PAMTEL-RT: WEB-BASED MULTIMEDIA PLATFORM FOR TELE-ASSISTANCE OF PEDIATRIC HEALTH EMERGENCIES IN REAL TIME IN TRAINING CENTERS

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Abstract.- In this paper, PAMTEL-RT, a web-based platform to provide remote health professional support and guidance during the initial assistance of emergency situations is presented. In particular, this platform focuses on the pediatric population and has been specifically designed to be used by non-healthcare professionals in training centers, such as educational or sport centers. It allows pediatricians in hospitals to use Information and Communication Technologies to assist or guide, in real-time, training personnel in charge of children when any emergency situation may arise. A direct and secure real-time connection between the medical and training centers is established, allowing sharing multiple media, such as audio, video, images, documents, text and data. Since the implementation relies on standard web-based technologies, cross-network, cross-platform and cross-device support are ensured. At first, an opinion and acceptance survey was conducted in order to collect requirements from some potential users to consider their opinions when designing and developing the platform. In line with the obtained results, the architecture of the platform has been designed, and a prototype has been developed and preliminarily evaluated through 12 drills/simulations in 7 education and sports centers. In the evaluation, 24 training personnel were involved, who considered that its usability was excellent and that it would have applicability in their centers. Furthermore, they considered that the included functionalities in the platform are appropriate and believed that the use of PAMTEL-RT could be highly effective in the early management of extreme emergency situations, and, in some cases, in avoiding tragic consequences.

Keywords: e-health, telehealth, pediatrics, ICT, web, webRTC

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1. Introduction

Telehealth is the use of electronic information and telecommunication technologies (ICT) to support clinical care and public health, and to promote patient education and professional development. The term telemedicine is often used interchangeably with telehealth, as it was once the all-encompassing term for the use of remote communication technologies in health care [1]. This paper presents a telehealth platform, called PAMTEL-RT, dedicated to remotely guide non-healthcare professionals during the initial management and assistance of pediatric emergencies in educational and sports centers. Its first aim is to provide medical specialized support remotely to a group of people (teachers and sports monitors[1]) who have a responsibility to provide first aid to their students or pupils, without having medical knowledge. They had previously voiced to pediatricians in their health departments their fears of these situations. It was initially proposed to public schools and sports centers as health services in Spain are also public services. In this section, firstly, the antecedents of the development of the platform are presented, and then the main contributions of the paper are summarized.

[1] In this paper, the term *sports monitor* is used to refer to professional or amateur sports trainers or supervisors and any other people in charge of children in sports centers

Unlike other countries, the main limitation problem in Spain is that most of the educational or sports centers have neither a nurse nor staff able to provide specialized care in cases of medical emergencies. In recent years, some recommendations coming from the regional government are being published in order to enhance cooperation among health and educational authorities. Since September 2016, a new rule was approved to connect chronic patients of school age to their nearest health-providing center. Beyond the above, in these cases, it is mandatory to provide immediate, non-specialized attention and to take the general actions that any citizen taking care of a minor would take. Children spend a considerable part of the day in educational and sports centers. There they may present situations of health emergency in which staff members, teachers, sports monitors, caregivers, etc. (hereinafter, training personnel) must provide initial non-professional attention (e.g., medicine or drug supply). Examples of emergency situations include hypoglycemia in diabetic children, seizures in epileptics, deep cuts, bleeding, etc. In such emergency situations, early actions may be the most important fact influencing the future course of the child's recovery. A pediatric patient is particularly vulnerable and therapeutic measures highly depend on characteristic variables of childhood. Pediatric physiology differs significantly from that of adults. Children exhibit different signs, symptoms and ailments – and misdiagnosis can have tragic consequences. In the Valencia Region, the person in charge of the management of each educational center must have a registry of students with chronic diseases or health problems, with individualized records, including affiliation data of the student and parents or legal guardians, a contact phone number and medical reports. These data must be provided by the student's parents/guardians when the children join the educational center and keep updated.

In case of an emergency, the delay between the request and the arrival of the professional non-pediatric emergency health services at the child's location can be too high and can result in irreparable consequences[2]. The limited resources in the health area (e.g., number of available ambulances, personnel, etc.), the geographical distance and the orographic properties of the area may prevent immediate emergency assistance. With the main aim of reducing that delay and trying to offer support to non-healthcare people at centers, the introduction of ICT seems particularly useful to quickly connect the training personnel with a pediatrician[3] for remote guidance during the initial management of the emergencies. At the same time, ICT help to optimize the use of limited resources and to reduce costs. Many times, the emergency is not as urgent as expected at the beginning and some taken actions (and associated costs) could have been avoided (e.g., the need of an ambulance). For example, in Table 1, some involved costs of actions taken during the responses to emergencies (in 2018, in Alcoi's Department of Health, Alicante, Spain) are summarized.

Table 1. Involved costs when assisting an emergency situation (in the geographical area depending on the Alcoi's Department of Health, in Alcoi's Hospital Mare de Deu dels Lliris, belonging to FISABIO, in Alicante, Spain)

Phone consultation to primary health care doctor	**Phone consultation to nursing service**	**Transport (Ambulance)**	**Emergency attention at Hospital**	**Emergency attention at local primary care service**	**SAMU[4]**	**Non-surgical hospitalization in the pediatric ward at hospital**
21,40€	15€	37,64€	189,49€	124,75€	390€	310,17€

In this paper, a web-based multimedia platform for synchronous tele-assistance of pediatric health emergencies in real time is presented. After conducting an initial survey to check the acceptance by some potential users of these kinds of platforms and to collect their preferences, its architecture was defined, and a prototype was developed, tested and assessed in real environments (but with emergency drills) with satisfactory results. When an emergency is detected, the platform allows training personnel to be quickly put in contact with the pediatrician in the medical center through a secured real-time multimedia connection. Fig. 1 shows an overview of the platform. The training personnel can establish a direct connection with the pediatrician with any portable device (tablet, mobile...) through the platform, by simply opening a web page. After authentication and a classification of the type of the emergency and their symptoms, secured bidirectional data and audio-visual (AV) connections are established. The information about the emergency is received by the pediatrician at the beginning , allowing him/her to access to the child's Electronic Health

[2] Outdoors emergency management and ambulance assistance in Spain work in the following way. Calls are received from everywhere in a regional call center named CICU (Spanish acronym for center for emergencies information and coordination). Here, emergencies are assessed, and a decision is taken in order to deliver either a technical support or a medicalized one, depending on the case.

[3] The assistance would be given by general pediatricians physically present on call, who are, in Spanish public regional hospitals, the ones attending pediatric emergency rooms, pediatric wards at all levels, delivery room and obstetric operating room for emergencies. At those hospitals, there are general pediatricians on call 24 hours a day and 365 days a year, enough to attend all of the calls in scholastic and sports timetables. In the case that a call from the platform overlaps a current pediatrician intervention at the hospital, the same protocol used in overlapping calls inside the hospital would be applied, additional medical personnel would be involved, and preferences would be established.

[4] SAMU: Spanish Emergency Transportation Service including specialized personnel and equipment (In Spanish: *Servicio de Atención Médica de Urgencia*)

Records or EHRs (including family and personal history, allergies, vaccinations, etc.). The pediatrician can view all the time, in a main window, the child's state through the video camera of the training personnel's access device. This way, a first estimation of the severity of the situation can be made, and the professional can take the (remote) control guiding its first assistance by the training personnel. Helpful links and files with text, audio or visual content (videos, animations or images) can also be provided by the pediatrician and shared with the training personnel to improve the guidance with useful complementary information. A shared pointer allows the professional to point or signal over the media assets (red dot in the figure).

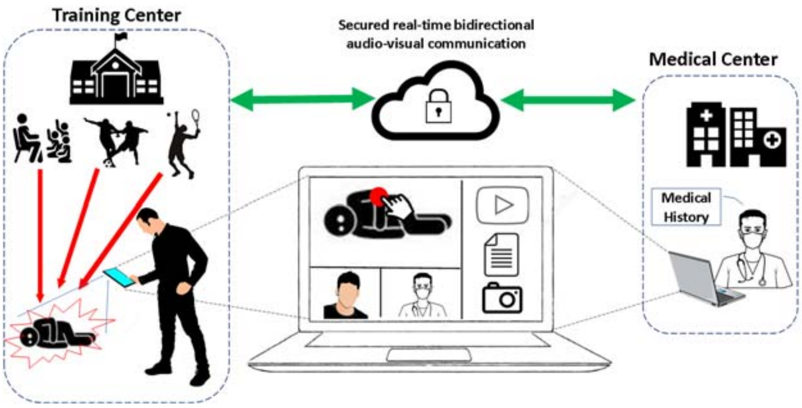

Fig. 1 General overview of the platform. It shows the people involved (the patient, a member of the training center and a pediatrician at the medical center), the real-time connection and a mockup of the GUI, including a big window with the real-time video of the child, and audio/video conferencing tools for the remote guidance by the pediatrician.

Regarding the needed technology, on the one hand, fast and reliable Internet connection is a key issue for providing effective telehealth services. On the other hand, in the training center side, the platform is based on the use of low-cost consumer-oriented devices, such as tablets or smartphones, which can foster its adoption in both public and private centers.

The main expected benefits of the presented platform can be summarized as:

a) Speed of action. Delay reduction in the first assistance of external emergencies with children.
b) Enhanced first assistance of external emergencies by non-professional health personnel, since it is (remotely) guided by professionals. Common mistakes made by non-professional health personnel when assisting external emergencies without the needed preparation can be avoided.
c) Immediate access to patient's EHR.
d) Instant professional medical support to the training personnel (diminishing fears and nervousness of non-professional health personnel).
e) Access to patient's health and condition prior to his/her arrival to the health center (when needed).
f) Social benefit. Parent satisfaction, relief for families, especially for those with children with chronic diseases, since they are aware that, when needed, their children will be assisted by training personnel under the guidance of a professional with knowledge of their EHRs.
g) Economic benefit. Optimized use of resources and reduction of unnecessary costs (e.g., transportation to the medical center when no special attention is needed).
h) It can be a training tool for both parties based on emergency drills or simulations.
i) Reductions in illness-related absence, travel times and emergency department use for non-urgent conditions.

To sum up, the main contributions of this paper are the following: i) Initial survey about the potential users' opinion, preferences, degree of acceptance and other concerns regarding the platform to be developed, with very interesting results; ii) Architecture design of the platform with novel features and some implementation details; iii) Functional prototype following the proposed architecture; and iv) Subjective assessment with promising results and their discussion.

The remainder of this paper is structured as follows. Some related works are summarized in Section 2. Section 3 presents the methodology and the results of an initial survey conducted with aim of gathering and selecting the requirements and functionalities of the platform. Section 4 presents the design choices and the rationale on using web-based technologies and components for the development of the platform. Then, the main functionalities of PAMTEL-RT are described in Section 5. The involved technologies, the architecture, the required equipment and some implementation details are presented in Section 6. The conducted evaluation of the platform in real scenarios, the followed methodology and the obtained results are summarized and discussed in Section 7. Finally, in Section 8, the conclusions and some future work are summarized. A supplementary file including complementary information is also provided.

2. Related works

The introduction of ICT in medicine will inevitably accompany many aspects of medical practice in the near future in Europe [2]. The 'digital transformation of health services' is seen as an important and influential process that has already had a substantial impact on current health care and health systems, and is expected to have a further fundamental impact on health care and health care delivery in the future [3]. Actually, in the last years there has been a significant increase in related publications regarding the use of ICT in pediatrics, the involved opportunities and challenges, and the analysis of pediatric telemedicine programs and models (e.g., [1], [4]-[12]), with hopeful results and remarkable success in the implementations. There also exist many telehealth systems with their associated mobile phone apps, mainly designed to assist most non-urgent clinical concerns, such as nausea, allergies, or cold and flu. The use of those apps for health management has been promoted both by independent reviews and by public initiatives [13]. In [4], [5] and [8], it is also emphasized that there still remain several barriers to the integration of telehealth into current practice (in the USA). Establishing the necessary technical, administrative, and operational infrastructure can be challenging. Among the identified barriers (in those papers) to the startup of growth for pediatric telehealth programs and also affecting their expansion, we can find the following ones: legal issues, lack of state regulation, technology costs and sustainability, lack of devices, resources to train providers, contracting problems, resources to train patients, patient preference for in-person care, technology-connectivity, lack of technology infrastructure on a national scale, reimbursement or inadequate payment for services. Likewise, these barriers are also found in Europe, and, therefore, in Spain. Regarding technology infrastructures, it is expected that the future adoption of future cellular network technologies (5G will reduce infrastructure barriers, mainly regarding end-to-end latency, jitter, data rate, and reliability) will improve the citizen's health assistance systems ([14], [15]). It will push towards the transition from specialized hospital-based care models to patient-centered ones. '*5G systems will truly spur new e-health and m-health applications, offering personalized and ubiquitous medical care, while paving the way for even more advanced scenarios, which are being targeted by long-term future 6G networks*' [15].

As far as the authors are aware, unlike in other countries, the use of telehealth solutions is not so widespread in Spain. Evidence for their implementation in Spain often come from pilot projects, many of which have been grant funded (e.g., *ICOR*[5], *Colabor@*[6], *Smart Assist*[7] projects and the *Carelife®*[8] solution). Unlike the platform presented in this paper, they have been designed just for tele-consulting, tele-research or tele-monitoring of patients. Independently of the benefits of telemedicine, our platform seems to be pioneer in providing assistance in pediatric emergencies, in solving several particularities in the described current Spanish scenario (non-healthcare professional presence at training centers, pediatric population concentration at these centers, unclear destination of patients under decisions taken by non-healthcare professionals…), and in providing extended and comprehensive pediatric availability and support, gaining time before critical situations, and saving costs.

3. Preliminary Study

Once the Scientific Research Ethics Committee of both funding institutions authorized the project to develop the platform presented in this paper, in January 2018, it was presented to the staff of educational and sports centers close to them. Centers inside the area covered by the Health Departments of Gandia and Alcoi cities (in the Valencian Community Region, in Spain) were selected. Their members were invited to carry out an on-line survey just intended for collecting opinions, expectations, degree of acceptance and other concerns from some potential users of the platform to be developed in the project. It was useful to gather and select some of its requirements, which were later transformed into functionalities of the platform (described in detail in Section 5). The information source for the conducted study was an anonymous, voluntary online survey with true/false, yes/no, multiple-choice, and open-ended questions[9]. Moreover, some statements were presented to the participants to obtain their opinion. In that case, 5-level Likert-type scales (e.g., the one with the values *Totally Disagree, Partially Disagree, Neutral, Partially Agree* and *Totally Agree*) were used. The survey was conducted between February 1 and April 1, 2018. A description of the project was provided at the beginning of the survey, including a general overview, emphasizing its main objectives and advantages, together with a consent form. The survey form consisted of four blocks of

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[5] https://www.imim.es/media/upload/arxius/oferta%20tecnologica/ICORweb%20IMIM_EN.pdf [last access: October 2020]
[6] https://ericlegras.wordpress.com/tag/colabor-telefonica/ [last access: October 2020]
[7] https://www.fundaciontecsos.es/en/projects/projects-progress/smart-assist [last access: October 2020]
[8] https://carelife.televes.com/?lang=en [last access: October 2020]
[9] The questionnaire is available in the supplementary file.

questions and its intended overall duration was less than 20 minutes. The first block was for collecting general data . The second one contained questions about the level of interest and expectations generated by the project. The third one included questions about technical characteristics to be included in the platform and, finally, a set of questions to analyze participants' personal opinions or particular concerns related to the use of the platform were included in a fourth block. The responses were processed and analyzed only by the researchers participating in the study. The most significant results are summarized in this section.

3.1. Participants

A study was carried out, with the answers of 119 training personnel (120 were received but one was excluded because it was incomplete) from 43 centers (33 educational centers and 10 sports centers). We had 34 participants that were male and 3 participants that were under 25 years old; 20 participants between 26 and 35 years old; 51 participants between 36 and 45 years old; 34 participants between 46 and 55 years old; and 11 participants between 56 and 65 years old. 85% of the participants were teachers while 8,4% were sports monitors, all in charge of children, especially school and pre-teen stages (4-14 years, Fig. 2). There were no records for the 0-2-year-old population, and data about students in high school and training cycles were excluded (the age of competence in pediatrics in Spain is up to 14 years old).

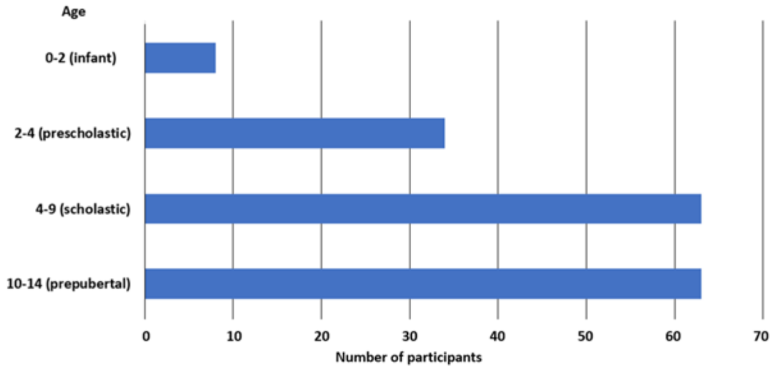


Fig. 2 Age (in years) of the students under supervision by the participants[10]

3.2. Results

In this section, the results of the other three blocks of the survey are summarized. In the second block, regarding interest shown in the platform by participants and their expectations, 99% of them would like to have a platform, like the one presented, available at their centers and would accept to use it. Most of them (92%) also found it very (34%) or somewhat (58%) interesting to have a platform like that available at training centers in their area. Only one of the participants declared to have heard something about a similar tool but used in private health centers and with another purpose (tele-consulting), which further proves the innovation provided by this project in Spain. Most of the participants (94%) also declared that they would fully (54%) or moderately (40%) feel more confident in having to face a medical emergency having the platform at their disposal. All of them agreed that the platform would provide a clear benefit for the health care of the children they are in charge of. A substantial 95% of them considered it would be very useful, and 86% considered that it would provide quite or a great deal of healthcare support. Only 3% of the participants declared they would not use the platform in case of emergency for different reasons (e.g., some of them stated that health care, in general, should only be provided by professionals and that they would not want to assume that responsibility). We saw that 54% of participants agreed (30%) or fully agreed (25%) with the statement '*A platform like the presented one would allow cost savings*'[11]. A majority of 87% of participants agreed (45%) or fully agreed (42%) with the statement '*the platform would contribute to a considerable saving of time in terms of the response period in emergency situations*'. All participants declared the platform could be useful for training, organizing services (e.g., ambulance), and to recover information, quality checking and further research about the provided assistance. As for the type of most probable health emergencies the platform would help them to assist, most of the participants identified seizure disorders (86%), diabetic patients (76%), syncope (73%) and traumas (63%). Asthma, febrile convulsions, anxiety attacks, choking, cardiac arrests, assessment of injuries, loss of consciousness and drowning were also identified, but by less than 10% of the participants. Regarding additional options and future improvements to be added to the platform, up to 92% of the participants considered convenient to

[10] Note that it was possible to select more than one option in the related question.
[11] In the description of the project that participants read at the beginning, costs in Table 1 were provided as an example.

include some kind of monitoring, such as (in order of preference) pulse oximetry (85%), level of sugar in blood (67%), temperature (63%) and electrocardiography monitoring (62%)[12].

In the third block with questions about technical aspects of the platform, most of the participants considered video (78%) and audio (77%) channels as the most appropriate to communicate with the remote pediatrician in real-time during the emergency, while only 21% of them considered a text chat channel as appropriate. Regarding the type of help participants would like to receive during the assistance of the emergency, most of them would like to receive guidance by using video (81%) or audio (80%) conferencing tools, while 26% would also like to receive related audio and video assets (selected by the pediatrician), and 12% would also like to receive related text documents. Considering the participants' technical skills (i.e., their familiarity with the use of mobile phones, tablets, social networks, video calls, etc.), most of them considered themselves quite (52%) or very skilled (20%). More than 75% would not mind installing the platform app on their own device. The rest preferred to access the platform by using a device from the training center. As the access device, most of them preferred a smartphone or tablet with Android operating system (71%), followed by iOS (44%).

The last section of the survey included open-ended responses or particular comments from participants. When asked about session recording, only 12% of the participants considered the help or guidance received, as well as the audio and video streams should not be recorded, considering possible subsequent responsibilities, and also in order to avoid possible problems due to non-compliance with the Spanish Organic Law on the Protection of Data (OLPD). We understand that some non-healthcare professionals may not feel sure of their eventual interventions and, therefore, may be reluctant to be recorded as any responsibility may affect them if episodes were reviewed. Some of the participants expressed the need for both training and an initial trial period prior to the use of the platform in real emergencies. Their main concerns regarding the functioning aspects were, above all, the possible network connection failures (especially in open areas, such as playgrounds or training stadiums) and the consequent delay in the attention this could cause, together with their legal implications or responsibilities. A common comment was the need of having a nurse in schools[13], as well as the necessary training on assisting different pathologies to anticipate possible problems with at-risk children. Several of them also emphasized the need to be in direct contact with an emergency telephone number if needed (nevertheless, in Spain this service is already available through the *112 emergency call* service).

3.3. Discussion

The project was favorably accepted by the potential users at educational/sports centers, and it could be considered to be an innovative breakthrough. The authors expect that the proposed platform will be an interesting instrument to support educational/sports communities, regardless of the ranges of age, sex, sport or study levels of their children. Logically, participants were not perfectly aware of the cost and time savings the platform may generate. Probably, without previous experience, they could not perceive how helpful the platform may be, providing real time connection, and allowing to start medical procedures quickly and in a guided way. Authors are firmly convinced of the valuable impact it could offer to both social and economic spheres. The use of this real time assisted attention tool could save expensive resources, besides avoiding social, family and work disturbances. It is also expected that the platform will provide a support tool for training personnel guiding them in medical emergency procedures. Families with children under 14 years old (especially those with chronic diseases) would probably feel safer and more reassured, knowing that medical services are remotely extended to the training centers. Additionally, population dispersion and orographic peculiarities in certain geographic areas would make real time AV connection even more useful. The training of potential users to use the platform is also expected to be very easy, as nowadays many educators are familiar with the use of the needed devices in their centers, such as tablets or smartphones, and the Graphical User Interface (GUI), presented in Section 5, is quite simple, intuitive and user-friendly. The most important fear in the use of the system comes from the weak definition of rules on registering and data protection. Regarding this, to the best of authors' knowledge, European Laws do not accurately regulate which medical procedures can be done on a telematics basis. Moreover, there is no uniformity on patients' rights nor on medical responsibility concerning this way of response. Anyway, it would be possible to delegate on the Spanish OLPD and on Patient Autonomy Laws to legally channel this activity. So, it seems that a legal framework will be soon necessary to cover these growing technological activities.

[12] The description and specific utility of the most common monitoring technologies recommended by pediatricians were provided. More than one option could be selected and even the opportunity to type new ones was given.
[13] In Spain, this measure is currently only under consideration by the new Madrid Community Regional Government (elected in May 2019) as it should honour its pledges during the election campaign.

Authors recognize that 119 participants is a small sample but, although as many participants to take part in the survey during the 2-month period scheduled for this task in the research project, we did not receive more responses. Nevertheless, we considered them as sufficient for the purpose of this survey (simply to know the opinions, degree of acceptance and other concerns from some potential users of the platform in order to take them into account when designing and developing it). Despite that limited sample of potential participants, but considering the high acceptance rate of the platform among them, its ease of use (as explained later) and potential benefits, authors expect the presented platform could be considered by regional authorities as a future tool for assisting pediatric emergencies in training centers.

4. Design Choices

This section, first, details the followed methodology to gather and select the requirements of the platform, which were then transformed into functionalities (described in Section 5). It also describes some design options and provides the rationale on the decision of using web-based technologies and components.

4.1. Selection of the Features of the Presented Platform

An initial phase for gathering requirements was performed with the goal of inspecting and getting recommendations and requirements from experts about the potential features the platform should include and selecting them after discussing potential options. This phase included different activities, the insights of which were combined and determined the final decisions: i) Search of other similar platforms, with the goal of identifying interesting and missing features. No similar ones were found and only very few ones for tele-consulting; ii) Analysis of the results of the described preliminary study, and the collected suggestions from the participants; and iii) User-centric activities, including interviews and focus groups with experts and potential users. The experts group included 5 pediatricians, 5 training personnel (3 teachers and 2 sports monitors) with some related experience in having attended some kind of emergency in the past, 2 computer engineers with expertise in audiovisual communication through IP networks, and 1 GUI designer. Different meetings with durations between 1 and 2 hours were attended by the authors and the experts group at the beginning. Once a preliminary idea of what to develop was agreed, the authors arranged different meetings with staff members of 4 educational centers and of 2 sports centers. From 3 to 5 members (with previous experience assisting in emergencies with children under 14) from each center attended the meetings and provided us with feedback about the project, which helped us to improve it. All of them were provided with a list of potential features, gathered from the previous tasks, and with several mockups of very preliminary GUI prototypes. In these activities, the appropriateness of adopting and/or adapting these features was discussed. In addition, useful feedback was received later when showcasing demos of different prototype versions of the platform and when conducting the subjective evaluation.

4.2. Use of web-based technologies and components

Two main options can be chosen for the development of media platforms: the use of either native (or platform-specific) or web components. An authors' discussion about implications of adopting each one of these options, in terms of key factors, such as support, ubiquity, development, maintenance, and usability issues can be found in [16]. As a summary, despite having slight advantages of using native applications in terms of more complete support for specific platforms, performance and usability, the differences are not so significant, especially regarding the development of media consumption platforms, which is the scope of this work. On the other hand, the use of Web applications can contribute to reduce the costs in terms of development, maintenance and distribution (principle of '*build and update once, run anywhere*'). Moreover, it can guarantee a more flexible and successful cross-platform, cross-device and cross-browser support, and also cross-network support, as the web traffic is not typically sensitive to firewall blocking policies and Network Address Translation (NAT) traversal issues (which contributes to a better ubiquity of the media applications/services to be deployed). Finally, although web components have not been typically conceived for providing precise timing and timely responsiveness [17], the recent advances in web technologies allow overcoming these issues ([17, 18, 19]). All these considerations support the decision in choosing web-based components for developing the platform.

5. Platform

In this section, first, the main functionalities of the platform are outlined, then the GUI of its main web pages are described and, finally, those functionalities are briefly explained in different subsections.

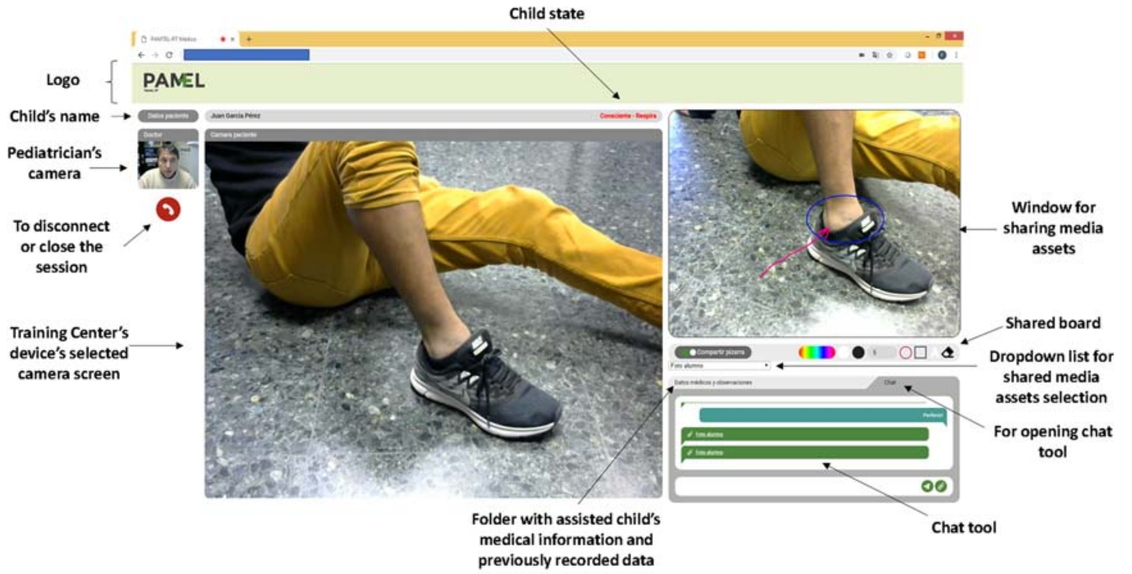
5.1. Main Functionalities

The main functionalities provided by PAMTEL-RT, which will be briefly described in the next subsections, are the following:

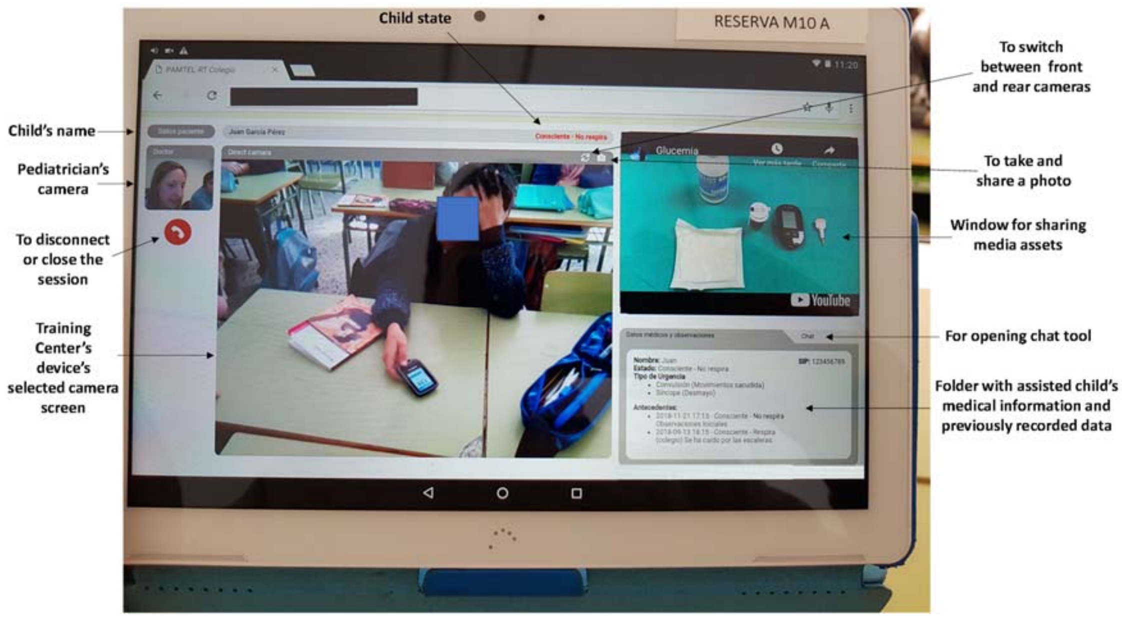
- Encrypted connection-oriented sessions between the training personnel and the pediatrician.
- Provision of the child medical pre-recorded information on the platform’s database.
- Shared and synchronized media content consumption.
- Interaction through several tools: a text chat tool, an audio/videoconference tool, playout control (by the pediatrician), shared board tool and exchange of files/photos.
- Uploading useful media assets to the platform’s media server to be shared during a session.
- Recording of the session’s data for further analysis/research.

5.2. General overview

After secure logging in to a web page, the main web page of PAMTEL-RT is shown on both sides: medical and training centers. In Fig. 3, the main parts and differences of both pages are briefly described.



a) Pediatrician’s main web page



b) Training Personnel’s main web page

Fig. 3 Platform’s main web pages for medical center and training center sides (a and b, respectively)

5.3. Uploading media assets

A tool has been included for HTTPS-based uploading media asset files to the platform’s media server, in order to be available for sharing them during a session. Their access path in the media server is stored in

[14] Spanish community health card identifier

the platform database. As required by the consulted experts, videos selected from YouTube may also be shared in the platform. To do so, the uploading tool also allows users to store their URLs in the database.

5.4. Encrypted connection-oriented sessions

The platform allows the training personnel to establish a real-time communication (RTC) session with the pediatrician via a Web-based technology, such as WebRTC (explained later), analogous to a videophone call but enhanced with many additional functionalities. It provides the establishment, management and leaving processes. This technology contributes to guarantee privacy since all the transmitted data is encrypted.

Once the training personnel has logged onto the platform, the child with health problems can be selected from a drop-down list[15], and the stored data for the selected child will be presented, as shown in Fig. 4. In it, the child Juan García Pérez is selected, who is diabetic and has several previously recorded emergency assistance episodes (shown on a screen with a hidden scroll -it appears when the cursor is passed over-). Once the child has been selected, and his/her data and history have been visualized, the main emergency situation must be selected between 4 exclusive alternatives (conscious-breathing, conscious-non breathing, unconscious-breathing or unconscious-non breathing) and the possible symptoms (bump, fall, convulsion, dyspnea, hemorrhage, wound, syncope, swelling or other), as shown in Fig. 5. Then, the call can be initiated (green telephone icon), and a big icon with an animation and sound indications will appear on both sides of the connection. When the pediatrician accepts the call by clicking on that icon, the main web page (Fig. 3) is shown to both parties with the corresponding options to interact. To finish the session, one of them just has to click on the red icon with a white telephone, located under the pediatrician's camera view (Fig. 3). A web page will appear (Fig. 6), to both parties to let them write some observations about the assisted incidence in their own words[16].

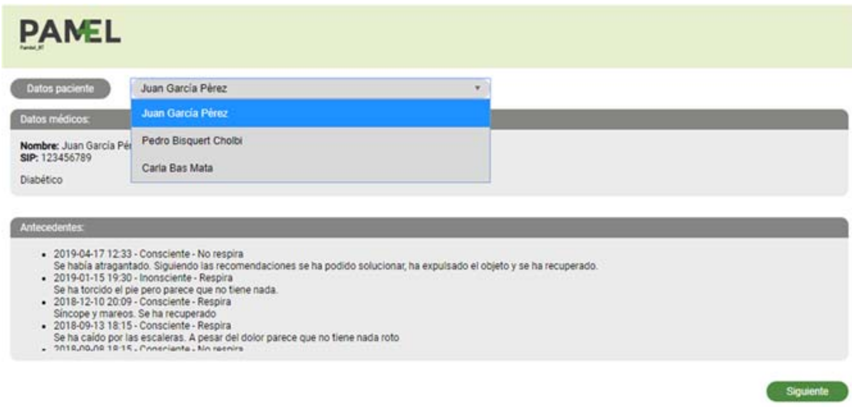


Fig. 4 Child selection and her/his recorded data

Fig. 5 Child main state and symptoms

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[15]The list of children and their personal data should be loaded to the database (one database for each educational or training center). That process will be in charge of that institution personnel and is out of the scope of this paper.

[16] This feature was required by both sides (pediatricians and training personnel) because they wanted to quickly ascertain the recent history of emergency events for each child in order to identify whether the problem is repetitive. We decided to separate both types of observations because training personnel wanted to record the data in their own words as they did not understand the medical terminology.

Fig. 6 Observations about the assistance.

5.5. Information about the assisted child

In the lower right part of the main web page (Fig. 3), the assisted child's name and medical useful data (SIP identifier and diagnosed health problems), the main state, symptoms and previously recorded data (medical history recorded in the databases of PAMTEL-RT) is provided in a folder (Fig. 7, left).

Fig. 7 The assisted child's information (left) and chat tool (right) folders.

5.6. Shared media content consumption in a synchronized way

When guiding an assistance, the pediatrician can share different kinds of media assets, such as pdf documents, static images (i.e. photos) and video files. The main page (Fig. 3) includes a drop-down list control with the assets already registered in the platform and the ones that have been exchanged by using the tool to exchange files or photos, included in the chat window. The shared media asset will be visualized on the top right window of the main web page (Fig. 3). Fig. 8 shows the detail of the drop-down list with media assets grouped in different categories.

Fig. 8 Drop-down list with media assets to be shared

It is worth noting that when the shared asset is a pdf document or a video, in order to allow both users to watch them in a synchronized way, synchronization mechanisms are needed in order to avoid inconsistencies during the interaction. If pediatrician is sharing a video and is commenting what he/she is watching, the training personnel should be watching the same content. Otherwise, confusion and, therefore, frustration or annoyance will be generated. In both cases, master/slave (M/S) control-based synchronization mechanism have been implemented. On the one hand, when the shared asset is a pdf document, the pediatrician's pdf viewer holds the master role, and the scroll bar control is activated only on its main web page (Fig. 9). The pediatrician's side pdf viewer process is considered as the *Master viewer process*, and the training personnel's process is considered as the *Slave viewer process*. Any pediatrician's scrolling action to select any page of the document will be sent to the other side to be repeated by the training personnel's pdf viewer. Both sides will visualize exactly the same portion of the same page in the viewer. On the other hand, when the shared asset is a video, a wall clock time reference and another M/S-based synchronization solution have been implemented for the control of the media playout processes on both sides. Likewise, the pediatrician's side media playout process is considered as the *Master playout process*, and the training personnel's side playout process is considered as the *Slave playout process*. Only the pediatrician has control of the video playout (the video player on its main web page includes the control icons for play/pause events, the progress bar to skip forward/backward to another video position, and the volume control), as shown in Fig. 10. A virtual clock time reference is shared, and an Inter-Destination Media Synchronization (IDMS) solution has been implemented following the M/S synchronization control Scheme ([20], [21]), explained in Section 6. This way, both the pediatrician and the training personnel watch the same video content and experience the playout control events in the same instant.


Osakidetza
TRIAJE EN PEDIATRÍA DE AP
02/02/2018

PROTOCOLO DE *TRIAJE* EN PEDIATRÍA DE AP

JUSTIFICACIÓN:
Necesidad de ordenar la asistencia de modo objetivo en épocas epidémicas o en consultas de pediatría que presenten elevada demanda, ya sea de forma puntual o habitual:
- **Épocas epidémicas** (bronquiolitis por VRS, en los meses de octubre a diciembre; gripe, en los meses de diciembre a febrero, etc.).
- **Cupos amplios**, con exceso de TIS.
- **Turnos de tarde**: mayor demanda por horarios escolares, de guardería y de trabajo de los padres.
- Necesidad de **doblar consultas.**

El sistema de *TRIAJE*, es una herramienta de ayuda en las situaciones que lo requieran, sin aumento de recursos humanos, y siempre de forma consensuada con la Organización de Servicios o con la jefatura de la UAP correspondiente. **Se trata de optimizar la atención partiendo de los recursos existentes.**

Este sistema de *TRIAJE* es compatible y complementario con el **Sistema de Gestión de la Demanda (SGD) desde el Área de Atención al Cliente (AAC)** y con el **SGD por enfermería de los Procesos Leves Autolimitados (PLA)**, que se han implantado o se está haciendo en algunas Organizaciones de Servicios.

OBJETIVOS DEL *TRIAJE*:
- **Discriminar la verdadera urgencia**, evitando que se demore la asistencia de niños graves.
- Dar **seguridad** a los padres. Reducir la **ansiedad** y aumentar la **satisfacción** al recibir una **atención preliminar inmediata.**

1 / 9

RIAJE **conlleva las siguientes ventajas:**
- Un progreso en la **seguridad del paciente.**

Fig. 9 Pdf viewer (with page change and hidden scroll controls), on the pediatrician's main web page

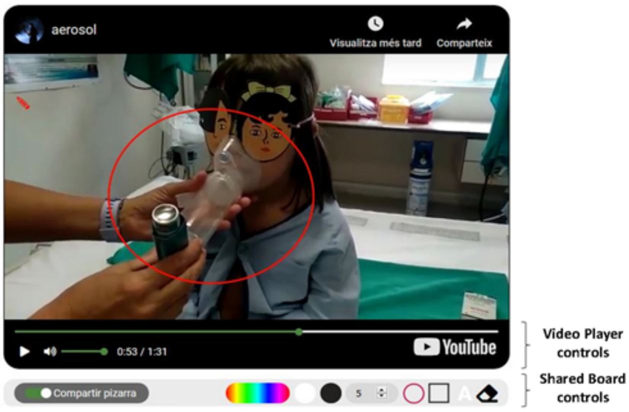

Fig. 10 Video Player and Shared Board controls, on the pediatrician's main web page

5.7. Other interaction tools

In this Section, the additional interaction tools included in PAMTEL-RT (text tool, shared board, exchange of files, and audio/videoconference tool) are presented.

5.7.1. Text chat tool

A private, secured and synchronized text chat tool is provided in a folder on the bottom right part of the main page, as shown in Fig. 7, right. The messages of both users are shown in different green colors.

5.7.2. Shared board tool

Every time the pediatrician shares a media asset with the training personnel, a switch control is shown below the asset viewer/player, to allow him or her to activate a shared board to draw or write over the asset (e.g., to mark some parts of it). When it is activated, a palette with some options appears, including the possibilities of selecting the color of drawing or text; changing the size or thickness of the drawing (of text or lines, respectively), writing text, drawing lines, ellipses or rectangles; or removing all of the drawings and text. If the media asset is a video, when the shared board is activated, the playout process is paused. This tool can also be used to share a pointer under the pediatrician's control. Fig. 10 shows the palette and an example of a circle drawing (viewed by both sides) over a paused frame of a shared YouTube video.

5.7.3. Exchange of files and photos

The chat tool on both sides includes an option to send files. Nevertheless, only the training personnel can send photos of the injured child to the pediatrician, by pressing on the top right corner camera icon of the training center's main camera screen (Fig. 3b). Notice that the icon is not present in the GUI of the pediatrician's side (Fig. 3a). In Fig. 7 (right), it can be seen that, in the last exchanged message, the training personnel has sent a file named "*Foto alumno*" ('*student's photo*', in English). Exchanged files/photos are flagged with a paperclip icon and underlined (as a URL). When the user clicks on them, they are opened in the window for sharing media assets on both sides and the shared board tool can be used to mark specific parts (e.g., swollen ankle in Fig. 3a). The shared files/photos are automatically added to the corresponding section of the media asset drop-down list (Fig. 8).

5.7.4. Audio and video conference tool

When a session is established, two audio and video bidirectional channels are enabled to use the audio and video conferencing tool. Two windows have been included in the main web page to view the camera videos from both ends (Fig. 3). In the biggest one, the video captured by the training personnel will be shown in order to provide as much detail of the child being attended to as possible. This was decided after the initial interviews with experts, since they asked for it to be included. The device used by the training personnel can have two cameras (e.g., front and rear cameras), but only one video stream can be sent. So, in order to switch between cameras, an icon has been included in the top bar of the educational institution main camera screen (Fig. 3b, the icon with circular arrows). The training personnel can select what camera the streamed video is taken from.

6. Technologies, architecture and implementation details

In this section, the architecture and components of the platform are described, then the involved technologies in the development are presented, and, finally, some implementation details are provided.

6.1. Involved technologies

As already mentioned, PAMTEL-RT has been developed by exclusively relying on standard web-based technologies. The involved technologies used in PAMTEL-RT are the following:

1. HTML5 (HTML, CSS and JavaScript). Among many others, the most important HTML elements used in PAMTEL-RT are the *video* (for the player) and *canvas* (for the shared board, player and viewers) elements. *AngularJS*[17] framework has been used.
2. *Node.js*[18]. Open-source, cross-platform runtime environment, written in JavaScript, for server-side and networking web-based applications.
3. *Socket.IO*[19]. Lightweight JavaScript library, which enables real-time, bidirectional, reliable and event-based communication between a browser and a (Node.js-based) web server. *Socket.io-encrypt*[20] package can be used for message encryption.
4. *WebRTC*[21]. Free, open project under standardization within Internet Engineering Task Force (IETF) and World Wide Web Consortium (W3C) that provides browsers and mobile applications with secured Real-Time Communications (RTC) capabilities, via simple APIs.
5. JSON[22] (JavaScript Object Notation). Easy-to-understand and lightweight and data-interchange format.

All of them, together with a database management system and synchronization mechanisms are combined in PAMTEL-RT in order to provide all the above presented tools and features.

6.2. Architecture

Fig. 11 presents an overview of the architecture of the platform, which includes the following main entities:

1. *Media Client*. Device with keyboard and mouse (or equivalent for tactile screens), camera and microphone. It includes several modules:
   - *Session Client* module, in charge of establishing, maintaining and/or releasing connections and of exchanging session information with the *Session Manager* module. When the connection is lost during a call (e.g. bad Internet connection), the client in the training center side includes a reconnection mechanism to restore the connection as soon as possible.
   - *Video player* module, to play the shared video media assets, which includes a player for YouTube videos and an HTTP-based adaptive streaming player for videos stored in the media server.
   - *Sync Client* module, which is in charge of the playout synchronization processes.
   - Several *modules for user interaction* (text, board, audio and video conference tools).
2. *Web Server*, which stores the PAMTEL-RT web site and all the associated needed resources.

[17] https://angularjs.org/ (last access: October 2020)
[18] https://nodejs.org/en/ (last access: October 2020)
[19] https://socket.io/ (last access: October 2020)
[20] https://www.npmjs.com/package/socket.io-encrypt (last access: October 2020)
[21] https://webrtc.org/ (last access: October 2020)
[22] https://www.json.org/ (last access: October 2020)

3. *Media Server*, which provides the stored media content, and all the related metadata.
4. *Session Manager*, in charge of the management of the connections (establishment, release, etc.) and of all the compiled session data from media clients (for future analysis purposes). It also provides all the signaling capabilities to manage the WebRTC connection.
5. *Communications Server*, in charge of the bidirectional exchange of control messages between entities by using Socket.IO library and the *Socket.io-encrypt* package.
6. *Data Server*, an SQL-based server in charge of managing the databases of the platform.
7. *Clock Server*, which provides a common wall clock reference to all the Media Clients.

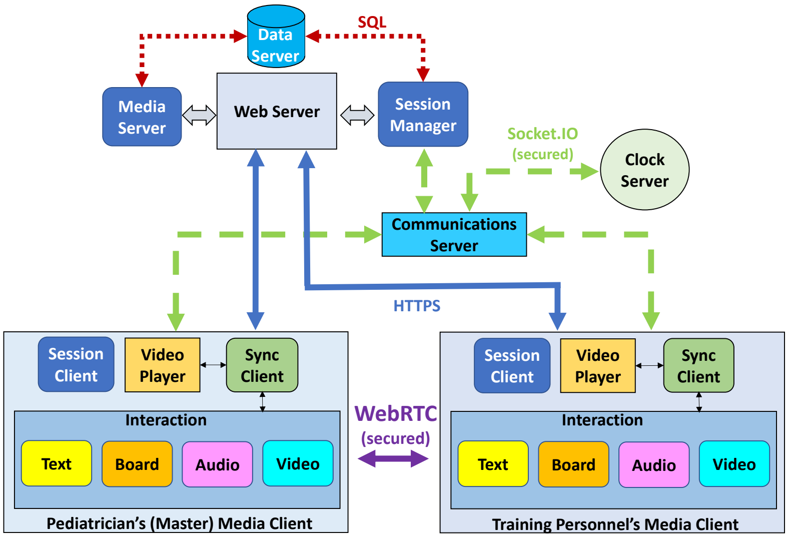

Fig. 11 Architecture overview of PAMTEL-RT, showing its main entities and components, and the technologies for the secured exchange of information between them. It shows the involved Servers and both Media Clients (and their modules) on each side of the platform: Health institution (bottom-left) and training center (bottom-right)

Each Server entity can be located in a different machine or some of them can also be implemented in the same machine. *Media Client* entities communicate with *Session Manager* and *Clock Server* entities through the *Communication Server* entity by using Socket.IO library and encryption. Data and control messages exchange between *Media Clients* is done by using WebRTC. More details are provided in the next subsection. Those are the minimum entities required for the platform. In order to make the platform more robust, redundancy and scalability issues should be considered (left for further study).

6.3. Required technical equipment

The minimum equipment required for the connection between both parties is very simple and cheap. At the training center, just a low-cost portable device (tablet, smartphone) with Internet connection (recommended: through both WiFi and 3G/4G/5G technologies), and one (optionally, two) camera is needed. At the medical institution simply a desktop PC (or also a portable device) with Internet connection is needed, with a camera. Both devices only need a WebRTC-compatible Internet browser. Licensed software is not required. As indicated above, each server can be running on an independent computer or all of them can be running on the same computer, but they should be located on the Medical institution side.

6.4. Implementation details

6.4.1. Servers

In the implemented prototype used for assessment, all the Servers and Session Manager entities have been implemented by using *node.js* except Data Server entity that is a MySQL Server. All of them are running on the same machine with the following features: Intel Core i7-6700 processor, 8GB of RAM, 1TB of HD, and Windows 10 OS. It was located at the UPV Campus in Gandia city.

6.4.2. Stored video assets formatting

When a video file (only mp4 video files are allowed in the prototype) is uploaded to the media server, a Python script is automatically run in order to process it and adapt to the MPEG DASH specification [22]. Four copies of that video are generated in different qualities (H.264-AVC; resolutions 1280x720, 854x480, 640x360 and 426x240pixels; 25fps) and then segmented in chunks of 3-second duration. Audio is encoded using AAC (48KHz). Ffmpeg[23], Bento4[24] and mpd (manifest) file creator tools are used. More details of the process can be found in [23]. The URL of the mpd file is stored in the video database of the platform.

6.4.3. Data communications

Bidirectional point to point encrypted data, audio and video connections between both Media Clients of the pediatrician and training personnel are established by using the WebRTC *RTCMultiConnection* library. This library needs a signaling server to relate all the users in an RTC session, which, in PAMTEL-RT, has been included in the Session Manager entity (Fig. 11). Socket.IO library is used for the secured communications of the Media Client entities with the Session Manager entity, through the Communications Server entity. All the relevant messages related to text chat, shared board, user-generated events (for playout control), and IDMS synchronization are exchanged through the *DataChannel* of WebRTC, achieving an almost instantaneous encrypted (i.e., secured) communication with very low latency. There is only one exception, the exchanged files and taken photos through the private text chat tool are directly uploaded to the Media Server entity by using Socket.IO and only their URLs are sent to the other Media Client entity.

6.4.4. Video Players

For YouTube videos, the *YouTube API* has been used to embed the *YouTube player* into an HTML *<iframe>* element. For stored videos, *Dash.js*[25] has been used, which is a reference client implementation for the playback of DASH-based content via JavaScript and compliant browsers. Both players natively provide elements and functions for playout control (play, pause, seek to, volume…).

6.4.5. Synchronization

PAMTEL-RT requires the synchronization of the playout of media elements in two devices located in different locations. To achieve it, two main components have been implemented: a virtual clock synchronization solution, and an adaptive IDMS solution. Both components are described in this section.

On the one hand, the availability of a coherent notion of time in a shared media session is a key requirement to achieve synchronized playback across devices. An ad-hoc simple virtual clock synchronization mechanism has been implemented to recreate the functionalities of typical clock synchronization protocols (such as, e.g., Network Time Protocol, NTP) in order to get a common virtual wall-clock reference. It consists of having a reference Time Server and adopting a request-reply protocol ([24]). Via the Communications Server entity, timestamped messages are periodically exchanged between the Media Client entities and the Clock Server. These messages are used to estimate the Round-Trip-Time (RTT) delays and skews (i.e., offsets) between the local clock of the Media Client entities and the reference clock of the Clock Server. By regularly executing this algorithm, it is possible to estimate and compensate for the clock skew between the Clock Server and both Media Client entities in the synchronization process. This mechanism allows time-aligning the virtual clocks of both Media Client entities with the one of the Clock Server, even if they do not support the same technology for clock synchronization, and without the need for installing additional plugins or modules. It is commonly known as *virtual clock synchronization* [25] and more details can be found in [26]. A periodic message exchange interval (e.g., 5 or 10s) can be set in the platform's configuration settings (parameter *Time request interval*, see supplementary file).

On the other hand, in order to achieve a synchronized playout between both distributed Media Client entities in PAMTEL-RT, an event-driven IDMS solution has been implemented. An M/S synchronization control scheme ([20], [25]) has been adopted. The pediatrician's Media Client entity is considered as the IDMS Master Client and the training personnel's one is considered as the IDMS Slave Client. During the playout process, the Pediatrician's IDMS Master Client periodically sends synchronization control messages, called *IDMS messages*, to the other IDMS Slave Media Client. The transmission interval of these IDMS messages can also be configured (e.g., every 1s, in the *IDMS interval* parameter, see supplementary file). To synchronize video playout in both Media Client entities, the IDMS messages include the following information of the pediatrician's IDMS Master Client: the current video playout position, and its current (common) virtual time. Upon receiving an IDMS message, the Slave Media Client calculates the asynchrony between its video playout timing and the IDMS Master Client's one. By using a compensation mechanism of the transit delays, highly accurate synchronization can be achieved. If the computed asynchrony exceeds an allowable threshold (configurable in the platform's configuration settings, in the *Asynchrony threshold* parameter, see supplementary file), the IDMS Slave Client must adjust its playout timing to synchronize with the IDMS Master Client's one.

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[23] https://www.ffmpeg.org/ (last access: October 2020)
[24] https://www.bento4.com/ (last access: October 2020)
[25] https://github.com/Dash-Industry-Forum/dash.js? (last access: October 2020)

The playout adjustments can be performed (depending on the value of the *Adjustment Type* parameter in the configuration settings) by following one of two strategies: aggressive or smooth. Aggressive strategy is the simplest one and consists of performing simple skips and pauses, with a magnitude equal to the detected asynchrony. Additionally, the asynchrony can also be eliminated by smoothly adjusting (i.e., either slowing down or speeding up) the playback rate during a specific time interval (this technique is known as Adaptive Media Playout or AMP ([27], [28], [29]), which is much more convenient because it minimizes the occurrence of long-term playout interruptions, which can be annoying to users (poor Quality of Experience or QoE, [26], [30]). To implement the AMP strategy, during the adjustment process, the playout rate is speeded up (if asynchrony is positive) or slowed down (if asynchrony is negative) a percentage up to 25%[26] (in parameter called *percentAMP,* included in the configuration settings, see supplementary file). After the adjustment time, the original video playout rate is restored to the normal rate. In order to avoid too long adjustment periods, very annoying for users, two additional parameters have been defined in the configuration settings: *Maximum Allowed Pause* or MAP and *Maximum Time of Adjustment* or MTA (see supplementary file). To avoid long unnecessary pauses, if the calculated asynchrony value is negative and exceeds the MAP, a backward skip will take place according to the calculated asynchrony. On the other hand, when AMP adjustment is configured, if the calculated asynchrony value is higher than the value of the MTA, the time of an AMP adjustment would be too long. Then, a skip in the playout is performed to get a coarse synchronization.

The platform also allows sharing the execution of (timestamped) playout control commands (i.e., playout control events) performed by the pediatrician, such as ‘play’, ‘pause’, ‘skip to position’ and ‘fast forward or FF’ commands, between both involved devices in a synchronized manner. All the exchanged messages for playout control and synchronization purposes are summarized in the supplementary file.

6.4.6. Shared board

To implement the shared board tool, the HTML 5 *canvas* element has been used. All the events executed by the Master Media Client over the canvas element to use the shared board controls and related messages are also sent via the established WebRTC *data channel* to be replicated in the Slave Media Client’s canvas. Examples of events are the mouse events, such as *mouseenter*, *mouseleave*, *mousedown*, *mousemove* and *mouseup.* All the messages related to the shared board are also summarized in the supplementary file.

6.4.7. Audio and video conference tool

The audio and video channels of the shared WebRTC session are used to enable the audio and video conference. The supplementary file includes the message sent by the Master Media Client to the Slave Media Client to activate/deactivate the audio and videoconference tool.

6.4.8. Configuration Settings

The parameters that can be configured in PAMTEL-RT are summarized in the supplementary file.

6.4.9. Stored Data

Some relevant data can be recorded during the sessions, with research purposes and with the consent of the participants, to be processed and analyzed off-line in order to study the behavior of both sides when using the platform (left for further work). On the current prototype, a relational database has been created including the following related tables:

- *Patients_data* table. It stores the data of the children (id, SIP, name, address, gender…).
- *Users* table. It stores all the authorized users’ information. For each user, it stores, the user id, user’s name, encrypted password, type of user (pediatrician or training personnel) and gender.
- *Session_data* table. For each session, it stores the session identifier (Id), date, starting (creation) instant, duration, the id of users on both sides and the id of the child.
- *Patient_in_session*_table. For each session, it stores the id of the session, the id of the child being treated, and the recorded observations written by the training personnel and by the pediatrician.
- *Videos_Watched_in_session* table. For each session, it stores the information of the shared videos. For each video watched, it stores the session id, the video id and the time (duration) the video has been watched.
- *Videos* table, which includes, for each video, its id, name, URL, and characteristics (aspect ratio, width, height and duration).

[26] According to [31], if the (increasing or decreasing) percentage is lower than 25%, it is not perceptible by users, and, depending of the content, up to 50% could be tolerated

- *Users_in_session* table. It stores data of the users participating in each session. For each session and participating user, it stores the session id, the user id, and information related with the used device, such as Operating System, browser (and version) and language.
- *Events_during_playout* table. It stores data about user-generated events affecting the media assets playout or visualization continuity, such as play, pause, skip, FF, etc. It stores the type of event and the instant in which it took place. Additional information is also stored depending on the type of event (e.g. in a skip, the initial and final position of the skip is recorded).

At the end of each session, its recording from the medical center side and the chat messages exchange can also be stored in a folder, using the id of the session as the name of the folder.

7. Evaluation

This section focuses on the subjective evaluation of some essential aspects of the tools provided by PAMTEL-RT, such as their GUI, usability, usefulness of the functionalities, applicability and the awakened interest. In order to test the platform, 12 drills[27] in real surroundings between educational and sports centers located in Gandia and Alcoy cities (Valencian region, Spain), and the Hospital Mare de Deu dels Lliris located in Alcoy city, have been conducted. Six drills have been conducted in 4 primary schools (2 in each city), with different teachers, whereas the other six drills have been conducted in 3 sports centers (two athletics training centers and the biggest football stadium) in Gandia city, in different disciplines (running, javelin throw, shot put and football). Involved centers are listed in the acknowledgement section. Of course, drills are not as real as actual situation, but we tried to mimic them. We tried to reproduce as faithfully as possible each medical situation we simulated. We mean, symptoms and signs were explained and reproduced by the selected children. After contacting the educational or sports centers, children with special illnesses or needs and with previous health problems were selected with the consent of their parents[28]. They were more used to suffering the simulated health problems and could repeat behavior patterns during the drills in a more realistic way. Moreover, some of them usually had specific medical devices in their backpacks to treat health problems (insulin suppliers, short-acting bronchodilators inhalers, etc.). The simulated problems during the drills were lack of insulin (in diabetic patients), asthma crisis, epileptic attack, knee/ankle sprain and attacks of dizziness. Each simulation of a medical situation involved a different child aged from 4 to 13 years old. In each drill, several training personnel were involved, and several medical situations were simulated with each of them. On the other side, different pediatricians were joined to attend calls from different centers. No teacher, sports monitor or pediatrician that was involved knew anything beforehand about the emergency that was to be simulated.

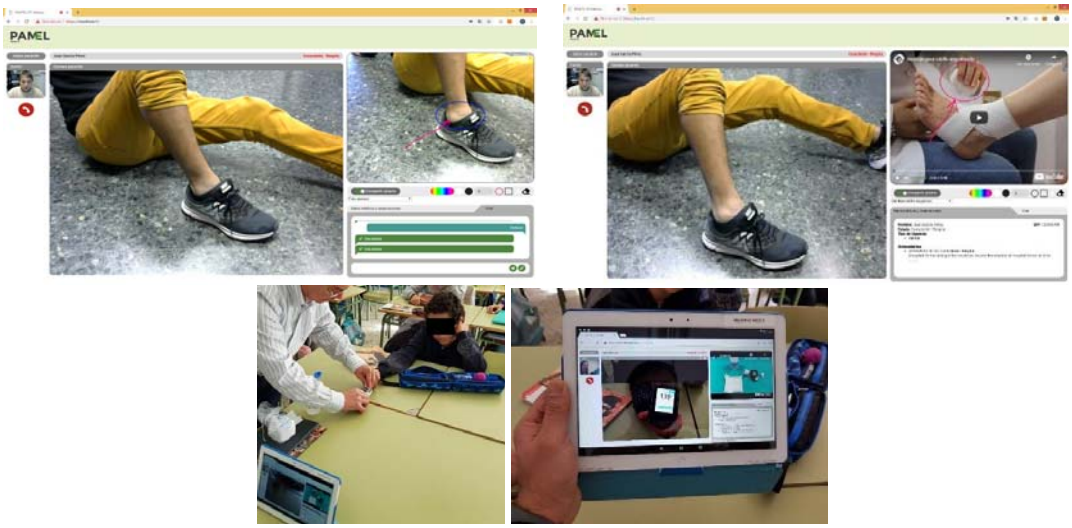
Fig. 12 presents some photographs taken during the drills (in both educational and sports centers, Fig. 12a and Fig. 12b, respectively). The photos in the top part of Fig. 12a show the pediatrician's GUI, while the ones in the bottom part show the teacher's GUI. The use of both ends cameras, chat, video (about how to make a bandage), photo sharing, and shared board tools is shown. In the photo on the top left, a snapshot of the child has been shared by the teacher and then the pediatrician is using the shared board to make some indications. In the photo on the top right, the pediatrician is sharing a YouTube video, also using the shared board tool to make indications. The photos in the bottom part of Fig. 12a were taken at the school, when a diabetic child was assisted by a teacher being remotely guided by a pediatrician. In that case, the child's own blood glucose monitoring device was used. In the photo on the right, the teacher is showing the measurement to the pediatrician by using the rear camera of the tablet. Fig. 12b, presents two photos of two different drills in an athletics-training center.

Participants. A total of 24 training personnel (17 teachers, 1 school director and 6 sports monitors), 14 females and 10 males, aged from 28 to 63 years old (mean value: 45,7; standard deviation: 11,43), and 3 pediatricians (2 females), different from the pediatricians coauthors of the paper, have been involved. Although 16 participants declared they had a technical profile (i.e., technical studies or work), none of the participants had previously used telematics tools for the same purpose as the one we have presented in this platform. They neither had any relation with the researchers nor previous knowledge about the project.

Equipment. During the drills, the training personnel used a 10" Android-based tablet with WiFi and 4G connections (if they did not have one, a Samsung Galaxy Tab S was used). The involved pediatricians worked at Hospital Mare de Deu dels Lliris in Alcoy city and used their office desktop PC with Windows 7 OS, an Intel core i3 processor and 4 MB of RAM. Google Chrome browser was used.

[27] The drills were approved by the Scientific Research Ethics Committees of both funding institutions (university and hospital), by the management teams of each involved training center and by their parent associations.
[28] All these parents declared a great personal interest in having the platform available in their centers as soon as possible.

Method. Before the beginning of the drills, the involved pediatricians were trained at the hospital about how to use the application in a 15-minute session. In each drill, all the involved teachers or sports monitors read a brief description of the platform and GUIs, including its features, and signed a consent form. Then, a 5-minute connection was established with one pediatrician, a co-author of the paper, in order to familiarize the participants (the other 3 pediatricians, teachers and sports monitors) with the use of all the provided features. Then, the drill took place, simulating some of the above-mentioned health problems. The duration of the simulation of each emergency situation depended on its assistance and was between 15 and 20 minutes, approximately. After the drills, each participant answered, during 5 minutes, the System Usability Scale (SUS) questionnaire ([32]), a set of qualitative questions regarding the tested functionalities, the aesthetics, usefulness and the overall use of the platform, and a final questionnaire with some few optional open-ended questions for collecting free-form feedback. The overall duration of the longest drill involving a participant (including reading of the description, training, up to 3 simulations, breaks, and filling out of the questionnaires) was 80 minutes, approximately.



a) Drills at the schools (top: pediatrician GUI; bottom: school GUI)


b) Drills at a sports center

Fig. 12 Some photos taken during the drills in schools or sports centers

7.1. Results

All the simulated emergency situations were correctly assisted by training personnel guided by the remote pediatrician. All of them totally agreed that the platform was easy to use. No participants encountered problems and difficulties using it. When asked about the resolution level of the remote assistance, 90% declared it was completely solved and 8,7% that it was solved quite completely. Regarding the statement "*I would like to use this platform frequently*", a 5-level Likert-type scale was used, with the following values: *Totally Disagree, Partially Disagree, Neutral, Partially Agree and Totally Agree*. 83% of the participants totally agreed with that statement; 4% partially agreed; 4% partially disagreed; and 9% totally disagreed. Regarding the evaluation of the usability of the platform, the 10 questions of the SUS questionnaire ([32]) are the following: *Q1:I think that I would like to use this system frequently; Q2: I found the system unnecessarily complex; Q3:I thought the system was easy to use; Q4: I think that I would need the support of a technical person to be able to use this system; Q5: I found the various functions in this system were well integrated; Q6: I thought there was too much inconsistency in this system; Q7: I imagine that most people would learn to use this system very quickly; Q8: I found the system very awkward to use; Q9: I felt very confident using the system; and Q10: I needed to learn a lot of things before I could get going with the system.* The obtained responses are summarized in Table 2. The obtained results (mean score value taking into account the SUS score of the 24 participants): 89,58; standard deviation value: 12,6) show that the overall usability of the platform is better than '*excellent*', according to the labelling in [33].

Table 2. Obtained responses to each question of the SUS questionnaire

Response (assigned value)	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Totally agree (5)	20	1	21	1	17	0	19	0	19	0
Partially Agree (4)	1	1	2	2	5	0	4	0	2	4
Neutral (3)	0	0	1	1	0	2	0	1	2	0
Partially disagree (2)	1	1	0	3	0	3	1	2	0	4
Totally disagree (1)	2	21	0	17	2	19	0	21	1	16

Participants were also asked about the attractiveness of the designed GUI. 87% agreed it is attractive (57% totally, and 30% partially), while 13% were neutral. No participants declared they disliked the current GUI. Only two of them suggested light modifications, such as, e.g., to use brighter colors, to enlarge the screen with the view of the pediatrician's webcam, or to include the option of filtering the students with previously identified health problems. The results of the participants' opinion regarding the statement "*an interaction channel based on X is appropriate on this kind of platform*" (being X = 'text', 'audio', 'audio and video'), by using the same Likert-type scale, are summarized in Fig. 13. They were also asked about whether they considered that any other interactivity channel should be included. No participant proposed new interaction channels. Regarding the statement "*the platform is a useful tool and with a clear utility and applicability nowadays*", most of them completely agreed (96%). The results of the participants' opinion regarding the statement "*the functionality X is useful in this platform*" (being X = 'shared pointer', 'shared board', 'files/photos exchange' or 'synchronized interactivity'), by using the same Likert-type scale, are summarized in Fig. 14. All the participants declared they would not include any additional functionalities, that it is sufficiently complete as it is. The open-ended comments from participants, mostly appreciated the usefulness of the platform in their workplace and that it would help to save their children's lives, as well as time and money. Some few selected comments are the following: '*The pediatrician indicated all the time what to do and how to do it*', '*It seems to me a very useful tool to be able to assist to an emergency, given the ignorance of how to proceed in certain situations*', '*Good tool, not only in a school*', '*Very interesting and very useful support tool for any medical emergency that may occur in an athletics school. Having the support of a professional, even remotely, in a critical situation, is very useful*', '*It is a very good initiative which I think should be in all educational and sports centers*', '*The support provided by video and audio, plus the possibility of sharing videos, or sharing photos, make this platform a very useful tool in schools*', and (only one a bit negative) '*The provided information is only useful if the sports monitor has previous training, otherwise it is difficult to understand complicated manipulations*'.

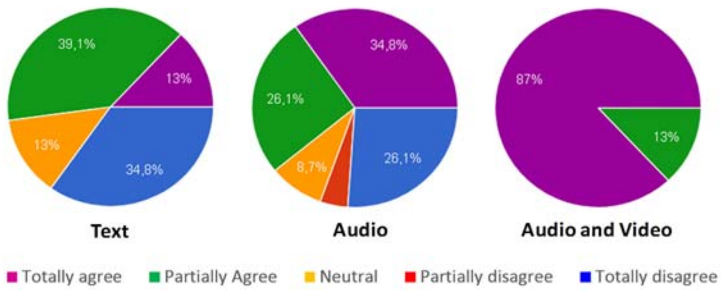


Fig. 13 Participant's opinions about interaction channel appropriateness

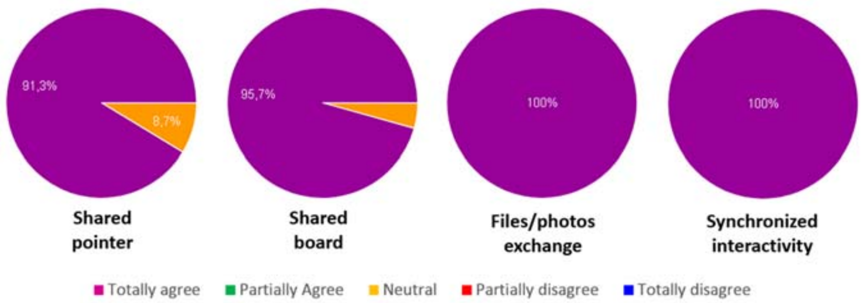


Fig. 14 Opinion about the utility of the main functionalities

7.2. Discussion

The purpose of the above preliminary conducted evaluation was solely to test the correct performance of the proposed platform in environments as realistic as possible (real equipment, available IP access networks in training centers, children with health problems, but simulated emergency situations). The authors consider the obtained evaluation results as satisfactory and promising. The features and components of the platform have been tested and performed adequately, mainly in terms of responsiveness and effectiveness. It is supported by the participants' opinion, ratings and satisfaction regarding all the evaluated aspects in the subjective study. Firstly, the results confirm that participants are, in general, very satisfied with its usability and with the provided functionalities. The platform is easy to use, and its applicability has been clear to the participants. Likewise, most of them have liked the designed GUI, and their suggestions will serve to enhance it in the future. Secondly, the participants' perception regarding performance aspects, such as interactive and timely responsiveness, synchronization and behavior, have been very positive. This supports the decision on the chosen technologies and components for developing the platform and it is also evidence of an appropriate design and implementation of its modules and features. Finally, most participants have highly appreciated the features provided by the platform, finding them very useful, and also believing that such features will contribute to a better response of an emergency, being guided all the time by a professional. Moreover, some participants believe that the platform can also be useful in many other relevant scenarios in which it can also potentially provide similar benefits (e.g., in adult centers).

8. Conclusions and Future Work

The current model of public healthcare provision in Spain is becoming increasingly unsustainable. Healthcare will need to be transformed, with ICT playing a central role. As far as the authors are aware, those technologies have not been used, at least in Spain, with the purpose of remotely guiding, in real-time, the assistance of pediatric emergencies that occur in educational or sports centers. In this paper, PAMTEL-RT, a web-based platform to provide this kind of service has been presented. Authors are convinced that it has great applicability and great impact, both socially and economically, and that it could be very useful in the first critical minutes of extreme emergencies.

From the social point of view, in general, knowing that pediatricians will be present (even remotely) in training centers is expected to have a very positive impact on society. The platform could facilitate, in a guided way, a faster and a slightly more professional assistance, provided in-situ by training personnel, in emergencies that affect the child population, and, particularly, those children with chronic diseases. One or, better, several practitioners could be permanently available at medical centers for this kind of emergency care. In case of emergency situations, a direct multimedia connection between training personnel and a practitioner would be established, as quickly as possible, and the assistance of the emergency would be guided by the latter (much better than if it is only conducted by a non-healthcare professional). Most medical emergencies could be considered with their different stages of severity[29], as well as the possible decompensations of patients affected by chronic diseases (which are likely already identified in their Health Center). *From the human point of view*, the platform could be a support for the (in most cases, inexperienced and stressed) training personnel. Authors expect that, especially for families with children with chronic diseases, it has an added value to know that there is an extension of the pediatric medical services of the medical center in the training center (e.g., a feeling of comfort). The population dispersion of certain Health Departments and their orographic peculiarities make it particularly interesting to have a direct AV connection with the health team at all times and in real time. It could take too much time for the health professionals to arrive at the training center to assist the emergencies and it could be too late and even dramatic in some situations. Moreover, if the child is finally sent to the medical center (in an ambulance or any other means of transport), when he/she arrives there the pediatrician will already have all the data about the child's condition and his/her EHR, gaining important time.

From the economic point of view, the required equipment in the platform is very cheap and the saving of resources is not negligible. Quick assistance of critical emergency situations by using the platform could prevent the use and displacement of certain medical equipment or supplies with a high cost. Some of this equipment is sometimes requested because the emergency has not been professionally assisted or even assisted with too much delay. Examples are respiratory assistance equipment needed when the patient is in a profound state of unconsciousness, or an injection of a certain drug. On the other hand, in emergencies of a mild or moderate nature, the platform could help to save travel costs of ambulances crewed by staff with high qualifications (see Table 1). Other costs to take into account would be the extra costs that could be indirectly paid by the child relatives when an emergency is not professionally assisted (e.g., when a child is sent to a medical center and it is not needed, their parents would probably have left their work and driven to the medical center).

Data from each session can be recorded in order to study what emergencies are the most common and to be able to establish different actuation protocols. Then the platform could also be used as a training tool, to, e.g., remotely teach training personnel how to assist those most typical emergencies, without the need of the displacement of the pediatrician to the training center. It would improve the quality of the attention

[29] The utility of PAMTEL-RT for extreme emergencies would still require both internal and external validation.

of future emergencies and also serve to obtain additional information on the peculiarities of the educational or sports centers, discovering their particular needs.

The results of the previously conducted acceptance study of the platform, the developed prototype, as well as the responses and interest expressed by the training personnel that participated in the drills or simulations are promising and encourage the authors to continue working to improve the platform and publicizing it in order to get the system working in as many Health Departments/Areas as possible, and as soon as possible. The cost of the system is low, and its scalability is expected to be very high due to the minimum requirements, resources and devices that are needed to set-up the platform.

It is important that the telehealth programs are sustained or expanded over the long term. Nevertheless, in Spain, we find the same barriers to overcome as the ones identified in [4], [5] and [8], especially the legal concerns, lack of state or region regulation, lack of devices in training centers, lack of resources to train educational and sports centers' personnel, technology-connectivity or reimbursement. It is obvious that to be able to use PAMTEL-RT in an effective and reliable way, training centers and surroundings should be provided with communications capabilities good enough to establish and maintain high quality IP-based AV calls during the sessions. Currently, in Spain, those identified technological barriers can easily be resolved but may entail increased infrastructure costs, e.g., by deploying high speed and low latency 5G network infrastructures for portable devices and by providing fast and reliable broadband Internet access for the medical and training centers. Interestingly, 5G networks will make it possible to assign different priorities to different e-health modalities, as shown in [14].

Although the presented platform is cost-effective, there are still numerous additional considerations before implementing it in a practice, including licensure, liability, privacy and security, technology, and workflow. As a knowledge transference strategy, the results presented in this paper have been reported to the Education, Research, Culture and Sports Department and the Universal and Public Health Department of the GV, to private health and training centers, and to all the parents associations in our region, as proof of evidence of the need and acceptance of this kind of platform to provide professional medical guidance when and where needed to prevent problems or mitigate further harm to our children. As for future actions, should a solution based on the proposed platform, finally, be considered to be adopted in our region, then the previous conduction of more high-quality studies on the protocols and procedures as well as on the effectiveness and safety of the system's practice will become paramount. Moreover, although the platform was initially intended for child emergencies at training centers, needless to say that it could be easily extended to the rest of population with the corresponding functionalities or features useful for other kinds of patients (e.g., for elderly people). The optional inclusion of physiologic sensors in the patient's side for remote monitoring during the treatment, the transmission of the corresponding data to the medical center side, and the inclusion of the measurements in the GUI of both sides will be considered as a further enhancement of the platform. In that case the equipment needed in training centers will be slightly more expensive (due to the cost of the sensor devices) nevertheless still affordable.

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