scanning during sleep and sleep manipulation is routinely employed for infants but seems less effective for children above the age of four (Janos et al, 2019). Most reviewed interventions occur at the hospital; at home, preparation is often limited to information booklets. More comprehensive solutions to child MRI preparation are rare.

Although all interventions' reported effects to prepare children for MRI scanning vary, almost every article documents positive outcomes overall. Nearly every measure included in the intervention results in decreases in the anesthesia rate. MRI preparation seems to increase patient satisfaction consistently and to decrease child and caretaker anxiety. All medical professionals involved are usually pleased with the increased patient engagement a child-focused intervention brings. The few reports on financial and organizational outcomes are straightforward and similar across hospitals: they show that MRI preparation decreases work burden on clinical staff, reduces waiting times for patients, and is financially beneficial for hospitals, even when preparatory materials require initial investments and/or new hires (e.g. Runge et al, 2018). This is because anesthetics and anesthesiology staff are responsible for a major part of the organizational work and expenses for each individual scan (see e.g. Törnqvist et al, 2015).

The table below summarizes the relevant literature that was included in this review.

citation	location	control condition	retrospective /prospective	Sample size	Original summary
Janos et al 2019	multiple locations	NA – review paper	NA – review paper	NA – review paper	Review discussing current interventions and research about pediatric MRI and child preparation.
Xu et al 2019	Presbyterian NY, USA, with Siemens	no control condition	retrospective	N=4234	Children were introduced to MRI with Marvel superhero-based educational materials and performed well in awake scans.
Kada et al 2019	Bergen, Norway	NA – no intervention tested	prospective	N=22	22 qualitative interviews with children and their parents discussed their MRI coping experience.
Heye et al 2019	Children's hospital Philadelphia, USA	no control condition	retrospective	N=350	Retrospective review of pediatric appendicitis patients shows that MRI without anesthesia is highly accurate for the diagnosis of appendicitis.
Perez et al 2019	Toronto, Canada	control condition	prospective	N=57	Contact with a therapy dog around their MRI scan reassured children, but did not make a significant difference for scan quality.
O'Connor & Halkett 2018	multiple locations	NA – review paper	NA – review paper	NA – review paper	Helpful systematic discussion of over 1000 studies about anesthesia reduction interventions for pediatric radiotherapy patients. Applies to MRI preparation.
Runge et al 2018	Lillebaelt Hospital Kolding, Denmark	control condition	prospective	N=81	An app for home use, radiographer training, a childrens' lounge and a child-friendly MRI room decreased anesthesia for age 4-6 from 57% to 5%, maintained image quality & cost-effectiveness.

Walker et al 2018	St. Jude, Memphis, TN, USA	NA – no intervention tested	prospective	N=101	A majority of 101 child caregivers was positive about MRI without anesthesia when asked about it in interviews, and provided further suggestions on pediatric MRI preparation.
Pahade et al 2018	six US hospitals	NA – no intervention tested	prospective	N=1161	Analysis of over 1000 surveys with MRI & CT patients and caregivers of pediatric MRI & CT patients, about their preferences of receiving information about MRI.
Hogan et al 2018	Presbyterian NY/Morgan Stanley, USA	control condition	prospective	N=50	A randomized controlled trial finds that prior video education improves relaxation and procedural understanding scores for pediatric MRI patients.
McGlashan et al 2018	Nottingham Children's Hospital, UK	control condition	prospective	N=21	A preparation video allowed for pediatric MRI without anesthesia and was found helpful in questionnaires – both for neurologically healthy controls and children with a neurological disorder.
Rothman et al 2016	Soroka U Medical, Beersheva, Israel	control condition	prospective	N=121	An intervention including simulator practice, a movie and booklet was associated with decreased need for anesthesia among children undergoing MRI scans.
Nordahl et al 2016	UC Davis Imaging Research, USA	no control condition	prospective	N=17	A behavior analyst successfully used a mock scanner to prepare children with autism (ASD) for awake MRI scans. Children were aided further with in-bore solutions during their scans.
Jernigan et al 2016	ten US hospitals	NA – no intervention tested	prospective	N=1493	Usable as a methods reference for comparing imaging across sites. Not an intervention study; reports behavior, brain imaging, and genotypes from over 1000 developmentally typical children.
Grissom et al 2015	St. Jude, Memphis, TN, USA	control condition	retrospective	N=116	A child-life specialist successfully reduced anxiety in pediatric radiotherapy patients. The paper specifies

					dimensions along which the child life specialist adapts their intervention.
Törnqvist et al 2015	Skåne U Hospital, Lund, Sweden	control condition	prospective	N=69	A storybook and audiovisual material before and during an MRI scan permitted awake scans with similar quality to anesthetized scans. Parent satisfaction was higher, treatment costs lower.
Vannest et al 2014	Cincinnati Children's, OH, USA	no control condition	prospective	N=220	After a desensitization protocol, researchers scanned either during a child's natural sleep or with a behavioral protocol that used a practice session, exploration and tangible reinforcers.
Barnea-Goraly et al 2014	Stanford, CA, USA	control condition	prospective	N=222	Behavioral training with either cheap or commercial mock MRI-scanners yielded high scan success rates for both diabetic and non-diabetic children.
Dean et al 2014	Providence, RI, USA or London, UK	no control condition	prospective	N=220	A protocol permitted MRI scans during sleep without anesthesia in children younger than 4.
Tsai et al 2013	Taipei Veterans General, Taiwan	control condition	prospective	N=19	Various therapeutic play measures before radiotherapy reduced several anxiety measures. Notable for its diverse theory-driven intervention design.

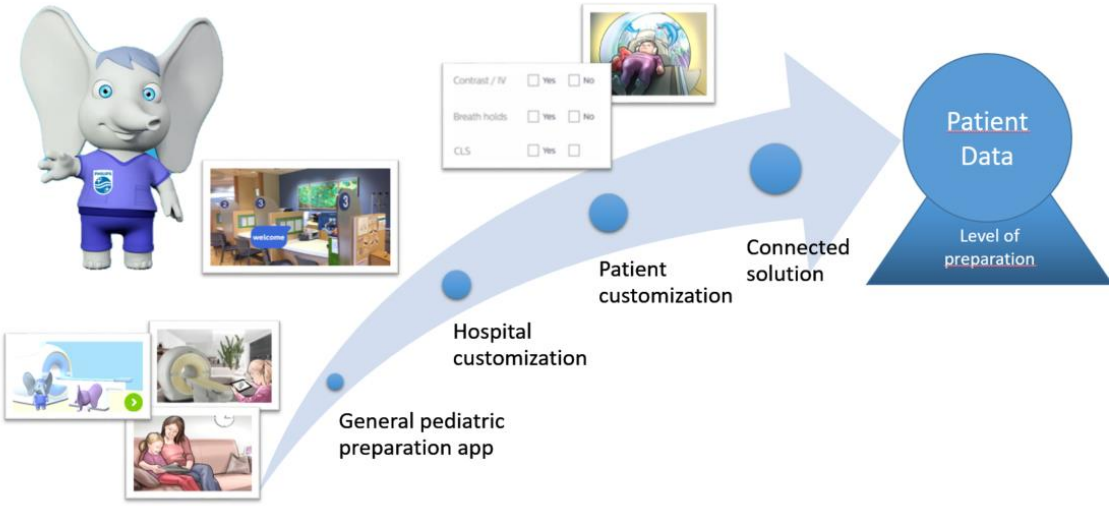
Attachment 2: Questionnaire results application specialists

Respondents

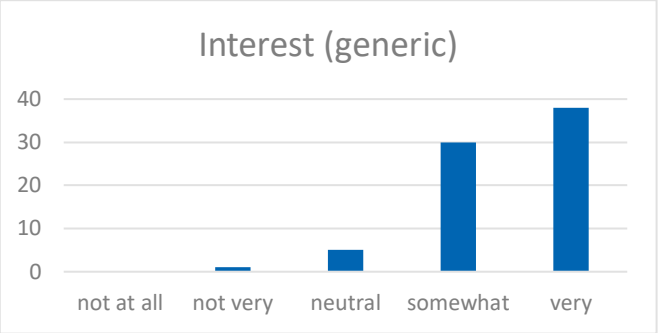
Respondents came from the following markets:

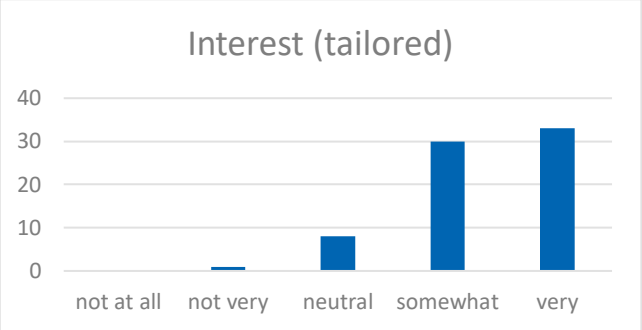
Region	# participants
Australia	3
Benelux	5
CEE	2
DACH	11
France	5
Iberia	2
India	3
Japan	3
Latam	3
MET	3
Nordics	6
North America	14
RCA	3
SE Asia	5
UK	3

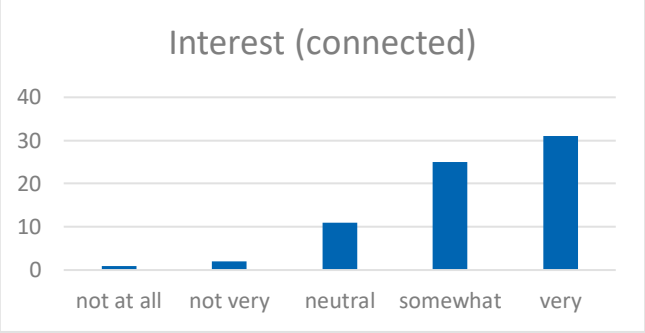
Interest & willingness to pay



How interested do you think “your” hospital would be in …?
How willing do you think “your” hospital would be to pay for …?
Scale: 1 (not at all)- to 5 (very).

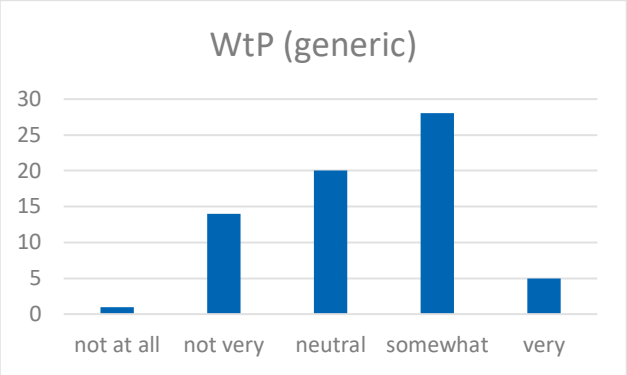


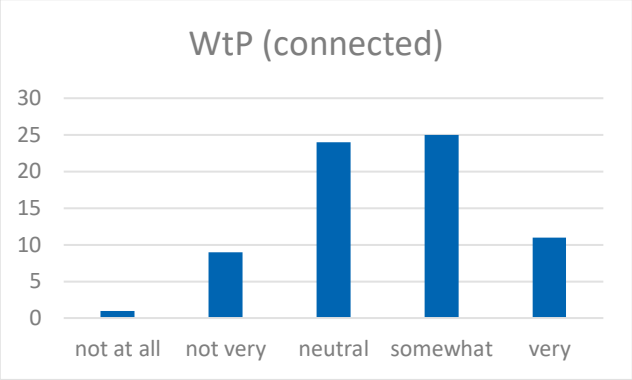


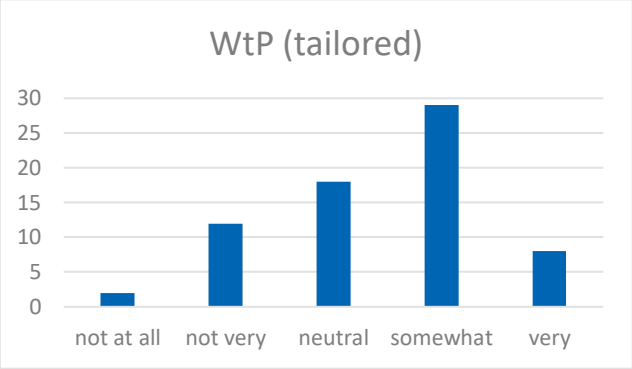


	Generic	Tailored	Connected
mean	4.42	4.32	4.19
median	5	4	4
N	74	72	70

How willing do you think “your” hospital would be to pay for …?
Scale: 1 (not at all)- to 5 (very).







	Generic	Tailored	Connected
mean	3.32	3.42	3.51
median	3	4	4
N	68	69	70

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