Clinicians' view of Tele-Glaucoma

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Abstract

Although recent advancements in technology have led to major transformations in healthcare services, the use of tele-monitoring in patient care is yet an emerging occurrence. This study examines factors that affect the adoption of video based remote treatment of senior patients in a tele-glaucoma project in a large hospital in Greece. Several themes emerge from the study encapsulating technical, usability, process, institutional, ethics and privacy, clinicians' behaviour and patients' demography related factors. The findings of the study showed that while the benefits of tele-monitoring service adoption were of foremost importance for doctors, usability and connectivity for enabling remote services was critical for its success.

Keywords: Europe, eye, glaucoma, tele-glaucoma, tele-monitoring.

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Introduction

Glaucoma is the principal source of irreversible blindness worldwide [1] and the number of people suffering from it is expected to increase from 64.3 million in 2013, to 76.0 million in 2020 and 111.8 million in 2040 [2]. The sight loss is preventable for patients diagnosed with glaucoma and most patients can expect to maintain their sight as long as they follow the treatment [3]. However, there are numerous reports showing that patient adherence to glaucoma treatments is poor [4-7] and/or clinicians are concerned over the improper administration of the treatment by patients [8]. This could lead to worsening the symptoms and even to sight loss [8]. By measuring the intraocular pressure clinicians are not able to determine whether the patient is adhering or not to the treatment [9] making it difficult for clinicians to determine whether the treatment is inefficient or improperly administered [4]. This often leads to a change in therapy even for patients to which the given therapy could be effective if the treatment is followed correctly resulting potentially in further decline in adherence if the treatment is more complex [10]. Therefore, it is useful to have a way by which clinicians could monitor how their patients continue to administer the treatment at home and intervene where necessary to guide them in properly administering the medication [11].

On the other hand, senior citizens are more prone to be affected by glaucoma [12]. These patients are likely to have lower mobility and sometimes require to be accompanied to hospital which could be an impediment considering that glaucoma requires frequent consultations [13]. In this context, using a tele-glaucoma system would allow these patients not only to save on transportation costs but also to be independent for a longer period of time therefore improving their quality of life. In addition, it is considered that using remote monitoring will not only help improve the quality of treatment and reduce patient burden, but also the workload on already overstretched health services [14]. This is especially the case for countries in which healthcare is free and is aimed at offering high quality health services to an ever increasing and ageing population. Countries in Europe such as Greece, where this study took place, are also affected by budget cuts to healthcare, thus adding further strain on resources.

Despite the potential tele-monitoring in glaucoma patients, tele-glaucoma has not been as extensively used and there are only few studies evaluating the use of tele-glaucoma [14]. The purpose of this article is to determine what factors affect the use of high definition video for tele-glaucoma on a large scale.

Adoption and Evaluation Frameworks

Adoption and evaluation frameworks have been extensively researched in information systems with the aim of determining factors that affect the long-term use of ICT. Numerous studies have proposed frameworks focusing on why the users accept or not a certain technology. According to [15] the most prominent models for technology adoption are: Theory of Reasoned Action (TRA) [16], Technology Acceptance Model (TAM) [17], Motivation Model (MM) [18], Theory of Planned Behaviour (TPB) [19], Combination of Technology Acceptance and Theory of Planned Behaviour models (combined TAM – TPB) [20], Model of PC Utilisation (MPCU) [21], Innovation Diffusion Theory (IDT) [22] and Social Cognitive Theory (SCT) [23]. Unified Theory of Acceptance and Use of Technology (UTAUT) [24] unifies the above models into a single adoption framework, which was subsequently extended into Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) [25], in order to adapt the original framework to the consumer context. UTAUT2 [25] is further extended better evaluate services that make use of high definition video-to-video communication. To this extent, the new model includes also constructs from the IS success model [26] and includes information regarding the perception of information privacy [15].

In healthcare [27] proposes another model for evaluating the video-to-video communication but in this case focusing on emergency services. This model considers the technical, user, application and process requirements. Currie [28] proposed an integrative model for health technology assessment, TEMPEST - which stands for technology, economic, market, political, evaluation, social and transformation and is an integrative model for health technology assessment. However, not all of the studies performed in healthcare have proposed new frameworks for evaluations. Some studies have used existing adoption models to evaluate their ICT research (e.g. [29], [30]), extended an existing technology acceptance model (e.g. [31] extended TAM by trust beliefs to study patient acceptance of e-health services) or have focused on evaluating the relevance of certain adoption models in healthcare [32]. For

example, [32] evaluates the usage of TAM in healthcare and concludes that it is important for the model to be adapted to the healthcare context. In the context of this research, we considered an exploratory approach being more accurate in providing a better picture of the factors, which might affect the adoption of tele-glaucoma services, as focusing on an existing framework could potentially lead to ignoring factors, which do not map to the framework.

Factors Affecting Video Communication for Tele-Applications

Several researchers have proposed indicators for evaluating user satisfaction with existing tele-applications. These indicators have been extensively studied both in healthcare [27] and outside this field: in education [33], [34]; museum settings [35], or in entrepreneurs' communication with local municipality services or with potential clients [36].

In education there are several studies that have looked into what factors affect the usage of video communication [33], [34]. Morse [34] presents experience in using videoconferencing for learning over a period of 14 years. He has found several challenges in the process: technical failures, organising and planning the classes, different school years in different locations, different time zones and daylight saving time, security, and variation in the equipment quality and nature. The study presented by Weerakkody et al. [33] presents the results of several focus groups with Irish and Greek teachers in order to determine what factors affect videoconferencing adoption in education. They have classified the results across two main categories (user and technical) each of them further on dividing into two other sub-categories. The main user factors were student experience and pedagogical factors (e.g. improvement in student knowledge after a videoconferencing session) and the technical factors were grouped across application (reliability, security, video quality) and network (quality of the network communication).

A four-category classification of the factors that affect usage of video in entrepreneur services was proposed in a study by Molnar et al. [36]: technical factors, cost factors, service improvements factors and risk factors (privacy, different communication expectations, reticence of the entrepreneurs in using the service). Popleteev et al. [35] looks at what factors should be included in evaluating video-to-video communication between the visitors of two

different museums. These factors have been grouped into three categories: technical indicators (multimedia quality and network latency), user indicators and process indicators. Across most of these services, network connectivity, quality of the video communication, reliability and usability of the application are highlighted as one of the main issue, whereas other factors are mostly application specific.

In healthcare, a four-category framework for evaluation is proposed also for the usage of emergency services [27] by combining the factors found in the literature regarding video communication. The following requirements are identified: technical requirements (related mostly to network parameters for ensuring a good connectivity), application requirements (focus on the technical issues on the application side such as support for codecs and hardware resources), process requirements (refers to the end-to end process tailored to the video scenario such as diagnostic time, survival rate, number of days spend in the hospital and travelling time), and user requirements (whether the application is easy to use, user satisfaction with the application and reliability). LeRouge et al. [37] proposes quality attribute model of the telemedicine video conferencing. The model is based on literature review, direct observations of the usage of tele-medicine and interviews with tele-medicine experts. The attributes that resulted from the study are grouped across four categories in the model: technical, usability, physical environment and human element.

Overall, the studies highlight the need of a relatively good infrastructure for the tele-applications to be successfully used and adopted [27, 33, 34, 35, 36]. Usability of the application and the utility of the service are also highlighted in several studies [27, 33, 37]. It is also noticeable that though several factors are present across all the studies, some factors are specific to the context in which the tele-applications are used. Considering the importance of context in the success or failure of the information systems [38], the section below focuses on existing research on tele-glaucoma, in order to create a better picture of this service.

Tele-Glaucoma

Current studies on tele-glaucoma have been focused either on the possibility of using such a system or the potential the system has on treatment. Tuulonen et al. [39] have shown that using tele-glaucoma services has the potential to reduce travel, cost and time for patients. Similar results were obtained by Arora et al. [40] that have shown reduced access time, cycle time and time spent in the waiting room for patients seen through tele-glaucoma as opposed to those seen at the hospital. Kiage et al. [41] and Maa et al. [42] look into the possibility of diagnosing glaucoma through a virtual tele-glaucoma system. A moderate agreement was obtained with challenges related to poor quality of images obtained in Kiage et al. [41] study, whereas Maa et al. [42] showed an 87% agreement between the glaucoma diagnoses through face-to-face and through the tele-glaucoma system. Elsewhere Verma et al. [43] shows that most patients monitored in a tele-glaucoma study did not require in-person consultations with an ophthalmologist as remote monitoring sufficed.

Despite its potential advantages there are few tele-glaucoma systems that have been successful and few studies have reported findings of tele-glaucoma treatment through remote monitoring [14]. Therefore, there is a greater need for studies that investigate the use of tele-monitoring techniques for treating glaucoma patients [14].

Research Context

The current study took place in the ophthalmology department of the Attikon Hospital in Athens, Greece (hereafter referred to as ATH). The hospital treats and performs surgery on patients with glaucoma from all over the Attica region. Eye-services units in Greek hospitals in particular are challenged by the continuous influx of new glaucoma referral patients while at the same time having to monitor existing glaucoma patients. With the predicted increase in numbers of glaucoma patients [2], hospital visits by patients need to be minimised where possible for those stable glaucoma patients by facilitating their treatment and monitoring outside hospital settings (at home). Moreover, most patients are elderly and have to commute to the hospital in order to be consulted. In this sense, the use of High Definition (HD) video for remote treatment of glaucoma could help eliminate non-essential commuting, facilitate better dialogue between patient and doctor, allow doctors to monitor the patients in their own environment and refer back to HD images for more precise diagnosis/prognosis.

Methods

The research reported here proceeded in three phases: the background research phase, generative phase, a pilot phase followed by a longitudinal study. While the background research phase [11] of the project emphasised discovering as much as possible about the relevant problem domain, the generative phase looked into finding solutions to the challenges encountered in the background phase and then chooses different approaches in implementing the tele-glaucoma prototype. This phase allowed learning from other studies and assisted in avoiding previously reported mistakes. The pilot project phase consisted of evaluating the tele-glaucoma system and testing it with several patients and doctors from the Attikon hospital in Athens, Greece. The pilot took place between January 2014 and October 2014. During the pilot phase, technical difficulties and other issues encountered were addressed and follow up interviews were held around December 2014 to record the doctors' opinions of usability and connectivity relating to the system. The pilot not only allowed the longitudinal testing of the tele-glaucoma before involving a larger number of patients, but also ensured that any impeding problems were addressed. Details about the tele-glaucoma application implementation and design, and details regarding the network connectivity have been presented in [8, 44, 45]. This article focuses on presenting the opinion of the three clinicians involved in the pilot: a senior consultant eye surgeon DR (01) and his assistants (DR 02 and DR03). Two patients took part during the pilot study stage and eight thereafter in the final stage of the system testing.

Semi-structured interviews [46] were used to consult the doctors as they allowed an agenda to be followed (in our case probing about the challenges discovered in the background research phase and pilot phase) but also giving the liberty to address other issues as they occur, which is not possible by using quantitative questionnaire based research or controlled experiments. The interviews were recorded and afterwards transcribed for the analysis. The analytical process was guided by content analysis [47]. The five-stage “framework” for analysis was followed. The “framework” involves the following steps: familiarisation, identifying a thematic framework, indexing, charting and mapping and interpretation [48], [49]. The analysis involved coding the interviews and then identifying themes and categories from the data. The initial coding scheme was derived from the literature research and was modified

through the analysis by either removing codes if not identified or adding future codes. NVivo (QRS International Pty Ltd., Victoria, Australia) was used for qualitative data analysis.

Findings from the Pilot Stage

The themes identified in the analysis of the pilot results were grouped into seven categories: technical issues (technical problems related to the network connectivity), usability issues (application usability problems), process issues (related to the process of using the camera and the context in which it is used), institutional support (the support provided or not by the institutions), ethical and privacy issues (any concerns related to the ethical problems related to the usage of tele-glaucoma, especially with senior people but also concerns related to the privacy of the participants using the system or security of the connection), fear of change (at the doctor level) and technology literacy (related to both doctor and patients). The themes were based on the literature review and similar frameworks proposed.

Technical issues

There were several **technical** problems that appeared particularly with connectivity and Internet-network issues. However the doctors noticed improvements as the project was evolving. DR02 stated that she has encountered network connectivity issues several times particularly during the early phase of the project in 2013. DR01 stated, *“sometimes we have to dial in several times before we are connected with the patient...Sometimes we get connected and although we can see the patient, we can’t hear the patient or the patient cannot hear us”*. DR02 suggested that these issues have shown up less during the pilot stage (first few months of the second year in 2014). DR02 was of the view that the system will not be effective and that doctors will not be able to use it unless the network connections are free of any interruptions. DR01 stressed that *“delay is a huge problem as communication with older patients become difficult and they get confused when there is a delay in voice in particular, like we have right now in our system... this has however improved during the last few months due to improvements made to the applications and technical detail..”*. As for the quality of video, both doctors have pointed out that the quality of the video is critically important in telemedicine. DR01 stressed that *“if the scientific and technological advantages of the video*

to video system are demonstrated to the policy makers as well as the wider medical community, then there is no doubt that the system will be implemented and adopted.” Therefore, addressing the existing technical issues and further testing of the tele-glaucoma application were clearly extremely important.

Usability issues

With regards to **usability** several issues were identified such as the need for a better device than currently used to allow the patients to rest their face in the right position, more training for patients on how to use the video application and improvements in the application functionality for doctors. DR02 suggested that the remote operation has faced some challenges regarding getting the elderly patients accustomed to the process of using a camera in place of the routine physical consultation that they are used to. In particular, it was suggested that most patients took a while to position the camera (and their face) in the right position where the doctor could see their eyes clearly. To this end *“we tried out various positions and even designed a gadget to allow patients to rest their chin and help focus the camera on their eye”* (DR02). Both doctors were of the view that if the system were to be adopted for a wider audience, it was critical that an appropriate piece of equipment is identified or developed for patients to comfortably rest their face and focus correctly on the camera allowing doctors to zoom video in and out when required for close examination of the eyes. In addition, DR01 stated that the patients also needed clear instructions on how to use the application. He stressed, *“we have to tell the patient which buttons to press next and brief them on the next steps in the consultation process”*. The functionality of the applications and user interface was discussed by both doctors. DR02 was of the view that *“for the time being, the doctors were satisfied with the level of interaction that takes place between the system and the doctor and the level of effort that the doctors had to put in to use the system”*. However, it was clear that if the tele-glaucoma system is to be used for a larger cohort of patients, then the current application functionality and layout needed some improvements. In particular, DR03 pointed out that *“at the moment when we finish one patient and move on to the next one, we had to close the application and restart it again.... This is fine as we are only testing the system with two patients currently, but this will need to change when we increase the number of patients”*.

Process issues

Both doctors agreed that they will face some challenges in terms of supporting the aftercare process of the patients. As DR02 stated *“most patients use their eye drops at night and when they know that they have a video to video system that they can use to consult their doctor, they will be tempted to dial in for the slightest problem.... This is quite common with elderly patients in Greece... However, if they call at night, their doctor may not be available for a patient consultation on the video to video system”*. *“Such process related issues may need to be considered before this system is ready for rolling out”* (DR02). Further, both doctors also agreed that the tele-glaucoma system will save time and allow them to see more patients in a day. As DR02 stated *“we can use the video for the 2nd and 3rd consultation rather than having to see the patient physically”*. Nonetheless, although DR03 thought that the tele-glaucoma system helps her in performing her job more efficiently and effectively, DR01 was more analytical about the potential of using it in improving his/her performance. DR01 suggested that *“it is quite hard to comment at this early stage on the impact of this technology on my performance as a doctor.... However, I believe that the system will be good in situations where I have to see many patients per day Then, I believe the system will make my job a little easier”*.

According to DR02, video technology was extremely helpful *“as it allowed the doctors to take close-up, high quality images of the patients eyes and store these images for further examination for a second or even third time by zooming in and out when needed... this allows us to ensure that we do not miss anything and helps to guarantee the diagnosis and recommend the correct medication allowing very little room for human error... Moreover, it will allow us to share patient information and images between the team... this knowledge sharing will allow better outcomes for patients”*. DR01 stated that the aftercare element of the treatment is important as the initial motivation for implementing the tele-glaucoma was based on the premise that it would be used for assisting patients with aftercare treatment (i.e. correctly administering their eye drop) rather than for diagnostics and/or consultation purpose. However, DR01 conceded that most glaucoma patients need step-by-step instructions on administering their eye drops, *“most glaucoma patients do not follow instructions and continue their eye drops as they should.*

When you tell the patient that they have to administer the eye drops for the rest of their lives, they usually do not want to accept this”.

Institutional support

While both doctors agreed that there is adequate support from their hospital to test and implement the system, they also thought that it was difficult to see how the system would be institutionalised in the longer term unless there is high level support from the medical council and health ministry in Greece. DR02 state that *“if policy makers support the use of video and telemedicine in general, then it will be quite easy to establish and further develop video to video as part of the treatment process in the ophthalmology field... certainly, our hospital is extremely keen as we see much potential for this technology and this is why we are supporting the [tele-glaucoma application] effort”.*

Ethical and privacy issues

According to DR01, older people will need more exposure to ICT for the system to be adopted widely by the older populations (55 +) who suffer from eye problems such as glaucoma. DR01 also stressed that *“doctors have to inform the patients of the ethical and privacy issues and put their minds at rest regarding which information will be used and which information will be stored for future use... for example I explain to the patients that only the images of their eye will be kept on patient record for future use and that no video will be stored on file”.*

Fear of change

DR01 suggested that *“doctors may fear losing patients if patients stop visiting them and get used to the remote monitoring.”* In this respect, the doctor thought that the system would be more suited for specialist hospital departments like his, rather than to be used in general practice.

Technology literacy

Both doctors agreed that the economic value proposition to both the patients and the hospital are clear in the system. *“Patients will save money from having to travel to hospital and doctors will save time allowing them to do more consultations per day”*. Moreover, DR01 suggested that most patients are now connected to the Internet and therefore will not need to incur any additional costs. However, he also acknowledged that there are still a large proportion of people (55+) who have limited exposure to technology and the Internet in Greece and Europe in general. Therefore, DR03 thought that it is difficult to predict the take-up of the system by the general public.

Post Pilot Findings (Longitudinal Study)

The longitudinal study findings were grouped into two categories: Tele-glaucoma assessment relative to traditional consultation (which included the advantages and drawbacks of tele-glaucoma as opposed to the face-to-face consultation) and usability and technical issues (which included comments related to the usability of the application or the network connectivity).

Tele-glaucoma Assessment Relative to Traditional Consultations

The participating doctors in the pilot study believed that the usage of tele-glaucoma service is highly adequate in treating and monitoring the patient’s progress as opposed to traditional health techniques. DR02 mentioned that *“It improved monitoring, reduced the need for Hospital examination, and its accuracy was satisfactory in areas of interest, compared to traditional monitoring”*. It also *“adds more flexibility in the monitoring of a patient”*. However, DR02 also cautioned *“we cannot replace traditional techniques”*, as traditional monitoring is better in some cases. Respondent DR03 said *“In specific aspects (e.g. intraocular pressure follow-up), the patient has to be examined closely”*, however the same doctor added that in his opinion: *“it should become a gold standard in several medical cases for the future”*.

Tele-glaucoma facilitated two-way communications between users (doctors and patients), and in doing so, it improves the patient’s follow up and assessment process. All doctors agreed that *“Communication with the doctor*

with a rough real-time assessment is beneficial for both sides” and “Facilitated doctor–patient communication and patient follow up”. The doctors believed that video-to-video application can be very helpful in examining patients at remote locations, saving them time and reduce their transportation cost. The doctors (DR01 and DR02) commented, *“It makes doctors more available to remote patients, it can reduce the cost of patient visits to Hospital”* and *“In remote patients it can help monitoring and communication, reduce unnecessary transportation, improve pre-hospital examination”*.

Usability and Technical Issues

The doctors indicated that the application was easy to use and understand both for them but also for the patient: *“The application was very user friendly for the doctor (and similarly for the patient)”*. The respondent managed to learn the application quickly and easily. DR01 said *“The learning curve of the software was very short and easy [...] More experienced users found the Application very easy”*. However, *“Some had difficulty in the beginning”* as majority of the participants in the pilot study were elderly who had very little knowledge of computers. It was hard for them to use the application at the start, but after some training they were able to use the application more effectively: *“Patients were mainly older, without any computer knowledge. They needed some training and help in the beginning, but they certainly enjoyed it”*.

Although usability issues were solved, technical difficulties were still posing problems: *“It took some time to make it work with a satisfactory and repeatable performance. A member of the supporting team (communication lines, computer technologist) had to be standing by most of the times”*. As DR 03 said: *“The main challenges, in my opinion, are some improvements in technical problems, the training of the patients, and maybe the cost of establishing the application.”*.

Discussion

Our study confirms that usability problems with the application and connectivity issues and its consequences (i.e. poor video quality) are of importance for the adoption of video technology in remote patient care. The usability issues can be addressed through a better involvement of the stakeholders and an iterative development of the

application that would allow addressing the problems found. The quality of the video is critical for accurate diagnosis of glaucoma. Network coverage and bandwidth is likely to increase and newer codecs and hardware will allow a better quality of the video connection in future. There are also possible solutions to be deployed over the existing networks to improve bandwidth and the quality video transmission without upgrade of the network being required [27].

Fear of change has been reported with the introduction of different technology in healthcare that is further enhanced in the way technology used in healthcare is portrayed by the press [50]. However, Oudshoorn [51] has shown that this fear is not justified as the introduction of ICT and tele-monitoring enhances healthcare service and makes more information available to clinicians for improved decision making. Therefore, any fear of change could be dispelled by educating clinicians of the benefits of ICT and involving them in the change process. Doctors might however fear financial implications that would result from patients having access to multiple sources of consultation [52].

Communication is also necessary in setting up the expectations on the clinician-patient relationship and reassuring the patient of privacy issues and how they should be dealt with. As most of the patients are senior citizens technical literacy might be an issue in using video-to-video for treating glaucoma. Having a relative to help the patient during the first consultation session is beneficial for those who do not have the confidence in using the technology. Another solution is teaching senior citizens how to use ICT as found in other examples where volunteers offer this service [53]. However, our study found that despite low literacy the older adults quickly learned the system. This finding is similar with the Piper & Hollan [54] that have found that older adults quickly adapt to the multi-touch screen computer.

Finally, support from the institution or policy makers is considered necessary if tele-glaucoma services are to be implemented as a mainstream service. In general, regulatory and financial issues need commitment from senior management and policy makers. These findings mirror those by Tanriverdi & Iacono [55] over a decade ago in

which institutional support was considered crucial for the diffusion of tele-health. The importance of institutional support is also mentioned on other e-health services, such as electronic health records [56].

Although care must be taken before generalising the results presented here, some of the results are likely to be found other in different tele-monitoring applications. The usability issues are an important component of any ICT application and they need to be addressed earlier on in the process. Network connectivity is likely to be an issue for tele-monitoring applications that need video connectivity; especially in rural areas where bandwidth is an issue. However, the necessity of high-speed networks is dependent of the tele-monitoring service, and what could be considered a low bandwidth for certain services could meet the requirements of another.

Fear of change is likely to be present when introducing any new system, however in tele-monitoring applications where senior people are the target users there is likely to be more reticence in adoption of technology due to low levels of technology literacy. Therefore, communication to raise awareness and education to promote the new online environment is important as found in studies elsewhere of using tele-conferencing systems in public sector context to engage with citizens [36].

Although usage of tele-monitoring for treating glaucoma has shown some positive results overall, our study findings also indicate that tele-monitoring might not be the best solution in certain cases. Depending on the patient's condition, on some occasions the patient may need to be examined closely by the doctor, or the patient will need access to equipment, which is available only in a hospital environment. Other conditions may require the administration of medication in a controlled environment with a doctor present, and in these cases tele-monitoring might not be a suitable solution.

Summary

This study looked at clinicians' views on factors that might affect the long term adoption of a tele-glaucoma system from the clinicians' point of view. The study took place with two clinicians who took part in a longitudinal study in a large hospital in Athens, Greece to implement a video-to-video system for treatment and monitoring of glaucoma patients. Several factors evolved as a result of the study and were grouped around seven themes: technical, usability, process, institutional support, ethics and privacy, clinicians' fear of change, and issues with technological literacy among the senior patients.

This study helps to better understand both the advantages and the difficulties encountered in using a tele-glaucoma system. Lowering the barriers found could help in facilitating the adoption of tele-glaucoma applications. These results could be of interest for policy makers and hospitals administrators who are considering the use of tele-monitoring systems. Although we have no reason to believe that the results of this study are not generalisable, care should be taken in interpreting the results of this study as it involved in-depth interviews with three clinicians in Greece and the results might differ depending on the country in which the study takes place.

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