

The State of Remote Patient Monitoring and its Implications on the Medical Industry

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On my honor as a University Student, I have neither given nor received
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Introduction

Raised in a family of doctors, I am passionate about the medical field but in my pursuit of computer science, I have become fascinated by the future and potential role of medical technologies. Rapidly growing is the use of wearables and remote patient monitoring (RPM) to continuously track patient health through data. RPM is a form of telemedicine which is the distribution of health care through remote technologies. Currently, RPM is being experimented with using Fitbits and other wearable devices, but such is expected to grow and could become an industry standard due to its potential for lower costs and higher efficiency in the medical field. As a result, RPM and other forms of telemedicine such as the use of online platforms to conduct appointments, could expand rapidly in the next few years and throughout the world. Traditionally, doctors have become accustomed to developing face-to-face and personal relationships with their patients whom they see when needed or periodically for check-ups. However, the rise of RPM threatens this paradigm and could create not only technical, but social and ethical challenges as well.

Research Question

I would like to study the advantages and disadvantages of RPM, each stakeholder involved, and its implications on the medical industry. For doctors, RPM can improve their ability to provide effective care and to more patients, increasing their revenue streams. Similarly, patients can be more aware of their health and have doctors alerted in case of emergencies. As of now, wearable technologies such as the Apple Watch and Oura smart ring can track blood pressure, blood oxygen, respiratory rate, heart rate, sleep, and more. Thus, such technologies can be extremely useful for preventive care, but is dependent upon the accuracy of

According to the University of Cambridge, RPM can also lead to “reductionism” in that doctors may not be able to determine the context of the data and understand the mental health of the patient, resulting in a lack of trust of the devices (PHG Foundation, 2020). The over-reliance of data may induce a false sense of complacency by both doctors and patients who look solely to the data for diagnoses resulting in misdiagnoses and overdiagnoses, increasing patient anxiety. As a result, RPM faces both optimism and skepticism from doctors and patients, creating a wicked problem with the involvement of multiple stakeholders such as the medical industry, patients, and wearable technology companies. Thus, the role of RPM in the future of the medical industry could benefit from an STS investigation. Understanding the benefits and especially, the limitations of RPM will also allow technology companies and relevant social groups to determine where innovations and improvements need to be made.

Literature Review:

Telemedicine, or telehealth, in comparison to in-person appointments, has shown to be as effective, but with reduced costs. According to a study describing the differences between an in-person and tele-geriatric consultation, evidence suggests that observation through videoconferencing provides equal benefits to an in-person meeting (Betkus et al., 2020). At the same time, costs decreased by over \$15,000 for 62 consultations due to travel savings and a decrease in consultation prices because of the ability for doctors to treat more patients (Betkus et al., 2020). As a result, Clark et al. (2020) argues that telemedicine allows patients in various locations to receive the quantity and quality of care deserved. The reduced healthcare costs, faster treatment, and reduced travel improve patient satisfaction. Patients can also take a more active role in their health with the security of their doctors, decreasing their anxiety (Clark et al., 2020). Such is the case for telemedicine, but the benefits of RPM with the use of wearables highly depends on the data accessible and its accuracy. Silvera-Tawil et al. (2020) highlights the various forms of wearables such as watches, smartphones, and garments required to measure

blood pressure, blood glucose, blood oxygen, heart rate, respiration, brain activity, motion, and acceleration. Although much of the use of wearables is conducted in research environments rather than commercial, accuracy of the wearables is comparable to currently utilized medical devices. Mainstream devices are able to reliably measure heart rate, steps, and sleep with a slight edge to smartphone apps rather than watches or bracelets (Xie et al., 2018). However, such watches had an accuracy over 80% for heart rate variability measures, indicating that common wearables may be beneficial for asthma or pulmonary disease, for example (Rahman et al., 2020). Thus, RPM can allow for earlier identification of symptoms, decreasing hospitalization costs and times without reducing the quality of care (Pekmezaris et al., 2012).

However, many sources recognize the ethical concerns involved with telemedicine and RPM. Telemedicine is more easily available to certain demographics, further increasing socioeconomic disparities. For example, telemedicine is less utilized by non-white people residing in poor areas and typically, elderly people (Pierce and Stevermer, 2020). Due to the pandemic however, elderly people are increasingly using telemedicine measures of healthcare (Pierce and Stevermer, 2020). Nevertheless, elderly people are often inexperienced with modern technology and poor communities have access to fewer healthcare services, physicians, and internet availability, reducing the ability to receive equal care as others who are younger or of a higher economic standing (Pierce and Stevermer, 2020). In addition, those who prioritize their health are more willing to utilize telemedicine and RPM, resulting in others to miss out on health insights and preventative care (PHG Foundation, 2020). Many sources also argue that RPM reduces patients to their data and in a sense, objects (Clark et al., 2020). Health data does not describe a patient's mental or emotional state and the lack of in-person interaction in comparison to normal in-person appointments could be further detrimental to their wellbeing (PHG Foundation, 2020). Subjects of RPM could also change their actions based on their data and become more anxious of the health through constant monitoring of their devices (McCaldin

et al., 2016). Effectively, patients could try to self-diagnose symptoms (McCaldin et al., 2016) or in the opposite scenario, over-rely on their data and miss diagnoses by their doctor (PHG Foundation, 2020).

Legal concerns are also present with the rise of telemedicine. Standardized legal frameworks remain elusive and differ from state-to-state as telemedicine is not yet clearly defined (Rita M. Marcoux, 2020). Although Congress passed the FDA Safety and Innovation Act which tasked the FDA with developing a regulatory framework for health information technology, reimbursement by payers to care providers is not clear (Rita M. Marcoux, 2020). In addition, many RPM devices or apps permit the sale of users' health data to third parties (PHG Foundation, 2020), allowing data to be shared inappropriately (Silvera-Tawil et al., 2020).

The benefits of RPM also depend on the accuracy of the data collected. However, due to conflicting evidence, it is not yet clear that commercial devices meet the same standards as current medical devices as they are known to be less accurate and less consistent (Silvera-Tawil et al., 2020). Patients are also less willing to share their mental wellbeing and behavior in telemedicine due to the difficulty to observe behavior through video (Betkus et al., 2020), potentially disproving the previously supported claim that patients will receive equal quality of care through telemedicine.

As evident, much of the literature on the topic of telemedicine and RPM clearly evaluates the proposed benefits, concerns, current regulations, and accuracy of wearable technologies, but emphasizes primarily on patients. The use of such technologies impacts not only the patients, however, but the physicians of the medical industry and wearable companies also. These impacts are not shown in current literature and provide opportunities for future research.

STS Frameworks and Research Method

RPM and telemedicine are emerging fields facing both optimism and skepticism but still in the process of construction. Due to the importance of wearables in RPM, it is necessary to analyze the users of such wearables and their roles in the development of the technology. However, various stakeholders (patients, doctors, and wearable companies) have different expectations for wearables. As a result, Pinch and Bijker's Social Construction of Technology (SCOT) will be utilized as it recognizes the interdependence of social and technical elements in technology. Under such framework, stakeholders actively shape technology and define the criteria for successful construction based on their respective interpretation. SCOT also analyzes the process of conflict resolution between each stakeholder and mechanisms for closure.

As telemedicine and RPM do not solely provide convenience for patients, but also fundamentally change how health is perceived, Verbeek's theory of mediation will also be utilized. Verbeek emphasizes that technology shape the relationship between humans and the world, thus altering reality. Designers create technology which in turn, shape the user's perceptions of the world. Using such ideology, telemedicine and RPM may alter the doctor-patient relationship and objectify patients, respectively.

As a result, users of wearable devices and telemedicine patients were surveyed in order to determine their satisfaction with such technologies, their ethical consequences, and regulation. However, the sample size and the extent of the surveys may be insufficient and unrepresentative of the medical industry and its patients. Due to differences in knowledge of technology, it was difficult to acquire data from older patients and of various socioeconomic standings, creating bias towards the preferences of younger and wealthy patients. A technology company was interviewed to better understand how health data can be privately secured and their role in RPM while physicians of various specialties were interviewed to discover their

concerns due to the lack of analysis on the impact of RPM in the medical industry. Specifically, an orthopedic surgeon, internal medicine physicians, and physical therapist were interviewed. Quantitative data related to the accuracy of wearables were acquired through further investigation of research studies as well as my technical study.

Data Collection and Analysis

The most influential stakeholders of RPM are those most impacted by the use of wearable devices: patients, their doctors, and wearable companies. Under RPM, patients have the ability to track valuable health data in real time while doctors assess this data to provide appropriate care. Wearable companies provide the devices necessary for RPM while abiding by regulations and the needs of both the patient and doctor. As a result, each social group is interrelated, but have different roles and thus, priorities in RPM.

To understand the role of patients and the current effectiveness of RPM, a survey was completed by over 50 people of the general public. The survey described RPM and telemedicine while gathering insight into the surveyees' usage and opinions of each form of medicine. Specifically, questions were asked regarding RPM and telemedicine usage, effectiveness, patient preference, data privacy, and legal concerns which have all been proven to be controversial based on a prior literature review and document analysis. Of the survey responses, the majority of surveyees were within the age group of 15-30 with no responses from those under 15. In addition, the male and female representation among the responses was fairly even with approximately 60% of the surveyees being male.

Although most surveyees do not share their health data to their physician, the majority already utilize health wearable products and are willing to share their data. Despite this loss of privacy, proven to be a concern mentioned in prior studies, many surveyees value the health benefits and preventative care RPM can provide for them. As a result, the ability for patients to

integrate RPM into their current lifestyle is promising. However, many surveyees felt that the wearable companies should value their interests more so than their doctor. Patients are interested in a device that captures accurate and relevant data, but also is affordable and practical. Such is evident through the popularity and use of devices such as Fitbits and Apple Watches which can provide relevant health data for medical purposes but are not utilized for such. Less than 5% of surveyees reported sharing their health data with their doctors. Thus, despite patient interest in RPM, many may be reluctant to utilize devices which are strictly for medical use, thereby reducing the potential effectiveness of RPM for the medical industry.

Doctors were interviewed in order to provide direct insight into the implications of RPM in the medical industry. Surprisingly, RPM was not utilized in such practices and was in fact, unknown to one of the doctors. Although RPM is not commonly implemented, the doctors agreed that RPM would provide a wider sample of vital data more representative of the patient to be used primarily for anomaly detection. Doctors could analyze a patient's health over time rather than a snapshot produced at an in-person appointment while patients could also be more aware of their health. Thus, doctors are similarly interested in a device that captures accurate data and lots of relevant data but provides real-time data transmission in order to provide the best care as soon as possible.

However, RPM should be further evaluated in the future upon its impact on the medical industry and patients as it is potentially too early to understand its effects. Doctors, themselves, do not have experience utilizing such technology, knowledge about RPM, health data, and how doctors would integrate the assessment of health data with other duties. Such technologies would also not replace in-person appointments, but act as a supplement. Regarding telemedicine appointments, doctors did not feel that telemedicine appointments were of the same quality as in-person appointments. Doctors felt that patients were less comfortable, hard to gauge in terms of mental health, and were unable to develop a strong relationship. As a result, RPM will likely

also act as a supplement due to the complete lack of interaction between the doctor and patient found in RPM.

Philips, a healthcare conglomerate and producer of wearable devices such as the Wearable Biosensor which measures vital signs, body posture, step count, and detects users' falls, was also interviewed to understand their role in RPM through an Associate Director of Clinical Development. Philips accommodates both the interests of the patient and doctor through minimal, but gold standard medical devices. As a result, wearable companies such as Phillips seek to provide a medical-grade device that can be integrated into the lives of the patient while maintaining user privacy. Currently, the company actively ensures the privacy of its users' data through strict government laws, private institution regulations, and contractual agreements with the party owning the data. Data is always protected if personally identifiable and if such information is not necessary, the data is automatically de-identified and encrypted. Furthermore, employees receive annual training in privacy protocols to prevent regulatory breaches and criminal charges. Thus, Philips with its high standards of user privacy can serve as a model for further government regulations or other companies. Consequently, patients may feel safer and more willing to engage in RPM while medical practices can ensure they are abiding by their regulations.

Due to these differences in interests, conflicts are present among the social groups. Although all are in agreement for the collection of accurate data, factors such as the ability to share data in real-time, the price, functionality, and privacy of the data present potential issues. For example, doctors would like to see as much data as possible from their patients, but regular users of wearable devices may be concerned for the privacy of sensitive health data being shared or the practicality of such devices. However, Philips exemplifies that privacy concerns of RPM may not be as significant as previously examined, despite some previously described surveyees' lack of comfort sharing data. Such interests are negotiated and are done so through discussions with the manufacturing company which also seeks to abide by regulations.

Dependent upon the power dynamics presented above and the ability for doctors and patients to influence manufacturers, wearables may not provide enough valuable information or be utilized comfortably by the patient. Consequently, wearables may currently be limited in their practicality for use in the medical field. However, as technology advances, devices that appeal to the interests of both the patient and doctor similar to the Apple Watch can provide a means of closure.

Nevertheless, as wearables and telemedicine are becoming more prevalent in society, they will actively help shape humans' interpretation of reality, by Verbeek's theory of mediation. Wearables are designed with the intention of both the doctor and patient by health companies such as Fitbit and Philips. Though such devices are created in order to improve a patient's wellbeing through representative data of their health, wearables alter humans' perception of privacy, themselves, and their medical care.

Constantly transmitting data related to personal location, activity, and health to another redefines personal boundaries as users lose their personal information in exchange for improved health. In addition, as wearable health data is meant to accurately represent the health of its user, users can perceive themselves as sources of data, alluding to surveillance capitalism, the commodification of personal data. Such is evident by the surveyees' strong belief of objectification as data when utilizing RPM.

In addition to oneself, but the reality of the medical industry as a whole can be altered by the usage of RPM. For example, many surveyees were hesitant in their doctor's ability to integrate RPM. If patients are unconfident in their doctor, they may likewise be hesitant to engage in RPM and question the ability of medical practitioners. Also, when tracking their own health data, patients may attempt to diagnose themselves, not only increasing stress and concerns, but reducing their reliance on their doctor. As a result, the doctor-patient relationship will be damaged, and medicine will be further depersonalized. However, RPM also alters

patients' ability to improve their health. Those in need of health care can easily contact doctors, making high quality medical care a reality for many.

Conclusion

RPM has the ability to improve the lives of its users through improved health analysis and preventative care but faces skepticism. Much of previous literature discusses concerns related to the patient, but other stakeholders and the implications of RPM on the medical industry as a whole have not been investigated.

Unlike traditional medicine, RPM centers around three main stakeholders: patients, doctors, and wearable companies. The inclusion of a new stakeholder into the health of the patient has raised privacy concerns, but as seen by Phillips, medical device companies currently face strict regulations. However, non-medical companies such as Apple or Fitbit may require further regulations if utilized in RPM, with Phillips serving as a model for such companies. Nevertheless, according to patients, privacy may not be as large a factor as previously believed as many patients value their health greater than privacy. Many are also interested in utilizing RPM and have wearable devices, but do not currently do so. Likewise, doctors believe that RPM can provide more representative data of patients, but a disparity may be present between the data that doctors are interested in and the data patients are interested in providing, as evident by current usage of RPM. However, the advancement of wearable devices and improvement of technologies such as the Apple Watch can accommodate both parties in the future.

With the rise of RPM in the future, the medical industry may be altered and further depersonalized. Less interaction with a doctor could not only damage the doctor-patient relationship, but also decrease patient reliance on doctors. Patients may begin to diagnose themselves, but due to the lack of knowledge of how to interpret such data, RPM may increase stress for patients and doctors, decreasing its effectiveness. Furthermore, patients may alter their

idea of themselves to be sources of data and objects instead of people. However, RPM may also alter the medical industry in a positive aspect as well. Patients can receive preventative care while doctors can provide care for more patients.

As a result, RPM may alter the medical industry and raise social concerns, but RPM should be further analyzed for its ethical implications in terms of socioeconomic status. The ability to improve the wellbeing of those with access to RPM technologies may further increase health inequalities and the extent of such impact provides a potential for future research.

Appendix A: Physician Questions

What do you consider are the advantages and disadvantages of telemedicine and rpm in the medical industry?

Do you feel that you are able/would be able to properly evaluate a patient's physical and emotional wellbeing through telemedicine and rpm and if not, how do you compensate for these shortcomings?

How will the use of telemedicine and RPM alter the medical field and your life as a doctor?

Are you able to provide equal treatment to an in-person experience?

Is the doctor-patient relationship affected?

How do you store patient's data?

Are wearables as accurate as medical devices or accurate enough to be used effectively?

Appendix B: Company Questions

How do you accommodate the interests of physicians and users in terms of data collection, privacy, and usability? Which do you focus on more?

How do you store sensitive data to maintain patient privacy?

How are you affected by government regulations, if any?

Do you see blockchain technology being utilized for health data?

How accurate are your devices in comparison to medical devices?

Appendix C: Survey Questions

Do you utilize any health wearables such as an Apple Watch, Fitbit, Oura Smart Ring, etc.?

If so, do you provide any of your health data to your physician?

If not, would you feel comfortable sharing your health data with your physician and wearable companies?

Is your health more important than your privacy?

Should the government be responsible to regulate health data?

Do you think RPM objectifies patients as data?

How confident are you in your physician to be able to adopt RPM?

Do you think wearable manufacturing companies should value the interests of the doctor more than the patient?

Who is responsible for a misdiagnosis based upon wearable data?

Have you utilized telemedicine (virtual medical appointments)?

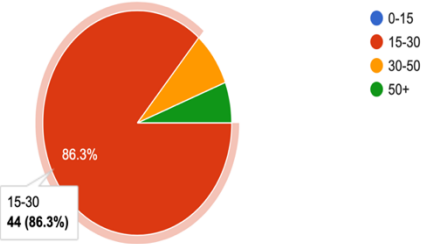
If so, do you feel that your experience was the same as an in-person appointment?

Do you believe that telemedicine can replace in-person appointments?

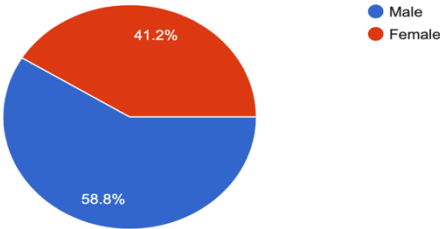
Do you prefer telemedicine appointments?

Appendix D: Survey Results

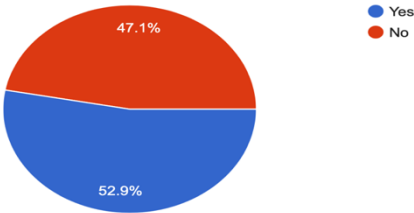
Age
51 responses



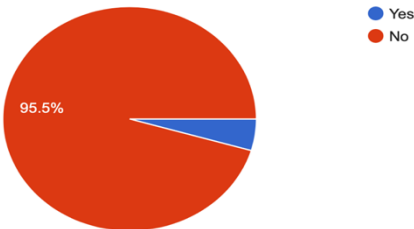
Sex
51 responses



Do you utilize any health wearables such as an Apple Watch, Fitbit, Oura Smart Ring, etc.?
51 responses

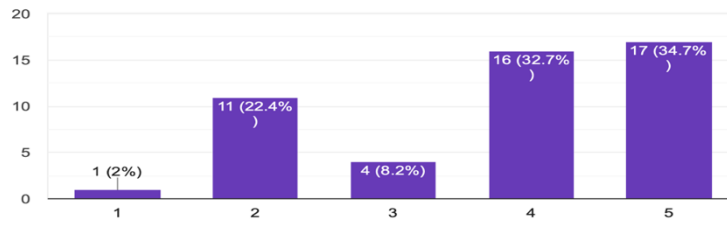


If so, do you provide any of your health data to your physician?
44 responses



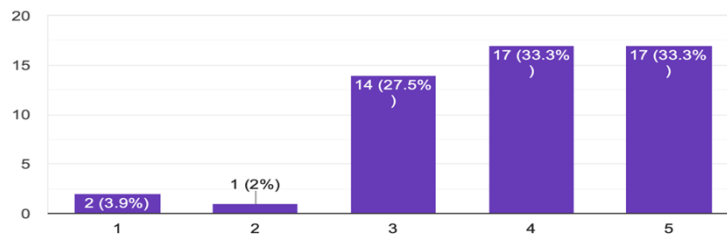
If not, would you feel comfortable sharing your health data with your physician and wearable companies?

49 responses



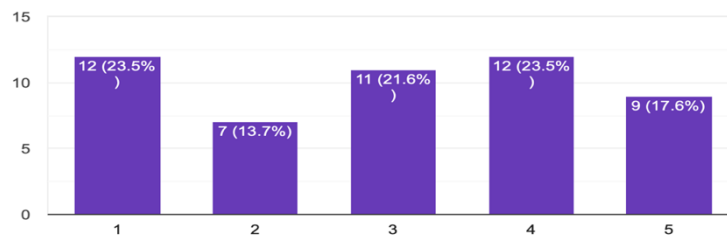
Is your health more important than your privacy?

51 responses



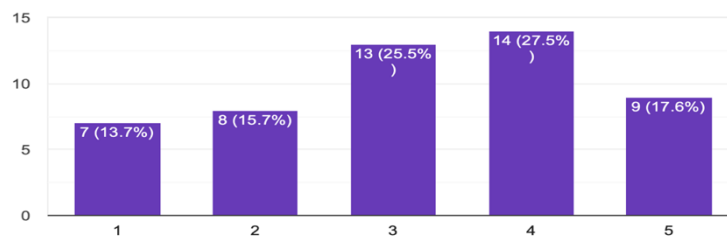
Should the government be responsible to regulate health data?

51 responses

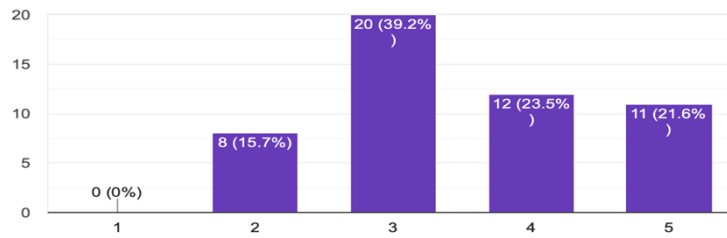


Do you think RPM objectifies patients as data?

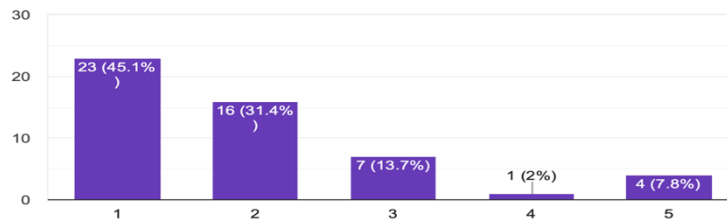
51 responses



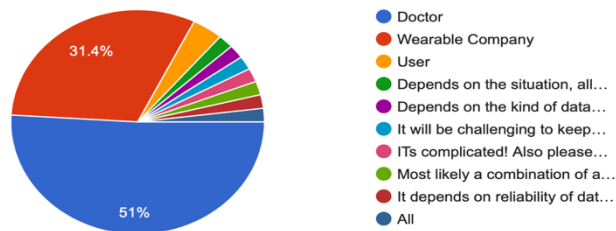
How confident are you in your physician to be able to adopt RPM?
51 responses



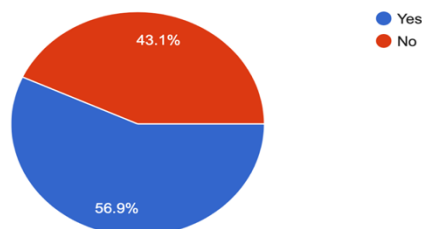
Do you think wearable manufacturing companies should value the interests of the doctor more than the patient?
51 responses



Who is responsible for a misdiagnosis based upon wearable data?
51 responses

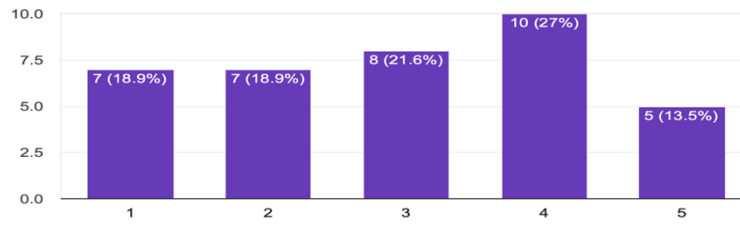


Have you utilized telemedicine?
51 responses



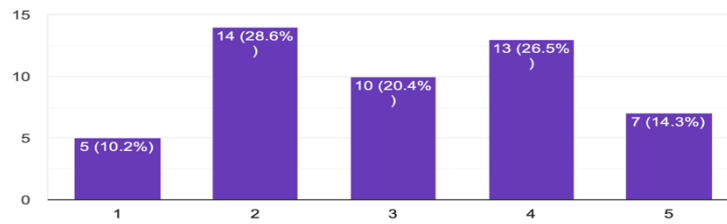
If so, do you feel that your experience was the same as an in-person appointment?

37 responses



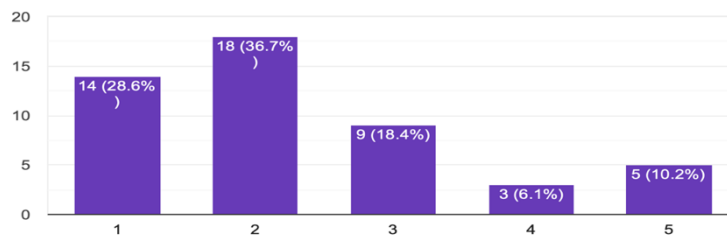
Do you feel that a doctor can analyze a patient's mental health through telemedicine?

49 responses



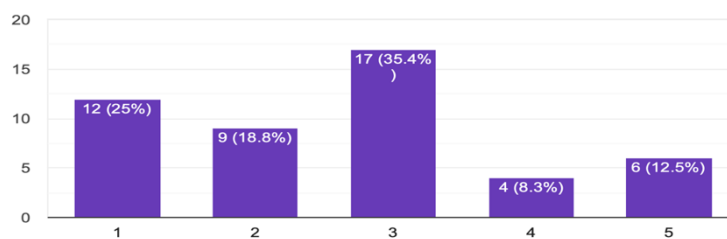
Do you believe that telemedicine can replace in-person appointments?

49 responses



Do you prefer telemedicine appointments?

48 responses



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