Université de Montréal
École de santé publique
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Evaluating the Feasibility and Impact of a Synchronous Health Technology Innovation in the Provision of Pediatric Health Care in a University Hospital

Par
Mahmoud Nadar

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Présentée par

Mahmoud Nadar

A été évaluée par un jury composé des personnes suivantes

Régis Blais

Président-rapporteur

Claude Sicotte

Directeur de recherche

Philippe Jouvet

Codirecteur

Luigi Lepanto

Membre du jury

Peter Laussen

Examinateur externe

Résumé

La prestation de soins critiques et d'orthophonie en milieu pédiatrique nécessite beaucoup de travail pour atteindre le niveau de soins souhaité. Plusieurs facteurs contribuent à ce problème, parmi lesquels la pénurie de ressources, les besoins pressants et l'augmentation du nombre d'enfants malades.

Parmi les solutions proposées, beaucoup pensent que la télémédecine synchrone peut être utile en donnant un accès virtuel immédiat aux compétences à distance. Ainsi, l'expertise pourrait être instantanément disponible via une plateforme permettant une communication efficace et capable de soutenir les soins pédiatriques. La télémédecine s'est beaucoup développée dans la prestation des soins critiques et de réadaptation pédiatriques, et ce aux plans diagnostique et thérapeutique. Pourtant, peu d'études ont examiné la faisabilité et évalué l'impact de la télémédecine sur la qualité des soins critiques et de réadaptation pédiatrique.

L'objectif principal de cette thèse était d'évaluer la faisabilité de la télémédecine synchrone dans deux contextes pédiatriques, critique et réadaptation, et d'évaluer son influence sur le processus de prestation de soins pédiatriques.

Le premier article présente les résultats d'une revue systématique qui synthétisait des études évaluant l'impact des modèles de télémédecine synchrone sur les résultats cliniques dans les établissements de soins de

courte durée en pédiatrie. Les résultats ont révélé que l'utilisation de la télémédecine synchrone avait pour effet d'améliorer la qualité des soins, de diminuer le taux de transfert, de réduire de la durée du séjour, de modifier ou renforcer le plan de soins médicaux, de réduire les complications et la gravité de la maladie, et de diminuer le taux de mortalité hospitalière et standardisé. Cependant, la revue de l'état de connaissances a révélé que la qualité des études incluses était faible et que des preuves de haute qualité étaient nécessaires.

Le deuxième article, fondé sur un devis pré/post, évalue la faisabilité de la télémédecine à domicile en orthophonie et son impact sur la satisfaction des enfants et orthophonistes, le coût économique, et les performances vocales. Cette étude a montré que la télémédecine en orthophonie était faisable et que les enfants et les orthophonistes étaient satisfaits du service. En outre, l'utilisation de la télémédecine en orthophonie a permis d'améliorer la voix et de faire économiser de l'argent aux parents.

Le troisième article évalue la faisabilité de la mise en place d'une plate-forme de télémédecine synchrone dans l'unité des soins intensifs pédiatriques (USIP). Pour qu'une solution de télémédecine synchrone à l'USIP soit faisable, elle nécessite une bonne préparation préalable à la mise en œuvre de la plate-forme de télémédecine synchrone pour être réellement utile. Avec des médecins résidents compétents et autonomes, l'utilité d'une plate-forme de télémédecine synchrone reliant les

intensivistes pédiatriques hors site et les médecins résidents sur site à l'USIP est faible. Cette étude a ajouté qu'un tel service pourrait être plus bénéfique que le modèle traditionnel des soins (face à face) pour les communications avec d'autres établissements de soins de santé éloignés, où le besoin d'expertise d'un intensiviste en soins intensifs pédiatriques est plus important.

Ces trois études permettent de conclure que la télémédecine synchrone est réalisable et peut avoir un impact sur la qualité des soins intensifs et de réadaptation pédiatrique. On peut déduire de cette thèse qu'il est important de prendre en compte le contexte dans lequel la technologie sera mise en œuvre. Traiter le contexte de l'USIP et celui de réadaptation de la même manière n'aboutit pas aux mêmes résultats et une innovation technologique pourrait réussir dans un contexte et échouer dans un autre.

Mots-clés: Télémédecine synchrone, télésanté, pédiatrie, soins intensifs, soins critiques, soins aigus, revue systématique, résultats cliniques, fellows, orthophonistes, performance de voix.

Summary

Delivering critical and speech-language pathology care in pediatric settings requires much hard work to reach the desired level of care for children. Several factors contribute to this problem, including resources shortage, pressing needs, and the growing number of ill children. Among the proposed solutions, many believe that synchronous telemedicine can play a role by providing virtual and immediate access to remote skills, with expertise could be made instantly available through a platform that allows efficient communication and is able to support pediatric care. Telemedicine has developed significantly in the provision of critical care and pediatric rehabilitation in terms of diagnosis and therapy. Yet, few studies have examined the feasibility and evaluated the impact of telemedicine on the quality of pediatric critical care and rehabilitation.

The main objective of this dissertation was to assess the feasibility of synchronous telemedicine in two pediatric settings—critical care and rehabilitation—and to evaluate its influence on the process of providing pediatric care.

The first article presented the results of a systematic review that synthesized studies evaluating the impacts of synchronous telemedicine models on clinical outcomes in pediatric acute care settings. The findings revealed that the use of synchronous telemedicine improved quality of care and resulted in a lower transfer rate, a shorter length of stay, a

change in or reinforcement of the medical care plan, a reduction in complications and illness severity, and a low hospital standardized mortality rate. However, the review of the state of knowledge revealed that the quality of the included studies was weak, so more high-quality evidences is needed.

The second article, which used a pre/post design, assesses the feasibility assessed the feasibility of home-based telepractice in speech-language pathology (TSLP) and its impact on satisfaction among the children and speech-language pathologists, economic cost, and voice performance. This study showed that TSLP is feasible and that both the children and the speech-language pathologists were satisfied with the service. In addition, the use of TSLP demonstrated more voice improvement at less cost to the parents.

The third article evaluated the feasibility of implementing a synchronous telemedicine platform in a pediatric intensive care unit (STEP-PICU). For a STEP-PICU to be feasible and truly helpful, it needs good preparation for the implementation of the telemedicine solution. With competent and autonomous fellows (a fellow is a physician who has completed their residency and elects to complete further training in a subspecialty), the usefulness of an synchronous telemedicine (STM) platform linking off-site pediatric intensivists and on-site fellows in a PICU is limited. This study added that such a service could be more beneficial than the traditional model of care (face to face) for communications with other remote

healthcare facilities, where there is a greater need for the expertise of a pediatric critical care intensivist.

These three studies allow us to conclude that STM is feasible and can have an impact on the quality of pediatric intensive care and rehabilitation. This thesis underscores the importance of taking into consideration the context in which the technology will be implemented. Treating the PICU and the rehabilitation contexts in the same way does not lead to the same results, and a technological innovation that succeeds in one setting may fail in another.

Keywords: Synchronous telemedicine, telehealth, e-health, pediatric intensive care, critical care, acute care, systematic review, clinical outcomes, fellows, speech-language pathologists, voice performance.

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List of abbreviations

CAPE-V - Auditory-Perceptual Evaluation of Voice

CICU - Cardiac ICUs

ED - Emergency department

ICT - Information and communication technologies

ICU - Intensive care unit

IS - Information system

LOS - Length of stay

NICU - Neonatal ICUs

PCCM - Pediatric critical care medicine

P2P - Peer-to-peer

PIs - pediatric intensivists

PICO - Population, intervention, comparison, outcomes

PICU - Pediatric Intensive Care Unit

pVHI - Pediatric voice handicap index

RCT - Randomized controlled trial

REACTS^{TM} - Remote education, augmented communication, training and supervision

SJUHC- Sainte-Justine University Healthcare Center

SLP - Speech-language pathology

STEP-PICU - Synchronous telemedicine platform in PICU

STM - Synchronous telemedicine

TM - Telemedicine

TSLP - Telepractice In speech-language pathology

USA - United States of America

USIP – Unité des soins intensifs pédiatriques

WHO - World health organization

3D - Three dimensions

Dedicated to

all my family

who supported me throughout this work!

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“He who asks for glory stays up all nights”

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Chapter I

Introduction

1.1 Statement of problem

1.1.1 Pediatric health services: from rehabilitation to intensive care

Pediatric healthcare services cover a wide range of inpatient and outpatient care. The inpatient care requires the patient to be admitted to the hospital. It includes general pediatric care, critical care, the cardiac intensive care, and other medical subspecialties. As for the outpatient care, it does not require an admission to the hospital and the procedure could be achieved in outpatients clinics. It includes nursing services, respiratory therapy, physiotherapy, speech-language pathology (SLP) and others. Both areas are complementary, with one completing the other. Improving one rather than both could affect the whole pediatric services continuum and the quality of pediatric healthcare.

In this thesis, two studies were carried out in two different pediatric settings. One targeted the medical area of pediatric critical care and the other targeted a paramedical setting, SLP.

1.1.2 Pressing needs and resources shortages… a consistent lack of care provision

In Canada, children represent 21.9 % of the population and 100% of the country's future (1). Supporting their health from birth is a responsibility and a tremendous opportunity to foster generations of healthy Canadians (2). Ten million deaths occur annually among children five years of age and younger in limited resource settings in developing countries, and 80%

of these deaths are estimated to be avoidable (3). In the USA, 6.7 million (9 %) were found to have unmet needs for pediatric subspecialty care in 2016 (4). This shortage of pediatric care is apparent in different segments, especially critical care and SLP.

1.1.3 Fewer pediatric professionals, more pediatric patients

1.1.3.1 Pediatric critical care

In most countries, pediatric critical care is underdeveloped. The majority of hospitals lack designated critical care units, healthcare staff trained to care for critically ill children, and adequate staffing (5). The labour shortage has intensified among pediatric intensivists (PIs), creating uncertainty around the future viability of the pediatrician workforce and its ability to meet the demand for care. In addition, work-life balance problems and incongruences in financial compensation when compared with other medical specialties may compound the problem and threaten the sustainability of the child health care system (6).

On the other hand, the growing demand for chronic care demand is likely to accelerate as modern advances in medicine increase the survival rate of neonatal patients with complex medical issues at birth (6). According to the American Academy of Pediatrics (7), the shortage of PIs is likely to detrimentally impact the care of children with chronic health conditions, as this population is growing. This directly affects patient care through decreased access and longer wait times, such as an average 14.5-week wait time for an appointment with an PI in the U.S. (8).

Furthermore, the growing need for pediatric critical care has only made matters worse. Today, providing continuous specialized care is a major challenge, especially critical care for the most critically ill children. This requires a high level of medical expertise from PIs as well as modern technologies and equipment in order to provide advanced care in the pediatric intensive care unit (PICU). The level of medical care and the sophistication of treatment in pediatric critical care has increased and, over time, has resulted in an acute need for PIs who are skilled, accessible and able to manage patients often with the help of the on-site fellows in the PICU. Moreover, this need for highly qualified critical care medical teams has increased significantly to ensure patient safety and high quality pediatric critical care.

However, children's needs to be treated by a PI are not being met, and many of them are being treated in less-than- ideal conditions. This appears to be due to several factors, including the shortage of PIs, which makes matters worse, especially in view of the growing number of PICU admissions (9), and the impossibility of having PIs at the patients' bedside around the clock.

Tis situation has generated great interest in finding ways to overcome these challenges and achieve these objectives by allowing off-site PIs to communicate remotely at any time to provide a virtual presence at the

bedside of patients and communicate with the on-site fellows to ensure continuity of high quality and safe pediatric critical care.

1.1.3.2 Speech-Language Pathology

The issue of the supply and demand of SLP services has been discussed in many sectors of service delivery across Canada and internationally. In Canada, program waitlists and caseload numbers in various sectors of SLP have long been a problem. waiting lists for the users are as long as 12 to 18 months, and the supply of speech language pathologists is insufficient to meet current and projected demands (10). According to the National Health Center for Health Statistics (11), almost half (44.8%) of U.S. children needing speech-language therapy did not receive SLP intervention services in 2012 due to a shortage of speech language pathologists. This shortage, associated with the higher concentration of speech language pathologists in urban areas, made the situation even more problematic in remote regions where their number has decreased significantly. Thus, children have been forced to travel long distances to receive the speech-language therapy, with resulting high rates of therapy nonadherence and non-attendance.

The shortage of speech language pathologists has been associated with an increase in the demand for speech therapy. Progress made in diagnostic technologies, the increased availability of specialists in schools, and a high level of parental awareness are the main factors that

have increased the number of diagnosed cases requiring SLP interventions.

1.2 Potential solution: innovative information technologies

Over the last few years the use of information and communication technologies (ICT) has become increasingly widespread in the assessment, diagnosis and treatment of many children's disorders. Defined as the remote delivery of health care services and clinical information using telecommunications technology, the telemedicine (TM) is considered by many as having the potential to greatly improve the quality, equity and affordability of health care around the world (12). There has been considerable interest in pediatric TM as a way to overcome distance barriers and to improve access to specialized services such as those offered by PIs and speech language pathologists, whose availability is very limited, particularly in remote regions.

Information and communications technology (ICT) is considered by many to offer a potential solution, as it can provide virtual, synchronous and immediate access to remote skills, making healthcare support instantly available through a platform with efficient communication and support for specialized pediatric critical care. As such, there is an emerging range of communication opportunities to support remote critical care coordination

by providing access to off-site PIs who can assist on-site fellows in the PICU.

As well, this same solution providing interactive and synchronous (real-time audiovisual) communication between speech language pathologists and patients may be effective for use in evaluations of speech and/or language disorders and for related interventions (13), especially for patients who live in remote and rural regions. Such new TM solutions, which are more responsive and flexible than traditional videoconferencing, may provide accessible alternatives and affordable telepractice for speech-language pathology (TSLP) services.

A home-based TSLP platform dedicated to serving children with speech-language disorders may improve access to an SLP and ensure appropriate remote care for children. Furthermore, the difficulties, inconveniences and costs associated with repeated traveling represent major barriers that may be overcome with such a TSLP service.

1.3 General objective of the dissertation

The objectives of this research were: (1) to conduct a systematic review of the previous literature on the impact of synchronous TM models on the clinical outcomes in pediatric acute care settings; (2) to evaluate the feasibility of a home-based TSLP service for treating children with voice disorders; and (3) to assess the impact of implementing a synchronous TM platform in a PICU between the off-site attendings PIs and the on-site

fellows. To this end, the feasibility study assessed the targeted benefits, which were measured in terms of system quality, information quality, service quality, use, user satisfaction, net benefits, economic analysis and health outcomes.

1.4 Organization of the dissertation

Following this introductory chapter, in which we present the research problem, the potential solution, the objectives of the research and the organization of the thesis, Chapter 2 presents the review of literature on the organizational issues in pediatric care, ICT as an innovative solution, and the impact of ICT on pediatric care. The aim of this second chapter was to review previous studies related to our research objectives. The pediatric care sub-section discusses the influence of organizational issues such as the highly specialized nature of pediatric care, the centralization of health care provision, resource shortages, and increased needs for interprofessional communication. It also reports on the innovative solution, the reality of the ICT and the different modes of telemedicine in health care organization. Moreover, the platform under study and its features are described, with all services that it provided. The last sub-section in the literature review chapter explains the impact of ICT on pediatric care and, in particular, on clinical outcomes in acute pediatric critical care, home-based pediatric TSLP services, and communication between off-site PIs and on-site fellows in a PICU.

Chapter 3 presents the methods employed in the present work. It provides the aims of the current dissertation, each under a specific objective for the three papers comprising this thesis. The research designs and their applications in the three papers are described. A detailed explanation is provided of the study setting, ethical considerations, designs, interventions, measures and instruments, and conceptual framework.

Chapter 4 presents the results of all three research papers. The three manuscripts have been published. Research paper 1, entitled “Impact of Synchronous Telemedicine Models on Clinical Outcomes in Pediatric Acute Care Settings: A Systematic Review”, revealed the current state of knowledge on the impact of the use of real-time telemedicine on clinical outcomes in pediatric acute care settings. The second paper, entitled “Home-based pediatric telepractice in speech-language pathology: Evaluation of a pilot study”, evaluated the feasibility of a home-based TSLP service in the treatment of children with voice disorders and assessed the impact of such a service on the children’s voice performance. Lastly, research paper 3, entitled “The Implementation of a Synchronous Telemedicine Platform Linking Off-Site Pediatric Intensivists and On-Site Fellows in a Pediatric Intensive Care Unit: A Feasibility Study”, assessed the feasibility of implementing a synchronous telemedicine platform in a PICU between the off-site attendings PIs and the on-site fellows.

Chapter 5, the discussion section, reviews the main results of the three papers and discusses the findings in relation to the papers' scientific contributions, strengths and limitations, before addressing current implications, emerging issues and avenues for future research. Finally, Chapter 6 completes the work with conclusions.

Chapter II

State of knowledge

In this chapter, we review previously published literature related to our research. This review of literature consists of three sections. The first presents organizational issues in pediatric care in four subsections: highly specialized care, the centralization of health care provision, resources shortages, and increased needs for interprofessional communication. The second section reviews ICT as an innovative solution. First, it presents the reality of ICT use in the healthcare organizations. Second, it distinguishes between the different modes of ICT and their multiple uses. Third, it describes the telemedicine platform under study in the current thesis. Lastly, the third section describes the impacts of technology on clinical outcomes in acute pediatric critical care, on home-based pediatric TSLP services, and on communication between off-site PIs and on-site fellows in a PICU.

2.1 Organizational issues in pediatric care

The organizational issues that have an impact on pediatric critical care and SLP are numerous and varied. In the context of the current investigation, four organizational issues affect both of the subjects addressed above: highly specialized care, the centralization of health care provision, resources shortages, and communication needs.

2.1.1 Highly specialized care: when it comes to health care, kids are different

Pediatric critical care medicine (PCCM) as a specialty is approaching 50 years of age (14). Since then, it was growing exponentially and becoming an important subspecialty to save lives and improve quality of life of critically ill children.

PCCM is not as simple as miniaturized adult critical care medicine. As it is known that physiological, psychological and emotional differences exists between adults and children. This differentiation requires distinct pediatric critical care interventions that take into consideration the specificity of children conditions. Because most pediatric critical patients are still physically developing, PIs must pay special attention to pediatric issues that are not present in adult patients (15).This is why PIs undergo specialized training that prepares them to effectively meet the critical health needs of children.

The spectrum of the PCCM is wide and covers multiple pediatric critical conditions. It provides care for infants, children and teens less than 18 years old with traumatic injuries or life threating illness, recovery care services after surgery, neurocritical care, cardiac intensive care, nutritional support, pain management, and complex patient evaluation (16).

The sensitivity and complexity of these pediatric critical acts require on the treating PI a high level of expertise and advanced medical skills. To meet this, a PI received the necessary training to be competent in all aspects of recognizing and managing critically ill pediatric patients with single or multiple organ system failures requiring ongoing monitoring and support (17).

This high level of required expertise is a double-edged sword. On the one hand, it ensures that children receive a high level of pediatric critical care; but on the other hand, it makes PIs irreplaceable by other medical specialists, such as specialists in pediatrics or adult critical care. The lack of availability of PIs can easily result in shortages that requires taking action to find alternatives such as a technology that can compensate for their absences in the provision of pediatric critical care.

As for the speech-language pathologists, theirs is a highly demanding health specialty, requiring a high level of expertise. The specialty has rigorous standards and requires a challenging program of studies, with a Masters degree in SPL required to enter practice in all jurisdictions in

Canada (18). Speech-language pathologists receive extensive training, must pass a national entrance exam, and complete a traineeship with clinical hours, where they work under a certified SLP. These high requirements delay the entrance of SLPs into the job market and make them in high demand, and it limits the number of faculty members available to teach (19).

SLPs are health professionals who identify, diagnose and treat communication and swallowing disorders at all times of life. With the odds in favour of treatment for children, they work with both adult and pediatric clients. According to the Canadian Association of Speech-Language Pathologists and Audiologists, thirty-one percent (31%) of the SLP respondents to the membership survey reported that they worked for a school board, with children, the highest single reported work setting (20). They managed children with communication challenges and supported those who interact with them regularly, such as parents, caregivers, teachers and other professionals in a variety of settings.

2.1.2 Centralization of health care provision

If there is two-tiered health care in Canada, it is not one of rich and poor but rather urban versus rural (21). The geographical centralization of pediatric critical care services has always been a major impediment to improving the quality of pediatric critical care. This centralization corresponds to the concentration of medical expertise and increasing patient volumes at tertiary care hospitals (22). The clinical argument

favouring centralization is that large centers have high patient volumes, concentrated resources and ready access to a range of sub-specialty expertise which in turn leads to improved patient outcomes (23).

This reality is becoming more frequent in non-urban areas where pediatric critical care is more difficult to maintain due to the difficulty of recruiting and retaining PIs, unfavourable salary scales, and the absence of financial rewards (24). These factors may explain reports that some children in rural emergencies are more likely to receive incorrect diagnoses, inappropriate treatment, and suboptimal medical management (25). In a study of transfers made to the emergency department of a Canadian pediatric university hospital between 2005 and 2010, Nathalie Lucas et al. found that in nearly 30% of cases, the professionals caring for the patients (doctors, nurses, respiratory therapists of the requesting centers) did not have the necessary expertise in pediatric resuscitation. It should also be noted that during this period, 70% of the patients transferred and admitted to this hospital's PICU were under 10 years of age. It was not uncommon for patients to arrive in the emergency room extubated or having lost their access routes for hemodynamic monitoring.

Given these concerns, non-urban pediatric critical services may tend to admit and/or transfer children with mild clinical conditions (26). Consequently, this approach increases sick patient admissions, unnecessary transfers, or overuse of expensive transportation modalities

(27). As a result, the patients who require critical pediatric medical care are sure to have difficulty accessing quality care in a timely manner, hence the importance of introducing technology as a way to connect the centralized PIs to rural regions.

The same principle applies to the SLP specialty, where the concentration of speech-language pathologists in urban areas creates recruitment challenges for the rural regions (19). The concentration of SLP faculties in urban areas, the lack of SLP human resources, the inability of rural areas to attract and retain the speech-language pathologists, and the length of their education and training are all factors that have driven speech-language pathologists to concentrate in urban areas at the expense of rural areas.

2.1.3 Workforce shortage

PIs have always been in short supply in most countries. In 2013, in a Pediatrician Workforce Policy Statement, the American Academy of Pediatrics concluded that there was a shortage of pediatric medical subspecialists and pediatric surgical specialists to meet the clinical needs of children living in rural and other underserved areas, and that this shortage would not be corrected for five years (28).

In 2015, Rudabaugh et al. (14) surveyed over 1,800 PIs and found that nearly one third of respondents planned to reduce their clinical workloads over the next five years. Twenty-five percent of respondents reported plans to retire (9.1%), leave practice for a nonclinical role in healthcare

(11.9%), or leave the practice of medicine entirely (5.4%). In the accompanying editorial to this survey, Wheeler (29) predicted that the growing transition to 24/7 in-house attending coverage in PCCM will likely compound the current shortages in the United States and Canada.

In addition, several other factors challenged the PCCM workforce, including an increase prevalence of in-house night calls, the emergence of pediatric cardiac critical care as a distinct practice area, more women entering PCCM, an evolving PICU patient population, and an aging workforce (14).

The same workforce shortage was found in speech-language pathology. Despite an abundance of unfilled positions, there was not enough SLPs to keep up with the demand. The demand for speech-language pathologists is on the rise, with job growth projected at 21% through 2024 according to the U.S. Bureau of Labor Statistics. This means an additional 25,400 speech-language pathologists will be needed to meet the demand between 2016 and 2026–an 18% increase in job openings (30). In 2017, there were 27 certified speech-language pathologists for every 100,000 Canadian residents (31). In the U.S. this ratio increases to 51.1 speech-language pathologists per 100,000 residents (30). This shortage has placed the pressure on schools and healthcare organizations.

2.1.4 Increased needs for interprofessional communication

Significant changes have occurred in the medical management models used in pediatric critical care. As cases become more complex (in terms

of the number of chronic medical conditions patients have), the burden of tasks such as documentation, data retrieval, and communication (with patients, families, and other providers) is increasing (32). In addition, improvements in the quality of medical care and the life expectancy of children has increased the demand for pediatric critical care and, by extension, the need for a growing number of PIs. All these factors have affected the provision of PCCM, such that the changing models of care delivery will undoubtedly impact the workload of PIs and require further communication between PCCM providers.

Turning to SLP, advances in SLP practices have increased the average improvement of communication disorders in children. The increase in alerts to teachers and parents concerning the early detection of SLP disorders has increased the need for SLP services (30). Lastly, early identification and diagnosis of SLP disorders in young children has increased the demand for SLP and required more communication between SLPs and ill children in more SLP sessions.

Given the current shortage of PIs and SLPs, such communication can be enhanced through the implementation of an innovative technology able to compensate for this lack of services.

2.2 Information and communication technologies: an innovative solution

2.2.1 Information and communication technologies in health care organization

Compared to other industries, the health care sector has only recently embraced the use of ICT. This tardiness may be due to cautious in adopting and using ICT in health care organizations. The use of ICT, specifically smartphones and tablets, has been growing rapidly (33). At the outset of the 21st century, ICT had begun to emerge and came into wide use in the year 2000. It is estimated that the amount of smartphone subscriptions in Europe will reach 880 million by 2021 (34), and the mobile applications market will expand even more, with currently over 160,000 mobile health apps and platforms currently available for download and use (35).

In 2005, the World Health Organization (WHO) urged member states, “to develop the infrastructure for ICT for health as deemed appropriate to promote equitable, affordable, and universal access to their benefits, and to continue to work with information and telecommunication providers in order to reduce costs and make eHealth successful” (36). The use of ICT has great potential as a way to support health care, so and it is worth taking the time to explore the evidence in terms of the benefits and implications for clinical practice.

The latest ICT innovations may have many benefits for both patients and professionals by linking healthcare professionals to each other, as well as connecting professionals with patients. ICT serve many purposes in health care, including diagnostics, consultation, medication prescription, monitoring, education, expertise transfer, counseling, management, and support. In addition, they can enhance patient care, improve public health, eases workflow, reduce healthcare costs, improve quality of care and life, shorten waiting times for patients, and improve access in rural areas (37).

There are many terms used to describe the use of ICT to support healthcare. These terms are often used interchangeably to describe a broad concept in remote healthcare delivery, but they represent a different use of the technology in this field, many terms have been used to cover more health functions, including but not limited to: telehealth, e-health, m-health, digital health, and telemedicine (33).

TM has been proposed as a potential solution capable of addressing the weaknesses in critical care resources, discrepancies in clinical outcomes and access to specialist expertise when needed (38). It may help remote community physicians by offering them synchronous TM-based consultations to provide critically ill children with high-quality pediatric critical care that is as close as possible to that provided in tertiary hospitals.

In its report on the second global survey on e-Health published in 2010, WHO re-adopted the same definition of TM it had proposed in 1998. At that time, the organization defined TM as “the delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals and their communities”(39).

Despite its widespread use in medicine over the last few decades, the term “telemedicine” is still ambiguous and needs more clarification. In a study carried out in 2007, scholars found 104 peer-reviewed definitions for this term (40). There are many interpretations as to what the term “TM” means. A chronological review showed that TM was originally used to designate the provision of remote medical services (41).

2.2.2 Modes of telemedicine: synchronous versus asynchronous

Synchronous (or real-time) TM typically involves the use of phone conversations or audiovisual technology to enable individuals to communicate live over a videoconference link (42). It is valid and reliable for a wide variety of clinical activities, including the diagnosis of diseases, the delivery of therapy, primary care consultations and acute care emergencies (43).

Most traditional services require, at a minimum, a telephone, video cameras, a sound system, computer displays, and a secure high-speed Internet connection to transmit data between sites (42).

However, synchronous TM faces many constraints, especially in terms of scheduling for professionals who are very busy or who cannot keep traditional office hours and are unable to keep appointments (43).

Asynchronous (or store-and-forward) TM is the transmission of data without the need for synchronous interaction between individuals (42). In contrast to synchronous TM, asynchronous technologies can help patients and clinicians communicate, without the need for such communication to occur in real time (43). It involves collecting digital documents (e.g., electrocardiograms, spirometry results, radiological images) at one location and transmitting them to a health professional in another location for review (42). The technology used for asynchronous TM can be any device capable of capturing a digital document, storing it, and downloading it for transmission to a remote site (42).

The use of asynchronous TM is popular in specialties such as dermatology, radiology and pathology, as well as some chronic diseases, where the clinician assesses images of the patient, determines a diagnosis, types out recommendations, and places orders for treatment (43).

2.2.3 Telemedicine platform under study

In this thesis, the implementation of a synchronous telemedicine service in the PICU and SLP department was under study. It involved the use of an interactive audio-video communication platform called REACTS™ (Remote Education, Augmented Communication, Training and Supervision), which was designed for virtual communication. It was an integrated, secure solution, with tools that allowed clinicians to participate in synchronous and multi-stream videoconferencing, file sharing (documents, videos, images, 3D objects), live file transfer, and secure and encrypted exchanges **(Figure.1)**; to consult patients using the camera of a desktop computer, tablet or smart phone; to view plots; and to engage in simultaneous live chats with multiple users (44).

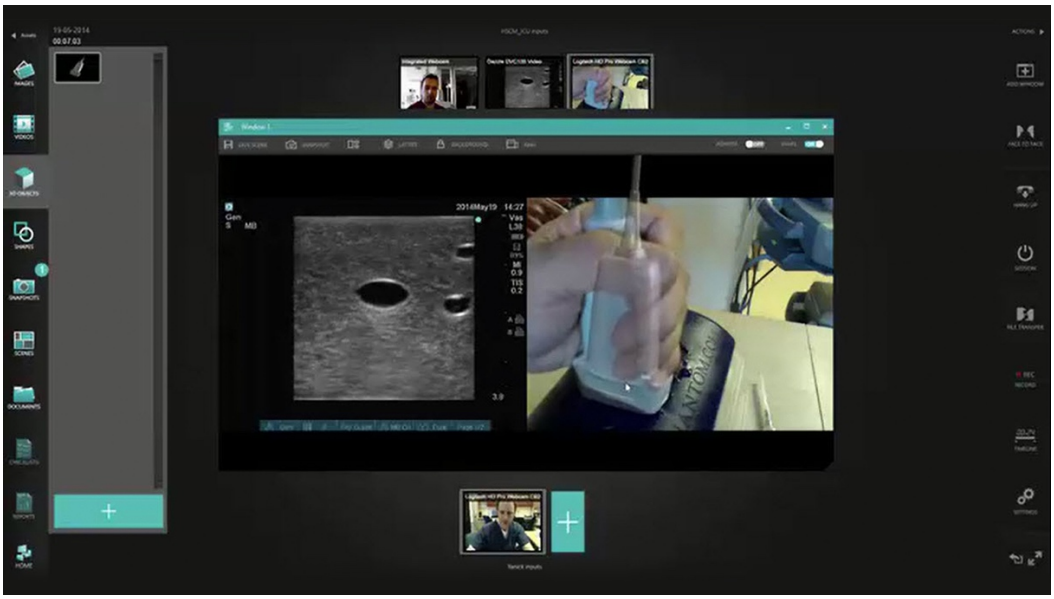
Figure. 1: Reacts™ Platform

It allowed the clinician to view rich visual information such as live videos of the patient, to access all laboratory tests and medical imaging (x-ray and ultrasound), as well as to monitor vital signs in real time **(Figure. 2)**.

Figure. 2: Reacts™ Platform

The service could also be used to clarify a care plan, evaluate a new or unstable patient, visualize clinical information, provide advice and reassurance if needed, and supervise procedures. In addition, it allowed users to share virtual pointers in order to direct attention to any aspect of a live broadcast and to simultaneously stream multiple video flows, including medical devices with video output **(Figure.3)**. It was specifically developed for the healthcare environment with the strictest security standards, where all connections are tunneled and encrypted using an SSL3 or higher system.

Figure. 3: Reacts^{TM} Platform



The system used peer-to-peer (P2P) session control (signaling) for multimedia interactions using XMPP and the Jingle library (45). For legal and data protection purposes, no clinical data can be saved on the telecare platform during a remote consulting session, such that no clinical data were stored outside the facility (46).

2.3 Impact of information and communication technologies on pediatric critical care

In this section, we present the impacts of ICT on three levels: their clinical outcomes in acute pediatric critical care, home-based pediatric TSLP services, and communications between off-site PIs and on-site fellows in a PICU.

2.3.1 Impact on clinical outcomes in acute pediatric critical care

Concerning pediatric critical health care settings, multiple studies (47-61) have underscored the effectiveness of synchronous TM for the delivery of healthcare services. This effectiveness lies in the fact that a pediatric critical physician can consult with a patient in real time, check clinical data and medical files, and observe medical images and monitoring equipment. Moreover, synchronous TM allows the pediatric critical physician to be virtually—present as if he/she is physically present beside the patient—to provide a beneficial and helpful remote consultation.

Previously, many studies have revealed that hospitals and physicians using synchronous TM technologies provided higher quality of care, were more efficient in resource use with improved cost-effectiveness, and had higher satisfaction among patients, parents, and remote providers (48, 49, 53). Furthermore, synchronous TM consultation between pediatric intensivists and community hospital physicians combined with a pediatric hospitalist program at the community hospital has the potential to improve triage of pediatric patients and reduce the need to transfer patients(56, 58). A retrospective review accomplished in 2015 has concluded that an international TM service in pediatric critical care was associated with lower cardiac intensive care unit and hospital length of stay (52, 61). Clinically, synchronous TM can reliably identified normal and abnormal findings of many aspects of circulatory, pulmonary and neurologic examinations in PICU patients(47, 54, 55).

For cardiac care, synchronous TM was a feasible option for pediatric intensivists seeking experienced assistance in the management of complex cardiac patients. Also, real-time remote assistance may improve the medical care of pediatric cardiac patients treated in developing countries (57). Besides, another study suggested that web-based conferencing facilitated dialogue and sharing of information between critical care clinicians in different geographical regions. Web-based conferencing may be an effective tool for global training to promote consistent practices that may help decrease costs while preserving quality (59).

However, and despite the high number of existing observational studies, the formal evidence to support the synchronous TM use in pediatric critical care was unfortunately limited and remained weak. In one of the rare multicenter randomized controlled trial in PICU settings, investigators have emphasized that generalizable evidence was required to inform clinical use and health system policy relating to the effectiveness and economic implications of the use in TM in pediatric retrieval (23). So, future investigations should evaluate the cost-effectiveness of such telemedicine systems (58).

Overall, our literature review of published studies has revealed that most were observational and did not provide robust evidences. Furthermore, no systematic reviews have been published on the feasibility and effectiveness of synchronous TM in pediatric critical care settings. Hence,

we need further high-quality studies to provide formal evidences of the effectiveness of synchronous TM for clinicians and policy-makers at various levels.

2.3.2 Impact on home-based pediatric TSLP services

In an era of rapid technological change, new synchronous TM between the speech-language pathologists and the patient can be effective in the evaluation of speech and/or language disorders and related interventions (13), especially for patients who live in remote and rural regions. Such new TM solutions with interactive audiovisual communication features, which are more responsive and flexible than traditional videoconferencing, may provide accessible alternatives and provide affordable TSLP services. A home-based TSLP, dedicated to serving children with speech-language disorders, could improve access to a SLP and ensure appropriate care for children at a distance. Furthermore, the difficulties, inconveniences and costs associated with repetitive travel represented major barriers that could be overcome by such a TSLP service.

As for the technical aspects, numerous studies have demonstrated successful implementation of TM in SLP. Preferred TSLP technologies were traditional videoconferencing (62, 63) or software (e.g. Skype, FaceTime, Polycom PVX (13, 64-70)) that can establish an audiovisual

connection between personal computers. As TM emerged in the first decade of this century, some studies reported technical difficulties and poor sound and image quality, making it impossible to carry out an accurate evaluation of remote patients without face-to-face consultations (63, 71). Other studies found the technical quality good enough to evaluate and treat children with stuttering or speech sound disorders (13, 62). Note that some technologies offered limited potential for interaction with the patients, which may have affected their motivation (13). By contrast, those that allowed inclusion of a playful element in the therapeutic protocol can enhance the children's motivation and improve attendance at the therapy sessions.

Clinically, the majority of published studies related to TSLP services were conducted in schools or healthcare centers and were mainly non-experimental assessments. Only one randomized controlled trial (RCT) (66), involving 14 children with speech sound disorders, was carried out in rural schools in the United States and showed an improvement in both groups of children. This RCT suggested that the use of telepractice interventions for children with speech or language disorders was comparable to face-to-face treatment.

Other studies (67, 70, 72) on TSLP reported similar results. The pilot study conducted by Grogan-Johnson et al (70) revealed that families were satisfied with TSLP and the progress made by the children with speech-language disorders was similar regardless of the two treatment

modalities: at distance or in person. These results were concordant with those reported by a recent study conducted in Australia (72), showing that a TSLP program improved the speech and language skills of children in both early childhood settings and primary school. In 2017, a systematic review supported that both telehealth and in-person primary school-age children can make significant and similar improvements. According to this review, telehealth delivery model has the potential to improve access to SLP services for children living in remote areas, reducing travel time and alleviating the detrimental effects of communication difficulties on education, social participation and employment (73).

Studies carried out in healthcare centers (13, 62) also reported clinical positive outcomes of TSLP. Sicotte et al. (62) conducted a study on four children and two adolescents with stuttering who were assessed and treated remotely at a local primary care center near their places of residence. This study reported very high levels of satisfaction among the families and SLP, on both the technical and clinical scales. Improved speech fluidity was observed among all the patients, who maintained (at least partially) their achievements after the intervention. Similarly, a series of treatments given to five children through FaceTime for iPad showed that the children reached the majority of their speech or language therapy goals, with the exception of a child with cognitive difficulties(13). Nevertheless, some authors emphasized an inherent constraint of TSLP,

to the extent that an initial face-to-face assessment remained necessary (63, 71).

Currently, home-based TSLP programs have seldom been evaluated, even if some studies (64, 65, 68) have indicated that interventions in the patient's environment were potentially more effective than those performed in clinical settings. In Australia (64), three children with stuttering were assessed and treated at home using the Lidcombe program delivered via webcam. The parents' acceptance of home TSLP was good, despite some occasional problems with the technology. Also, the results of the intervention were similar to those obtained in another study with children treated face-to-face (74). Several benefits related to home treatment were reported, including a greater level of comfort among the children in their environment and the time saved. However, the authors pointed out that more sessions or supplementary follow-up, and more sessions may be required (64).

Two other studies have described the use of the Camperdown program via webcam (68) and a videoconference platform with adolescents with stuttering (65). The Phase I study showed that intervention using this modality resulted in an average of 93% reduction of stuttering among the three participating adolescents (68). These results were only reproduced in the Phase II study involving 16 adolescents, where only 50% of the patients showed a positive response to intervention (65).

In summary, most studies suggest that TSLP holds promise since it addresses a need among families that, without it, might be deprived of care. However, the evidence on the clinical effectiveness of this treatment modality is still limited. The number of studies investigating home-based TSLP is also limited and, to our knowledge, none has involved children with voice disorders.

2.3.3 Impact on communication between off-site pediatric intensivists and on-site fellows in a PICU

Several studies (75-79) have reported that implementations of TM to guide medical decisions have been helpful. They can eliminate uncertainty about a diagnosis, and optimize patient care. However, the consequences of implementing such new modalities, with respect to their impact on fellows' education, autonomy and clinical experience, are unknown.

A review of the literature on the implementation of tele-ICU systems, such as the synchronous telemedicine platform in PICU (STEP-PICU), showed that such studies can assess two main types of outcomes: (1) outcomes related to feasibility, and (2) outcomes related to the impacts of such new modalities on various stakeholders, ranging from caregivers to families.

Over the last decade, a few studies have examined the feasibility of using a synchronous TM platform with PICU patients. In 2012, a retrospective study was conducted to investigate the hypothesis that nighttime TM can help staff intensivists to remotely manage patients in a PICU, preserve

continuity of care, and communicate with the fellows in a unit where fellows provide nighttime, onsite care, with super-vision by staff intensivists available by pager. The results of this study revealed that audio and video qualities were excellent, 94% and 85% respectively at the time (80). This study also found that reasons for initiating TM calls in the PICU were not limited to verbal medical consultations, but went beyond this to involve patient assessment (98%), team meetings (25%), and / or parent updates (40%).

More recently, a study conducted in 2015 concluded that 96.1% of clinicians thought that the characteristics of a TM system, such as ease of use, can highly influence the use of telemedicine technology (77). Specifically, the system's ease of use determined the learnability of the system by users and the work efficiency.

Moeckli and his collaborators studied the success factors of TM implementation in the ICU and reported that tele-ICU understanding, impact on work systems, perceived usefulness, and relationships were factors influencing acceptance and utilization of a tele-ICU system (78).

The impact of TM has been studied in many medical contexts (PICU, ICU, and other medical services). In a study undertaken in 1,100-bed tertiary-care community hospital (79), scholars noted that 69% of fellows thought that the tele-ICU system demonstrated an innovative approach to critically ill patients. Moreover, 37% and 77% agreed that tele-ICU was, respectively, a valuable education experience and associated with

improved patient safety. However, in this study 34% of fellows reported that tele-ICU did not improve communication or teamwork (75, 79).

Another study (75) conducted in South Dakota, USA involved 28 hospitals in which a tele-ICU system was implemented. Respondents in this study indicated that tele-ICU facilitated care for seriously ill patients at their hospital. Additionally, in this study 100% of the providers (physicians and fellows) responded that tele-ICU makes caring for patients in the ICU less burdensome, whereas 25% of the nurses disagreed.

In conclusion, the review of published studies shows that STM is widely used in critical and rehabilitation pediatric care and many initiatives were launched in terms of provision of care. However, the state of knowledge had revealed a divergence of views among the previous studies with differences about the relevance of STM depending on the settings.

The addendum of the current thesis boils down to three aims. First, it completes an inventory of previous published literature to better understand the impact of STM on the clinical outcomes in acute pediatric care. Second, it conducts an anticipatory pilot project to evaluate the feasibility of a home-based TSLP service for treating children with voice disorders. Thirdly, it assessed the impact of implementing a STM platform in a PICU between the off-site attendings PIs and the on-site fellows in order to perceive the effect of such a provision care model on the functioning of the critical pediatric care in PCU.

Chapter III

Methods

Since this dissertation includes two different research methods (one for the systematic review and another for the two-case study, pediatric critical care and SLP), the methodology section presents two designs. The first part outlines the design adopted to conduct the systematic review (article 1), and the second part focuses on the study design used in the multiple case analysis with two cases: one in rehabilitation (article 2) and another in critical care (article 3).

3.1 Method used in the systematic review

The aim is to conduct a systematic review of the previous literature on the impact of synchronous TM models on the clinical outcomes in pediatric acute care settings.

3.1.1 Literature search

This review was conducted based on the guidelines of the Preferred Reporting Items for Systematic and Meta-Analyses statement (81, 82).

In order to identify the required key words for our searches, we formulated a Population, Intervention, Comparison, Outcomes (PICO) question to orient the search and obtain the specific studies that would best serve our review. Then a search strategy (Appendix. 1) was developed and applied consistently in an electronic search using Medical Subject Headings. The following databases were targeted: all EBM Reviews, MEDLINE, EMBASE, Global Health, PubMed and CINAHL. We also looked for gray

literature by scoping Google Scholar, the HMIC (Healthcare Management Information Consortium), OpenGrey and OpenDOAR. In addition, we searched through a large number of information technology conference abstracts outside the field of pediatrics (e.g., the International Society for Telemedicine and eHealth, the American Medical Informatics Association, and the American Telemedicine Association). Furthermore, all the references cited in the included articles were rigorously screened to verify if any studies had been missed. Each of these steps in the literature search were performed with the assistance of a university librarian experienced in database searches.

3.1.2 Study selection criteria

In order to consistently select reliable studies for our review, we established a list of criteria to control the selection process. The list included study design, participant characteristics, technology type, interventions, settings, outcome measures and languages.

3.1.3 Study design

All studies with a formal quantitative method were eligible for the systematic review. This includes RCTs, quasi-experimental controlled trials, longitudinal and cross-sectional studies, controlled before-after studies and observational surveys. Similarly, qualitative studies with relevant, valid and reliable data regarding our review's objectives were included. Descriptive studies and case reports were excluded. Studies in

English and French were considered for full-text analysis as the authors of this review are proficient in both languages.

3.1.4 Participants and settings

Since our review is dedicated to the acute pediatric segment, it included only studies on samples of children under 18 years old and involving pediatric acute care physicians. There were no restrictions on other characteristics, such as gender, family socioeconomic status, ethnicity, education level and grade of illness acuity.

As for the settings, only studies conducted with consultants in PICUs, pediatric cardiac ICUs (CICU), neonatal ICUs (NICU), and pediatric ED were included, as this is where most acute interventions occur.

3.1.5 Technology type

Only studies using a synchronous telecommunication method were selected, as most interventions in the acute care pediatric settings need real-time communication and immediate interventions.

3.1.6 Interventions

A wide range of synchronous TM applications were used in pediatric acute care settings, so we considered for inclusion every study that had examined one or more clinical outcomes. Given this context, we included all interventions that could address the health status of participants in terms of diagnosis, treatment, follow-up and consultation, education or

any other activity performed in pediatric acute care settings, including but not limited to, clinical interventions, continuous monitoring of patients' clinical data, intermittent tele-rounding and teleconsultations.

3.1.7 Outcome measures

Studies eligible for inclusion had to contain data on the clinical outcomes for their participants. These clinical outcomes could be cited in several forms, including: quality of care, hospital and standardized mortality rate, transfer rate, complications and illness severity, change in medical management, and length of stay.

3.1.8 Data collection and validity assessment

3.1.8.1 Study selection

The electronic search strategy was carried out from January 1, 2000, to April 30, 2018. The year 2000 was chosen as the lower time limit because STM technologies had begun to emerge at the beginning of the 21st century and came into wide use as of the year 2000.

Two authors (MN, CS) separately carried out the selection process by screening and examining each title of the selected papers. In a second round, the two reviewers also independently examined the qualified papers' abstracts. Then both investigators independently analyzed the full-text relevant studies in an in-depth examination. When the authors found more than one published article containing the same participants sample and settings, but with different outcomes, all of these articles were

retained for extraction. In cases of disagreement between the reviewers, they met to discuss their differences and reach a consensus.

3.1.8.2 Data extraction and bias assessment

The two reviewers have extracted the following relevant information from the selected papers: telecommunication method, intervention, sample characteristics and size, study settings and outcomes. Regarding the outcomes, the two reviewers pooled the minimum and maximum observed values for each outcome retrieved from more than one study and used to aggregate its values. Moreover, the authors obtained general information from the selected studies, such as author names, publication year and journal, funding sources, conflicts of interest, objectives and study design.

At the same time, each reviewer assessed the research methods used in the selected studies to distinguish rigorous evidence from weak evidence. To this end, many tools were available such as the Cochrane Collaboration tool to assess risk of bias, AMSTAR tool, Ballard & Montgomery checklist, QUIPS, QUADAS, CASP qualitative checklist, COSMIN, OHAT, the Grading of Recommendations Assessment, Development and Evaluation, and others. We have used the Grading of Recommendations Assessment, Development and Evaluation scale (83) because it has the potential to cover all types of design including the quantitative and qualitative studies unlike other tools where each one is designed for a specific type of studies' designs. This scale proposes four

levels for grading the quality of the evidence: high (A), moderate (B), low (C), and very low (D). High-quality evidence (A) includes high-quality studies with consistent results, i.e. randomized and controlled trials, systematic reviews and meta-analyses. At this high level (A), reviewers are very confident that the true effect lies close to that of the estimate of the effect (83). Moderate-quality evidence (B) includes well performed studies with some limitations. To arrive at this rating (B), reviewers consider features in controlled trials such as randomization, allocation concealment, blinding, and the use of intention to treat analysis (83). As for the low level (C), it encompasses studies with severe limitations. Observational studies, in every form (prospective, retrospective, cross-sectional, etc.), begin as low-quality evidence. In observational studies, reviewers consider appropriate measurement of exposure and outcome as well as appropriate control of confounding factors. At level C, the confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect. Finally, the grade of very low-quality evidence (D) includes studies that rely on expert opinions, provide no direct research evidence and have very severe limitations (83). Reviewers have very little confidence in the effect estimate: The true effect is likely to be substantially different from its estimate, and any estimate of effect is highly uncertain.

3.2 Method used in the cases conducted in a PICU and SLP.

In this section, we present the settings, ethical considerations, and conceptual framework of the studies in a single paragraph since both were conducted in the same facility, approved by the same ethics committee, and used the same conceptual framework. On the other hand, their designs (a systematic review design for the first study, and multiple case studies for the other two studies), participants and recruitment, interventions, measuring instruments and health outcomes are presented separately.

3.2.1 Study setting

The two studies were conducted in the Sainte-Justine University Healthcare Center (SJUHC) in Montreal, Canada. It was the largest mother-child center in Canada and Quebec where it was the only health care establishment exclusively dedicated to children, adolescents and mothers (84). The first study was performed at the SLP department while the second was conducted in the PICU. The PICU at the SJUHC admitted more than 1,000 patients per year. It provided tertiary and quaternary care in all medical and surgical specialties, complete with access to high-tech monitoring and care equipment (e.g. extracorporeal support, hemofiltration) (85). It also provided pediatric intensivist training for the

entire Quebec healthcare system and to international students through its medical fellowship in pediatric intensive care.

The choice of the SJUHC as the site for these studies was an opportunistic and reasoned choice. On the one hand, the TM platform was planned for diffusion in this establishment. On the other hand, the logic of the promoters was that if such a system would work in the SJUHC, it would likely work in any other SLP department or PICU, given the highly complex clinical cases treated in this hospital.

3.2.2 Ethical considerations

These two studies were conducted in accordance with the standards of good clinical practice. The participants' names were not disclosed, and a code was assigned to each participant. Both projects were approved by the research ethics committee of the SJUHC (Appendix 2). Documents generated as part of this study will be kept for a period of seven years.

The participating clinicians (PIs, fellows, or SLPs) received a questionnaire that included a fact sheet explaining the objectives of the study and related ethical issues (Appendix 3). Completing the questionnaire was considered to constitute consent to participate to the research. Participation was voluntary, which meant that clinicians could choose or refuse to participate. If they refused to participate there was no loss of benefits, nor were there benefits to which they would otherwise be entitled. They were free to withdraw from the study at any time without any repercussions.

Patient consent was only asked for the TSLP project, and each parent (mother or father) gave her/his consent. This consent was obtained before the child was recruited for the study. Concerning the STEP-PICU study, the patient's consent was not needed since TM encounters with data exchange between PIs and fellows represented an alternative form of conventional medical practice (pager and telephone), recognized by the College of Physicians of Quebec, and no patient data was collected. TM encounters realized through REACTS^{TM} were considered part of the treatment process.

3.2.3 Conceptual framework

In order to guide the choice of the studied variables, researchers were used the conceptual framework developed by DeLone and McLean (86). Since its development, this model has been used in a wide variety of studies of information systems, including clinical data systems (87, 88). The DeLone and McLean Information System (IS) Success Model is a comprehensive and multidimensional model designed for measuring the IS success. Its postulation is based on the Shanon and Weaver framework (89) that defined the *technical* level of communication as the accuracy and efficiency of the communication system that produces information. The *semantic level* was the success of the information in conveying the intended meaning. The *effectiveness* level was the effect of the information on the receiver. Delone and McLean model consisted

in its first version (Appendix. 4) of six categories: “system quality, information quality, use, user satisfaction, individual impacts, and organizational impacts” (86). Based on research contributions since the publication of the model, Delone and McLean have lately updated their original success framework (Appendix. 5) in 2003. This updating was summarized by adding a new category “service quality” and substituting that of “use” by “intention to use”. As to individual and organizational impacts, they have been replaced by “net benefits”(90).

The three categories “System quality”, “information quality” and “service quality” singularly and jointly affect both “intention to use” and “user satisfaction”. Additionally, the degree of “intention to use” can affect the degree of “user satisfaction”- positively or negatively- as well as the reverse being true (86). As a result of this “use” and “user satisfaction”, certain “net benefits” will occur. If the IS or service was to be continued, it was assumed that the “net benefits” from the perspective of the user of the system were positive, thus influencing and reinforcing subsequent “intention to use” and “user satisfaction”. These feedback loops were still valid, however, even if the “net benefits” were negative. The lack of positive benefits was likely to lead to decreased use and possible discontinuance of the system (90).

3.2.4 TSLP Study's method

3.2.4.1 Data collection

We conducted a double-design study. Adopting a prospective design, a structured questionnaire was longitudinally administered at the end of each tele-treatment encounter. The same questionnaire was also used at the end of the entire experiment to obtain a summary evaluation of the full treatment. Questions were added to this questionnaire to assess the economic cost dimensions. The last objective was assessed through a pre/post design by comparing the voice outcomes before and after the intervention.

3.2.4.2 Participants and recruitment

The target population was patients under the age of 18 with a voice disorder. Because the voice clinic at SJUHC has a supraregional mandate, offering SLP services to children across the province and not limited to the Montreal area, it was of interest to select patients treated in this clinic for the current study. In addition, a few parents of children with voice disorder, traveling long distances, had previously expressed their wish for an alternative treatment modality instead of face-to-face services. A convenience sample of six patients was recruited and considered sufficient to conduct a pilot study and perform the assessment.

To be eligible for this study, each selected family had to have the following technologies at home:

1. A personal computer (PC type) with a 2.8 GHz processor or higher;
2. A Windows 7 or later operating system (Apple Mac not supported) and 2 GB of RAM (RAM).
3. Disk space of 75 MB or more;
4. A camera and microphone (USB or integrated);
5. An Internet connection with a bandwidth of at least 1 Mbit/s.

In addition to these preconditions, participants had to meet the following inclusion criteria:

1. Be over 6 years old;
2. Have laryngeal nodules and be referred by an ear, nose and throat specialist to the voice clinic for assessment and follow-up in speech therapy;
3. Able to interact via a visual modality;
4. Demonstrated involvement by the parents to ensure good remote monitoring.

The exclusion criteria for the children were the following:

1. Associated disorders, such as language disorder, speech sound disorder, intellectual disability, hearing loss or Attention Deficit Hyperactivity Disorder, that may interfere with distance interactions;
2. Have received speech-language treatments in the six months prior to the study.

3.2.4.3 Study Intervention

All patients were seen by a certified SLP with four years of experience with this population. The intervention for each patient was launched at the SJUHC with a 60 minutes face-to-face consultation for an initial voice

assessment according to the usual protocol. At the same time, to ensure proper handling and use of the platform, a training session was also held with the recruited families to familiarize them with the platform's settings and features.

Following this initial consultation, the virtual individual treatments were remotely delivered for all the TSLP sessions.

Every TSLP session took place in a four-step process that included:

1. Discussion with the parent and child (explanations and / or feedback from the previous meeting);
2. A warm-up;
3. Work on the goal according to the child's progress;
4. Explanation of the self-training exercises in preparation for the next session.

At the beginning of the tele-treatment, the encounters were given once per week. Later, the treatment sessions were provided once every two weeks according to the child's progress, i.e. once he/she had attained 80% of the intervention's objectives. Finally, when the patient began to generalize the objectives in a spontaneous context, the TSLP encounters were given on a monthly basis. In this manner, a maximum of 12 sessions were offered over a period that varied from 3 to 6 months.

Once the required TSLP sessions were completed, a second face-to-face consultation was held at the SJUHC to re-evaluate the children's voice performance.

3.2.4.4 Measurement and health outcomes

A structured questionnaire was developed to measure the feasibility of the TSLP service, the level of satisfaction of the SLP, children and parents and the two economic cost dimensions (Appendix. 6). For health outcomes (voice performance), we used two validated scales: the Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V) (Appendix. 7) (91) to assess perceived voice quality deviations and the pediatric Voice Handicap Index (pVHI) (Appendix. 8) (92) to evaluate pediatric dysphonia. Two items of the CAPE-V scale (pitch and loudness) were removed from the measure since the included children did not reveal problems with these voice parameters. The internal consistency of each scale was validated using Cronbach's alpha.

Feasibility, satisfaction, economic impact and health outcomes

The technical feasibility of the TSLP service was assessed by measuring three main features of the platform: its intrinsic *system qualities* with seven dimensions: ease of use (three items), image quality (two items), workflow integration (two items), response time (two items), reliability (three items), accessibility (one item), and perceived usefulness (three items); *data quality* with two dimensions: completeness (one item), and reliability and validity (one item); and, *quality of technical support* (three items). Clinical feasibility was assessed by measuring two dimensions: the degree of patient adherence to the SLP instructions (one item) and the therapeutic relationship between the patient and the SLP (four items).

As for satisfaction, we assessed the overall level of satisfaction (eight items) among the SLP, the children and their parents. For the economic component, four questions were used to assess two cost dimensions: the magnitude of economic savings from the point of view of the patients and their willingness to pay for access to such tele-treatments. The health outcomes were first measured using the pVHI, which is a 23-item parental proxy scale that is regularly used to assess the effects of dysphonia in the pediatric population. We also used the CAPE-V, which assesses six quality features: overall severity, roughness, breathiness, strain, pitch, and loudness. Both scales were used pre-post treatment to evaluate the change in the child's voice disorders as measured before and after the intervention.

3.2.5 STEP-PICU study's method

3.2.5.1 Study design

We conducted a prospective mixed study. Two sources of data were mobilized: a survey with a structured questionnaire and direct non-intrusive observation.

First, we conducted a cross-sectional evaluation to assess the perceptions and attitudes of respondents towards the use of the STEP-PICU in a real PICU context. Structured questionnaires, completed by both on-site and off-site physician users, were employed to assess their perceptions and attitudes about the implementation and use of the new

STEP-PICU platform. Second, direct non-intrusive observation was conducted by one of the researchers (MN) in order to study opportunities and obstacles in the STEP-PICU's implementation process. Observations were made throughout the several different implementation steps, ranging from preparatory staff meetings to the series of events during use of the TM platform in a real-world context.

3.2.5.2 Study Intervention

At SJUHC, the PIs are available 24/7 but do not provide 24-hour on-site coverage. They are generally on-site during daytime hours but not in the evening, at night or on holidays. During these periods, in-house coverage of all PICU patients is provided by fellows who are on call and consult with a PI as often as necessary to discuss patients' conditions and address specific problems. The fellows at SJUHC were being trained in a medical specialty and had varying degrees of experience and seniority.

When on call, the fellows have regular exchanges with PIs, during which they need to describe a patient's health status, ask for advice on the best possible management and receive advice and suggestions based on the information provided. Usually, most exchanges between fellows and PIs take the form of telephone discussions during which some clinical data, such as lab results, can be objectively transmitted while other clinical information, such as various aspects of the clinical exam, radiographic imaging, and electrocardiogram tracings, were communicated as best as possible by the fellows, who describe what they see. Before the STEP-

PICU pilot project, the usual means of communication were traditional technologies such as a pager, a short message service, or a cellphone.

The TM encounters, which took place between October 2017 and March 2018, encompassed a two-step process: a text message to plan a session followed by an audio-visual synchronous TM encounter. If deemed indicated, the fellow and the PI engaged in further discussion of the case through a STEP-PICU encounter. The decision to launch an encounter was only based on the shared judgment of fellows and PIs after they had discussed the case. No nurses, parents or residents were involved in this process. At the hospital, the telemedicine platform's software, a webcam and a microphone were installed on a mobile computer cart typically used for medical rounds. The computer on the cart had all the necessary medical software to provide access to medical imaging (SYNAPSE®, Fujifilm, town-state), laboratory results (SOFTLAB®, SCC Soft Computer, Clearwater-US), and the data in the critical care electronic medical record used in the PICU (ICCA®, Philips, Toronto-Canada). Moreover, it was possible to remotely assist a fellow performing a technical intervention with an ultrasound machine. This assistance could be achieved through a feature provided by the platform, through which the off-site PI could virtually manipulate the transducer of the ultrasound machine and the fellow only had to follow the PIs' instructions to perform the intervention.

To facilitate use of the STEP-PICU, three simulated sessions were organized one month before the platform's go-live. Following these sessions, the participants expressed their satisfaction and comfort with the platform. The fellows were then encouraged to initiate encounters with the PIs. The simulated sessions consisted of clinical case scenarios in which the fellows and PIs engaged in TM communications to learn how to use the platform's features and understand its integration with other clinical software (laboratory results, medical imaging, and medical record). The results for this phase were positive: the future users tried out the new technology and their initial acceptance was promising. During the simulation phase, no technical or connection challenges arose, possibly because the simulation sessions were conducted on-site and everyone was connected to the internal network of the hospital, which prevented the problem of proxy and firewall from occurring. In addition, the one-month period of the simulation was too short to test an update of the platform and its consequences.

3.2.5.3 Participants & recruitment

The target population included fellows and PIs of the PICU. All participants received an e-mailed questionnaire. At the end of the implementation period, both fellows and PIs completed and returned the questionnaire within the following week. If a respondent had not completed the questionnaire at that time, two reminders were sent. Each completed questionnaire reflected the user's perceptions of all the STEP-

PICU sessions he/she had participated in during the implementation period.

3.2.5.4 Measurement

The survey questionnaire was based on an existing and validated questionnaire developed by Sicotte et al. (87) (Appendix. 9). The internal consistency of each scale was validated using Cronbach's alpha. The questionnaire (Appendix. 10) encompassed 67 questions (10 related to socio-demographic characteristics; 53 questions assessing users' perceptions with 10-item Likert scales ranging from zero (strongly disagree) to 10 (strongly agree); and 4 open questions to better describe the attitudes and perceptions of participants).

For each of the perception dimensions, several variables were mobilized. Seven variables evaluated **system quality**: ease of use (five items), screen quality (two items), REACTS-SYNAPSE-SOFTLAB integration (three items), response time (three items), reliability (three items), accessibility (three items), and perceived usefulness (three items). **Data quality** was evaluated with five variables: completeness (one item), reliability and validity (two items), availability (one item), safety (one item), and the quality of inter-site integration of the data generated by the various sites (two items). **Quality of technical support** was assessed with one variable (five items) concerning the whole system. **Use** of the platform was measured with two variables: frequency of use (one item) and intensity of use (three items). **Overall satisfaction** was measured

with one variable (three items). As for the **benefits** dimension, it was measured in terms of improved productivity (seven items), quality of medical services (two items), and access to medical services (three items). A mean score for each dimension was calculated by dividing the scores of its items by the number of items and adding them together.

To better describe the pros and cons of the implementation process, four open questions were included in the questionnaire. These questions addressed the following themes: potential causes of a diminished use of the platform, the fellows' need for external expertise, the usefulness of the platform as a response to needs for patient care, and suggestions on how to improve platform use.

In addition, one of the investigators observed the entire process of the platform experiment. As a non-participant observer, he attended all the pre-implementation preparatory meetings organized with the PICU team. There he observed the preparations and discussions between the pediatric intensivists and fellows to identify the facilitators and obstacles encountered by the users. He also observed under what conditions the telemedicine sessions were held. Technical problems were easily observed in this manner. Furthermore, he was then able to observe the interventions of the technical support team in response to user requests.

CHAPTER IV

RESULTS

Chapter 4 contains three research papers forming the main body of the dissertation and all three were published in scientific journals. They are presented in chronological order given their finishing in data collection and analysis.

4.1 Article 1

Nadar, M., Jouvet, P., Tucci, M., Toledano, T. & Sicotte, C. (2018). Impact of Synchronous Telemedicine Models on Clinical Outcomes in Pediatric Acute Care Settings: A Systematic Review. *Pediatric Critical Care Medicine,* 19 (12), 662-71.

4.2 Article 2

Nadar, M., Fortin, A.J., Malas, K., Dimova, M. & Sicotte, C. (2019). Home-based pediatric telepractice in speech-language pathology: Evaluation of a pilot study. *International Journal of Information Research and Review,* 5 (9).

4.2 Article 3

Nadar, M., Jouvet, P., Tucci, M., Toledano, T., Cyr, M., & Sicotte, C. (2019). The Implementation of a Synchronous Telemedicine Platform Linking Off-Site Pediatric Intensivists and On-Site Fellows in a Pediatric Intensive Care Unit: A Feasibility Study. *International Journal of Medical Informatics*, 129 (2019), 219-225.

4.1 Article 1

Online Review Article

Impact of Synchronous Telemedicine Models on Clinical Outcomes in Pediatric Acute Care Settings: A Systematic Review*

Mahmoud Nadar, PhD[1–3]; Philippe Jouvet, PhD, MD[2]; Marisa Tucci, MD[2]; Baruch Toledano, MD[2]; Claude Sicotte, PhD[1,3]

Objectives: To evaluate the impact of synchronous telemedicine models on the clinical outcomes in pediatric acute care settings.

Data Sources: Citations from EBM Reviews, MEDLINE, EMBASE, Global Health, PubMed, and CINAHL.

Study Selection: We identified studies that evaluated the impact of synchronous telemedicine on clinical outcomes between January 2000 and April 2018. All studies involving acutely ill children in PICUs, pediatric cardiac ICUs, neonatal ICUs, and pediatric emergency departments were included. Publication inclusion criteria were study design, participants characteristics, technology type, interventions, settings, outcome measures, and languages.

Data Extraction: Two authors independently screened each article for inclusion and extracted information, including telecommunication method, intervention characteristics, sample characteristics and size, outcomes, and settings.

Data Synthesis: Out of the 789 studies initially identified, 24 were included. The six main outcomes of interest published were quality of care, hospital and standardized mortality rate, transfer rate, complications and illness severity, change in medical management, and length of stay. The use of synchronous telemedicine results improved quality of care and resulted in a decrease in the transfer rate (31–87.5%) (four studies), a shorter length of stay (8.2 vs 15.1 d) (six studies), a change or reinforcement of the medical care plan, a reduction in complications and illness severity, and a low hospital and standardized mortality rate. Overall, the quality of the included studies was weak.

Conclusions: Despite the broad recommendations found for using telemedicine in pediatric acute care settings, high-quality evidence of its impacts is still lacking. Further robust studies are needed to better determine the clinical effectiveness and the associated impacts of telemedicine in pediatric acute care settings. (*Pediatr Crit Care Med* 2018; 19:e662–e671)

Key Words: acute care; clinical outcomes; pediatric; pediatric intensive care unit; systematic review; telemedicine

Health inequities are a serious problem in all countries. Inequalities in health services exist across all segments of the population, including children (1). Several factors lead to these inequalities, including racial, ethnic, economic, social, cultural, and geographic factors. The geographic factor effectively deepens differences between areas in term of access to health services, especially in remote regions. In the United States in 2006, only 8.5% of emergency departments (EDs) reported having a pediatrician in the ED 24 hours a day, 7 days a week (2). As a result, many children face significant access barriers to pediatric health services, including fast access to acute care resources.

To overcome the geographical barrier, synchronous telemedicine (STM) has been proposed as a way to improve access to pediatric acute care (3). It would help clinicians in remote areas through STM-based consultations that provide acutely ill children with high-quality pediatric acute care that more closely approximates the care received in tertiary care hospitals.

In pediatric acute healthcare settings, multiple studies (4–17) have pointed out the effectiveness of STM in healthcare service provision. This is because pediatric acute care

*See also p. 1180.

[1]Department of Management, Evaluation and Health Policy, School of Public Health, University of Montreal, Montreal, QC, Canada.

[2]Division of Pediatric Critical Care, Department of Pediatrics, Sainte-Justine University Hospital, Montreal, Montreal, QC, Canada.

[3]Public Health Research Institute of the University of Montreal, Montreal, Montreal, QC, Canada.

This work was performed at the Division of Pediatric Critical Care, Sainte-Justine University Hospital, Montreal, QC, Canada.

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For information regarding this article, E-mail: mahmoud.nadar@umontreal.ca

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physicians can assess the patient in real-time, check clinical data and medical files, observe medical images and monitoring equipment, and provide a beneficial and helpful remote consultation. Other investigations have shown that provider hospitals and physicians using STM interventions provide a higher quality of care, are more efficient in their use of resources with improved cost-effectiveness, and procure higher level of satisfaction among remote patients and clinicians (5, 6, 10).

However, despite the significant number of observational studies, the formal evidence to support STM use in pediatric acute care is limited and remains weak. This weakness is principally due to the inconclusive and mixed results generated by this kind of study. To evaluate the impact of STM models on clinical outcomes among pediatric acute care patients, we conducted a systematic review.

MATERIALS AND METHODS

This review was conducted based on the guidelines in the Preferred Reporting Items for Systematic and Meta-Analyses statement (18, 19).

Literature Search

In order to identify the required Key Words for our searches, we formulated a Population, Intervention, Comparison, Outcomes question to orient the search and obtain the specific studies that would best serve our review. Then a search strategy (**Appendix 1**, Supplemental Digital Content 1, http://links.lww.com/PCC/A771) was developed and applied consistently in an electronic search using Medical Subject Headings. The following databases were targeted: all EBM Reviews, MEDLINE, EMBASE, Global Health, PubMed, and CINAHL. We also looked for gray literature by scoping Google Scholar, the Healthcare Management Information Consortium, OpenGrey, and OpenDOAR. In addition, we searched through a large number of information technology conference abstracts outside the field of pediatrics (e.g., the International Society for Telemedicine and eHealth, the American Medical Informatics Association, and the American Telemedicine Association). Furthermore, all the references cited in the included articles were rigorously screened to verify if any studies had been missed. Each of these steps in the literature search was performed with the assistance of a university librarian experienced in database searches.

Study Selection Criteria

In order to consistently select reliable studies for our review, we established a list of criteria to control the selection process. The list included study design, participant characteristics, technology type, interventions, settings, outcome measures, and languages.

Study Design. All studies with a formal quantitative method were eligible for the systematic review. This includes randomized controlled trials (RCTs), quasi-experimental controlled trials, longitudinal and cross-sectional studies, controlled before-after studies, and observational surveys. Similarly, qualitative studies with relevant, valid and reliable data regarding our review's objectives were included. Descriptive studies and case reports were excluded. Studies in English and French were considered for full-text analysis as the authors of this review are proficient in both these languages.

Participants and Settings. Since our review is dedicated to the acute pediatric segment, it included only studies on samples of children under 18 years old and involving pediatric acute care physicians. There were no restrictions on other characteristics, such as gender, family socioeconomic status, ethnicity, education level, and grade of illness acuity.

As for the settings, only studies conducted with consultants in PICUs, pediatric cardiac ICUs (CICUs), neonatal ICUs (NICUs), and pediatric ED were included, as this is where most acute interventions occur.

Technology Type. Only studies using a synchronous telecommunication method were selected, as most interventions in the acute care pediatric settings need real-time communication and immediate interventions.

Interventions. A wide range of STM applications are used in pediatric acute care settings, so we considered for inclusion every study that had examined one or more clinical outcomes. Given this context, we included all interventions that could address the health status of participants in terms of diagnosis, treatment, follow-up and consultation, education, or any other activity performed in pediatric acute care settings, including but not limited to, clinical interventions, continuous monitoring of patients' clinical data, intermittent telerounding, and teleconsultations.

Outcome Measures. Studies eligible for inclusion had to contain data on the clinical outcomes for their participants. These clinical outcomes could be cited in several forms, including but not limited to mortality rate, standardized mortality rate, length of stay (LOS), quality of care, transfer rate, complications, and change in medical management.

Data Collection and Validity Assessment

Study Selection. The electronic search strategy was carried out from January 1, 2000, to April 30, 2018. The year 2000 was chosen as the lower time limit because STM technologies had begun to emerge at the beginning of the 21st century and came into wide use as of the year 2000.

Two authors (M.N., C.S.) separately carried out the selection process by screening and examining each title. In a second round, the two reviewers also independently examined the qualified articles' abstracts. Then both investigators independently analyzed the full-text relevant studies in an in-depth examination. When the authors found more than one published article containing the same participants sample and settings, but with different outcomes, all of these articles were retained for extraction. In cases of disagreement between the reviewers, they met to discuss their differences and reach a consensus.

Data Extraction and Bias Assessment. The two reviewers have extracted the following relevant information from the selected papers: telecommunication method, intervention, sample characteristics and size, study settings, and outcomes. Regarding the outcomes, the two reviewers pooled the

minimum and maximum observed values for each outcome retrieved from more than one study and used to aggregate its values. Furthermore, the authors obtained general information from the selected studies, such as author names, publication year and journal, funding sources, conflicts of interest, objectives, and study design.

At the same time, each reviewer assessed the research methods used in the selected studies to distinguish rigorous evidence from weak evidence. To this end, the authors have used the Grading of Recommendations Assessment, Development and Evaluation scale (20) to assess the quality of the included studies. This scale proposes four levels for grading the quality of the evidence: high (A), moderate (B), low (C), and very low (D). High-quality evidence (A) includes high-quality studies with consistent results, that is, randomized and controlled trials, systematic reviews, and meta-analyses. At this high level (A), reviewers are very confident that the true effect lies close to that of the estimate of the effect (20). Moderate-quality evidence (B) includes well-performed studies with some limitations. To arrive at this rating (B), reviewers consider features in controlled trials such as randomization, allocation concealment, blinding, and the use of intention to treat analysis (20). As for the low level (C), it encompasses studies with severe limitations. Observational studies, in every form (prospective, retrospective, cross-sectional, etc), begin as low-quality evidence. In observational studies, reviewers consider appropriate measurement of exposure and outcome as well as appropriate control of confounding factors. At level C, the confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect. Finally, the grade of very low-quality evidence (D) includes studies that rely on expert opinions, provide no direct research evidence and have very severe limitations (20). Reviewers have very little confidence in the effect estimate: The true effect is likely to be substantially different from its estimate, and any estimate of effect is highly uncertain.

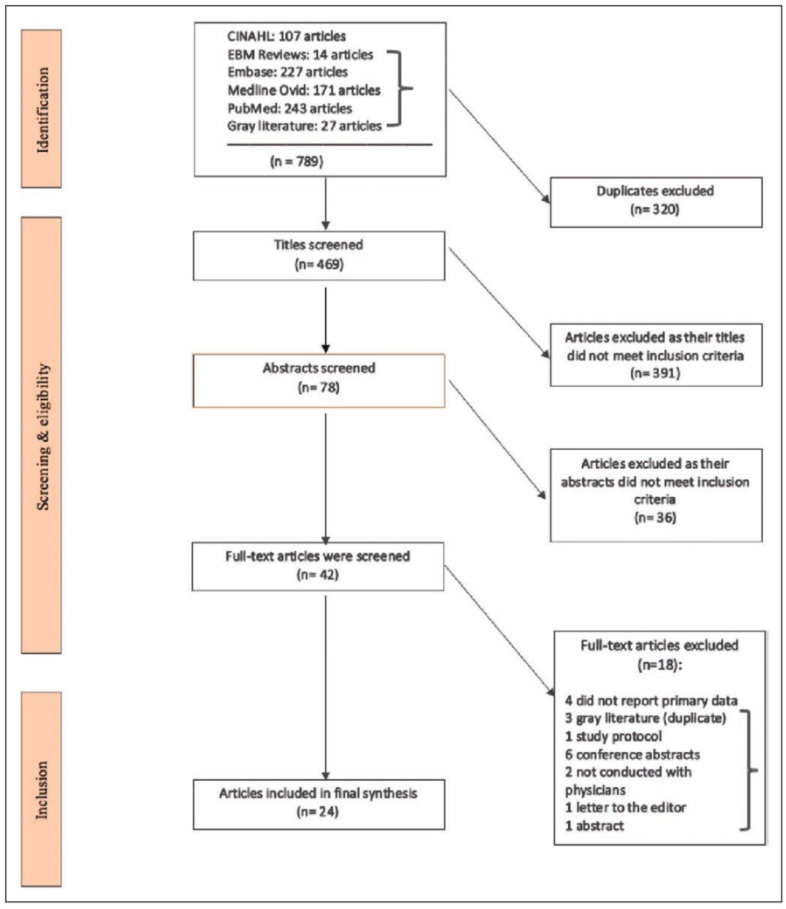

Figure 1. The Preferred Reporting Items for Systematic Review and Meta-Analyses flowchart clarifies the flow process for study identification, screening and eligibility, and inclusion.

RESULTS

Study Characteristics and Designs

Out of the 789 studies initially identified, 24 were included for final analysis (**Fig. 1**). All 24 studies were retrieved from the electronic databases and conducted with consultants. Our search of the gray literature identified three studies already in our sample of 24 studies; they represented duplicate results and were not retained. Eleven of the 24 studies were conducted in an ED (13, 21–30), four in a NICU (31–34), seven in a PICU or pediatric CICU (9, 14, 35–39), and two in a trauma ICU (7, 8) (**Table 1**). As for study design, only one RCT (21) was included in the final review. All the other studies were observational studies, including seven with a prospective design and 16 with a retrospective design. A large majority of included studies (20/24) were conducted in the United States; the remaining four studies were conducted in Colombia (two studies), Canada (one study), and Australia (one study). Nineteen of the 24 studies were conducted over the last 5 years, and the sample size ranged from 16 to 1,106 participants.

Impact of STM on the Clinical Outcomes

Table 2 provides a summary of the clinical outcomes reported in each study.

Quality of Care. In this section, we present two aspects of the results on quality of care: quality of care measured with hard outcomes and the perceptions of self-reporting providers.

Quality of Care With Hard Outcomes. In the context of an RCT on remote simulation experiences, high-fidelity simulation scenarios of critically ill children presenting to a community hospital and progressing to cardiopulmonary arrest were performed by remote pediatric critical care medicine fellows (21). This RCT reported that 40% of clinical teams successfully defibrillated pulseless ventricular tachycardia in 180 seconds or less, with no significant difference from the control group ($p = 0.7$). In a study conducted in NICU, Makkar et al (34) concluded that neonates managed through STM consultations had fewer days of supplemental oxygen and fewer noninvasive ventilation support days and reached full enteral feeds sooner than those who received standard care.

The study conducted by Harvey et al (29) concluded that STM consultations reduce PICU admissions. According to this study, the odds of triage to a non-ICU level of care for patients receiving STM consultations were 2.55 times greater than the odds for patients receiving telephone consultations ($p = 0.0005$). Similarly, 58% of patients with STM and 73% of the control patients were admitted to the PICU ($p = 0.13$) (35). Furthermore, Hernandez et al (30) pointed out that 8.6% of the pediatric patients triaged as critically ill received telemedicine consultations.

Self-Reporting Providers. Four studies (14, 25, 27, 31) reported high percentages in the quality of medical care. Through an episodic teleconsultation model to a remote ED, both pediatric intensivists (89%) and referring providers (88%) stated that telemedicine consultations improved the quality of care (27). In a NICU setting, 93.3% of local providers self-reported that the STM consultations improved patient safety and/or quality of care in six remote clinic health system sites (31). On the other hand, these percentages decreased to 75% according to the CICU intensivists in the context of an international STM program (14). In a study of 320 patients and conducted at five remote EDs and regional PICUs (25), the mean adjusted overall quality of care score for patients who received STM consultations was 5.76 (on a scale of 1–7 ranging from "extremely inappropriate" to "extremely appropriate"), only 0.50 (95% CI, 0.17–0.84) higher than the mean adjusted score for patients who received none-telemedicine consultations or telephone consultations ($p < 0.01$).

Hospital and Standardized Mortality Rate. Although the difference between patients receiving STM consultations and those receiving face-to-face consultations was not statistically significant, two studies conducted at a tertiary PICU and a community hospital reported a lower hospital mortality rate, with 2.1% for the STM cohort versus 2.6% for the controls (8), and 7.2% for patients who benefited from STM versus 9.1% for those who received standard care (9).

After transferring to a PICU, the standardized mortality rates for telemedicine and nontelemedicine cohorts were 0.81 (95% CI, 0.53–1.09) and 1.02 (95% CI, 0.71–1.33; $p = 0.07$), respectively (22). Another study carried out in a PICU showed that the observed mortality rate was 76% lower than expected in patients receiving teleconsultations, compared with 32% lower than expected in those transferred to the referral hospital without an STM consultation (8). As for CICU settings, the hospital survival rate was higher among patients during the telemedicine period compared with their peers during the pre-telemedicine period (54.1% vs 29.8%; $p = 0.002$) (39).

Transfer Rate. Four studies (13, 26, 31, 38) found that the transfer rate decreased in children who received teleconsultations. However, some intrastudy differences were observed in terms of the extent of the decrease.

A recent study released in 2018 (38) reported that 37% of patients who received STM consultations required a transfer to a PICU, whereas all the controls were transported ($p < 0.0001$). This percentage was different from that obtained by LaBarbera et al (13), who reported that the transfer rates were lower in the STM cohort with 87.5% transferred, compared with a 100% transport rate for patients receiving pediatric intensivist telephone consultations (pre-telemedicine) ($p = 0.04$).

In the same vein, a NICU study concluded that 66.7% of neonates receiving STM consultations were transferred to a higher level of care, versus 32% who were able to remain at the referring hospital (31).

According to the self-reporting of the PICU intensivists, one study concluded that a transfer was avoided in 47% of the cases that used STM. In contrast, the referring clinicians estimated that STM reduced the need for a transfer in 31% of the cases (26).

Based on the value ranges of the evaluated studies, this systematic review estimates that the utilization of STM was demonstrated to decrease the transfer rates by between 31% (minimum) (sample size: 14 referring clinicians) (26) and 87.5% (maximum) (sample size: 153 patients) (13), depending on the setting.

Complications, Illness Severity, and Medication Errors. Only one study examined complications with the use of STM, reporting no complications with its use in a NICU (40). Patients transferred from an ED to the regional PICU with STM support arrived less ill when compared with patients transferred from an ED without STM (Pediatric Risk of Mortality III score of 3.2 vs 4.0 [$p < 0.05$], respectively [22]). As for medication errors, one study (28) reported that medications for patients who received telemedicine consultations had significantly fewer physician-related errors than medications for patients who received telephone consultations or no consultations (3.4% vs 10.8% and 12.5%, respectively; $p < 0.05$). Furthermore, this study concluded that medications for patients who received telemedicine consultations were less likely to have physician-related errors than medications for patients who received telephone consultations (odds ratio, 0.19; $p < 0.05$) or no consultation (odds ratio, 0.13; $p < 0.05$).

TABLE 1. Summary of Studies Included in the Review

References	Year	Country	Study Design
ED studies			
Yang et al (21)	2017	United States	Randomized controlled trial
Harvey et al (29)	2017	United States	Retrospective
Dayal et al (22)	2016	United States	Retrospective
Hernandez et al (30)	2015	United States	Retrospective
Yang et al (23)	2015	United States	Retrospective
Yang et al (24)	2015	United States	Retrospective
LaBarbera et al (13)	2013	United States	Retrospective
Dharmar et al (25)	2013	United States	Retrospective with concurrent surveys
Desai et al (26)	2013	Australia	Prospective
Dharmar et al (28)	2013	United States	Retrospective
Heath et al (27)	2009	United States	Prospective
PICU and cardiac PICU			
Holt et al (38)	2018	Canada	Prospective
Lopez-Magallon et al (39)	2017	United States	Retrospective
Lopez-Magallon et al (9)	2015	United States	Retrospective and pre/post intervention
Robison and Slamon (35)	2014	United States	Prospective
Otero et al (37)	2014	Colombia	Retrospective
Yager et al (36)	2012	United States	Retrospective
Munoz et al (14)	2012	Colombia	Retrospective case series
NICU studies			
Makkar et al (34)	2018	United States	Retrospective
Fang et al (31)	2016	United States	Prospective
Garingo et al (32)	2015	United States	Prospective
Fang et al (33)	2014	United States	Prospective simulation resuscitation
Trauma ICU studies			
Marcin et al (7)	2004	United States	Retrospective/nonconcurrent cohort
Marcin et al (8)	2004	United States	Retrospective/nonconcurrent cohort

CICU = cardiac ICU, ED = emergency department, NICU = neonatal ICU, TM = telemedicine.

Sample	Settings	Technology	Grading of Recommendations Assessment, Development and Evaluation
30 simulation sessions (15 control and 15 intervention)	ED	Telephone (control) and audiovisual conferencing (intervention)	B
422 patients (telephone consultations); 62 patients (TM consultations)	ED	Interactive videoconferencing unit	C
582 patients transferred with telemedicine (TM); 524 patients transferred without TM	ED	Audiovisual interactive communication	C
308 TM consultations	ED	Interactive audiovisual communication	C
71 received teleconsultations; 64 received telephone consultation	ED	Land phone and live audiovisual conferencing	C
74 received TM teleconsultations; 64 received telephone consultation	ED	Land phone and live audiovisual conferencing	C
41 patients (pre-TM); 56 patients (post-TM); 56 patients (non-TM)	ED	Real-time two-way audiovisual conferencing	C
58 patients (TM consultations); 63 patients (telephone consultations); 199 patients (nonspecialist consultations)	ED	Interactive audiovisual communication	C
16 teleconsultations	ED	Audiovisual live communication	C
73 patients (TM consultations); 85 patients (telephone consultations); 76 patients (no specialist consultations)	ED	Bidirectional videoconferencing	C
63 teleconsultations	ED	Telephone lines and hardware-based dedicated videoconferencing systems	C
38 patients with TM; 193 patients (control)	PICU	Remote presence robotic technology	B
109 patients (TM period); 57 patients (pre-TM period)	Pediatric CICU	Real-time communication videoconferencing	C
282 TM teleconsultations; 269 pre-TM consultations	Pediatric CICU	Real-time communication videoconferencing	C
43 patients with TM (intervention); 48 patients (control)	PICU	Interactive and audiovisual communication	C
1,040 teleconsultations (retrospective part) 27 respondents (cross-sectional)	Pediatric CICU	Audiovisual live conferencing	C
56 teleconsultations	PICU	Audiovisual live conferencing	C
71 teleconsultations	Pediatric CICU	Audiovisual live conferencing	C
87 neonates with TM (intervention group); 56 neonates (standard group)	NICU	Audiovisual telemedicine system	C
64 neonatologists and general providers	NICU	Video telemedicine consultation	B
197 consultations (onsite neonatologists); 176 teleconsultations (offsite neonatologists)	NICU	Mobile robot with live audiovisual communication system	B
23 participants (intervention); 23 participants (control)	NICU	Real-time audiovisual communication	C
47 patients received teleconsultations; 179 nontransferred patients	Trauma ICU	Live, interactive, two-way audiovisual consultation	C
429 patients	Trauma ICU	Live, interactive, two-way audiovisual consultation	C

TABLE 2. Summary of Clinical Outcomes Reported in the Review

Main Outcomes	References	Measurement Unit
Hospital and/or standardized mortality ratio	Marcin et al (8)	Mean % and ratio mean
	Lopez-Magallon et al (9)	Mean %
	Dayal et al (22)	Ratio mean; CI
	Lopez-Magallon et al (39)	Mean %
QOC	Munoz et al (14)	Mean % (physician evaluation of QOC)
	Dharmar et al (25)	Mean ratio (QOC score)
	Heath et al (27)	Mean % (physician evaluation of QOC)
	Fang et al (31)	Mean % (physician evaluation of QOC)
	Yang et al (21)	Mean % (clinical outcomes)
	Makkar et al (34)	Not applicable
	Robison and Slamon (35)	Mean % (PICU admission)
	Harvey et al (29)	Odds ratio (triage to a lower level of care)
	Hernandez et al (30)	Percentage % (patients triaged as critically ill via synchronous telemedicine)
Transfer rate	LaBarbera et al (13)	Percentage % (transferred cases)
	Desai et al (26)	Percentage % (transferred cases)
	Holt et al (38)	Percentage % (transferred cases)
	Fang et al (31)	Percentage % (transferred cases)
Complications, illness severity, and medication errors	Dayal et al (22)	Pediatric Risk of Mortality III mean score
	Garingo et al (40)	Kappa agreement ratio
	Dharmar et al (28)	Percentage % (medication errors) and odds ratio
Change in medical management	Munoz et al (14)	Percentage % (change in medical plan)
	Dharmar et al (25)	Percentage % (change in medical plan)
	Otero et al (37)	Score mean (SD) (change in medical plan)
	Yager et al (36)	Percentage % (change or reinforcement of medical plan)
	Yang et al (21)	Mean % (clinical outcomes)
Length of stay	Lopez-Magallon et al (9)	Mean days (SD)
	Dayal et al (22)	Mean days (SD)
	Garingo et al (32)	Median days (interquartile range)
	Makkar et al (34)	Not applicable
	Holt et al (38)	Mean days
	Lopez-Magallon et al (39)	Mean days

QOC = quality of care.

Change in Medical Management. Five studies reported a significant change in medical management after a synchronous teleconsultation (14, 21, 25, 36, 37). In the RCT conducted in 2017 and based on simulation scenarios (21), requests for or use of a backboard and stepstool during cardiopulmonary resuscitation occurred in 15 (100%) out of 15 scenarios ($p = 0.006$) compared with 5 (33%) out of 15 scenarios ($p = 0.07$), respectively, in the intervention group with STM support.

In two separate studies (14, 36), 84% of respondents self-reported that they had changed their medical plan in at least 50% of the posttelemedicine cases (14), whereas a modification in medical management and a reinforcement of the existing care plan occurred in 32% and 39% of encounters, respectively (36). When comparing consultations using audiovisual telecommunication with those using land lines, the remote ED physicians changed their diagnoses (47.8% vs 13.3%; $p < 0.01$)

and therapeutic interventions (55.2% vs 7.1%; $p < 0.01$) more frequently with audiovisual telecommunication (25). After a retrospective analysis of 1,040 teleconsultations and a survey of 27 physicians (37), it was reported that the physicians sometimes changed their clinical practices due to telemedicine encounters (mean, 2.7 ± 0.61; with 0 = never and 5 = always).

LOS. A study carried out in a CICU reported that the LOS in hospital was significantly shorter after the implementation of telemedicine (14 d vs 21 d; $p < 0.02$) (9). Another study conducted in a NICU concluded that neonates who received STM consultations had shorter hospital stay (12.2 d) than those who received conventional care (15.1 d) (34).

On the other hand, Holt et al (38) reported that there was no statistically significant difference in hospital LOS between transported participants receiving STM and the controls (6 vs 5.7 d). Similarly, Dayal et al (22) concluded that patients transferred to a PICU after an STM consultation had spent 3.1 days in hospital versus 3.8 days for those transferred without an STM.

Surprisingly, Lopez-Magallon et al (39) concluded that patients' hospital LOS was longer during the telemedicine period than the pretelemedicine period (67 vs 28 d; $p < 0.001$). According to the authors, significantly longer hospital LOS seemed to be driven by increased hospital survival (54.1% for telemedicine period vs 29.8%, for pretelemedicine group $p = 0.002$). Similarly, another study concluded that patients cared for by an off-site neonatologist using a remote-controlled robot had a longer LOS (21 d) than those cared for by an on-site NICU team (16 d) (32).

Overall, the similar measures used in the included studies allowed us to aggregate the results and estimate LOS in a value range of 8.2 days (minimum) for STM to 15.1 days (maximum) for standard care, depending on the settings.

DISCUSSION

Despite the broad recommendation to use telemedicine with acutely ill patients, this systematic review found a lack of robust evidence in the current literature that could be used to guide STM practice in pediatric acute care settings. In general, the preliminary nature of the feasibility and observational studies limits the generalizability of the results, an aspect that could be remedied in future studies with more refined versions of the interventions, larger samples, and the inclusion of a control group.

This review's findings suggest that over the last 5 years, pediatric acute care application-based research has grown steadily, with a significant increase in positive clinical outcomes.

The current review analyzed 24 studies with substantial differences in their interventions and outcomes measures. Due to these differences, we were unable to aggregate statistical data for most outcomes except for two: the transfer rate and the LOS.

After examining the values ranges of the outcomes results, our systematic review concludes that the evaluated studies demonstrate that the utilization of STM improved the quality of care, decreased the transfer rate, shortened the LOS, changed or reinforced the medical care plan, reduced complications, illness severity and medication errors, and decreased the hospital stay and standardized mortality rate.

However, the evidence on quality of care is weak because of the poor quality of most of the reviewed studies. These studies were based on self-reporting by physicians without measuring the quality of care with objective indicators. In future studies, we recommend measuring quality of care with more objective and hard outcomes. Nevertheless, the strongest evidence on quality of care appeared in a RCT conducted in situ with high-fidelity simulation scenarios where real-time telemedicine was associated with an indicator of high-quality cardiopulmonary resuscitation: more frequent use of a backboard and stepstool. The results of our review are congruent with a previous systematic review demonstrating that telemedicine was comparable to face-to-face care in adult emergency medicine and was beneficial in surgical and NICUs as well as in patient transfer in neurosurgery (41).

Much like the case of quality of care, the studies suffer from a weakness related to the impact of STM on changes to medical management. All the reviewed studies were based on the individual perceptions of clinicians, with no data extracted from medical records and analyzed.

Concerning hospital mortality rates, the conclusions drawn from the results of the studies included in the current review are concordant with those reported in a meta-analysis and showed that, when compared with face-to-face care, telemedicine is associated with lower adult and PICU mortality (risk ratio [RR], 0.79) and hospital mortality (RR, 0.83) (42). Similarly, two adult-ICU studies showed a reduction in the hospital mortality rate from 13.6% to 11.8% and from 11% to 10%, respectively, attributable to the use of STM (43, 44). Knowing that the majority of studies demonstrating a reduction in mortality in both adults and pediatrics occurred in a tele-ICU model of critical care telemedicine, continuous monitoring, and recurring interventions by a centrally located intensivist on patients admitted at remote sites improve the chances of survival and decrease the mortality rates among these patients.

In spite of the paucity of studies examining the relationship between STM and medical errors, the literature shows that STM is a promising alternative that reduces medication errors (28). Hence, using STM consultations to assess and treat patients can be a reasonable way of dealing with medical complications (32) and severity of illness (22) in infants and children admitted to a NICU or an ED.

Despite the divergent results of the studies on LOS in our review, it has led to the conclusion that—based on the results of most of the included studies—STM decreases LOS for patients receiving care through STM. This conclusion is concordant with the results of an adult ICU meta-analysis, which found statistically significant reductions in ICU and hospital LOS (42).

This review has several strengths and limitations. One strength is that it encompassed all acute care units where acutely ill children are managed (PICU, NICU, CICU, ED). Such a broad inclusion rule helps highlight any differences between acute care units with respect to the impact of STM on clinical outcomes.

A second strength of this review is its exhaustive review of the literature that included, in addition to the classic databases, gray literature, and conference abstracts. Despite the fact that the searches of the gray literature and conferences abstracts only resulted in the retrieval of duplicated studies, it was useful to ensure that we did not miss any relevant studies. So this exhaustive literature review has presented the available knowledge about STM for physicians working in pediatric acute care settings and has recommended avenues for future researches.

In spite the strengths of this review, some limitations need to be noted. Most of the included studies were retrospective, which resulted in a substantial amount of missing data and a which reduced the size and power of the study. In addition, there was potential selection bias in the studies that were observational. As we limited our search to English and French-language publications, there is also the possibility that other relevant studies might have been missed.

CONCLUSIONS

As we observed from the published studies, there is evidence of continuous but slow growth in the frequency of STM use and of positive impacts on clinical outcomes in the field of pediatric acute care medicine. However, this review underscores the weak methodological quality of most of the studies investigating STM in pediatric acute care and is focused on the implications of levels of evidence for future research (the lower the quality, the more likely further research would change our confidence in the estimates, and the estimates themselves). Further multisite RCTs or quasi-experimental studies are needed to determine clinical effectiveness and the associated impacts. Given the considerable number of telemedicine activities, with over 450 telemedicine programs worldwide and 360 of them in the United States (45), the number of published studies on STM in pediatric acute care remains limited. This highlights the importance of conducting more research on the application of STM interventions in pediatric acute care settings. Policymakers and other stakeholders would benefit from better evidence-based data on the effectiveness of telemedicine.

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4.2 Article 2

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REVIEW ARTICLE

HOME-BASED PEDIATRIC TELEPRACTICE IN SPEECH-LANGUAGE PATHOLOGY: EVALUATION OF A PILOT STUDY

[1,2,4,*]Mahmoud Nadar, [1,4]Claude Sicotte, [3]Annie Joëlle Fortin, [3]Kathy Malas and [3]Miroslava Dimova

[1]Department of Management, Evaluation and Health Policy, School of Public Health, University of Montreal, Canada
[2] University of Quebec in Outaouais, Health Sciences and Nursing Department, Canada
[3]Centre Hospitalier Universitaire Sainte-Justine, Montréal, Canada
[4]Public Health Research Institute of the University of Montreal, Montreal, Canada

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ABSTRACT

Introduction: There has been considerable interest in whether a home-based telepractice in speech-language pathology (TSLP) can increase access to the services of speech-language pathologist (SLP). Most of the studies reported in the literature suggest that TSL Prepresents a promising avenue. However, the evidence on the clinical efficacy of this treatment modality in home-based applications isvery limited. The aim of the current study was to assess the technical and clinical feasibility of home-based TSLP in an application with children with voice disorders. It also sought to assess the impact of TSLP on the patients' and SLP satisfaction, economic cost, and voice performance. **Method:** We conducted a double-design study. The target population was patients under the age of 18 with a voice disorder and Internet access at home. A convenience sample was used, with six patients recruited prospectively. A structured questionnaire was administered to measure the feasibility of the TSLP service and its impact on the SLP, parents and children satisfaction, and ontwo economic cost dimensions.As for the health outcomes (voice performance), we used two validated scales: the Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V) and the pediatric Voice Handicap Index (pVHI). **Results:** Across all six patients, a total of 46 TSLP sessions were delivered by a registered SLP. Our results show that TSLP is clinically feasible. In terms of technical feasibility, some problems were encountered such as connection problems, freezing of images and sound, and signal transmission delays. Notwithstanding, both the patients and SLP were satisfied with the service in all sessions. From a patient economics point of view, the mean estimated amount of money saved was US$167.80/patient (SD ± 116.88), and the amount parents would bewilling to pay for sucha service was US$140(SD ± 52.83). As for health outcomes, a Wilcoxon Signed-Ranks Test showed thatpost-TSLP overall severity, measured with the CAPE-V scale, was significantly lower than pre-TSLP scores (P=.027). Similarly, the total score on the pVHIwas significantly lower after the TSLP sessions (P= .043). Both positive outcomes indicate that the TSLP service can contribute to voice improvement. **Conclusion:** These results support the feasibility, utility and benefit of TSLP services for children with voice disorders. Good logistical preparation is required before launching the service. Effectiveness should be further documented through comparative clinical trials and utility through qualitative study of parents' and clinicians' experiences.

INTRODUCTION

Overthe last few years the use of information and communication technologies has become increasingly widespread in the assessment, diagnosis and treatment of communication disorders. There has been considerable interest in pediatric telepractice to overcome distance barriers and to increase access to specialized services such as those offered by speech-language pathologist (SLP), whose availability is very limited, particularly in remote regions (O'Brian, 2014; Sicotte, 2003).

In addition, children and adolescents enjoy using computers and the Internet, and this can considerably enhance patient motivation (Carey, 2012). In an era of rapid technological change, new digitalplatforms providing interactive and synchronous (real-time audiovisual communication) telecommunication between the SLP and the patient can be effective in the evaluation of speech and/or language disorders and related interventions (Isaki, 2015), especially for patients who live in remote and rural regions. Such new telehealth solutions with interactive audiovisual communication features, which are more responsive and flexible than traditional

videoconferencing, may provide accessible alternatives and provide affordabletelepractice in speech-language pathology (TSLP) services. A home-based TSL Ponone of these advanced platforms dedicated to serving children with speech-language disorders could improve access to a SLP and ensure appropriate care for children at a distance. Furthermore, the difficulties, inconveniences and costs associated with repetitive travel represent major barriers that could be overcome by such a TSLP service. As for the service's technical aspects, numerous studies have demonstrated successful implementation of telehealth in speech-language pathology. Preferred TSLP technologies are traditional videoconferencing (Sicotte, 2003; Jessiman, 2003) or software (e.g. Skype, Face Time, Polycom PVX (O'Brian, 2014; Carey, 2012; Isaki, 2015; Carey, 2014; Grogan-Johnson, 2013; Gabel, 2013; Grogan-Johnson, 2011; Grogan-Johnson, 2010) that can establish an audiovisual connection between personal computers. As telehealth emerged in the first decade of this century, some studies reported technical difficulties and poor sound and image quality, making it impossible to carry out an accurate evaluation of remote patients without face-to-face consultations (Jessiman, 2003; Eriks-Brophy, 2005).

Otherstudies found the technical quality good enough to evaluate and treat children with stuttering or speech sound disorders (Sicotte, 2003; Isaki, 2015). Note that some technologies offered limited potential for interaction with the patients, which may have affected their motivation (Isaki, 2015). By contrast, those that allow inclusion of a playful element in the therapeutic protocol can enhance the children's motivation and improve attendance at the therapy sessions. Clinically, the majority of published studies related to TSLP services were conducted in schools or healthcare centers and were mainly non-experimental assessments. Only one randomized controlled trial (RCT) (Grogan-Johnson, 2013), involving 14 children with speech sound disorders, was carried out in rural schools in the United States and showed an improvement in both groups of children. This RCT suggested that the use of telepractice interventions for children with speech or language disorders is comparable to face-to-face treatment.

Other studies (Gabel, 2013; Grogan-Johnson, 2010; Fairweather, 2016) on TSLP reported similar results. The pilot study conducted by Grogan-Johnson et al. (Grogan-Johnson, 2010). revealed that families were satisfied with TSLP and the progress made by the children with speech-language disorders was similar regardless of the two treatment modalities: at distance or in person. These results are concordant with those reported by a recent study conducted in Australia (Fairweather, 2016), showing that a TSLP program improved the speech and language skills of children in both early childhood settings and primary school. In 2017, a systematic review supported that both telehealth and in-person primary school-age children can make significant and similar improvements. According to this review, telehealth delivery model has the potential to improve access to SLP services for children living in remote areas, reducing travel time and alleviating the detrimental effects of communication difficulties on education, social participation and employment (Wales, 2017). Studies carried out in healthcare centers (Sicotte, 2003; Isaki, 2015) also reportedclinical positive outcomes of TSLP. Sicotte et al. (2003) conducted a study on four children and two adolescents with stuttering who were assessed and treated remotely at a local primary care center near their places of residence. This study reported very high levels of satisfaction among the families and SLP, on both the technical and clinical scales. Improved speech fluidity was observed among all the patients, who maintained (at least partially) their achievements after the intervention. Similarly, a series of treatments given to five children through Face Time for iPad showed that the children reached the majority of their speech or language therapy goals, with the exception of a child with cognitive difficulties[4]. Nevertheless, some authors emphasized an inherent constraint of TSLP,to the extent that an initial face-to-face assessment remains necessary (Jessiman, 2003; Eriks-Brophy, 2008). Currently, home-based TSLP programs have seldom been evaluated, even if some studies[1, 3, 6]have indicated that interventions in the patient's environment are potentially more effective than those performed in clinical settings. In Australia (O'Brian, 2014), three children with stuttering were assessed and treated at home using the Lidcom be program delivered via webcam. The parents' acceptance of home TSLP was good, despite some occasional problems with the technology. Also, the results of the intervention were similar to those obtained in another study with children treated face-to-face (Rousseau, 2007). Several benefits related to home treatment were reported, including a greater level of comfort among the children in their environment and the time saved. However, the authors pointed out that more sessions or supplementary follow-up, and more sessions may be required (O'Brian, 2014).

Two other studies have described the use of the Camper down program via webcam (Carey, 2012) anda videoconference platform with adolescents with stuttering (Carey et al., 2014). The Phase I study showed that intervention using this modality resulted in an average of 93% reduction of stuttering among the three participating adolescents (Carey, 2012). These results were only reproduced in the Phase II study involving 16 adolescents, where only 50% of the patients showed a positive response to intervention (Carey, 2014). In summary, most studies suggest that TSLP is a promising avenue since it addresses a need among families that, without it, mightbe deprived of care. However, the evidence on the clinical effectiveness of this treatment modality it still limited. The number of studies investigating home-based TSLP is also restricted and, to our knowledge, none has involved children with voice disorders. Therefore, this study aims to enrich knowledge in the field of home-based TSLP for treating children with voice disorders using a secure new technology that promotes greater interaction. Our study addressed several objectives. First, we assessed the technical and clinical feasibility of a TSLP platform providing tele-treatments to children suffering from voice disorders. Second, we evaluated the levels of satisfaction of the SLP, children and parents with the TSLP treatments. Third, we assessed two economic cost dimensions associated with home care, from the parent's point of view. Finally, we evaluated the impact of the TSLP service on health outcomes in terms of voice performance.

METHODS

Study design: We conducted a double-design study. Adopting a prospective design, a structured questionnaire was administered at the end of each tele-treatment session to achieve the first three objectives.

The same questionnaire was also used at the end of the entire experiment to obtain a summary evaluation of the full treatment. Questions were added to this questionnaire to assess the economic cost dimensions. The last objective was assessed through a pre/post design by comparing the voice outcomes before and after the intervention.

Study setting: The home-based TSLP was offered by the speech-language pathology department of the Centre Hospitalier Universitaire Sainte-Justine (CHUSJ), a pediatric university hospital center located in Montreal.

The platform under study: The TSLP service involves the use of an interactive audio-video communication platform called REACTS™ (Remote Education, Augmented Communication, Training and Supervision), which is designed for virtual communication. It is an integrated, secure solution, with tools that allow clinicians to participate in synchronous, face to face communication, high-quality video calls, in point-to-point or conference mode and multi-stream videoconferencing with patients, parents and other users. It also permits file sharing (documents, videos, images, 3D objects), live file transfer, secure and encrypted exchanges with patients using the camera of a desktop computer, tablet or smart phone. These exchanges can engage in simultaneous live chats with multiple users (Reacts, 2015). In addition, it allows users to share virtual pointers in order to direct attention to any element of a live broadcast and to simultaneously stream multiple video flows, including medical devices with video output (Beaulieu, 2017). It was specifically developed for the healthcare environment with the strictest security standards, where all connections are tunneled and encrypted using an SSL3 or higher system. The designers use peer-to-peer (P2P) session control (signaling) for multimedia interactions using XMPP and the Jingle library (https://www.iitreacts.com/Features; https://www.iitreacts.com/News/InTheNews/20150212_canadianHealthCareTechnology). For legal and data protection purposes, no clinical data can be saved on the telehealth platform during a remote consulting session, so no clinical data were stored outside the CHUSJ.

Participants and recruitment: The target population was patients under the age of 18 with a voice disorder. Because the voice clinic at CHUSJ has a supraregional mandate, offering SLP services to children across the province and not limited to the Montreal area, it was of interest to select patients treated in this clinic for the current study. In addition, a few parents of children with voice disorder, traveling long distances, had previously expressed their wish for an alternative treatment modality instead of face-to-face services. A convenience sample of six patients was recruited and considered sufficient to conduct a pilot study and perform the assessment.

To be eligible for this study, each selected family had to have the following technologies:

- A personal computer (PC type) with a 2.8 GHz processor or higher;
- A Windows 7 or later operating system (Apple Mac not supported) and 2 GB of RAM (RAM).
- Disk spaceof 75 MB or more;
- A camera and microphone (USB or integrated);
- An Internet connection with a bandwidth of at least 1 Mbit/s.

In addition to these preconditions, participants had tomeet the following inclusion criteria:

- Be over 6 years old;
- Have laryngeal nodules and be referred by an ear, nose and throat specialist to the voice clinic for assessment and follow-up in speech therapy;
- Able to interact via a visual modality;
- Demonstrated involvement by the parents to ensure good remote monitoring.

The exclusion criteria for the children were the following:

- Associated disorders, such as language disorder, speech sound disorder, intellectual disability, hearing loss or ADHD, that may interfere with distance interactions;
- Have received speech-language treatments in the six months prior to the study.

Study Intervention: All patients were seen by a certified SLP with four years of experience with this population. The intervention for each patient was launched at the CHUSJ with a 60 minutes face-to-face consultation for an initial voice assessment according to the usual protocol. At the same time, to ensure proper handling and use of the platform, a training session was also held with the recruited families to familiarize them with the platform's settings and features. Following this initial consultation, the virtual individual treatments were remotely delivered for all the TSLP sessions.

Every TSLP session took place in a four-step process that included:

- Discussion with the parent and child (explanations and / or feedback from the previous meeting);
- A warm-up;
- Work on the goal according to the child's progress;
- Explanation of the self-training exercises in preparation for the next session.

At the beginning of the tele-treatment, the sessions were given once per week. Later, the treatment sessions were provided once every two weeks according to the child's progress, i.e. once he/she had attained 80% of the intervention's objectives. Finally, when the patient began to generalize the objectives in a spontaneous context, the TSLP sessions were given on a monthly basis. In this manner, a maximum of 12 sessions were offered over a period that varied from 3 to 6 months. Once the required TSLP sessions were completed, a second face-to-face consultation was held at the CHUSJto re-evaluate the children's voice performance.

Measuring instruments and health outcomes: A structured questionnaire was developed to measure the feasibility of the TSLP service, the level of satisfaction of the SLP, children and parents and the two economic cost dimensions. For health outcomes (voice performance), we used two validated scales: the Consensus Auditory-Perceptual Evaluation of Voice

(CAPE-V)[19] to assess perceived voice quality deviations and the pediatric Voice Handicap Index (pVHI)[20]to evaluate pediatric dysphonia. Two items of the CAPE-V scale (pitch and loudness) were removed from the measure since the included children did not reveal problems with these voice parameters. The internal consistency of each scale was validated using Cronbach's alpha.

Feasibility, satisfaction, economic impact and health outcomes
The technical feasibility of the TSLP service was assessed by measuring three main features of the platform (Appendix 1): its **intrinsic technical qualities** with seven dimensions: ease of use (three items), image quality (two items), workflow integration (two items), response time (two items), reliability (three items), accessibility (one item), and perceived usefulness (three items);**data quality** with two dimensions: completeness (one item), and reliability and validity (one item); and, **quality of technical support** (three items).Clinical feasibility was assessed by measuring two dimensions: the degree of patient adherence to the SLP instructions (one item) and the therapeutic relationship between the patient and the SLP (four items).

As for satisfaction, we assessed the overall level of satisfaction (eight items) among the SLP, the children and their parents. For the economic component, four questions were used to assess two cost dimensions: the magnitude of economic savings from the point of view of the patients and their willingness to pay for access to such tele-treatments. The health outcomes were first measured using the pVHI, which is a 23-item parental proxy scale that is regularly used to assess the effects of dysphonia in the pediatric population. We also used the CAPE-V, which assesses six quality features: overall severity, roughness, breathiness, strain, pitch, and loudness. Both scales were used pre-post treatment to evaluate the change in the child's voice disorders as measured before and after the intervention. The present study was approved by the research ethics committee of the Centre Hospitalier Universitaire Sainte Justine (#4188) and written consent was obtained from all parents.

RESULTS

Sociodemographic characteristics: A total of six patients (mean age, 9 years; range, 6-11 years) were enrolled in the study. More than 80% (83.3%) of them consulted the SLP for a hoarse voice and/or frequent voice loss and 16.7% because of nodules. Forty-six TSLP sessions were delivered to these patients by the same SLP. Out of a total of 46 sessions, only five were not completed due to technical problems, resulting in a mean of 6.83 sessions per patient. As shown in Table 1, the total mean duration of a TSLP session was 43.52 minutes, with a pre-session that averaged 16.62 minutes and was used for preparation purposes. All the participants lived within a 5 Km to 25 Km radius of the CHUSJ (mean, 14.6 km). The mean home download bandwidth available for the TSLP treatment was 33.46 megabits/second.

Feasibility assessment: Throughout the TSLP sessions, the SLP evaluated both aspects of feasibility: clinical and technical. Concerning the clinical aspect, the SLP was highly satisfied (84%) with the degree of patient adherence to her instructions (Figure1). However, her satisfaction with the technical aspects was significantly lower. High percentages of dissatisfaction were observed regarding sound quality (40% dissatisfied) and image quality (48% highly dissatisfied). Similarly weak ratings were observed for response time: delays in the sound signal (40% dissatisfied) and delays in the image signal (45% dissatisfied). We also assessed the quality of the therapeutic relationship. The average levels of satisfaction were 4.61 (SD ± 0.44) for the patients and 4.5 (SD ± 0.83) for the SLP (Figure2).Three children (2, 3, 4) reported the highest level of satisfaction (a score of 5/5), a score similar to that for the SLP. The three other children (1, 5, 6) also had high satisfaction scores (4 or higher). Two of them had higher scores than the SLP. Overall, the results show that the therapeutic relationship was highly appreciated by both the patients and the SLP.

Parents' satisfaction and patients' motivation: The children's motivation mean was high both during (4.8; ±0.31) and after (4.6; ±0.54) the TSLP sessions. The mean satisfaction of the parents at the completion of TSLP sessions was quite high (4.5; ±0.57) and almost the same among all six parents. Five showed a high level of satisfaction with the quality of TSLP, with scores close to 4.8/5(Figure 3).

Analysis of the two economic cost dimensions analysis: Two cost dimensions of TSLP from the point of view of the patients were documented: an estimate of the amount of money saved and an estimate of the amount of money that the parents would be willing to pay to have access to such healthcare services. The mean amount of money saved was US$167.80/patient (SD ± 116.88) (Figure4), taking into account the fact that the patients lived within a 25-kilometer radius of the CHUSJ. The savings were mainly attributable to transportation and parking costs (recurrent costs for each in-person speech therapy session). Only one parent (patient 5)economized more than the others due to the saving of hisnon-paid leaves from work. The mean amount that the parents would be willing to pay for such services was US$140/parent for the entire treatment (SD ± 52.83) with four of the six parents declared the amount ofUS$174.10(Figure 4). These amounts only covered the telecommunications component of the services, i.e. the annual fees for the platform license and the family's purchase of necessary equipment. In Quebec, the cost of healthcare services is covered by a universal health insurance program. Thus, in the present case, the costs of the services provided by the SLP were covered by the state (financed by tax revenue), such that no direct care costs were incurred by the parents.

Health outcomes: voice performance

CAPE-V scale: As Table 2 shows, the pre-post TSLP median scores(overall severity, roughness, breathiness, and strain) dropped from 25.00, 26.50, 34.50, and 36.50 to8.50, 10.50, 5.00, and 4.50, respectively, in the post-TSLP sessions. In order to verify whether the differences between the pre and post-TSLP were statistically significant, we used the Wilcoxon Signed-Rank Test. The results indicate that the post-TSLP CAPE-V scores were statistically significantly lower than the pre-TSLP scores. More specifically, the four subscales of CAPE-V—overall severity (P=.027), roughness (P=.043), breathiness (P= .028) and strain (P=.027)—decreased after the TSLP treatments, and these decreases were statistically significant. These results suggest that intervention using TSLP is effective to improve children's voice disorders.

Table 1. Sociodemographic, clinical, and technical characteristics of the children treated(N=6)

	Age	Gender	Distance home-hospital (km)	Reason for consultation	Computer skills of parents	No. of sessions / patient	Preparation time/session in minutes (mean)	Download bandwidth in mbps (Mean)	Session duration in minutes (Mean)
Patient 1	10	M	15	Nodules	Intermediate	11	13.18	24.65	29.54
Patient 2	11	M	5	Hoarse voice	Intermediate	6	15.83	36.07	42.50
Patient 3	6	M	5	Hoarse voice Frequent voice loss	Intermediate	7	16.42	23.94	44.28
Patient 4	11	M	25	Hoarse voice Frequent voice loss	Intermediate	6	20.83	43.22	51.50
Patient 5	8	F	15	Frequent voice loss	Intermediate	6	17.50	51.54	43.33
Patient 6	8	M	20	Hoarse voice	Intermediate	10	16	21.37	50
Total Mean	9	Male: 5 Female:1	14.6	Hoarse voice and/or Frequent voice loss (83.3%) Nodules (16.6%)	Intermediate (100%)	6.83	16.62	33.46	43.52

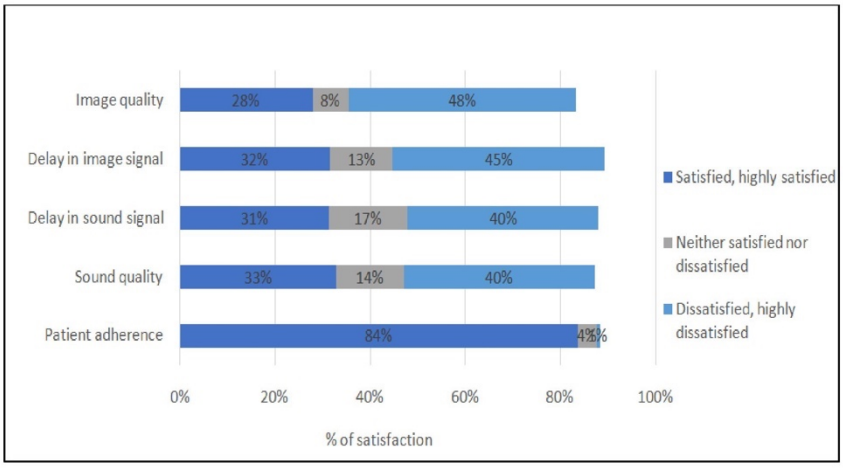
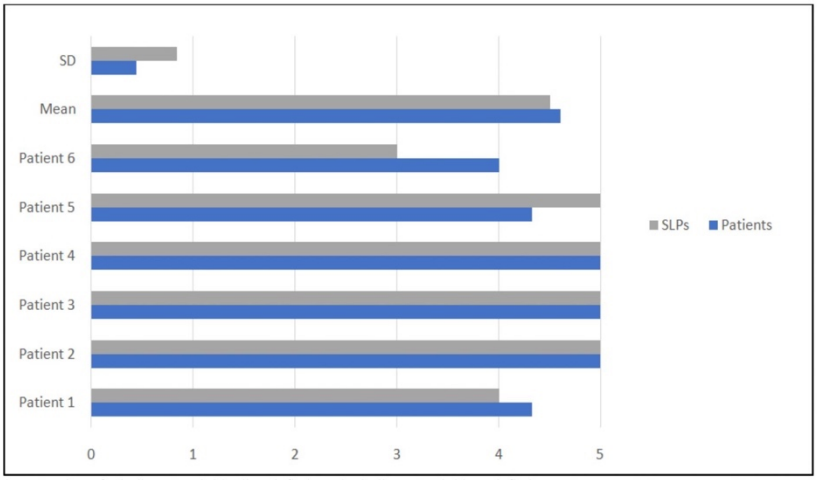
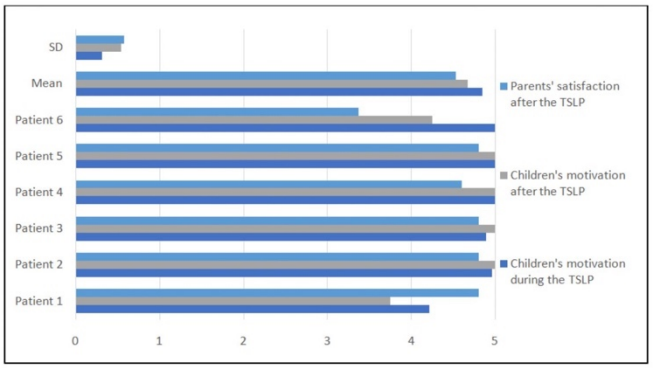


Figure 1.Feasibility of the TSLP service according to the SLP (N=6).



[a]Where a rating of 1 indicates "Highly dissatisfied" and 5 indicates "Highly satisfied".

Figure 2. Satisfaction with the therapeutic relationship in the TSLP sessions (N=6).



[a]Where a rating of 1 indicates "Highly demotivated/dissatisfied" and 5 indicates "Highly motivated/satisfied".

Figure 3. Patient's motivation and parents' satisfaction (N=6)

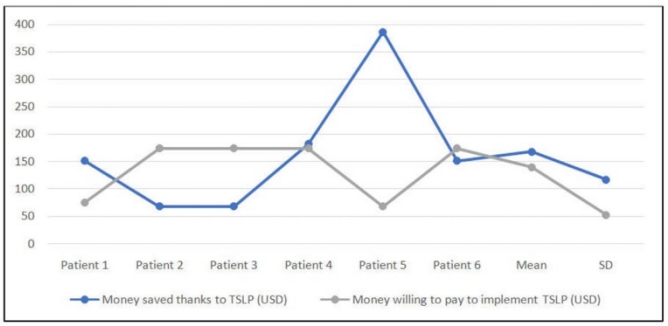


Figure 4. Cost estimates from the patient's perspective (N=6)

Table 2. Results of the Wilcoxon Signed Rank Test on the CAPE-V subscales (N=6)

Subscale	Mean (SD)	Median (¬/100)	P-value (2-tailed)
Overall severity	28.67 (±12.92) *	25.00 *	.027 ***
	8.00 (±3.95)**	8.50**	
Roughness	24.17 (±9.36) *	26.50 *	.043 ***
	9.83 (±5.38)**	10.50**	
Breathiness	34.83 (±14.89) *	34.50 *	.028 ***
	5.00 (±3.28)**	5.00**	
Strain	38.33 (±12.94)*	36.50 *	.027 ***
	4.67 (±3.20)**	4.50**	
Pitch	0.00 (±.00) *	0.00 *	1.000
	0.00 (±.00)**	0.00**	
Loudness	0.00 (±.00) *	0.00 *	1.000
	0.00 (±.00)**	0.00**	

* Pre-TSLP ** Post-TSLP *** (*P<.05)*

Table 3.Results of the Wilcoxon Signed Rank Test on the pVHI scores

Subscale	Mean (SD)	Median	P-value (2-tailed)
Functional scale (I-F)	5.33 (±3.20) *	6.50 (¬/28) *	.068
	1.67 (±1.50) **	1.00 (¬/28) **	
Physical scale (II-P)	17.00 (±3.16) *	16.50 (¬/36) *	.046***
	8.33 (±5.20) **	9.00 (¬/36) **	
Emotional scale (III-E)	4.50 (±4.46) *	4.00 (¬/28) *	.136
	1.00 (±1.26) **	0.50 (¬/28) **	
Total score	26.83 (±8.70) *	28.50 (¬/92) *	.043***
	11.00 (±6.72) **	9.50 (¬/92) **	
Overall severity	2.00 (±.63) *	2.25 (¬/4) *	.024***
	0.50 (±0.54) **	1.00 (¬/4) **	

* Pre-TSLP; ** Post-TSLP; *** (*P<.05)*

pVHI scale: The Pvhi scale also showed a similar improvement (Table 3). The total median score showed a positive improvement, decreasing from a pre-TSLP score of 28.50 to a post-TSLP score of 9.50. Regarding overall severity, the median rating fell by 1.25 points from the pre (2.25) to post-TSLP (1.00). In order to statistically verify the differences between pre and post-TSLP, we ran a Wilcoxon Signed-Rank Test of the three subscales presented below (Table 3). Only one of the three pVHI subscales showed a statistically significant decrease (physical subscale) in the post-TSLP treatment (P= .046). Even though the two other scores decreased post-TSLP, the differences were not statistically significant ([functional scale, P= .068], [emotional scale, P= .136]). Despite this lack of statistical differences in two of the subscales, the total score on the pVHI scale showed a statistically significant difference at post-TSLP treatment (P= .043), where a beneficial improvement was foundin the voice performance. In addition, the score for overall severity was low post-TSLP compared to the pre-TSLP period, and the result was statistically significant (P= .024). As for the previous scale, these results also showed the efficacy of TSLP in improving voice disorders in children in the functional, physical, and emotional dimensions.

DISCUSSION

TSLP has sparked significant interest in recent years. However, its impact through home-based tele-treatments remains ill-defined. The current study of a sample of children with voice disorders evaluated an innovative Internet-platform that provides home-based TSLP treatments. This pilot study demonstrates that the use of synchronous telehealth in speech-language pathology is feasible, sustainable and clinically efficacious in improving the voice performance of children. Furthermore, the intervention was positively assessed in terms of the satisfaction expressed by both the SLP and the parents. Overall, these results are consistent with previous pilot studies (Sicotte, 2003; Isaki, 2015; Grogan-Johnson, 2013; Gabel, 2013; Grogan-Johnson, 2010), which demonstrated high satisfaction among patients and SLPs and efficiency in TSLP treatments. Our results also show that the SL Pevaluation of the TSLP treatments differed with respect to their clinical and technical performances. Satisfaction with their clinical performance was high, reflecting positive appraisal by the SLP of the ability to deliver speech-language therapy at a distance. A high level of satisfaction was also found with the functionalities of the TSLP platform that allowed the use of illustration materials and visual aids. These functionalities enhanced patient adherence to instructions and strengthened the therapeutic relationship between the SLP and thechild. The SL Pevaluation of the platform's technical performance was less favorable. Our results are partly discordant with those obtained by Sicotte et al.[2], who reported that the perceptions of the SLP and the children were more favorable for the technical performance. In the current study, dissatisfaction was especially present for the first treatments sessions. One explanation is that solutions were proposed along the project to overcome the technical problems. The technical problems were in part attributable to the quality of the Internet connection needed between the CHUSJ delivering the TSLP treatments and the children's homes. Due to high security standards, the TSLP platform was not recognized by the internal network of the CHUSJ and wash enceblocked by its firewall. At the beginning of the project, the SLP was obliged to use a public network (which was usually overloaded and provided a slow Internet connection). This was the main reason for the delay in image and sound signals transmission. With the help of the information technology technicians and direction, a better solution was developed to overcome the firewall block. Furthermore, the results were very positive in terms of the patients' motivation and the parents' satisfaction, with no difference found between the period during the TSLP sessions and the period after they were complete. These results are congruent with Isaki et al.[4], which found no statistically significant change in personal opinions about telepractice before and after therapy, reflecting a similar consistency.

In addition, the economic cost estimates showed a positive appraisal by the parents. First, lower personal expenses to access care represented direct savings to the parents. Second, the parents' willingness to pay for the infrastructure needed to secure TSLP—here the telecommunications and software expenses—showed the clientele's positive opinion of such a tele-service. The high level of satisfaction with the TSLP treatments and the rather low cost of the TSLP infrastructure may explain their willingness to pay for access to such tele-treatments at home. These findings are consistent with the current literature[2], which has demonstrated in a similar context, that parents consider the personal expenses reasonable. Last but not least, it is important to mention that the TSLP treatments achieved significant benefits in terms of voice performance and thus health outcomes. The treated children showed statistically significant improvements in the roughness, breathiness, strain and overall severity of their voices. Similarly, this study has found a statistically significant decrease in voice handicap, mainly in terms of the physical aspect and the overall severity.

There are, however, several limitations to this study. First, we acknowledge that it is a pilot study, with a small sample size which limits its ability to support the effectiveness of the TSLP. Second, the selection process of the patients and the absence of control group may have cause a selection bias. Third, for the purpose of this exploratory study, only one patient profile (voice disorders) in one setting (CHUSJ) was included. It would be useful to conduct other studies including patients with other speech and/or language disorders and in other settings. In sum, this study confirms that TSLP treatment is not only feasible, it also appears to be sustainable. It offers a promising alternative to face-to-face treatment without compromising health outcomes to the extent that the positive results of this study are consistent with other studies demonstrating improved speech and language outcomes[1-3, 6, 7]. It would be interesting to conduct a cluster RCT with a sufficient number of patients to confirm these preliminary results.

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Appendix 1. Outcomes, dimensions and items used in the questionnaire

Outcomes	Dimensions	Items
Technical Feasibility a.Intrinsic technical qualities	a.Ease of use	1.Are you satisfied with the ease of use of the REACTS platform? 2.Are you satisfied with the time it took to learn how to usethe REACTSplatform? 3.Are you satisfied with your level of fluency in using the REACTSplatform?
	b.Screen quality	1.Are you satisfied with the quality of the image? 2.Are you satisfied with the sound quality?
	c.Workflow integration	1.In your opinion, is it easy to integrate and use your usual therapeutic tools with the REACTSplatform? If not, why? 2.What changes/modifications did you have to make to your speech therapy interventions related to use REACTS?
	d.Response time	1.Are you satisfied with the delay in signal transmission delay for the image? 2.Are you satisfied with the signal transmission delay for sound?
	e.Reliability	1.Are you satisfied with the stepsrequired to prepare sessions on the REACTSplatform? 2.What types of difficulties were encountered by the patient/parent when using REACTS(practical, technical, clinical, etc.)? 3.What was most difficult to grasp about using the REACTSplatform?
	f.Accessibility	1.What problems did you encounter when using REACTSfor your speech therapy interventions?
	g.Perceived usefulness	1.In your opinion, is the REACTSplatform an effective medium for speech therapy interventions?Why? 2.How would you describe the improvements in your patient's voice? 3.What benefits did you see in using REACTSfor your speech therapy interventions?
b.Data quality	a.Completeness	1.In your opinion, was the quality of service received the same as if it had been offered in the regular intervention room (i.e. face-to-face treatment)?
	b.Reliability & validity	1.Was the quality of the intervention toolsusedwith REACTSas reliable as those used in face-to-face treatment?
b.Quality of technical support		1.Are you satisfied with the quality of the technical support offered? 2.Are you satisfied with the online help resources (tutorials and other documents)? 3.What problems did you encounter when using REACTSto conduct your speech therapy interventions?
Clinical Feasibility	a.The degree of patient adherence to guidelines	1.Are you satisfied with the degree of patient adherence to your guidelines?
	b.The therapeutic relationship	1.Are you satisfied with the quality of the therapeutic relationship with the patient (perspective of the SLP)? During the previous sessions (perspective of the child): 2.I felt at ease with my SLP. 3.I found that the SLPcared for me. 4.I found that the SLPwanted to help me.
Satisfaction		* Perspective of the SLP The activities during the various sessions: 1.Are useful for the patient. 2.Are important to the patient. 3.Will help me to improve. *Perspective of the child At today's session: 4.I did what I could. 5.I'm happy with what I did. 6.I had fun. 7.I worked well. *Perspective of the parents 8.In general, was your child motivated to receive his speech therapy treatment with the REACTS platform?
Economic Cost	a.Money saved	1.Did you have to spend money on equipment to gain access to the REACTS platform (camera, microphone, etc.)? 2.If you would have had to travel for the treatment, how much transportation costs would you have incurred?
	b.Amount willing to pay	1.In a hypothetical scenario, would you be willing to pay for your child to receive treatment with the REACTS platform? 2.What amount you would be willing to pay for such treatment?
Health Outcomes		1.pVHI 2.CAPE-V

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4.3 Article 3

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The implementation of a synchronous telemedicine platform linking off-site pediatric intensivists and on-site fellows in a pediatric intensive care unit: A feasibility study

Mahmoud Nadar[a,b,c,*], Philippe Jouvet[d], Marisa Tucci[d], Baruch Toledano[d], Martin Cyr[e], Claude Sicotte[b,c]

[a] Department of Nursing and Health Sciences, Université du Québec en Outaouais, C.P. 1250, Succursale Hull, Gatineau, Quebec, J8X 3X7, Canada
[b] Department of Management, Evaluation and Health Policy, School of Public Health, University of Montreal, 7101 Park Ave, Montreal, Québec, H3N1X9, Canada
[c] Public Health Research Institute of the University of Montreal, 7101 Park Ave, Montreal, Québec, H3N1X9, Canada
[d] Division of Pediatric Critical Care, Department of Pediatrics, Sainte-Justine University Hospital, 3175 Chemin de la côte-Sainte-Catherine, Montreal, Québec, H3T1C5, Canada
[e] Department of Biomedical Engineering, Sainte-Justine University Hospital, 3175 Chemin de la côte-Sainte-Catherine, Montreal, Québec, H3T1C5, Canada

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ABSTRACT

Objective: The aim of this study was to assess the feasibility of implementing a synchronous telemedicine platform in a pediatric intensive care unit (STEP-PICU).

Method: A prospective mixed study was conducted. Two sources of data were mobilised: a survey with structured questionnaires and direct non-intrusive observation.

The study site was the PICU of a university hospital. Users' perceptions of six aspects of the STEP-PICU were studied: telemedicine system quality, data quality, quality of technical support, use of the new system, overall satisfaction and system benefits.

Results: During the 6-month experimentation period, use of the telemedicine platform was rather limited and fell short of the promoter's expectations.The mean scores for the six user perception dimensions were low, with no differences between the two groups of users. A Mann-Whitney test showed that being an off-site pediatric intensivist or on-site fellow did not make a statistically significant difference in responses on system quality ($p = .518$), data quality ($p = 1.00$), quality of technical support ($p = 1.00$), system use ($p = .556$), overall satisfaction ($p = .482$), or benefits ($p = .365$). The low use of the STEP-PICU was attributed to three root causes: human factors, the platform's functionalities, and technical problems.

Discussion: The synchronous telemedicine service for PICU was feasible but would need good pre-implementation preparation to be truly helpful. Its usefulness during the night shift and holiday on-call periods was scored as low by the off-site pediatric intensivists and the on-site fellows. It would appear that such a service could be more beneficial for communications with other remote healthcare facilities, where there is a greater need for the expertise of a pediatric critical care intensivist.

1. Introduction

In most countries, providing pediatric critical care remains a challenge. The majority of hospitals lack designated intensive care units, and there is a scarcity of healthcare staff trained to care for critically ill children [1]. In Canada, children represent 21.9% of the population and 100% of the country's future [2]. Ensuring their good health from birth is a responsibility and a tremendous opportunity to foster generations of healthy Canadians [3]. In the USA, out of 73 million children, 6.7 million (9%) suffered from unmet needs for pediatric subspecialty care in 2016 [4].

Today, providing continuous specialized care is a major challenge, especially intensive care for the most critically ill children. It requires a high level of medical expertise among pediatric intensivists (PIs)

* Corresponding author at: Université du Québec en Outaouais, Department of Nursing and Health Sciences. C.P. 1250, Succursale Hull, Gatineau, Quebec, J8X 3X7, Canada.
E-mail addresses: Mahmoud.nadar@uqo.ca (M. Nadar), philippe.jouvet@umontreal.ca (P. Jouvet), marisa.tucci@recherche-ste-justine.qc.ca (M. Tucci), baruch.toledano@umontreal.ca (B. Toledano), martin.cyr.hsj@ssss.gouv.qc.ca (M. Cyr), claude.sicotte@umontreal.ca (C. Sicotte).

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combined to modern technologies and equipment to provide advanced care in the pediatric intensive care unit (PICU). The level of medical care and sophisticated treatment expertise in pediatric critical care has continuously increased, resulting in an acute need for skilled, easily accessible PIs. Moreover, there is a greater need for highly qualified critical care medical teams to ensure patient safety and high-quality pediatric critical care.

However, despite the best efforts deployed, many children in need of critical care are treated in less-than-ideal conditions. This situation can be explained by several factors, but one main factor - especially in view of the growing number of PICU admissions- remains the shortage of PIs and the fact that they cannot be at the patient's bedside around the clock [5]. This shortage increases the workload for the on-site fellows, who compensate for the PIs' inability to be on-site by contacting them remotely via telemedicine in order to ensure continuity of care.

One way would be to ensure better communications with off-site PIs, who can support the on-site fellows and ensure high-quality and safe pediatric critical care delivery. Many believe that information technologies (IT) can be useful by providing virtual, synchronous and immediate access to remote skills. To this end, there is an emerging range of communication technologies, such as telemedicine platforms that allow efficient communication and are able to support specialized care, that can support remote critical care and better care coordination by providing communication access to off-site PIs who can then assist on-site fellows in the PICU.

The usual telephone conversations offer poor data-sharing capabilities. When clinical information needs to be transmitted to off-site PIs for a visual assessment, communication platforms such as text messages, emails with images and Skype video connections are providing better solutions and ease of access. But these means of communication are not secure and at high risk of causing a breach of patient confidentiality. Consequently, a more suitable solution would be to use a synchronous telemedicine platform (STEP) in the PICU to enhance and improve the exchanges between off-site PIs and on-site fellows. Such remote capabilities can be used to optimize diagnosis, treatment, and management of PICU patients.

Many studies [6–10] have reported that the implementation of a telemedicine service in an intensive care unit to support medical decisions was helpful. It can eliminate uncertainty about a diagnosis and optimize critical care. Thus, despite the supposed benefits of tele-ICU systems, their implementation still needs more investigation, especially in intensive pediatric settings where research is scarce. To our knowledge, only one study has examined this feasibility of telemedicine in a PICU between on-site fellows and off-site PIs [11]. Although it concluded that telemedicine in a PICU is valuable and feasible, it revealed several limitations that suggest that its results require consolidation, including the lack of "buy-in" and/or the discomfort expressed by some PIs in using the technology. Furthermore, that study mentioned that its retrospective nature limited its ability to cover some of the feedback on the system. It pointed out that a prospective study, like ours, would be needed to collect direct feedback from the end-users participating in this model of care.The aim of this study was to assess the feasibility of implementing a STEP-PICU in pediatric critical care. To this end, a feasibility study was conducted. To take into account the barriers and benefits identified in previous studies, we assessed several users' perceptions of the new system: system quality, information quality, service quality, use, user satisfaction, and net benefits for PIs and fellows.

2. Method

2.1. Study setting

The study was conducted in the PICU of the Sainte-Justine University Healthcare Center (SJUHC) in Montreal, Canada. It is the largest mother-child center in Canada and Quebec's only health care establishment exclusively dedicated to children, adolescents and mothers [12]. The PICU at the SHUHC admits more than 1000 patients per year. It provides tertiary and quaternary care in all medical and surgical specialties, complete with access to high-tech monitoring and care equipment (e.g. extracorporeal support, hemofiltration) [13]. It also provides pediatric intensivist training for the entire Quebec healthcare system and to international students through its medical fellowship in pediatric intensive care.

The choice of the SJUHC as the site for this study was an opportunistic and reasoned choice. On the one hand, the telemedicine platform was planned for in this establishment. On the other hand, the logic was that if such a system would work in the SJUHC, it would likely work in any other PICU, given the highly complex clinical cases treated in this hospital.

This study was approved by the research ethics committee of the SJUHC.

2.2. Study intervention

At SJUHC, the PIs are available 24/7 but do not provide 24 -h on-site coverage. They are generally on-site during daytime hours but not in the evening, at night or on holidays. During these periods, in-house coverage of all PICU patients is provided by fellows who are on call and consult with a PI as often as necessary to discuss patients' conditions and address specific problems. The fellows at SJUHC were being trained in a medical speciality and had varying degrees of experience and seniority.

When on call, the fellows have regular exchanges with PIs, during which they need to describe a patient's health status, ask for advice on the best possible management and receive advice and suggestions based on the information provided. Usually, most exchanges between fellows and PIs take the form of telephone discussions during which some clinical data, such as lab results, can be objectively transmitted while other clinical information, such as various aspects of the clinical exam, radiographic imaging, and electrocardiogram tracings, are communicated as best as possible by the fellows, who describe what they see. Before the STEP-PICU pilot project, the usual means of communication were traditional technologies such as a pager, a short message service, or a cellphone.

The telemedicine encounters, which took place between October 2017 and March 2018, encompassed a two-step process: a text message to plan a session followed by an audio-visual synchronous telemedicine encounter. If deemed indicated, the fellow and the PI engaged in further discussion of the case through a STEP-PICU encounter. The decision to launch an encounter was only based on the shared judgment of fellows and PIs after they had discussed the case. No nurses, parents or residents were involved in this process. At the hospital, the telemedicine platform's software, a webcam and a microphone were installed on a mobile computer cart typically used for medical rounds. The computer on the cart had all the necessary medical software to provide access to medical imaging (SYNAPSE®, Fujifilm, town-state), laboratory results (SOFTLAB®, SCC Soft Computer, Clearwater-US), and the data in the critical care electronic medical record used in the PICU (ICCA®, Philips, Toronto-Canada). Moreover, it was possible to remotely assist a fellow performing a technical intervention with an ultrasound machine. This assistance could be achieved through a feature provided by the platform, through which the off-site PI could virtually manipulate the transducer of the ultrasound machine and the fellow only had to follow the PIs' instructions to perform the intervention.

To facilitate use of the STEP-PICU, three simulated sessions were organized one month before the platform's go-live. Following these sessions, the participants expressed their satisfaction and comfort with the platform. The fellows were then encouraged to initiate telemedicine sessions with the PIs. The simulated sessions consisted of clinical case scenarios in which the fellows and pediatric intensivists engaged in telemedicine communications to learn how to use the platform's features and understand its integration with other clinical software

(laboratory results, medical imaging, and medical record). The results for this phase were positive: the future users tried out the new technology and their initial acceptance was promising. During the simulation phase, no technical or connection challenges arose, possibly because the simulation sessions were conducted on-site and everyone was connected to the internal network of the hospital, which prevented the problem of proxy and firewall from occurring. In addition, the one-month period of the simulation was too short to test an update of the platform and its consequences.

2.3. Participants & recruitment

The target population included fellows and PIs of the PICU. All participants received an e-mailed questionnaire. At the end of the implementation period, both fellows and PIs completed and returned the questionnaire within the following week. If a respondent had not completed the questionnaire at that time, two reminders were sent. Each completed questionnaire reflected the user's perceptions of all the STEP-PICU sessions he/she had participated in during the implementation period.

2.4. Users' perceptions and attitude variables

To determine the variables of the study, we adopted a multidimensional perspective using the conceptual model developed by DeLone and McLean. This comprehensive model defines the characteristics of a successful information and communication system [14]. It has been used in a wide variety of studies of information systems, including clinical data systems [15,16]. The model is based on the Shanon and Weaver framework [17], which defines the technical level of communication as the accuracy and efficiency of the communication system that produces information. The DeLone and McLean model proposes several dimensions to define a successful information and communication system (Appendix A): system quality, information quality, service quality, use, user satisfaction, and benefits [14,18].

2.5. Measurement

The survey questionnaire was based on an existing and validated questionnaire developed by Sicotte et al. [15]. The internal consistency of each scale was validated using Cronbach's alpha. The questionnaire encompassed 67 questions (10 related to socio-demographic characteristics; 53 questions assessing users' perceptions with 10-item Likert scales ranging from zero (strongly disagree) to 10 (strongly agree); and 4 open questions to better describe the attitudes and perceptions of participants).

For each of the perception dimensions, several variables were mobilized. Seven variables evaluated system quality: ease of use (five items), screen quality (two items), REACTS-SYNAPSE-SOFTLAB integration (three items), response time (three items), reliability (three items), accessibility (three items), and perceived usefulness (three items). Data quality was evaluated with five variables: completeness (one item), reliability and validity (two items), availability (one item), safety (one item), and the quality of inter-site integration of the data generated by the various sites (two items). Quality of technical support was assessed with one variable (five items) concerning the whole system. Use of the platform was measured with two variables: frequency of use (one item) and intensity of use (three items). Overall satisfaction was measured with one variable (three items). As for the benefits dimension, it was measured in terms of improved productivity (seven items), quality of medical services (two items), and access to medical services (three items). A mean score for each dimension was calculated by dividing the scores of its items by the number of items and adding them together.

To better describe the pros and cons of the implementation process, four open questions were included in the questionnaire. These questions addressed the following themes: potential causes of a diminished use of the platform, the fellows' need for external expertise, the usefulness of the platform as a response to needs for patient care, and suggestions on how to improve platform use.

In addition, one of the investigators observed the entire process of the platform experiment. As a non-participant observer, he attended all the pre-implementation preparatory meetings organized with the PICU team. There he observed the preparations and discussions between the pediatric intensivists and fellows to identify the facilitators and obstacles encountered by the users. He also observed under what conditions the telemedicine sessions were held. Technical problems were easily observed in this manner. Furthermore, he was then able to observe the interventions of the technical support team in response to user requests.

2.6. Data collection

We conducted a prospective mixed study. Two sources of data were mobilised: a survey with structured questionnaires and direct non-intrusive observation.

First, we conducted a cross-sectional evaluation to assess the perceptions and attitudes of respondents towards the use of the STEP-PICU in a real PICU context. Structured questionnaires, completed by both on-site and off-site physician users, were employed to assess their perceptions and attitudes about the implementation and use of the new STEP-PICU platform. Second, direct non-intrusive observation was conducted by one of the researchers (MN) in order to study opportunities and obstacles in the STEP-PICU's implementation process. Observations were made throughout the several different implementation steps, ranging from preparatory staff meetings to the series of events during use of the telemedicine platform in a real-world context.

2.7. Telemedicine platform under study

This implementation of a synchronous telemedicine service in a PICU involved the use of an interactive audio-video communication platform called REACTS™ (Remote Education, Augmented Communication, Training and Supervision), which is designed for virtual communication. It is an integrated, secure solution, with tools that allow clinicians to participate in synchronous and multi-stream videoconferencing, file sharing (documents, videos, images, 3D objects), live file transfer, and secure and encrypted exchanges; to consult patients using the camera of a desktop computer, tablet or smart phone; to view plots; and to engage in simultaneous live chats with multiple users [19]. More specifically, it allowed the off-site PIs to view rich visual information such as live videos of the patient, to access all laboratory tests and medical imaging (x-ray and ultrasound), as well as to monitor vital signs in real time. The service could also be used by on-site fellows to clarify a care plan, evaluate a new or unstable patient, visualize clinical information not usually available to the PI, provide advice and reassurance if needed, and supervise procedures.

In addition, this platform allows users to share virtual pointers in order to direct attention to any aspect of a live broadcast and to simultaneously stream multiple video flows, including medical devices with video output. It was specifically developed for the healthcare environment with the strictest security standards, where all connections are tunneled and encrypted using an SSL3 or higher system. The system uses peer-to-peer (P2P) session control (signaling) for multimedia interactions using XMPP and the Jingle library [20]. For legal and data protection purposes, no clinical data can be saved on the telecare platform during a remote consulting session, such that no clinical data were stored outside the SJUHC [21].

For the present pilot project, licenses were purchased for all participants so that they could install REACTS on their own devices. These licenses were purchased and financed by the chair of evaluative

Table 1
Professional characteristics of the fellows.

The fellow ID #	Age (years)	Total number of years of fellowship post-residency	# of years accumulated in the PICU of SJUHC
1	35	6 years	3 years
2	37	5 years	3 years
3	29	1 year	1 year
4	30	2 years	2 years
5	31	1 year	1 year
6	36	5.5 years	1 year
7	29	2 years	2 years
8	35	4 years	3 years

research held by one of the authors.

3. Results

3.1. Telemedicine use

During the 6-month experimentation period, use of the telemedicine platform was rather limited and fell short of the promoter's expectations. Only fifteen telemedicine encounters were held, involving 14 participants (8 fellows and 6 intensivist physicians). All these encounters took place between 9:00 pm and 11:30 pm and lasted between 8 and 17 min, with an average of 13 min per session. The reasons for initiating the encounter included informing PIs about medical changes in patients' conditions and consulting with them on further changes to medical management (56% of the encounters), sharing laboratory and/or radiological results (35% of the encounters), and patient transfer (9% of the encounters). Five of the eight fellows were between 31 and 40 years of age (Table 1) and 5 of the 6 pediatric intensivists were between 51 and 60 years of age. Except for one PI, none of the participants had any previous experience with telemedicine. As for their location, the fellows were always on-site while the PIs were always off-site.

3.2. Analysis of users' perceptions

As shown in Table 2, the scores were low in all the dimensions assessing the users' perceptions. The added value of the new system was thus poorly perceived. Appendix B provides the detailed scores for the underlying items.

Table 2
Users' Perceptions and Attitude Dimensions for Each Group of Users.

Users' Perceptions and Attitudes	Mean	SD	Min	Max
System quality	4.59	1.73	1.82	6.95
Pediatric intensivists	4.26	1.02	2.59	7.71
Fellows	4.40	1.32	1.82	6.95
Total				
Data quality	5.19	2.37	1	8
Pediatric intensivists	5.81	1.12	4.29	7.71
Fellows	5.52	1.75	1	8
Total				
Quality of technical support	5.66	1.83	3.00	8.20
Pediatric intensivists	5.93	1.58	4.40	8.00
Fellows	5.81	1.63	3.00	8.20
Total				
System use	5.66	1.83	3.00	8.20
Pediatric intensivists	5.93	1.58	4.40	8.00
Fellows	2.39	1.31	1.00	4.50
Total				
Overall satisfaction	4.00	1.80	1.33	6.00
Pediatric intensivists	3.14	1.84	1.00	5.00
Fellows	3.53	1.80	1.00	6.00
Total				
Benefits	3.22	1.28	1.62	4.70
Pediatric intensivists	2.70	1.25	1.33	5.50
Fellows	2.93	1.24	1.33	5.50
Total				

Table 3
Bivariate Analysis of Users' Perceptions.

	PIs off-site physicians	Fellow on-site physicians
System quality	4.59 (± 1.73)	4.26 (± 1.02)
Mean score (± SD)	8.33	6.88
Mean rank		
P-value*	.518	
Data quality	5.19 (± 2.37)	5.81 (± 1.12)
Mean score (± SD)	7.00	7.00
Mean rank		
P-value*	1.0	
Quality of technical support	5.66 (± 1.83)	5.93 (± 1.58)
Mean score (± SD)	7.00	7.00
Mean rank		
P-value*	1.0	
System use	2.75 (± 1.50)	2.12 (± 1.18)
Mean score (± SD)	8.25	6.94
Mean rank		
P-value	.556	
Overall satisfaction	4.00 (± 1.80)	3.14 (± 1.84)
Mean score (± SD)	7.92	6.21
Mean rank		
P-value*	.428	
Benefits	3.22 (± 1.28)	2.70 (± 1.25)
Mean score (± SD)	8.67	6.63
Mean rank		
P-value*	.365	

* $P < 0.05$.

Concerning the three first dimensions, the best score was reported in the "quality of technical support" dimension and did not exceed 6 on a 10-point scale. As for system quality, both the PIs (4.6/10) and the fellows (4.3/10) were slightly dissatisfied with the platform functionalities. The highest score reported by the fellows on the quality of data provided by the platform was in the middle of the scale (5.8/10). Concerning overall satisfaction, the participants expressed considerable dissatisfaction with their use of STEP-PICU (3/10 for the fellows and 4/10 for the PIs). Even lower scores were reported on the benefits generated by STEP-PICU (2.7/10 for the fellows and 3.2/10 for the PIs).

Moreover, the mean scores for all the dimensions were very similar between the intensivist physicians and the fellows (Table 3). Since our sample was not large, we performed a non-parametric test for the bivariate analysis. To evaluate the effect of being a PI (off-site) physician or a fellow (on-site), we ran a Mann-Whitney test that found no statistically significant difference between being an off-site PI or on-site fellow in any of the dimensions of the study (Table 3).

Furthermore, the results of the content analysis of the questionnaire's open questions are congruent with the observed low level of use.

3.2.1. Causes of the limited use

When questioned about the underuse of the telemedicine platform, PIs and fellows revealed three main reasons: human factors, the platform functionalities, and technical problems.

The first reason for the low use of the telemedicine platform was related to some well-known human factors: workload, lack of time, training and motivation. Due to the workload in the PICU, the fellows were continually in a race against time. They had very limited time to learn and integrate new routines into their day-to-day practices. New routines had to offer significant added value if they were to be considered and, eventually, adopted. The STEP-PICU failed to offer such added value. On the one hand, the technology did not represent real added value for the PICU team, but on the other hand it required a considerable amount of time to master. Moreover, the PICU workload was especially intense during the evenings and holidays, which were precisely the periods when the platform was supposed to be useful.

Faced with such an overload risk, the fellows preferred to perform any other clinical tasks requested of them rather than spend time trying to use the telemedicine platform. Using the STEP-PICU was not a priority for them, so they only used it once they had finished all their other clinical duties.

The two other organizational factors were lack of training and motivation. According to some users, the training period was not long enough to sufficiently train the PICU team on the platform. In addition, many fellows believed that some of the pediatric intensivists were not sufficiently motivated to use it. This limited use of the platform within a sub-group of PIs. This result is congruent with our observation that not all the PICU's pediatric intensivists were involved to the same degree.

Second, platform characteristics were mentioned as one of the barriers to use. Notwithstanding the platform's interesting features, particularly with respect to its multimedia capability and data security, it had some flaws that affected ease of use. The most often reported shortcoming was the long wait when logging in, which was difficult to bear in the context of the fast pace of intensive care. In addition, some users mentioned the fact that the platform was not compatible with their own devices. Those who had an old smartphone or MacBook had difficulty configuring the platform. User-friendliness was also cited as a weakness. One fellow went so far as to say that the platform's performance was very primitive in terms of ease-of-use and accessibility. This second result is also congruent with our observation conducted during the monthly implementation meetings.

Another drawback of the platform was its network performance. Poor network interoperability within the hospital-secured Intranet was observed. Several fellows failed to login because the platform was not recognized by the hospital network firewall. This problem, occurring at the beginning of the project, had serious consequences. First, it significantly delayed the implementation due to the length of time taken by the IT technicians to solve it. Second, since the early users experienced this problem, they had the perception that the platform was not sufficiently user-friendly. Similarly, it is worth mentioning the rate at which the platform was updated. Three separate updates were performed in the six-month implementation period, and each one was associated with many disturbances for users.

3.2.2. Benefits

With the exception of clinical data security, the majority of the respondents did not associate any significant benefit with their use of the telemedicine platform. Most indicated that it added little or nothing to their practice (*"REACTS does not meet any of my needs at this time"*). A few physicians went even further, pointing out that the technology made them less efficient and kept them from completing their duties in a timely manner ("*Absolutely not beneficial. I think that REACTS made things slower, when it was enough to just make a phone call to have a clear answer from the pediatric intensivist. We rarely need to send an image or a video…"*). Only two fellows indicated that STEP-PICU allowed them to thoroughly discuss the patient's condition with the pediatric intensivists by providing access to synchronous visualization of patients, medical imagery, and clinical data (*"REACTS allows me to discuss the patient's condition with the pediatric intensivist and share all the relevant information"*).

3.3. Discussion

The current study fails to demonstrate the usefulness of a telemedicine service allowing synchronous communication between off-site pediatric intensivists and on-site fellows. in the current study, both groups of users, the PIs and fellows, agreed that the STEP-PICU did not improve or facilitate the workflow in the PICU. The participants underlined that the context and circumstances in which the platform was used did not help prove the value it can add in support of their work in the PICU.

These results differ from most of the results reported in the literature. For instance, they differ from those obtained by Yager et al. [11], who pointed out that nighttime telemedicine linking on-call staff intensivists with pediatric intensive care unit bedside care providers, patients, and their families is feasible and may enhance team communication and impact patient management. Our results are also discordant with those of Rohs et al. [22], who found that the residents gave positive scores to telemedicine in an ICU as a valuable educational resource and an improvement in terms of continuity of patient care, quality of patient care, and communication and teamwork coordination. It also helped the residents feel more confident taking care of critically ill patients, providing recommendations consistent with ICU team routines, and knowing that there was a Tele-ICU pediatric intensivist available at night made them more likely to ask a question. In 2015, a study [23] conducted in a NICU similarly showed that 100% of on-site physicians felt comfortable with their interaction with the off-site physicians via telemedicine. In the same manner, a multicentric study [24] conducted in a pediatric cardiac critical care setting showed that a large majority (96%) of pediatric intensivists and fellows were satisfied or very satisfied with the telemedicine service.

Beyond the three main barriers – human factors, the platform functionalities and technical problems – identified in this study, some participants reported another potential factor that was the high competence of a large number of on-site fellows who may be then needing less guidance from off-site PIs. Indeed, according to few PIs and fellows, the high level of skills and knowledge among the PICU's fellows reduced the need to ask for external advice ("*There is no doubt that the expertise of the on-site fellows greatly limited the use of REACTS*"). It is thus possible that for such cases, the platform's multimedia communication capabilities did not bring much added value ("*The fellows were able to 'see' and describe the situations to us. By talking to them, we knew what we needed to know and wether we should come in or stay at home, but we did not really need to see anything*").

Furthermore, the relevance of asking for an opinion from the off-site PI who was on call was very limited since, generally, a simple phone call was enough for a fellow to obtain an answer to a question ("*The communication between PIS and fellows were well 'oiled' because we rubbed shoulders every day, and we trusted each other because we knew each other*"). In this context, the fellows' calls were, in most cases, justified when they requested an on-site visit by an off-site PI rather than remote decision support ("*The high level of expertise among the fellows was such that, finally, we either needed a telephone discussion (because we were able to briefly describe the patient and his exams, without needing to show a color image of the patient), or we needed the PI on site*"). This observation was confirmed by our observation of the monthly PICU meeting wher it was regularly noticed that some of the fellows were very competent and did not needed help from the PIs.

However, although it was reported that the competence an professional autonomy of on-site fellows might be a potential cause behind the low use of the platform, it would be premature to conclude that the fellows were so competent that they had nothing to learn from the PIs.

Indeed, many participants still recognized the attractiveness and relevance of such a technology. They underlined for instance that such technology would be useful for another type of user, providing tele-expertise to external healthcare facilities. The implementation of the platform was considered worthwhile in peripheral hospitals where pediatricians face critical cases and require an opinion from a pediatric intensivist. Furthermore, the workload and lack of time of on-site fellows worked against them adopting the new processes. Their use of the technology would be facilitated if the means could be found to set aside more time for the new processes. At the same time, it would be useful to provide more in-depth training to ensure that all users are familiar with the platform. As for motivation, it is of the utmost importance to involve all the significant staff members, such as the pediatric intensivists, in the project. The involvement of key actors is known as a success factor for the adoption of information technology.

The platform's poor ease of use was a barrier for several users.

Reducing the complexity of the login process, rendering it comparable to other communication applications, would help users work with the platform more easily. An improved SMS function would be an asset. This service should be available at all times and needs to start up instantly.

The first months of the project were plagued with technical problems related to connection issues. Despite the fact that these technical problems were resolved by the IT department, this implementation stage exacerbated users' negative perceptions of the new STEP-PICU system. This observation was consistent with those made by Yager et al. [11], who reported unsuccessful network links during the first two months of the project.

There are several limitations to this study. First, we acknowledge that it is a pilot study, with a small sample size. Conducting future studies with larger and representative samples would be very relevant. Similarly, only one healthcare setting was used. It would be useful to conduct other studies with PICUs in other settings. Third, the homogeneity of the study sample, which was composed of only fellows with no novice or intermediate residents, may have strongly contributed to our negative results. Including parents', residents', and bedside registered nurses' perceptions might have generated different results on users' perceptions of the platform. Lastly, the lack of impact of STEP-PICU encounters on measures of patient care was one of the study's limitations. The addition of objective measurements such as the recommendations made by PIs, changes to medical management after encounters, and the number of failed and dropped encounters could add new perspectives to the study.

4. Conclusion

This study has concluded that synchronous telemedicine service linking pediatric intensivists, both on-site and off-site, is feasible provided that all the circumstances of success are guaranteed. In the current study, the unperceived benefits of the telemedicine service were probably due to an incomplete preparation of success factors, including technical support, pre-training sessions on the platform, and organizational issues. The factors that frustrated users probably obscured the benefits of the STEP-PICU and partially contributed to the impression that telemedicine was not needed in a PICU between on-site fellows and off-site PIs.

Such a negative conclusion merits further discussion. First, this is not a definitive judgment, to the extent that several studies have, to the contrary, showed positive results. Second, this study's results are even more pertinent since negative results are not often published. These negative results remind us that meeting user needs remains a fundamental aspect of technology diffusion. Without usefulness, there is no point to hoping for usage. Such a technology could be more beneficial in a context where there is a greater need for a pediatric critical care intensivist, for instance, at external facilities where an expertise gap between on-site fellows or internists and off-site pediatric intensivists would be a more fertile environment. Along the same line of reasoning, it would be interesting to expand the scope of such studies to examine the need to link other on-site PICU health providers (residents, registered nurses, respiratory therapists) to off-site pediatric intensivists.

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Authors statement

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

We understand that the Corresponding Author is the sole contact for the Editorial process (including Editorial Manager and direct communications with the office). He is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs. We confirm that we have provided a current, correct email address which is accessible by the Corresponding Author.

Declaration of interest

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ijmedinf.2019.06.009.

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CHAPTER V

DISCUSSION

Chapter 5 is organized into four sections. The first section discusses the principal findings of the three research papers in light of the results of other published studies. The second section outlines the scientific contributions of the current work and what our findings have added to the discipline's knowledge. The third section presents the limitations of the three studies. Lastly, we present our recommendations on future research into STM in pediatric care.

5.1 Summary of results

The overall aim of the current dissertation was to assess the feasibility of STM and its influence on the process of providing pediatric care. To do that, we conducted three studies in two fields: critical care, represented by a PICU and rehabilitation, represented by SLP.

The overall results of these studies showed that STM is technically feasible and has several benefits and advantages in pediatric care, in both its critical care and rehabilitation aspects. This results' analysis stems from the conceptual framework of Delone & McLean which fixes the evaluation of an IS solution by addressing three aspects: the information quality generated by the informatic solution, the system quality with its intrinsic features, and the service quality with the technical support. Our findings reveal that the use of STM may improve the quality of pediatric care provision by affecting the different factors that influence it (e.g. resources shortages, pressing needs, the consistent lack of

pediatric care provision, and a growing number of pediatric patients). This improvement in the quality of care arises from the analysis' angle proposed by the conceptual framework and determined by the "benefits" dimension. According to this dimension, the assessment of an IS solution should examine its potential to impact the provided service. In addition, our results underscore the importance of properly preparing the context in which STM will be implemented. Such preparation is a strong determinant of the implementation's success.

On the other hand, our results pointed out some differences between critical care and rehabilitation in the degree of benefit achieved from STM. These differences are due to the fact that STM does not work the same way in all clinical departments, and each specialty is practiced under different circumstances, in different contexts, and with different interests. The main observed difference between critical care and rehabilitation was related to the need for STM in the provision of pediatric care. We found that in the SLP department the need for STM was realistic and accurate, while the results from the implementation in specialized care to improve the coordination between off-site PIs and on-site fellows in a PICU were less convincing, showing that such an STM added no value.

In the first article entitled *"Impact of Synchronous Telemedicine Models on Clinical Outcomes in Pediatric Acute Care Settings: A Systematic Review"*, we evaluated the impact of STM models on clinical outcomes

among pediatric acute care patients. We concluded the following: (1) the utilization of STM improved quality of care, decreased the transfer rate, shortened the LOS, changed or reinforced the medical care plan, reduced complications, illness severity and medication errors, and decreased the standardized mortality rate; and (2) despite the broad recommendation to use STM with acutely ill patients, there is lack of robust evidence in the published literature that could be used to guide STM practice in pediatric acute care settings. The evidence we reviewed was weak due to the poor quality of most of the reviewed studies. These studies were based on self-reporting by physicians, without measuring the clinical outcomes using objective indicators.

Compared to the published papers, the results of our review are congruent with a previous systematic review demonstrating that STM was comparable to face-to-face care in adult emergency medicine and was beneficial in surgical and NICUs as well as in patient transfers in neurosurgery (113). Concerning hospital mortality rates, the conclusions drawn from the results of the studies included in the current review are concordant with those reported in a meta-analysis. They showed that, when compared with face-to-face care, telemedicine is associated with lower adult and PICU mortality (risk ratio [RR], 0.79) and hospital mortality (RR, 0.83) (114). As for LOS, the utilization of STM decreases it. This conclusion is concordant with the results of an adult ICU meta-analysis,

which found statistically significant reductions in ICU and hospital LOS (114).

The primary goal of the second article, entitled *" Home-based pediatric telepractice in speech-language pathology: Evaluation of a pilot study",* was to assess the technical and clinical feasibility of a TSLP service as well as satisfaction levels among the different stakeholders with this service. Moreover, it evaluated the economic cost of the TSLP service and its impact on voice performance.

This study demonstrated that use of TSLP is feasible, sustainable and clinically efficacious in improving children's voice performance. Furthermore, the intervention was positively assessed in terms of the satisfaction expressed by both the SLP and the parents. Overall, these results are consistent with previous pilot studies (13, 62, 66, 67, 70), which demonstrated high satisfaction among patients and speech-language pathologists, and the efficiency of TSLP treatments.

Satisfaction with clinical performance was high, reflecting a positive appraisal by speech-language pathologists of the technology's ability to deliver speech-language therapy at a distance. However, the speech-language pathologists' evaluations of the platform's technical performance were less favourable. Our results are partly discordant with those obtained by Sicotte et al.(62), who reported that the SLP and the children had more favourable perceptions of the technical performance.

Furthermore, our results were very positive in terms of the patients'

motivation and their parents' satisfaction. These results are congruent with Isaki et al.(13), which found no statistically significant change in personal opinions about telepractice before and after therapy, reflecting a similar consistency. As for the economic cost estimates, their study showed a positive appraisal by the parents. These findings are consistent with the current literature (62), which has demonstrated in a similar context, that parents consider the personal expenses reasonable.

In addition, we concluded that the TSLP treatments achieved significant benefits in terms of voice performance and, therefore, health outcomes. The treated children showed statistically significant improvements in the roughness (CI: 4.19–15.48), breathiness (CI: 1.55–8.45), strain (CI: 1.30–8.03) and overall severity (CI: 3.86–12.14) of their voices.

In article 3, entitled *"The implementation of a synchronous telemedicine platform linking off-site pediatric intensivists and on-site fellows in a pediatric intensive care unit: a feasibility study"*, the major objective was to assess the feasibility of implementing an STM platform in a PICU. Our study showed a failure to demonstrate the usefulness of an STM service providing synchronous communication between off-site pediatric intensivists and on-site fellows. Both groups of stakeholders, the PIs and the fellows, agreed that STEP-PICU did not improve or facilitate the workflow in the PICU.

One point worth mentioning is the context surrounding this study. It was carried out in a PICU with fellows who are mostly at the end of their

professional education. The fact that they were at this stage of their training means that they were autonomous, competent, and did not have much need to call the attendings PIs. In addition, the platform's poor ease of use was a barrier for several users. Reducing the complexity of the login process, rendering it comparable to other communication applications, would help users work with the platform more easily. The first months of the project were plagued with technical problems related to connection issues. Despite the fact that these technical problems were resolved by the IT department, this implementation stage exacerbated users' negative perceptions of the new STEP-PICU system.

This is why the study found no significant improvements in terms of a wide range of issues, such as an improved quality of pediatric critical care, saved time, improved learning and professional skills, and enhanced relationships and communications. This conclusion should be taken in context and does not suggest in an absolute way that STM is not useful in PICUs.

These results therefore differ from most of the results published in the literature. For instance, they divaricate from those obtained by Yager et al. (80), who pointed out that nighttime TM linking on-call staff intensivists with PICU bedside care providers, patients, and their families is feasible and may enhance team communication and impact patient management. Our results are also discordant with those of Rohs et al. (121), who found that the residents gave positive scores to TM in an ICU as a valuable

educational resource and a source of improvements to continuity of care, quality of care, and communication and teamwork coordination. It also helped the residents feel more confident in the care they were providing to critically ill patients and when providing recommendations consistent with ICU team routines. Knowing that there was a Tele-ICU pediatric intensivist available at night made them more likely to ask a question. In 2015, a study (105) conducted in a NICU similarly showed that 100% of on-site physicians felt comfortable using TM to interact with off-site physicians. In the same manner, a multicentric study (109) conducted in a pediatric cardiac critical care setting showed that a large majority (96%) of pediatric intensivists and fellows were satisfied or very satisfied with the TM service.

5.2 Scientific contributions

This dissertation has contributed substantive findings to the existing literature on the use and impact of STM in pediatric care, in particular in critical care and SLP.

The findings from *article 1* gave a clear picture of the current state of the impact of STM use on clinical outcomes in pediatric acute care settings. This systematic review supported the need for STM in acute pediatric settings and underscored the impact of this use on improving clinical outcomes among acute pediatric patients. In particular, the systematic

review brought new information to the fore by concluding that the published studies did not provide robust evidence of the impact of STM on clinical outcomes, and that there is still a lack of high-quality evidence. The results from *article 2* shed a light on the question of the feasibility of an STM platform in an SLP department and recommended its use between on-site speech-language therapists and off-site patients. What makes this study stand out from previous ones was the studied population, since the number of studies investigating home-based TSLP has been limited, and none has involved children with voice disorders. This article's findings support the feasibility, utility and benefit of TSLP services for children with voice disorders. Furthermore, it has pointed out that good logistical preparation is required before launching an STM service.

As for *article 3*, our results are completely different from what we found in the literature. Although the findings agreed with previous studies on technical feasibility, they suggest that linking the off-site pediatric intensivists to the on-site fellows through the STM during the night shift and holiday on-call periods is of minimal use to them. However, this negative conclusion applies only to a specific group of fellows.

Significantly, this study found that fellows who are more competent, autonomous, and advanced in their studies have less need to contact the on-call attendings PIs. In addition, it suggests that the STM service could be more beneficial for communications with remote healthcare facilities,

where there is a greater need for the expertise of a pediatric critical care intensivist.

5.3 Limitations of this work

Since the current dissertation encompassed two different research designs, one for the systematic review and one for the case studies, we present the limitations of this work in two separate sections.

5.3.1 Limitations of the systematic review

The main limitation of the systematic review was that most of the studies reviewed were retrospective. This resulted in a substantial amount of missing data and reduced the size and power of the studies. In addition, there was potential selection bias in the observational studies. As we limited our search to English and French-language publications, there is also the possibility that other relevant studies might have been missed.

5.3.2 Limitations of TSLP and STEP-PICU

First, we acknowledge that these were pilot studies, with small sample sizes that limit their ability to reliably ensure the effectiveness of the STM. This affects the generalizability of the results. The transferability of the conclusions of this dissertation was based on a case study approach and a detailed description of the context of each study. For example, the functions of the STM service, in a PICU and in SLP, have been described in detail, which leaves others to judge the transferability of the results to

another context. As for the systematic review, we provided detailed information on the technologies and contexts of the various studies, so that the reader can better recognize which elements are likely to apply to a particular situation.

Second, the patient selection process, the setting, and the absence of a control group may have caused a selection bias. For the purpose of the exploratory study of TSLP, only one patient profile (voice disorders) in one setting (SJUHC) was included. Adding other profiles (e.g. speaking disorders) could have provided a better understanding of how TSLP is used in practice. Another limitation was that only one healthcare setting was used for both studies. It would be useful to conduct other studies with PICUs and SLP departments in other settings.

Third, the results may have been unduly influenced by the homogeneity of the study sample, which was composed of only speech-language pathologists or highly competent fellows with no novice or intermediate residents. Including the perceptions of parents, residents, and bedside registered nurses might have generated different results on users' perceptions of the STM service.

Another limitation of the two studies stems from the use of a written questionnaire. The responses provided by the participants were thus a self-reported measure related to the different constructs of the theoretical model being tested. In this regard, questions may be raised about

methodological considerations related to social desirability. The participants may have not responded according to their actual lived situation but rather according to their perception of the actual adoption and use of the STM, and even responded differently to questions about their satisfaction out of fear of a breach of confidentiality or of the anonymity of the data.

Lastly, the outcomes measurement based on the participants' perceptions was a limitation. New perspectives could have been added to the study through the addition of objective measurements, such as the recommendations made by speech-language pathologists and PIs, changes to medical management after TM encounters, and the number of failed and dropped encounters.

5.4 Recommendations and future research

The evidence produced in the current dissertation is relevant to evidence-based pediatric care on how STM should be implemented and it influences the provision of pediatric care. The main objective of this research was to enrich our knowledge about the feasibility and impact of STM in critical and rehabilitation pediatric care. Using two complementary research designs—a systematic review and multiple cases studies—we approached this question from three distinct angles, shedding light on different aspects of the phenomenon. In conclusion, we have presented

some recommendations for research and practice, given our entire approach.

5.4.1 Recommendations for future research

Our research has shed light on various issues that should be considered when conducting future studies on STM in pediatric care. It has also highlighted specific themes that should be carefully considered by researchers interested in transforming the role of speech-language pathologists, pediatric intensivists, and fellows involved in delivering e-pediatric care.

First, although the benefits promised by STM are numerous and widely recommended, few studies have provided high-quality evidence based on applications of the technology. This conclusion has two implications for the conduct of future studies. First, research should focus on conducting cluster RCTs and multicentric studies with a sufficient number and varied types of participants (patients, parents, and other health professionals) in order to understand and confirm the influences of multiple actors on the development and use of STM.

Second, studies to describe the effects of STM solutions should use mixed-methods designs. On the one hand, it appears essential to mobilize qualitative methods in order to better understand the phenomena during a technology's implementation. For example, our understanding of the influences of STM could be enriched by grounded

theory and ethnographic studies, which allow for careful observation of actors and their use of STM technology. On the other hand, this type of study should serve as the basis for quasi-experimental studies, targeting the indicators that are most likely to be influenced by the use of STM in a particular context. Moreover, future studies should introduce more outcomes in order to extend the coverage of the studied concepts and phenomena.

Lastly, the results come from measurements made at a specific point in time. Therefore, longitudinal studies would make it possible to better appreciate changes in how the technology is implemented and its adoption by pediatric health professionals. These implications for research suggest that the more the STM technology is deployed in an organization, the more certain linkages are intensified, and the stronger the explanations of variance in the variables.

5.4.2 Recommendations for professional practice

The results of this work have shown that STM can influence the provision of pediatric care in both of its tracks: rehabilitation and critical care. However, various problems and challenges arose, leading us to develop certain recommendations, as much for pediatric physicians and fellows, speech-language pathologists, decision-makers and managers in the different pediatric departments and settings.

Pediatric physicians, fellows, and speech-language pathologists should be involved in the development and implementation of STM. This involvement should begin right from the conceptualization, in the industry, of the design of the solution, all the way through to the last steps of its implementation and evaluation. For instance, speech-language therapists should improve TSLP by developing digitalized versions of the educational materials used during their sessions with patients, instead of using paper versions. Such a digital materials could facilitate their work and improve the quality of their sessions as perceived by patients. In a critical care context, clinicians should find other uses for STM, e.g., staff education and communications with families and caregivers. In addition, they have to broaden their view to include external hospitals, where there is a greater need for specialist consulting.

What is important is that they know that STM is primarily used to make clinical data, information and knowledge more accessible and manageable, and easier to communicate and store, as they provide professional care to patients. This holistic care goes beyond a biophysical conception of care and takes into account the psychosocial and spiritual dimensions of care needs, not only from a curative perspective, but also from the perspective of promoting health and preventing disease. In this respect, the STM must support these essential aspects of their professional practice. In addition, STM could support the integration of

information for the delivery of care, patient education, research and the introduction of evidence-based best practices.

As for decision-makers, IT developers and managers, they have a mandate to consider the points of view of end users regarding the user-friendliness of the STM solution. A user-friendly solution constitutes a very important part of the adoption process. Without it, end users will strongly resist against deployment. In addition, the development and implementation of STM solutions should take into account the potential for effects that go beyond the technical issues related to professional work. As such, the importance of the different logics involved, conveying different interests, should not be underestimated. The various points of views of stakeholders involved in the implementation and use of STM technologies should also be considered, in order to identify all the issues and challenges associated with this technology.

Lastly, it is important to stress once more that our findings should not be solely relied upon for causal inference. As with any study, additional research is needed to explore whether these patterns of findings can be replicated in other samples and in other settings, under different clinical and organizational conditions.

CHAPTER VI
CONCLUSION

Synchronous telemedicine solutions have great potential for resolving dysfunctions in the delivery of pediatric care. Considerable organizational and financial investment is key to encouraging its deployment in the health system, as we try to better understand its implications on the quality and safety of pediatric health care.

This dissertation strengthens and contributes to current empirical knowledge on implementing and assessing the impact of synchronous telemedicine solutions in pediatric care. In line with the existing literature, we demonstrated the consistent increase in the frequency of STM use and of positive impacts on clinical outcomes in the field of pediatric acute care medicine.

Furthermore, this thesis confirmed that TSLP is not only feasible, it also appears to be sustainable. It offers a promising alternative to face-to-face treatment without compromising health outcomes.

As for the PICU setting, this research concludes that an STM application linking pediatric intensivists and fellows, both on-site and off-site, is feasible provided that all the conditions for success are in place. The fact that benefits of the STM solution were not perceived was probably due to a set of factors that should be taken into consideration in their context. These factors, which frustrated users, probably obscured the benefits of the STEP-PICU, and partially contributed to the impression that STM was not needed in a PICU between on-site fellows and off-site PIs.

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APPENDICES

APPENDIX I. SEARCH STRATEGY FOR DATA BANKS

A) Pubmed:

1. Telemedicine:
Telemedicine[MAJR] OR telemedicine[TI] OR teleconsultation*[TIAB] OR tele-consultation*[TIAB] OR teleexpert*[TIAB] OR tele-expert*[TIAB] OR mobile health[TIAB] OR M-Health[TIAB] OR telehealth[TIAB] OR tele-health[TIAB] OR e-health[TIAB] OR telemedicine[OT] OR teleconsultation*[OT] OR tele-consultation*[OT] OR teleexpert*[OT] OR tele-expert*[OT] OR mobile health[OT] OR M-Health[OT] OR telehealth[OT] OR tele-health[OT]

2. Tele-Critical care:
Telecritical care[TIAB] OR tele-intensive care[TIAB] OR tele-ICU[TIAB] OR
tele-emergenc*[TIAB] OR teleemergenc*[TIAB] OR Telecritical care[OT] OR tele-intensive care[OT] OR tele-ICU[OT] OR tele-emergenc*[OT] OR teleemergenc*[OT]

3. Teleneonatology:
Teleneonatology[TIAB] OR tele-neonatology[TIAB] OR Teleneonatology[OT] OR tele-neonatology[OT]

4. Critical care:
Critical care[MH] OR Intensive care, neonatal[MH] OR intensive care units, pediatric[MH] OR intensive care units, neonatal[MH] OR Emergencies[MH] OR Emergency Service, Hospital[MH] OR Emergency Medical Services[MH] OR Emergency medicine[MH] OR Emergency Treatment[MH] OR NICU[TIAB] OR PICU[TIAB] OR critical care[TIAB] OR intensive care[TIAB] OR emergenc*[TI] OR NICU[OT] OR PICU[OT] OR critical care[OT] OR intensive care[OT] OR emergenc*[OT]

5. Pediatric:
pediatric[TIAB] OR pediatrics[TIAB] OR paediatric[TIAB] OR paediatrics[TIAB] OR infant[TIAB] OR infants[TIAB] OR babies[TIAB] OR baby[TIAB] OR Neonat*[TIAB] OR prematur*[TIAB] OR Preterm[TIAB] OR Preterms[TIAB] OR newborn[TIAB] OR new born[TIAB] OR newborns[TIAB] OR new borns[TIAB] OR low birth weight[TIAB] OR ELBW[TIAB] OR VLBW[TIAB] OR LBW[TIAB] OR Small for Gestational Age[TIAB] OR infancy[TIAB] OR Toddler[TIAB] OR Toddlers[TIAB] OR toddlerhood[TIAB] OR teenage[TIAB] OR teenager[TIAB] OR teenagers[TIAB] OR teen[TIAB] OR teens[TIAB] OR adolescen*[TIAB] OR Kid[TIAB] OR kids[TIAB] OR child[TIAB] OR children[TIAB] OR childhood[TIAB] OR preschool*[TIAB] OR juvenil*[TIAB] OR boys[TIAB] OR boy[TIAB] OR girls[TIAB] OR girl[TIAB] OR schoolchild*[TIAB] OR pre school*[TIAB] OR pubert*[TIAB] OR childs[TIAB] OR childrens[TIAB] OR youth[TIAB] OR pediatric[OT] OR pediatrics[OT] OR paediatric[OT] OR paediatrics[OT] OR infant[OT] OR infants[OT] OR babies[OT] OR baby[OT] OR Neonat*[OT] OR prematur*[OT] OR Preterm[OT] OR Preterms[OT] OR newborn[OT] OR

new born[OT] OR newborns[OT] OR new borns[OT] OR low birth weight[OT] OR ELBW[OT] OR VLBW[OT] OR LBW[OT] OR Small for Gestational Age[OT] OR infancy[OT] OR Toddler[OT] OR Toddlers[OT] OR toddlerhood[OT] OR teenage[OT] OR teenager[OT] OR teenagers[OT] OR teen[OT] OR teens[OT] OR adolescen*[OT] OR Kid[OT] OR kids[OT] OR child[OT] OR children[OT] OR childhood[OT] OR preschool*[OT] OR juvenil*[OT] OR boys[OT] OR boy[OT] OR girls[OT] OR girl[OT] OR schoolchild*[OT] OR pre school*[OT] OR pubert*[OT] OR childs[OT] OR childrens[OT] OR youth[OT] OR Infant[MH] OR child[MH] OR (adolescent[MH] NOT adult[MH:Noexp]) OR "Hospitals, Pediatric"[MH] OR pediatrics[MH] OR "Neonatology"[MH] OR "Perinatology"[MH] OR Adolescent, Hospitalized[MH] OR Child, Hospitalized[MH] OR pediatric*[Affiliation] OR paediatric*[Affiliation] OR children*[Affiliation]

6. 1 AND 4 AND 5
7. 2 AND 5
8. (3 OR 6 OR 7) NOT (adult*[TI] OR home[TI])

B) Medline (Ovid)

1. Telemedicine:
Telemedicine OR (telemedicine OR teleconsultation OR tele-consultation* OR teleexpert* OR tele-expert* OR mobile health OR M-Health OR telehealth OR tele-health OR e-health).ti,ab,kw

2. Tele-Critical care:
(Telecritical care OR tele-intensive care OR tele-ICU OR tele-emergenc* OR teleemergenc*).ti,ab,kw

3. teleneonatology:
(Teleneonatology OR tele-neonatology).ti,ab,kw

4. Critical care:
Critical care/ OR Intensive care, neonatal/ OR intensive care units, pediatric/ OR intensive care units, neonatal/ OR Emergencies/ OR Emergency Service, Hospital/ OR Emergency Medical Services/ OR Emergency medicine/ OR Emergency Treatment/ OR (NICU OR PICU OR critical care OR intensive care).ti,ab,kw OR emergenc*.ti

5. Pediatric:
(pediatric OR pediatrics OR paediatric OR paediatrics OR infant OR infants OR babies OR baby OR Neonat* OR prematur* OR Preterm OR Preterms OR newborn OR new born OR newborns OR new borns OR low birth weight OR ELBW OR VLBW OR LBW OR Small for Gestational Age OR infancy OR Toddler OR Toddlers OR toddlerhood OR teenage OR teenager OR teenagers OR teen OR teens OR adolescen* OR Kid OR kids OR child OR children OR childhood OR preschool* OR juvenil* OR boys OR boy OR girls OR girl OR schoolchild* OR pre school* OR

pubert* OR childs OR childrens OR youth).ti,ab,kw OR Exp Infant/ OR Exp child/ OR (adolescent/ NOT Exp adult/) OR Hospitals, Pediatric/ OR pediatrics/ OR Neonatology/ OR Perinatology/ OR Adolescent, Hospitalized/ OR Child, Hospitalized/ OR (pediatric* OR paediatric* OR child*).in

6. 1 AND 4 AND 5
7. 2 AND 5
8. (3 OR 6 OR 7) NOT (adult OR home).ti

C) Embase et EBM Reviews

1. Telemedicine:
*Telemedicine/ OR *teleconsultation/ OR (telemedicine OR teleconsultation* OR tele-consultation* OR teleexpert* OR tele-expert* OR mobile health OR M-Health OR telehealth OR tele-health OR e-health).ti,ab,kw

2. Telecritical care:
(Telecritical care OR tele-intensive care OR tele-ICU OR tele-emergenc* OR teleemergenc*).ti,ab,kw

3. Teleneonatology:
(Teleneonatology OR tele-neonatology).ti,ab,kw

4. Critical care:
Exp *Intensive care/ OR *intensive care unit/ OR exp *emergency care/ OR *emergency medicine/ OR *emergency physician* OR *emergency health service/ OR Exp *emergency treatment/ OR (NICU OR PICU OR critical care OR intensive care).ti,kw OR emergenc*.ti

5. Pediatric:
(pediatric OR pediatrics OR paediatric OR paediatrics OR infant OR infants OR babies OR baby OR Neonat* OR prematur* OR Preterm OR Preterms OR newborn OR new born OR newborns OR new borns OR low birth weight OR ELBW OR VLBW OR LBW OR Small for Gestational Age OR infancy OR Toddler OR Toddlers OR toddlerhood OR teenage OR teenager OR teenagers OR teen OR teens OR adolescen* OR Kid OR kids OR child OR children OR childhood OR preschool* OR juvenil* OR boys OR boy OR girls OR girl OR schoolchild* OR pre school* OR pubert* OR childs OR childrens OR youth) OR Exp child/ OR (adolescent/ NOT exp adult/) OR (pediatric* or paediatric* or child*).in.

6. 1 AND 4 AND 5
7. 2 AND 5
8. (3 OR 6 OR 7) NOT (adult* OR home).ti

D) CINAHL

1. Telemedicine:
(MH Telemedicine) OR (MH Telehealth) OR TI (telemedicine OR teleconsultation* OR tele-consultation* OR teleexpert* OR tele-expert* OR mobile health OR M-Health OR telehealth OR tele-health OR e-health) OR AB (telemedicine OR teleconsultation* OR tele-consultation* OR teleexpert* OR tele-expert* OR mobile health OR M-Health OR telehealth OR tele-health OR e-health)

2. TeleCritical care:
TI (Telecritical care OR tele-intensive care OR tele-ICU OR tele-emergenc* OR teleemergenc*) OR AB (Telecritical care OR tele-intensive care OR tele-ICU OR tele-emergenc* OR teleemergenc*)

3. Teleneonatology:
TI (Teleneonatology OR tele-neonatology) OR AB (Teleneonatology OR tele-neonatology)

4. Critical care:
(MH Critical care+) OR (MH Intensive care, neonatal) OR (MH Intensive Care Units +) OR (MH Emergencies) OR (MH Emergency Service+) OR (MH Physicians, Emergency) OR (MH Emergency medicine) OR (MH Emergency Treatment) OR TI (NICU OR PICU OR critical care OR intensive care OR emergenc*) OR AB (NICU OR PICU OR critical care OR intensive care)

5. Pediatric:
TI (pediatric OR pediatrics OR paediatric OR paediatrics OR infant OR infants OR babies OR baby OR Neonat* OR prematur* OR Preterm OR Preterms OR newborn OR new born OR newborns OR new borns OR low birth weight OR ELBW OR VLBW OR LBW OR Small for Gestational Age OR infancy OR Toddler OR Toddlers OR toddlerhood OR teenage OR teenager OR teenagers OR teen OR teens OR adolescen* OR Kid OR kids OR child OR children OR childhood OR preschool* OR juvenil* OR boys OR boy OR girls OR girl OR schoolchild* OR pre school* OR pubert* OR childs OR childrens OR youth) OR AB (pediatric OR pediatrics OR paediatric OR paediatrics OR infant OR infants OR babies OR baby OR Neonat* OR prematur* OR Preterm OR Preterms OR newborn OR new born OR newborns OR new borns OR low birth weight OR ELBW OR VLBW OR LBW OR Small for Gestational Age OR infancy OR Toddler OR Toddlers OR toddlerhood OR teenage OR teenager OR teenagers OR teen OR teens OR adolescen* OR Kid OR kids OR child OR children OR childhood OR preschool* OR juvenil* OR boys OR boy OR girls OR girl OR schoolchild* OR pre school* OR pubert* OR childs OR childrens OR youth) OR MH (Child+) OR (MH Infant+) OR AF (pediatric* OR paediatric* OR child*) OR ((MH adolescence+) NOT (MH adult+)) OR (MH Hospitals, Pediatric) OR (MH Pediatrics+)

6. 1 AND 4 AND 5
7. 2 AND 5
8. (3 OR 6 OR 7) NOT TI (adult* OR home)

APPENDIX II. ETHICAL APPROVAL & AUTHORIZATION OF THE HEAD OF THE DEPARTMENT

CHU Sainte-Justine
Le centre hospitalier universitaire mère-enfant
Université de Montréal

Le 11 août 2016

Annie-Joëlle Fortin
CHU Sainte-Justine

Objet	Renouvellement de l'approbation éthique - CÉR
	2016-969, 4188 Faisabilité d'un projet d'intervention clinique en téléorthophonie via la plateforme REACTS Co-chercheurs : Miroslava Dimova; Martin Cyr; Kathy Malas

Bonjour,

L'approbation éthique de votre projet cité en rubrique a été renouvelée par le Comité d'éthique de la recherche du CHU Sainte-Justine en date du 10 août 2016 et les documents suivants ont été approuvés :

- Protocole de recherche daté du 29 juillet 2015
- Formulaire d'information et de consentement daté du 29 juillet 2015

Le formulaire d'information et de consentement estampillé a été déposé dans le dossier du projet. Nous vous prions de vous servir de cette version estampillée.

Tous les projets de recherche impliquant des sujets humains doivent être réévalués annuellement. La durée de votre approbation sera effective jusqu'au **10 août 2017**. Il est de votre responsabilité de soumettre une demande au comité pour que l'approbation éthique soit renouvelée avant la date d'expiration. Il est également de votre responsabilité d'aviser le comité dans les plus brefs délais de toute modification au projet et/ou de tout événement grave et inattendu susceptible d'augmenter le niveau de risque ou d'influer sur le bien-être du participant.

En vous souhaitant une bonne poursuite de votre projet,

CHU Sainte-Justine
Le centre hospitalier universitaire mère-enfant

Université de Montréal

Le 23 janvier 2017

Docteur Philippe Jouvet
CHU Sainte-Justine

Objet	Approbation éthique initiale - CÉR
	2017-1329 l'évaluation d'une plateforme (REACTS) de télémédecine synchronisée dans l'unité des soins intensifs pédiatriques - CHUSJ **Marisa Tucci; claude sicotte; Mahmoud Nadar**

Docteur,

Le Comité d'éthique de la recherche du CHU Sainte-Justine, en comité délégué tenu le 15 septembre 2016, a évalué le projet mentionné en rubrique. Suite à vos réponses satisfaisantes, le Comité accorde son approbation éthique en date du 19 janvier 2017.

Ce dernier confirme également avoir assuré l'examen scientifique ainsi que l'examen de convenance du projet.

Les documents suivants ont été approuvés:

- Protocole de recherche daté de juin 2016
- Questionnaires d'évaluation d'une plateforme de télémédecine synchronisée (REACTS) non datés (versions française et anglaise)
- Lettre d'information non datée

Tous les projets de recherche impliquant des sujets humains doivent être réévalués annuellement. La durée de votre approbation sera effective jusqu'au **19 janvier 2018.** Il est de votre responsabilité de soumettre une demande au comité pour que l'approbation éthique soit renouvelée avant la date d'expiration. Il est également de votre responsabilité d'aviser le comité dans les plus brefs délais de toute modification au projet et/ou de tout événement grave et inattendu susceptible d'augmenter le niveau de risque ou d'influer sur le bien-être du participant.

Considérez que pour une collaboration avec un tiers impliquant des transferts de fonds ou de données/matériel biologique, une entente (contrat) est nécessaire. Celle-ci doit être gérée par le Bureau des ententes de recherche.

A noter que :

- Le Comité d'éthique de la recherche du CHU Sainte-Justine (numéro FWA00021692) est désigné par le gouvernement du Québec (MSSS).
- La composition de ce comité d'éthique pour la recherche satisfait aux exigences pertinentes prévues dans le titre 5 de la partie C du Règlement sur les aliments et drogues.

- Le comité d'éthique de la recherche exerce ses activités d'une manière conforme aux Bonnes pratiques cliniques, à

CHU Sainte-Justine
Le centre hospitalier universitaire mère-enfant
Université de Montréal

Le 07 septembre 2016

Docteur Philippe Jouvet
Centre de recherche du CHU Sainte-Justine

Objet	**Décision de révision du Comité scientifique** Accepté; transmis au Comité d'éthique
	l'évaluation d'une plateforme (REACTS) de télémédecine synchronisée dans l'unité des soins intensifs pédiatriques - CHUSJ **Projet numéro** : 2017-1329

Bonjour,

À la lumière des documents relatifs au projet, le Comité scientifique a pris la décision, lors de sa réunion du 06 septembre 2016, d'approuver le projet et le transmettre au Comité d'éthique de la recherche pour évaluation éthique.

Veuillez agréer l'expression de mes sentiments distingués.

Président du Comité scientifique de la recherche

CHU Sainte-Justine
Le centre hospitalier universitaire mère-enfant

Université de Montréal

Autorisation du chef de service/département

Projet de recherche : L'évaluation d'une plateforme (REACTS) de télémédecine synchronisée dans l'unité des soins intensifs pédiatriques - CHUSJ

Nom du chercheur responsable : Dr Philippe Jouvet

Service/Département : Soins intensifs pédiatriques

En tant que chef de service/département, j'autorise que ce projet de recherche se déroule dans le service/département ci-haut.

APPENDIX III. INFORMATION AND CONSENT FORM

CHU Sainte-Justine
Le centre hospitalier universitaire mère-enfant
Université de Montréal

APPROUVÉ PAR LE COMITÉ D'ÉTHIQUE
10 AOÛT 2016
#2016-969
CHU SAINTE-JUSTINE

FORMULAIRE D'INFORMATION ET DE CONSENTEMENT

Titre du projet : Faisabilité d'un projet d'intervention clinique en téléorthophonie via la plateforme REACTS

Nom des chercheurs

Chercheur responsable au CHU Sainte-Justine :
- Annie-Joëlle Fortin, chef professionnel en orthophonie et audiologie, CHU Sainte-Justine.

Chercheurs collaborateurs :
- Miroslava Dimova, orthophoniste du plateau infrastructures spécialisées du CHU Sainte-Justine
- Gabrielle Legris, orthophoniste du plateau CIRENE du CHU Sainte-Justine
- Martin Cyr, chef de service du génie biomédical du CHU Sainte-Justine
- Mariève Simoncelli, conseillère en évaluation à l'UETMIS du CHU Sainte-Justine
- Nina N'Diaye, conseillère en évaluation à l'UETMIS du CHU Sainte-Justine
- Kathy Malas, orthophoniste et responsable clinico-académique de la fonction des maladies chroniques et complexes au CHU Sainte-Justine.

Source de financement : projet réalisé à même le budget opérationnel du service d'orthophonie

Invitation à participer à un projet de recherche

Le CHU Sainte-Justine participe à des recherches dans le but d'améliorer la prise en charge précoce des enfants avec des difficultés de langage et de la parole. Nous sollicitons aujourd'hui votre participation en lien avec l'intervention de la voix et de la parole de votre enfant. Nous vous invitons à lire ce formulaire d'information afin de décider si vous souhaitez participer à ce projet de recherche. Il est important de bien comprendre ce formulaire. N'hésitez pas à poser des questions. Prenez le temps nécessaire pour prendre votre décision.

1. **Quelle est la nature de cette recherche?**

L'offre de thérapies de téléorthophonie à domicile (séances d'orthophonie à distance) à des enfants atteints de troubles du langage permettrait d'améliorer l'accessibilité aux services d'un orthophoniste, et potentiellement d'assurer une prise en charge adaptée aux besoins de votre enfant sans que vous ayez besoin de vous déplacer pour le suivi.

- Objectifs de la recherche

Nous désirons évaluer la possibilité d'offrir des thérapies de téléorthophonie (séances d'orthophonie à distance) à domicile via une plateforme appelée REACTS auprès d'enfants ayant un trouble de la voix ou d'enfants trachéostomisés. Nous désirons également mesurer votre satisfaction par rapport à ce mode de suivi à distance.

- Nombre de participants impliqués et envergure du projet

Nous solliciterons la participation de six patients ayant un trouble de la voix et deux patients trachéostomisés âgés de moins de 18 ans, ayant accès à Internet à leur domicile et dont les familles possèdent un ordinateur muni d'un microphone et d'une caméra.

Ce projet s'étendra sur 12 semaines à raison d'une rencontre par semaine. Une à deux rencontres d'évaluation en face à face (permettant d'évaluer les habiletés de votre enfant) et suivie de 9 à 10 rencontres d'intervention à distance. Il serait souhaitable que vous vous présentiez pour une rencontre face à face de fin d'étude correspondant à l'évaluation prévue à la fin de l'étude.

2. **Comment se déroulera le projet?**

- **Modalités de participation**

Les parents et leurs enfants âgés de moins de 18 ans en attente d'évaluation et de suivi avec l'orthophoniste de la clinique de voix et de la clinique des trachéostomisés seront sollicités à participer par l'orthophoniste de la clinique à la première séance d'évaluation. L'équipe de recherche consultera le dossier médical de votre enfant pour obtenir les informations pertinentes à cette recherche.

- **Activités demandées au participant**

Nous vous demanderons de vous déplacer au CHU Sainte-Justine pour une première rencontre en face à face pour l'évaluation de la voix ou pour l'évaluation de la tolérance et/ou validation de la bonne candidature au port de la valve phonatoire ou du cap occlusif.

Ensuite, des rencontres d'intervention à distance via la plateforme REACTS vous seront offertes en respectant le protocole clinique standard en face à face selon trois étapes :
Étape 1 – Discussion avec votre enfant et vous (explications et/ou retour par rapport à la rencontre précédente)
Étape 2 – Rencontre orthophonique à distance, à votre domicile, avec vous et votre enfant
Étape 3 – Bilan et recommandations jusqu'à la prochaine séance

Nous vous demanderons également de compléter des formulaires de satisfaction au cours du suivi. Pour le questionnaire de satisfaction, il sera complété une seule fois à la fin du projet. Pour les patients trachéotomisés, vous compléterez une note d'évolution lors de la période d'évaluation, soit les deux premières rencontres. Pour les patients avec un trouble de la voix, un questionnaire portant sur la qualité de vie sera complété à la première rencontre et en fin de projet. Une échelle de motivation sera complétée à la fin de chaque séance avec l'orthophoniste.

Pour les rencontres d'intervention via la plateforme REACTS, nous vous inviterons à vous connecter à votre compte REACTS 10 min avant la rencontre afin de nous assurer que la plateforme fonctionne bien. Si vous ne réussissez pas à vous connecter à l'heure de votre rendez-vous, vous pourrez appeler votre orthophoniste. Si le problème n'est pas réglé 15 min après le rendez-vous avec l'orthophoniste et les services de l'informatique du CHU Sainte-Justine, celui-ci sera déplacé à l'intérieur de 7 jours. Si des problèmes de connexion se produisent à nouveau, nous vous offrirons un suivi en personne au service d'orthophonie du CHU Sainte-Justine.

3. **Quels sont les avantages et bénéfices?**

La téléorthophonie à domicile pourrait permettre de mieux intervenir dans le contexte naturel de votre enfant, augmentant possiblement l'efficacité de l'intervention, la motivation de votre enfant et votre satisfaction quant au service reçu. Aussi, la téléorthophonie à domicile réduit le nombre de déplacements au CHU Sainte-Justine.

4. **Quels sont les inconvénients et les risques?**

Aucun inconvénient n'est encouru par la participation au projet sur la santé de votre enfant. Seuls des problèmes techniques pourraient arriver (plateforme qui ne fonctionne pas), vous obligeant peut-être alors à reporter le rendez-vous ou vous déplacer en clinique plutôt que de faire l'intervention. Soulignons que cette plateforme est déjà utilisée dans d'autres centres hospitaliers dans le cadre de projets de recherche.

5. **Comment la confidentialité est-elle assurée?**

Tous les renseignements obtenus sur votre enfant dans le cadre de ce projet seront confidentiels, à moins d'une autorisation de votre part ou d'une exception de la loi. Pour ce faire, ces renseignements seront codés et conservés sous clé au CHU Sainte-Justine sous la responsabilité d'Annie-Joëlle Fortin. Les données seront détruites sept années après la fin du projet de recherche.

Les données concernant le suivi orthophonique de l'enfant seront aussi versées dans le dossier médical.
Aucune donnée clinique ne sera sauvegardée par les orthophonistes via la plateforme Reacts pendant le suivi à distance. Par conséquent, aucune donnée clinique ne sera stockée à l'extérieur du CHU Sainte-Justine.

Cependant, aux fins de vérifier le bon déroulement de la recherche et d'assurer votre protection, il est possible qu'un délégué du Comité d'éthique de la Recherche du CHU Sainte-Justine consulte les données collectées durant le projet de recherche.

Par ailleurs, les résultats de cette étude pourront être publiés ou communiqués dans un congrès scientifique, mais aucune information pouvant identifier votre enfant ne sera alors dévoilée.

6. **Responsabilité**

En signant ce formulaire de consentement, vous ne renoncez à aucun de vos droits prévus par la loi ni à ceux de votre enfant. De plus, vous ne libérez pas les investigateurs de leur responsabilité légale et professionnelle.

Aucune compensation financière n'est prévue pour les frais de déplacement ou autres frais.

7. **Liberté de participation**

Il est entendu que votre participation à ce projet est tout à fait libre et volontaire et que vous pouvez, à tout moment, refuser de participer ou mettre fin à votre participation sans avoir à fournir de raison. De plus, un refus de participer ou une interruption de participation n'aura aucun impact sur les services que votre enfant pourrait recevoir en dehors de ce projet. Les données collectées au cours du projet de recherche seront retirées du dossier de recherche à votre demande.

8. **En cas de questions ou de difficultés, avec qui peut-on communiquer?**
Pour plus d'information concernant cette recherche, contactez Annie-Joëlle au (514) 345-4931 #5670, une des chercheuses responsable du projet.
Pour tout renseignement sur les droits de votre enfant à titre de participant à ce projet de recherche, vous pouvez contacter le Commissaire local aux plaintes et à la qualité des services du CHU Sainte-Justine au (514) 345-4749.

9. **Consentement et assentiment**

Faisabilité d'un projet d'intervention clinique en téléorthophonie via la plateforme REACTS

On m'a expliqué la nature et le déroulement du projet de recherche. J'ai pris connaissance du formulaire de consentement et on m'en a remis un exemplaire. J'ai eu l'occasion de

poser des questions auxquelles on a répondu. Après réflexion, j'accepte de participer et que mon enfant participe à ce projet de recherche.

J'autorise l'équipe de recherche à consulter mon dossier médical, ou le dossier médical de mon enfant, pour obtenir les informations pertinentes à ce projet.

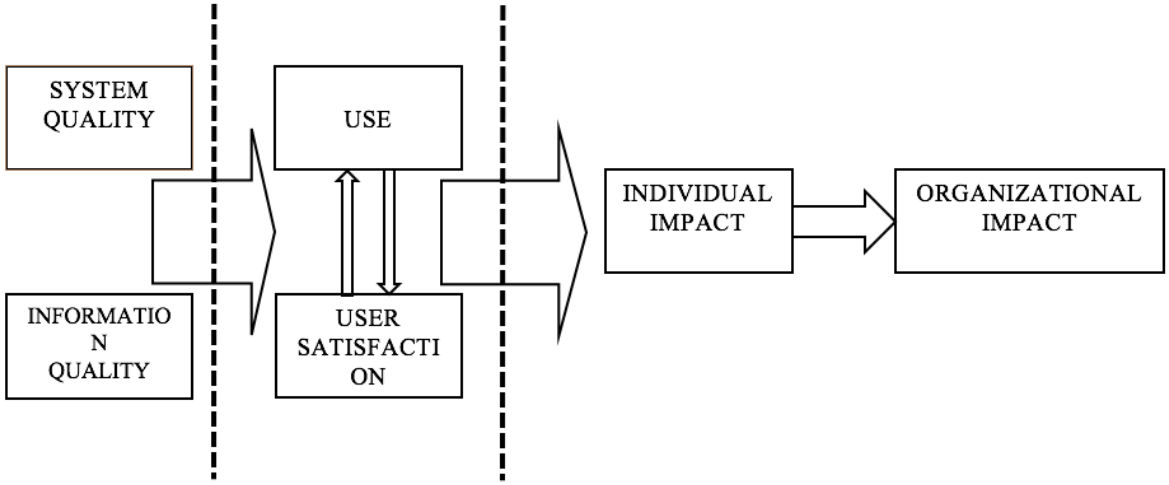
Nom de l'enfant (Lettres moulées)	Assentiment de l'enfant capable de comprendre la nature du projet (signature ou Assentiment verbal obtenu par :	Date

Nom du parent, tuteur (Lettres moulées)	Consentement (signature)	Date

J'ai expliqué au participant et/ou à son parent/tuteur tous les aspects pertinents de la recherche et j'ai répondu aux questions qu'ils m'ont posées. Je leur ai indiqué que la participation au projet de recherche est libre et volontaire et que la participation peut être cessée en tout temps.

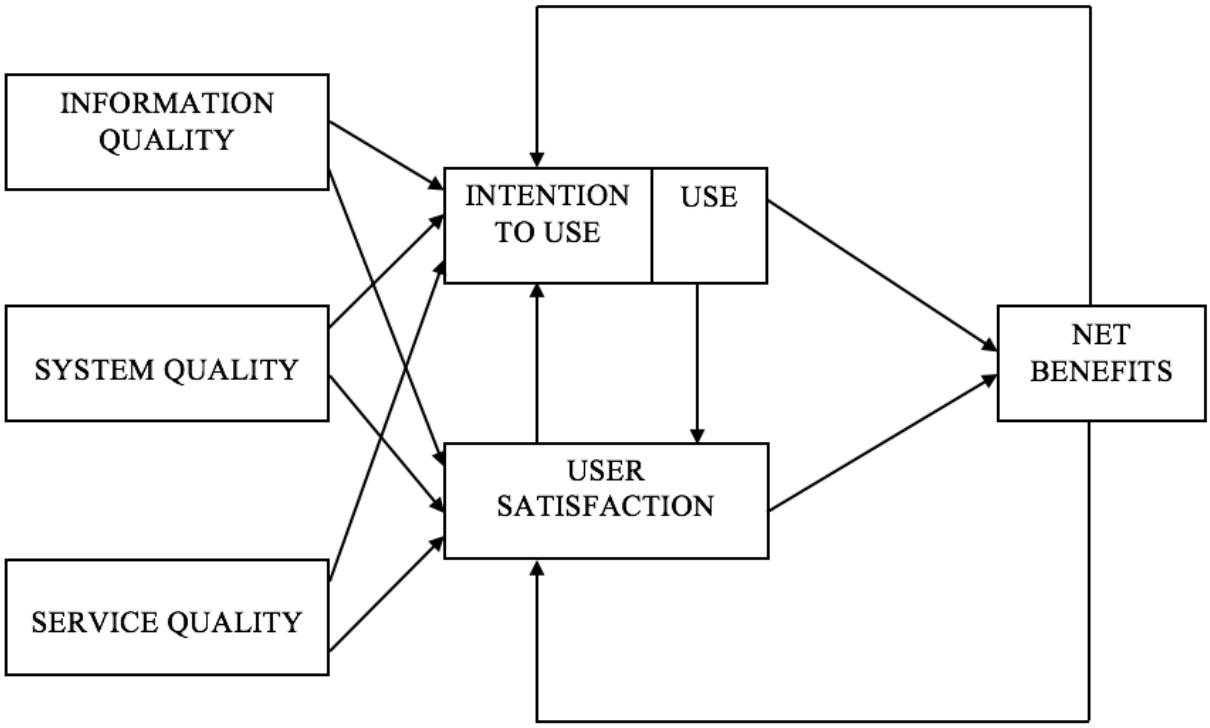
Nom de la personne qui a obtenu le consentement (Lettres moulées)	Signature	Date

APPENDIX IV. THE FIRST VERSION OF D&M MODEL, 1992



The first version of D&M model, 1992 (15)

APPENDIX V. THE UPDATED VERSION OF D&M MODEL, 2003



The updated version of D&M model, 2003 (19)

APPENDIX VI. OUTCOMES, DIMENSIONS, AND ITEMS OF TSLP PROJECT

Outcomes	Dimensions	Items
Technical Feasibility a. Intrinsic technical qualities	a. Ease of use	1. Are you satisfied with the ease of use of the REACTS platform? 2. Are you satisfied with the time it took to learn how to use the REACTS platform? 3. Are you satisfied with your level of fluency in using the REACTS platform?
	b. Screen quality	1. Are you satisfied with the quality of the image? 2. Are you satisfied with the sound quality?
	c. Workflow integration	1. In your opinion, is it easy to integrate and use your usual therapeutic tools with the REACTS platform? If not, why? 2. What changes/modifications did you have to make to your speech therapy interventions related to use REACTS ?
	d. Response time	1. Are you satisfied with the delay in signal transmission delay for the image? 2. Are you satisfied with the signal transmission delay for sound?
	e. Reliability	1. Are you satisfied with the steps required to prepare sessions on the REACTS platform? 2. What types of difficulties were encountered by the patient/parent when using REACTS (practical, technical, clinical, etc.)?

		3. What was most difficult to grasp about using the REACTS platform?
	f. Accessibility	1. What problems did you encounter when using REACTS for your speech therapy interventions?
	g. Perceived usefulness	1. In your opinion, is the REACTS platform an effective medium for speech therapy interventions? Why? 2. How would you describe the improvements in your patient's voice? 3. What benefits did you see in using REACTS for your speech therapy interventions?
b. Data quality	a. Completeness	1. In your opinion, was the quality of service received the same as if it had been offered in the regular intervention room (i.e. face-to-face treatment)?
	b. Reliability & validity	1. Was the quality of the intervention tools used with REACTS as reliable as those used in face-to-face treatment?
b. Quality of technical support		1. Are you satisfied with the quality of the technical support offered? 2. Are you satisfied with the online help resources (tutorials and other documents)? 3. What problems did you encounter when using REACTS to conduct your speech therapy interventions?

Clinical Feasibility	a. The degree of patient adherence to guidelines	1. Are you satisfied with the degree of patient adherence to your guidelines?
	b. The therapeutic relationship	1. Are you satisfied with the quality of the therapeutic relationship with the patient (perspective of the SLP)? During the previous sessions (perspective of the child): 2. I felt at ease with my SLP. 3. I found that the SLP cared for me. 4. I found that the SLP wanted to help me.
Satisfaction		* Perspective of the SLP The activities during the various sessions: 1. Are useful for the patient. 2. Are important to the patient. 3. Will help me to improve. *Perspective of the child At today's session: 4. I did what I could. 5. I'm happy with what I did. 6. I had fun. 7. I worked well. *Perspective of the parents 8. In general, was your child motivated to receive his speech therapy treatment with the REACTS platform?

Economic Cost	a. Money saved	1. Did you have to spend money on equipment to gain access to the REACTS platform (camera, microphone, etc.)? 2. If you would have had to travel for the treatment, how much transportation costs would you have incurred?
	b. Amount willing to pay	1. In a hypothetical scenario, would you be willing to pay for your child to receive treatment with the REACTS platform? 2. What amount you would be willing to pay for such treatment?
Health Outcomes		1. pVHI 2. CAPE-V

Appendix VII. The Consensus Auditory-Perceptual Evaluation of Voice

Appendix C

CAPE-V Form

Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V)

Name:_____ **Date:**_____

The following parameters of voice quality will be rated upon completion of the following tasks:
1. Sustained vowels, /a/ and /i/ for 3-5 seconds duration each.
2. Sentence production:
   a. The blue spot is on the key again.
   b. How hard did he hit him?
   c. We were away a year ago.
   d. We eat eggs every Easter.
   e. My mama makes lemon muffins.
   f. Peter will keep at the peak.
3. Spontaneous speech in response to: "Tell me about your voice problem." or "Tell me how your voice is functioning."

Legend: C = Consistent I = Intermittent
MI = Mildly Deviant
MO =Moderately Deviant
SE = Severely Deviant

			SCORE
Overall Severity	MI MO SE	C I	/100
Roughness	MI MO SE	C I	/100
Breathiness	MI MO SE	C I	/100
Strain	MI MO SE	C I	/100
Pitch	(Indicate the nature of the abnormality): _____ MI MO SE	C I	/100
Loudness	(Indicate the nature of the abnormality): _____ MI MO SE	C I	/100
_____	MI MO SE	C I	/100
_____	MI MO SE	C I	/100

COMMENTS ABOUT RESONANCE: NORMAL OTHER (Provide description):_____

ADDITIONAL FEATURES (for example, diplophonia, fry, falsetto, asthenia, aphonia, pitch instability, tremor, wet/gurgly, or other relevant terms):

Clinician:_____

Note. This form may be photocopied for clinical purposes. Also available online at http://ajslp.asha.org.

APPENDIX VIII. THE PEDIATRIC VOICE HANDICAP INDEX

Subject Number: _____ Date: _____

I would rate my/my child's talkativeness as the following (circle response)

1	2	3	4	5	6	7
Quiet Listener			Average Talker			Extremely Talkative

To be filled out by Staff:

F= _____
P= _____
E= _____
Total= _____

Talkativeness: _____

Instructions: These are statements that many people have used to describe their voices and the effects of their voices on their lives. Circle the response that indicates how frequently you have the same experience.

0=Never 1=Almost Never 2=Sometimes 3=Almost always 4=Always

Part I - F

1)	My child's voice makes it difficult for people to hear him/her	0 1 2 3 4
2)	People have difficulty understanding my child in a noisy room	0 1 2 3 4
3)	At home, we have difficulty hearing my child when he/she calls through the house.	0 1 2 3 4
4)	My child tends to avoid communicating because of his/her voice.	0 1 2 3 4
5)	My child speaks with friends, neighbors, or relatives less often because of his/her voice.	0 1 2 3 4
6)	People ask my child to repeat him/herself when speaking face-to-face.	0 1 2 3 4
7)	My child's voice difficulties restrict personal, educational and social activities.	0 1 2 3 4

Part II – P

1)	My child runs out of air when talking	0 1 2 3 4
2)	The sound of my child's voice changes throughout the day	0 1 2 3 4
3)	People ask, 'What's wrong with your child's voice?"	0 1 2 3 4
4)	My child's voice sounds dry, raspy, and/or hoarse	0 1 2 3 4
5)	The quality of my child's voice is unpredictable	0 1 2 3 4
6)	My child uses a great deal of effort to speak (e.g., straining)	0 1 2 3 4
7)	My child's voice is worse in the evening	0 1 2 3 4

0=Never 1=Almost Never 2=Sometimes 3=Almost always 4=Always

8)	My child's voice "gives out" when speaking	0 1 2 3 4
9)	My child has to yell in order for others to hear him/her.	0 1 2 3 4

Part III – E

1)	My child appears tense when talking to others because of his or her voice.	0 1 2 3 4
2)	People seem irritated with my child's voice	0 1 2 3 4
3)	I find other people don't understand my child's voice problem	0 1 2 3 4
4)	My child is frustrated with his/her voice problem	0 1 2 3 4
5)	My child is less outgoing because of his/her voice problem	0 1 2 3 4
6)	My child is annoyed when people ask him/her to repeat	0 1 2 3 4
7)	My child is embarrassed when people ask him/her to repeat	0 1 2 3 4

Overall Severity Rating of Voice
(Please place "X" mark anywhere along this line to indicate the severity of your child's voice; the verbal descriptions serve as a guide)

_____

Normal Severe

APPENDIX IX. QUESTIONNAIRE EVALUATING THE REGIONAL SYSTEM OF DIGITAL RADIOLOGY

HEC MONTRÉAL

Groupe de Recherche
Interdisciplinaire en Santé
Université de Montréal

Étude du Système PACS Régional

– Un système de radiologie numérique –

SVP LIRE AVANT DE COMPLÉTER LE QUESTIONNAIRE

Bien que les directions des établissements, responsables du PACS régional, aient donné leur accord à la tenue de cette recherche, vous ne devez pas vous sentir obligé d'y participer. Vous êtes libre de refuser de participer à ce projet et vous pouvez décider en tout temps d'arrêter de répondre aux questions.
Par contre, la valeur des résultats de cette recherche repose sur la participation du plus grand nombre possible de répondants. Nous espérons donc obtenir votre précieuse collaboration.
Le fait de remplir ce questionnaire sera considéré comme votre consentement à participer à la recherche. Si vous avez des questions concernant cette recherche, vous pouvez contacter les chercheurs principaux aux coordonnées inscrites au bas de cette page.

1. Veuillez répondre aux questions en vous basant sur vos impressions personnelles et en choisissant les réponses qui reflètent le mieux vos opinions. Répondez sans hésitation, car ce sont vos premières impressions qui reflètent généralement le mieux votre pensée. Vous avez simplement à noircir ou cocher votre choix de réponse.
2. La plupart des questions portent sur le système **PACS** (Picture Archiving and Communication System) incluant le **SIR** (Système d'information en radiologie) mais excluant la **dictée**. Lorsqu'une question est plus spécifique, nous précisons la ou les composantes considérées.
3. Le questionnaire a été conçu pour être complété par les **radiologues**, les **technologues en radiologie** et plus largement par l'ensemble des **médecins généralistes et spécialistes**. Il est possible que, compte tenu de vos fonctions ou de votre utilisation du système, certaines questions ne s'appliquent pas dans votre cas : laissez alors la question sans réponse et passez à la suivante.
4. Les informations recueillies resteront strictement confidentielles et ne seront utilisées que pour la diffusion de résultats utiles pour contribuer à l'amélioration du système de radiologie numérique dans votre région. Également, une diffusion des résultats sera menée plus largement dans le cadre de forums scientifiques ou professionnels.
5. Compte tenu des mesures de confidentialité qui seront prises, votre participation ne devrait pas vous causer de préjudice pas plus qu'elle ne vous profitera directement.
6. **Veuillez nous retourner le questionnaire complété en utilisant l'enveloppe préadressée jointe**.

SECTION 1. UTILISATION DU SYSTÈME PACS RÉGIONAL

SVP, encercler ou marquer d'un X votre choix de réponse	**Tout à fait en désaccord**									**Tout à fait en accord**
J'utilise fréquemment le système PACS dans le cadre de mes fonctions	1	2	3	4	5	6	7	8	9	10
J'utilise le système PACS pour la grande majorité de ma clientèle	1	2	3	4	5	6	7	8	9	10
J'utilise un large éventail des fonctionnalités offertes par le système PACS	1	2	3	4	5	6	7	8	9	10
J'utilise fréquemment le système PACS pour obtenir des données cliniques provenant d'autres établissements	1	2	3	4	5	6	7	8	9	10

SECTION 2. QUALITÉ DU SYSTÈME PACS RÉGIONAL

	Tout à fait en désaccord									**Tout à fait en accord**
De façon générale, le système PACS est facile à utiliser	1	2	3	4	5	6	7	8	9	10
Il est facile d'apprendre la maîtrise des fonctionnalités du système PACS	1	2	3	4	5	6	7	8	9	10
Les interfaces graphiques du PACS sont claires et faciles à comprendre	1	2	3	4	5	6	7	8	9	10
Il est facile de retrouver dans le PACS les images provenant des autres établissements	1	2	3	4	5	6	7	8	9	10
Il est facile de transmettre à partir du PACS des images et informations à d'autres établissements	1	2	3	4	5	6	7	8	9	10
La qualité des écrans PC disponibles dans l'établissement est adéquate	1	2	3	4	5	6	7	8	9	10
La qualité des écrans spécialisés, propre au PACS, est adéquate	1	2	3	4	5	6	7	8	9	10
La qualité des écrans favorise mon utilisation du PACS	1	2	3	4	5	6	7	8	9	10
Les sous-systèmes PACS/SIR (Système d'information en radiologie) sont bien intégrés	1	2	3	4	5	6	7	8	9	10
Les sous-systèmes PACS/SIR/Dictée sont bien intégrés	1	2	3	4	5	6	7	8	9	10
L'utilisation conjointe du PACS/SIR/Dictée facilite le travail	1	2	3	4	5	6	7	8	9	10
Lorsque les données d'un même patient proviennent de différents établissements, les systèmes PACS/SIR fournissent des informations bien intégrées	1	2	3	4	5	6	7	8	9	10
Lorsque les données d'un même patient proviennent de différents établissements, les systèmes PACS/SIR/Dictée fournissent des informations bien intégrées	1	2	3	4	5	6	7	8	9	10
J'ai l'impression que le téléchargement des images est rapide	1	2	3	4	5	6	7	8	9	10
L'accès aux images externes provenant des autres établissements est rapide	1	2	3	4	5	6	7	8	9	10
L'utilisation du PACS – excluant la gestion des images – est rapide	1	2	3	4	5	6	7	8	9	10
Il est rare que le PACS soit hors service pour cause de bris techniques	1	2	3	4	5	6	7	8	9	10
Les arrêts imprévus du PACS se produisent rarement	1	2	3	4	5	6	7	8	9	10
L'utilisation du PACS est ininterrompue grâce à l'absence des *bugs* informatiques	1	2	3	4	5	6	7	8	9	10
Le nombre de postes de travail PACS est suffisant	1	2	3	4	5	6	7	8	9	10
Rarement, j'ai dû attendre avant d'avoir accès à un poste de travail pour consulter le PACS	1	2	3	4	5	6	7	8	9	10
Du PC de mon domicile personnel, j'ai facilement accès au système PACS	1	2	3	4	5	6	7	8	9	10
Dans l'ensemble, le PACS offre une gamme complète de fonctionnalités en soutien à la réalisation de mes tâches professionnelles	1	2	3	4	5	6	7	8	9	10
L'harmonisation entre ma pratique clinique et le PACS est très bonne	1	2	3	4	5	6	7	8	9	10
Utiliser le PACS est compatible avec tous les aspects de ma tâche	1	2	3	4	5	6	7	8	9	10

SECTION 3. QUALITÉ DE L'INFORMATION

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	Tout à fait en désaccord									Tout à fait en accord
Les images du PACS – produites localement dans votre établissement – sont :										
• Complètes	1	2	3	4	5	6	7	8	9	10
• Fiables et précises	1	2	3	4	5	6	7	8	9	10
• Bien organisées et judicieusement présentées	1	2	3	4	5	6	7	8	9	10
• Disponibles au moment opportun	1	2	3	4	5	6	7	8	9	10
• Sécurisées et confidentielles	1	2	3	4	5	6	7	8	9	10
Les images du PACS – produites à l'externe par les autres établissements – sont :										
• Complètes	1	2	3	4	5	6	7	8	9	10
• Fiables et précises	1	2	3	4	5	6	7	8	9	10
• Bien organisées et judicieusement présentées	1	2	3	4	5	6	7	8	9	10
• Disponibles au moment opportun	1	2	3	4	5	6	7	8	9	10
• Sécurisées et confidentielles	1	2	3	4	5	6	7	8	9	10
Les données cliniques provenant d'établissements différents fournies par le SIR pour un même patient sont bien intégrées	1	2	3	4	5	6	7	8	9	10
Les images provenant d'établissements différents fournies par le PACS pour un même patient sont bien intégrées	1	2	3	4	5	6	7	8	9	10

SECTION 4. QUALITÉ DU SOUTIEN TECHNIQUE

	Tout à fait en désaccord									Tout à fait en accord
Le personnel de votre hôpital offrant l'assistance technique pour lePACS										
• Est facilement accessible	1	2	3	4	5	6	7	8	9	10
• Assure un service rapide	1	2	3	4	5	6	7	8	9	10
• Est compétent	1	2	3	4	5	6	7	8	9	10
• Est à l'écoute des besoins des usagers	1	2	3	4	5	6	7	8	9	10
• Parvient à trouver des solutions satisfaisantes	1	2	3	4	5	6	7	8	9	10
Le personnel offrant l'assistance technique pour le PACS dans votre clinique médicale hors hôpital										
• Est facilement accessible	1	2	3	4	5	6	7	8	9	10
• Assure un service rapide	1	2	3	4	5	6	7	8	9	10
• Est compétent	1	2	3	4	5	6	7	8	9	10
• Est à l'écoute des besoins des usagers	1	2	3	4	5	6	7	8	9	10
• Parvient à trouver des solutions satisfaisantes	1	2	3	4	5	6	7	8	9	10

SECTION 5. SATISFACTION GLOBALE

	Tout à fait en désaccord									Tout à fait en accord

Globalement, mon expérience d'utilisation du système PACS est satisfaisante	1	2	3	4	5	6	7	8	9	10
Il est agréable d'utiliser le système PACS dans le cadre de mon travail	1	2	3	4	5	6	7	8	9	10
Globalement, l'utilisation du PACS est plus satisfaisante que l'utilisation de l'ancien système	1	2	3	4	5	6	7	8	9	10

SECTION 6. BÉNÉFICES

	Tout à fait en désaccord	**Tout à fait en accord**

Ma productivité personnelle est améliorée grâce à l'utilisation du système PACS	1	2	3	4	5	6	7	8	9	10
L'utilisation du PACS me permet de gagner du temps	1	2	3	4	5	6	7	8	9	10
L'utilisation du PACS me permet de diminuer mes déplacements	1	2	3	4	5	6	7	8	9	10
La charge de travail a augmenté avec le plus grand nombre d'examens en imagerie médicale à réaliser notamment en provenance de l'externe	1	2	3	4	5	6	7	8	9	10
L'utilisation du PACS a augmenté la qualité des soins en comparaison de l'utilisation des films	1	2	3	4	5	6	7	8	9	10
Le recours au PACS a amélioré la qualité des diagnostics en imagerie médicale	1	2	3	4	5	6	7	8	9	10
Le PACS a réduit les délais entre une demande d'examens et la réception des résultats	1	2	3	4	5	6	7	8	9	10
Le PACS a entraîné une amélioration des relations entre les professionnels	1	2	3	4	5	6	7	8	9	10
L'accessibilité aux services d'imagerie médicale a été améliorée par le PACS	1	2	3	4	5	6	7	8	9	10
Le PACS régional a diminué le temps moyen d'attente des patients dans la région	1	2	3	4	5	6	7	8	9	10
Le système PACS a permis de réduire les transferts de patients entre les établissements	1	2	3	4	5	6	7	8	9	10
Le PACS a atténué les problèmes liés à la pénurie de personnel en imagerie médicale	1	2	3	4	5	6	7	8	9	10
Mon expérience personnelle avec le PACS est meilleure que ce que j'avais espéré	1	2	3	4	5	6	7	8	9	10
En général, les bénéfices obtenus grâce au PACS correspondent à mes attentes initiales	1	2	3	4	5	6	7	8	9	10
La facilité d'accès aux images des autres établissements est supérieure à ce que je souhaitais initialement	1	2	3	4	5	6	7	8	9	10

SECTION 7. INTENTIONS FUTURES

	Tout à fait en désaccord									**Tout à fait en accord**
Je désire poursuivre l'utilisation du système PACS dans mes activités cliniques	1	2	3	4	5	6	7	8	9	10
Je désire poursuivre l'utilisation du PACS pour obtenir les données d'imagerie des autres établissements	1	2	3	4	5	6	7	8	9	10
Si je le pouvais, j'aimerais augmenter encore ma maîtrise du système PACS	1	2	3	4	5	6	7	8	9	10

APPENDIX X. MEASURED OUTCOMES OF THE STEP_PICU PROJECT

User Perception Items
In general, has the REACTS platform been easy to use? Pediatric intensivists Fellows Total
It was easy to learn the functionalities of the REACTS platform Pediatric intensivists Fellows Total
REACTS' graphical user interfaces were clear and easy to understand Pediatric intensivists Fellows Total
It was easy to find in REACTS the images coming from the other site/installation Pediatric intensivists Fellows Total
It was easy to transmit and/or receive images and information to/from the other site/facility using REACTS Pediatric intensivists Fellows Total
The quality of the PC screens available at my site was adequate Pediatric intensivists Fellows Total
The quality of the screens favored my use of the REACTS platform Pediatric intensivists Fellows Total
The subsystems REACTS/SYNAPSE (Radiological Information System)/SOFTLAB (Laboratory Results) were well integrated Pediatric intensivists Fellows Total
Joint use of REACTS/SYNAPSE/SOFTLAB facilitated the work Pediatric intensivists Fellows Total
When data on the same patient came from different sites/facilities, REACTS/SYNAPSE/SOFTLAB systems provided well-integrated information Pediatric intensivists Fellows Total
The system quickly downloaded images/videos/documents Pediatric intensivists

Fellows Total
The system provided quick access to external images/videos/documents from the other site/installation Pediatric intensivists Fellows Total
Excluding image/video/document management, REACTS provided quick responses to my commands Pediatric intensivists Fellows Total
REACTS was rarely offline due to technical issues Pediatric intensivists Fellows Total
Unexpected shutdowns of REACTS have were rare Pediatric intensivists Fellows Total
The use of REACTS was continuous thanks to the absence of computer bugs Pediatric intensivists Fellows Total
There was a sufficient number of REACTS workstations in the unit Pediatric intensivists Fellows Total
I rarely had to wait for access to a workstation to use the REACTS platform Pediatric intensivists Fellows Total
I had easy access to the REACTS platform from my personal PC/tablet/smartphone Pediatric intensivists Fellows Total
Overall, REACTS offered a full range of features to support my work Pediatric intensivists Fellows Total
REACTS worked quite seamlessly with my clinical practice Pediatric intensivists Fellows Total
Using REACTS was compatible with all aspects of my job Pediatric intensivists Fellows Total
System quality Pediatric intensivists

Fellows **Total**
Images of REACTS at your site/installation (home) were complete Pediatric intensivists Fellows Total
The REACTS images at your site/installation (home) were reliable and accurate Pediatric intensivists Fellows Total
REACTS images at your site/installation (home) were well organized and well presented Pediatric intensivists Fellows Total
REACTS images at your site/installation (home) were available at the appropriate time Pediatric intensivists Fellows Total
REACTS images at your site/installation (home) were secure and confidential Pediatric intensivists Fellows Total
Clinical data from the other site/facility for the same patient was well integrated Pediatric intensivists Fellows Total
Images/videos from another site/facility provided by REACTS for the same patient were well integrated Pediatric intensivists Fellows Total
Data quality Pediatric intensivists **Fellows** **Total**
The staff providing technical assistance on REACTS in your site/facility was easily accessible Pediatric intensivists Fellows Total
The staff providing technical support on REACTS in your site/facility provided prompt service Pediatric intensivists Fellows Total
The staff providing technical support on REACTS in your site/ facility was competent Pediatric intensivists Fellows Total
The staff providing technical support on REACTS in your site/facility listened to the needs of users Pediatric intensivists Fellows

Total
The staff providing technical support on REACTS in your site/facility were able to find satisfactory solutions to technical problems Pediatric intensivists Fellows Total
Quality of technical support Pediatric intensivists **Fellows** **Total**
I used the REACTS platform frequently as part of my duties Pediatric intensivists Fellows Total
I used the REACTS platform for the vast majority of my clients when needed Pediatric intensivists Fellows Total
I used a wide range of the features on the REACTS platform Pediatric intensivists Fellows Total
I have used the REACTS platform frequently to obtain clinical data from other sites/facilities Pediatric intensivists Fellows Total
System use Pediatric intensivists **Fellows** **Total**
Overall, my experience using the REACTS platform has been satisfactory Pediatric intensivists Fellows Total
I enjoyed using the REACTS platform as part of my job Pediatric intensivists Fellows Total
Overall, my use of REACTS has been more satisfactory than my use of other software Pediatric intensivists Fellows Total
Overall satisfaction Pediatric intensivists **Fellows** **Total**
My personal productivity improved through my use of the REACTS platform Pediatric intensivists Fellows

Total
Using REACTS saved me time Pediatric intensivists Fellows Total
Using REACTS improved my learning and professional skills Pediatric intensivists Fellows Total
The workload increased with the use of REACTS Pediatric intensivists Fellows Total
Using REACTS was stressful for me Pediatric intensivists Fellows Total
The use of REACTS improved relationships and communications between the pediatric intensivists and the fellows Pediatric intensivists Fellows Total
The use of REACTS reduced the time between making a request and obtaining assistance/medical expertise. Pediatric intensivists Fellows Total
The use of REACTS reduced the sense of professional autonomy among the fellows Pediatric intensivists Fellows Total
The use of REACTS improved fellows' access to support services/medical expertise from the pediatric intensivists Pediatric intensivists Fellows Total
The use of REACTS decreased patients' average waiting time to receive care Pediatric intensivists Fellows Total
The use of REACTS improved the quality of pediatric critical care assessments, diagnoses and treatments Pediatric intensivists Fellows Total
The use of REACTS improved the quality and continuity of care Pediatric intensivists Fellows Total
Benefits

Pediatric intensivists	
Fellows	
Total	

APPENDIX XI. USERS PERCEPTION ITEMS SCORES FOR STEP_PICU PROJECT

User Perception Items	Mean	SD	Min	Max
System quality dimension				
In general, has the REACTS platform been easy to use?				
Pediatric intensivists	5.17	1.83	3	7
Fellows	4.29	2.13	2	8
Total	4.69	1.97	2	8
It was easy to learn the functionalities of the REACTS platform				
Pediatric intensivists	6.17	2.13	2	8
Fellows	5.43	2.22	3	9
Total	5.77	2.12	2	9
REACTS' graphical user interfaces were clear and easy to understand				
Pediatric intensivists	6.83	3.06	1	10
Fellows	5.86	2.26	1	10
Total	6.31	2.59	1	10
It was easy to find in REACTS the images coming from the other site/installation				
Pediatric intensivists	3.83	2.48	1	8
Fellows	3.20	2.68	1	8
Total	3.55	2.46	1	8
It was easy to transmit and/or receive images and information to/from the other site/facility using REACTS				
Pediatric intensivists	4.00	2.44	1	8
Fellows	3.20	1.78	1	5
Total	3.64	2.11	1	8
The quality of the PC screens available at my site was adequate				
Pediatric intensivists	5.83	3.06	1	10
Fellows	8.00	1.15	7	10
Total	7.00	2.41	1	10
The quality of the screens favored my use of the REACTS platform				
Pediatric intensivists	5.17	2.31	2	8
Fellows	3.29	2.43	1	8
Total	4.15	2.47	1	8
The subsystems REACTS/SYNAPSE (Radiological Information System)/SOFTLAB (Laboratory Results) were well integrated				
Pediatric intensivists	4.00	2.53	1	7
Fellows	5.29	1.97	1	7
Total	4.69	2.25	1	7
Joint use of REACTS/SYNAPSE/SOFTLAB facilitated the work				
Pediatric intensivists				
Fellows	4.83	3.31	1	8
Total	2.00	1.15	1	4
	3.31	2.72	1	8

When data on the same patient came from different sites/facilities, REACTS/SYNAPSE/SOFTLAB systems provided well-integrated information				
Pediatric intensivists	4.17	2.92	1	8
Fellows	2.80	2.04	1	5
Total	3.55	2.54	1	8
The system quickly downloaded images/videos/documents				
Pediatric intensivists	5.17	2.92	1	8
Fellows	4.57	2.69	1	8
Total	4.85	2.70	1	8
The system provided quick access to external images/videos/documents from the other site/installation				
Pediatric intensivists	4.00	3.03	1	8
Fellows	4.14	2.19	1	6
Total	4.08	2.49	1	8
Excluding image/video/document management, REACTS provided quick responses to my commands				
Pediatric intensivists	5.50	2.95	2	8
Fellows	5.43	3.20	1	9
Total	5.46	2.96	1	9
REACTS was rarely offline due to technical issues				
Pediatric intensivists				
Fellows	4.00	2.44	2	8
Total	2.50	1.60	1	6
	3.14	2.07	1	8
Unexpected shutdowns of REACTS have were rare				
Pediatric intensivists	4.33	3.01	1	9
Fellows	4.86	1.21	3	6
Total	4.62	2.14	1	9
The use of REACTS was continuous thanks to the absence of computer bugs				
Pediatric intensivists	2.83	2.22	1	7
Fellows	2.50	1.77	1	5
Total	2.64	1.90	1	7
There was a sufficient number of REACTS workstations in the unit				
Pediatric intensivists	5.33	2.24	2	8
Fellows	6.75	3.32	2	10
Total	6.14	2.95	2	10
I rarely had to wait for access to a workstation to use the REACTS platform				
Pediatric intensivists	3.67	2.58	1	8
Fellows	7.00	2.64	4	10
Total	5.46	3.04	1	10
I had easy access to the REACTS platform from my personal PC/tablet/smartphone				
Pediatric intensivists	4.17	2.99	1	8
Fellows	5.29	3.14	1	8
Total	4.77	3.00	1	8

Overall, REACTS offered a full range of features to support my work				
Pediatric intensivists	4.50	2.25	1	7
Fellows	3.00	2.58	1	8
Total	3.69	2.46	1	8
REACTS worked quite seamlessly with my clinical practice				
Pediatric intensivists				
Fellows	3.33	2.33	1	7
Total	1.86	.90	1	3
	2.54	1.80	1	7
Using REACTS was compatible with all aspects of my job				
Pediatric intensivists	4.17	2.04	1	7
Fellows	2.29	1.38	1	4
Total	3.15	1.90	1	7
System quality				
Pediatric intensivists	**4.59**	**1.73**	**1.82**	**6.95**
Fellows	**4.26**	**1.02**	**2.59**	**7.71**
Total	**4.40**	**1.32**	**1.82**	**6.95**
Data quality dimension				
Images of REACTS at your site/installation (home) were complete				
Pediatric intensivists	4.67	2.80	1	8
Fellows	6.00	1.54	5	9
Total	5.33	2.27	1	9
The REACTS images at your site/installation (home) were reliable and accurate				
Pediatric intensivists	5.17	2.71	1	8
Fellows	5.75	1.70	4	8
Total	5.40	2.27	1	8
REACTS images at your site/installation (home) were well organized and well presented				
Pediatric intensivists	5.00	2.60	1	8
Fellows	6.00	1.41	5	8
Total	5.50	2.17	1	8
REACTS images at your site/installation (home) were available at the appropriate time				
Pediatric intensivists	5.17	2.63	1	8
Fellows	5.75	.95	5	8
Total	5.40	2.06	1	8
REACTS images at your site/installation (home) were secure and confidential				
Pediatric intensivists	6.67	2.94	1	9
Fellows	7.00	2.44	5	10
Total	6.80	2.61	1	10
Clinical data from the other site/facility for the same patient was well integrated				
Pediatric intensivists	4.83	2.48	1	8
Fellows	5.86	1.21	5	8
Total	5.38	1.89	1	8

Images/videos from another site/facility provided by REACTS for the same patient were well integrated				
Pediatric intensivists	4.83	2.48	1	8
Fellows	5.00	2.55	1	8
Total	4.91	2.38	1	8
Data quality				
Pediatric intensivists	**5.19**	**2.37**	**1**	**8**
Fellows	**5.81**	**1.12**	**4.29**	**7.71**
Total	**5.52**	**1.75**	**1**	**8**
Quality of technical support dimension				
The staff providing technical assistance on REACTS in your site/facility was easily accessible				
Pediatric intensivists	6.33	1.50	5	8
Fellows	5.86	2.11	2	8
Total	6.08	1.80	2	8
The staff providing technical support on REACTS in your site/facility provided prompt service				
Pediatric intensivists	5.00	1.67	2	7
Fellows	6.75	1.50	5	8
Total	5.70	1.76	2	8
The staff providing technical support on REACTS in your site/ facility was competent				
Pediatric intensivists	5.83	2.31	2	8
Fellows	7.00	1.41	5	8
Total	6.36	1.96	2	8
The staff providing technical support on REACTS in your site/facility listened to the needs of users				
Pediatric intensivists	5.67	2.73	2	10
Fellows	6.40	1.14	5	8
Total	6.00	2.09	2	10
The staff providing technical support on REACTS in your site/facility were able to find satisfactory solutions to technical problems				
Pediatric intensivists	5.50	2.42	2	9
Fellows	5.57	1.81	4	8
Total	5.54	2.02	2	9
Quality of technical support				
Pediatric intensivists	**5.66**	**1.83**	**3.00**	**8.20**
Fellows	**5.93**	**1.58**	**4.40**	**8.00**
Total	**5.81**	**1.63**	**3.00**	**8.20**
Use dimension				
I used the REACTS platform frequently as part of my duties				
Pediatric intensivists	3.17	2.13	1	7
Fellows	2.13	1.35	1	5
Total	2.57	1.74	1	7
I used the REACTS platform for the vast majority of my clients when needed				
Pediatric intensivists	3.67	3.44	1	9
Fellows	2.13	1.45	1	5

Total	2.79	2.51	1	9
I used a wide range of the features on the REACTS platform				
Pediatric intensivists	2.17	1.16	1	4
Fellows	2.50	1.30	1	4
Total	2.36	1.21	1	4
I have used the REACTS platform frequently to obtain clinical data from other sites/facilities				
Pediatric intensivists	2.00	1.09	1	4
Fellows	1.86	1.06	1	4
Total	1.92	1.03	1	4
System use				
Pediatric intensivists	**5.66**	**1.83**	**3.00**	**8.20**
Fellows	**5.93**	**1.58**	**4.40**	**8.00**
Total	**2.39**	**1.31**	**1.00**	**4.50**
Satisfaction dimension				
Overall, my experience using the REACTS platform has been satisfactory				
Pediatric intensivists	4.00	1.89	2	7
Fellows	3.43	2.22	1	6
Total	3.69	2.01	1	7
I enjoyed using the REACTS platform as part of my job				
Pediatric intensivists	4.50	2.34	1	7
Fellows	2.86	1.57	1	5
Total	3.62	2.06	1	7
Overall, my use of REACTS has been more satisfactory than my use of other software				
Pediatric intensivists	3.50	2.51	1	7
Fellows	3.14	1.86	1	5
Total	3.31	2.09	1	7
Overall satisfaction				
Pediatric intensivists	**4.00**	**1.80**	**1.33**	**6.00**
Fellows	**3.14**	**1.84**	**1.00**	**5.00**
Total	**3.53**	**1.80**	**1.00**	**6.00**
Benefits dimension				
My personal productivity improved through my use of the REACTS platform				
Pediatric intensivists	2.67	1.63	1	5
Fellows	1.71	.95	1	3
Total	2.15	1.34	1	5
Using REACTS saved me time				
Pediatric intensivists	2.67	1.63	1	5
Fellows	1.29	.48	1	2
Total	1.92	1.32	1	5
Using REACTS improved my learning and professional skills				
Pediatric intensivists	2.00	1.67	1	5
Fellows	2.00	1.41	1	4
Total	2.00	1.47	1	5

The workload increased with the use of REACTS				
Pediatric intensivists	5.50	1.04	4	7
Fellows	8.38	1.68	6	10
Total	7.14	2.03	4	10
Using REACTS was stressful for me				
Pediatric intensivists	4.17	2.22	1	6
Fellows	3.57	2.50	1	8
Total	3.85	2.30	1	8
The use of REACTS improved relationships and communications between the pediatric intensivists and the fellows				
Pediatric intensivists	3.17	1.72	1	6
Fellows	2.00	1.30	1	4
Total	2.50	1.55	1	6
The use of REACTS reduced the time between making a request and obtaining assistance/medical expertise.				
Pediatric intensivists	2.83	1.94	1	6
Fellows	1.57	.53	1	2
Total	2.15	1.46	1	6
The use of REACTS reduced the sense of professional autonomy among the fellows				
Pediatric intensivists	4.83	2.04	1	7
Fellows	4.14	3.62	1	10
Total	4.46	2.90	1	10
The use of REACTS improved fellows' access to support services/medical expertise from the pediatric intensivists				
Pediatric intensivists	3.17	2.13	1	6
Fellows	2.00	1.00	1	3
Total	2.54	1.66	1	6
The use of REACTS decreased patients' average waiting time to receive care				
Pediatric intensivists	2.83	2.22	1	6
Fellows	1.57	.78	1	3
Total	2.15	1.67	1	6
The use of REACTS improved the quality of pediatric critical care assessments, diagnoses and treatments				
Pediatric intensivists	2.83	2.13	1	6
Fellows	1.86	.69	1	3
Total	2.31	1.54	1	6
The use of REACTS improved the quality and continuity of care				
Pediatric intensivists				
Fellows	3.50	1.87	1	6
Total	2.00	1.00	1	3
	2.69	1.60	1	6
Benefits				
Pediatric intensivists	**3.22**	**1.28**	**1.62**	**4.70**
Fellows	**2.70**	**1.25**	**1.33**	**5.50**
Total	**2.93**	**1.24**	**1.33**	**5.50**