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Digital Avatars of Medical Practitioners in a Clinical Setting – Perceptions and Challenges in India

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***Abstract*: India has one government doctor for every 950 people, as shown by figures from the National Health Profile Report 2023 on the country's health sector. The National Health Profile 2023 report also found that 1,560,000 doctors were registered in India by the end of 2023. The World Health Organization (WHO) recommends a target of 1 doctor per 1,000 people to maintain an effective healthcare system. With a ratio of around 1:910, India is close to meeting this benchmark, but there are still challenges related to geographic distribution, rural-urban disparities, and the overall healthcare infrastructure. With technology like digital twins available, there is an exciting case for developing digital twins for medical doctors, which can be used to address this vast gap in the doctor-patient ratio. While many potential opportunities exist in using Digital Twins For Doctors (DTDs), understanding their limitations is also essential. The use of DTDs can have both social and legal implications. Understanding the perceptions around benefits, pain points, and challenges among the stakeholders in the healthcare system in India will help understand how DTDs can be effectively used to supplement clinical care activities. Surveys were conducted with 1351 stakeholders, including doctors, healthcare administrators, students pursuing medicine, and active patients. All data was reviewed for accuracy. Using a combination of closed and open-ended questions, statistical analysis, word cloud and thematic analysis were attempted. We discuss the practical implications of these findings for interpreting the use of DTDs in clinical settings in India and the role of stakeholders in the evaluation and implementation of DTDs.**

***Keywords*: Digital Twins, Healthcare AI, Doctor Avatars, Patient Engagement, Clinical Technology Adoption, India.**

1. Introduction

Recent advancements in Artificial Intelligence (AI), big data, cloud computing, and lower data management costs have helped build software tools that generate digital twins of real human faces and their voices for realistic communication. In this research, we explore the idea behind using AI software as a health assistance tool by exploring the concept of Digital Twins of Doctors (DTDs), where doctors could provide better patient engagement, share disease-related information, and do a host of other patient-related activities using their digital avatar.

Digital twins for doctors are software-driven AI-generated digital avatars of doctors that closely resemble their physiological and potential behavioural characteristics. Nevertheless, many issues exist, including economic, social and legal challenges. Systematic research is needed to understand better the challenges, benefits, and perspectives of the different healthcare ecosystem stakeholders (patients, doctors, and healthcare administrators). As a step towards this direction, we report findings from structured interviews with doctors, healthcare administrators, patients and medical students in this holistic qualitative research since we need to capture a broader perspective of the healthcare ecosystem, including medical providers, administrators, medical students and patients.

Advancements in the generative AI field have enabled the development of powerful educational avatars. These avatars embody a human and can, for instance, listen to users' spoken input, generate an answer utilising a large-language model, and reply by speaking with a synthetic voice. The benefits of using AI-based educational avatars, which include individualized and contextualized instruction. AI avatars are developed personas in software using AI and machine learning and pattern recognition techniques [1], are used to generate lifelike digital characters which could be humans, animals or objects. Variants of the software include adding facial features, voices and intonation, emotional cues, and behavioural attributes of the entity of interest. AI avatars closely resemble real persons. AI avatars have several advantages, including enhanced trustworthiness and increased AI system adoption. AI avatars also enable human-like interaction and engagement. AI avatars have their share of issues, such as the potential for psychological impact, discrimination, and biases [2].

Some industries where digital avatars are used include the video game industry, tech-assisted education, etc. A specific category of these characters, "deepfakes," has gained popularity [3]. Generative AI creates deepfakes where the person is copied in all aspects, and it is tough to differentiate the software avatar version from the natural person. A constructive use case in healthcare is the creation of digital avatars for doctors, also known as digital twins for doctors (DTDs); they are essentially

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digital replicas of the doctor (i.e., real-life-like avatars controlled by software) and could be lifelike software-driven conversational agents as well. Healthcare agents have many benefits, which are researched and documented in published literature [5]. The use of conversational agents with unconstrained natural language input capabilities for health-related purposes is an emerging field of research, where the few published studies were mainly quasi-experimental, and rarely evaluated efficacy or safety. Future studies would benefit from more robust experimental designs and standardized reporting. These agents can engage in doctor-patient interactions in a naturalistic manner, which enables the blossoming of trust [6] and engagement with patients, thereby improving patient communication [7] and satisfaction [8]. However, these agents require significant resources and effort in designing [9]. Designers have to make several design decisions, such as appearance, behaviourisms [10] and attire [11], that can impact our perception of a virtual software agent (e.g., credibility and expertise).

There are many solutions for designing these software agents. One novel option is the development and use of digital avatars. In healthcare, it is digital avatars for doctors where you can create an avatar like a patient's doctor with a familiar face and voice. Digital twins for doctors may have a significant advantage due to the ability to make the digital avatar of the doctor look, talk and behave like the doctor in real life. This can have advantages for doctors in sharing information about best practices for post-hospitalisation care, sharing dos and not about hygiene and wound care, patient pre/post procedure instructions/masterclasses on disease, interpreting different aspects of lab results, etc. etc.), which is often not possible during their short-duration one-to-one sessions with doctors [12]. Digital twins for doctors (DTDs) are essentially digital replicas of the doctor (i.e., real-life-like avatars controlled by software) and could be lifelike software-driven conversational agents. DTDs can also help prepare patients to discuss socially taboo areas without fear (e.g., sexual orientation issues, sexually transmitted diseases or similar topics) by providing them with a safe and private platform for discussion and obtaining information and possibly advice. Healthcare professionals (doctors, nurses and support staff) can also benefit from DTDs as they can better manage their time and resources using health assistance tech tools like DTDs. Health assist tech tools are AI-powered tools designed to assist healthcare professionals in managing non-critical tasks, such as patient engagement and information sharing.

While many potential opportunities exist in DTDs, understanding their limitations is critical. When used, DTDs have political, economic, social, and legal implications. Problems can present themselves around information tampering with DTDs, sharing malicious information via DTDs, or hacking the digital avatar, which may lead to the violation of healthcare data privacy [13] and eventually lead to distrust of the medical practitioner.

While digital twins for doctors offer numerous benefits, it is essential to acknowledge the potential challenges they present. Over-reliance on the digital avatar and reduced physical doctor-patient interaction due to time constraints are significant concerns. Other challenges include the potential liability for the actions of the DTD when it may harm the patient or any other stakeholder in the healthcare setting. These challenges underscore the need for a cautious and thorough consideration of DTDs in healthcare.

Research is needed on the usage of DTDs as there are potential benefits and challenges in the use cases, especially in the healthcare industry [14]. Prior studies have investigated doctors' perceptions regarding adopting related technologies, such as chatbots [15] and avatars; reviewing and researching benefits, challenges and concerns in use cases of DTDs in the healthcare industry should be done to ascertain perceptions of stakeholders and correlation to contentious issues like deepfakes [16]. Researchers have urged the study of the social implications surrounding deepfake technology, which involves understanding the perceptions of all the relevant stakeholders (doctors, patients, hospital administrators, and future doctors) before adopting them. Therefore, in this work, we take the first step by examining stakeholders' perceptions of potentially utilising DTDs in healthcare. Understanding doctors, hospital administrators, and patients' perceptions about DTDs should provide a good idea about use cases for DTDs and pain points to overcome. The research would also help understand if researchers, doctors, and associated stakeholders have a similar understanding of potential opportunities and concerns regarding DTD. Having that research done would help all stakeholders take a guided approach towards implementing DTD's in healthcare. In that regard, we address the following research question: What are doctors' and associated stakeholders' perceptions of using DTDs in patient care?

The scope of this research is to explore the benefits of using digital twin avatars in clinical settings, concerns around using digital twin avatars, the medical fraternity perspective on patient reception vis-à-vis use of digital avatars and the willingness of the medical fraternity to use digital twin avatars in clinical settings.

2. Purpose of the Present Study

India has one government doctor for every 950 people, figures from a report on the country's health sector. The National Health Profile 2023 report also found that 1,560,000 doctors were registered in India by the end of 2023. The World Health Organization (WHO) recommends a target of 1 doctor per 1,000 people to maintain an effective healthcare system. India, with a ratio of around 1:910, is close to meeting this benchmark, but there are still challenges related to geographic distribution, rural-urban disparities, and the overall healthcare infrastructure. With technology like Digital twins available, there is an interesting case to be made for developing digital twins of medical doctors, which can then be used to address this vast gap in doctor-patient ratio.

Artificial Intelligence (AI) is increasingly influential across various sectors, including healthcare, with the potential to revolutionise clinical practice. However, risks associated with AI adoption in medicine have also been identified. Despite the general understanding that AI will impact healthcare, studies

that assess medical doctors' perceptions about AI use in medicine are still scarce.

While many potential opportunities exist in DTDs, understanding their limitations is also essential. The use of DTDs can have both social and legal implications. For instance, the synthesised media with DTDs may be tampered with to spread misinformation, promote harmful behaviours, or distort expert opinions, which would lead to the wrong portrayal of the doctors. Another potential limitation is that overuse of DTDs may further reduce doctor-patient communication, which is already a concern in existing patient care. Further, if DTDs are used as a replacement tool for healthcare professionals rather than as a supplementary tool, then reduced human-human communication may negatively affect patient mental health. In addition, when DTDs cause harm, legal concerns about whom to blame (patient software programmer or doctor) may also arise [17].

Given that DTDs have potential benefits and limitations in patient care, research efforts are required to systematically study their implications before widely adopting them.

3. Method

A. Research Design

Relevant guidelines and regulations carried out the study and all methods by keeping the survey anonymous and not recording personal information. The study surveyed India's doctors, hospital administrators, patients, and medical residents. Surveys were chosen as the data-gathering method because the stakeholders are extremely busy, and a video-embedded survey can help explore and understand stakeholders' perceptions, feelings, and ideas regarding DTDs. In addition, the surveys allow participants time to become aware and understand the concept of digital twins and DTD by watching the introductory videos and sample use cases. Two pilot sessions were conducted with a hospital and its stakeholders to test if the video used in this study and survey provided optimal information for the potential survey respondents regarding their understanding and for them to respond appropriately.

Participants were informed that identifiable information would not be used for publication, and the questions were modified to avoid collecting personal information. After participants consented to participate in the study, they were asked questions about their role in healthcare, its benefits and challenges, patients' trust in technology, opinions around the use of AI, etc.

Since digital avatars are a very recent technology and many in India may not be aware of it, especially in the healthcare sector, an introductory video around digital twins along with two other use case videos (one video showcasing a DTD explaining to a pre-diabetic and the second video explaining to a patient about a fall they had and follow-up) was shown to all to provide details on what digital twins are and what they can do. A video demonstrated a human-like digital avatar (see Fig. 1), providing an overview of digital avatars. The participants also shared a video on how avatar videos can be created using the commercial platform ColoyssianCreator [18]. This helped participants understand the new technology, visually see and understand what digital twins meant, and provide an understanding-by-example approach for potential survey respondents. After the introductory video, the participants were asked the instructions for the survey to visualise a similar digital avatar of themselves and then answer questions about benefits, challenges and use cases from a clinical setting perspective. The doctor participants were also asked whether they would be interested in creating their digital twin for patient communication and exploring using a digital avatar to perform essential patient screening before the consultation. The questions were framed as open-ended and some close-ended to obtain concrete thinking patterns. The survey questionnaire and videos can be provided on request.

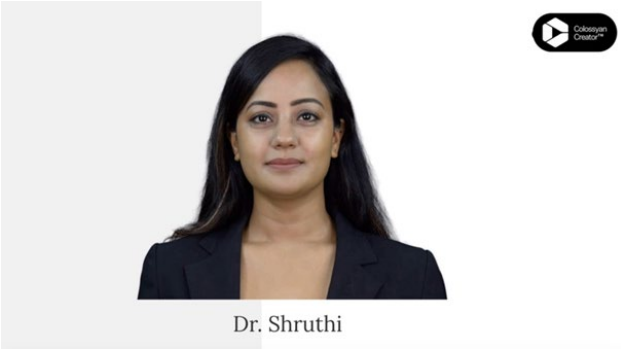

Fig. 1. A video with an introduction to DTD and its use cases

Script used for Introduction to DTD Using Dr. Shruthi's DTD avatar
Artificial Intelligence has tools capable of generating digital twins of real human faces and voices for interactive communication. In this research, we will explore utilising Digital Twins of Doctors in healthcare because using a doctor's identity can provide benefits like enhancing the credibility of the health information delivered using computers. We study Al-generated digital replicas of doctors that closely resemble their characteristics. However, there exist limitations, including the social implications of using a doctor's identity, potential negative impacts on doctor-patient communication, and liability concerns. To ensure a comprehensive understanding of Digital twins usage in healthcare before widespread adoption, systematic research is essential. Al-generated characters closely resemble humans through the realistic rendering of faces, voices, emotions and behaviours. While they are often associated with misusing this technology for deceptive purposes, they can also be used constructively. One such constructive application in the healthcare context is the creation of Digital Twins of Doctors, a digital replica of a doctor that resembles a real doctor and can help enhance certain parts of the patient's curative journey.

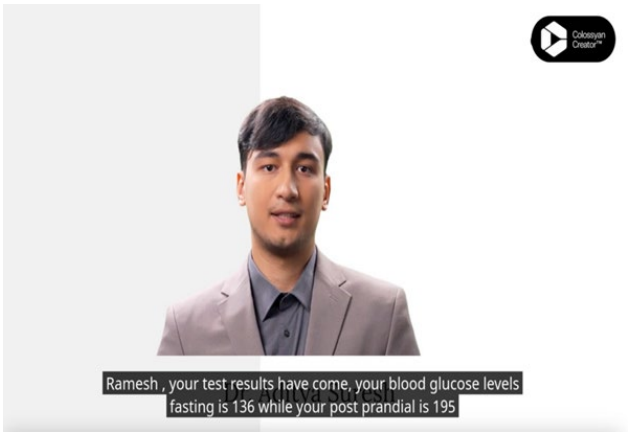

Fig. 2. An awareness video with a doctor digital avatar explaining blood test results

Script used for Pre-Diabetes Use Case Using Dr Aditya Suresh's DTD avatar
Mr. Ramesh, your test results have come. Your blood glucose levels fasting are 136, while your postprandial is 195. You are pre-diabetic, so you need to be on a strict diet and increase your exercise regimen. Cut out all sugary and oily foods, eat lots of green vegetables, and get the exercise needed. You may also consult a nutritionist for the same. Let us review in 12 weeks and see how things are, and then we can decide if we need to start medication.

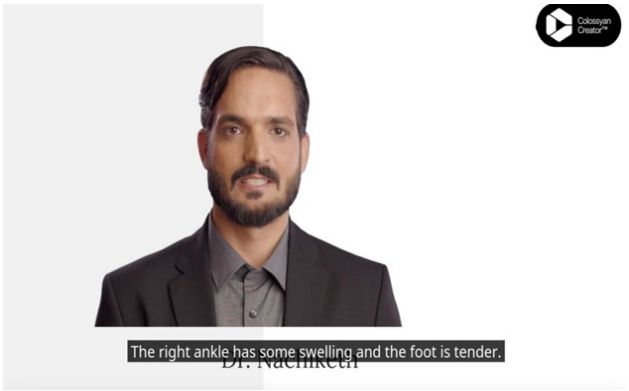

Fig. 3. An awareness video of a doctor digital avatar explaining to a patient who has had a fall

Script used for a Patient Fall and Twisted Ankle Use Case Using Dr. Nachiketh's DTD avatar
Mrs. Meena, I do not see any acute distress, your vital signs are good. Your chest is Clear with a regular heart rate and rhythm, no murmurs. I do not see any oedema in the extremities. The spine is straight, with no significant muscle spasm or tenderness. Both knees appear to be non-traumatic, with no deformity or significant tenderness. The right ankle has some swelling, and the foot is tender. We will place you on some painkillers, and let us review them in a few days. You can call back if there are any problems.

B. Survey Design

- The survey respondents must be doctors, healthcare administrators, medical students, or active patients. Participants were recruited via email and WhatsApp.

In total, 1352 participants participated in the study. The breakdown of survey responses by role is as follows:

- Doctors: 310 responses
- Healthcare Administrators: 339 responses
- Medical Students: 338 responses
- Patients: 358 responses

A sample size of one thousand respondents was chosen as an optimum sample size for a study of this nature. Data collection was completed once the collection date was closed.

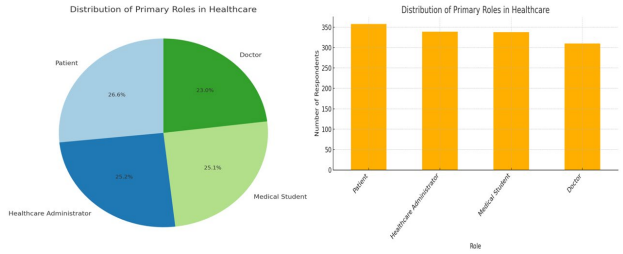

Fig. 4. The breakup of the survey respondents

4. Data Analysis

Surveys were analysed and reviewed for accuracy. Using open-ended questions, a word cloud and thematic analysis (19) were attempted for a few questions; the rest were analysed using statistical models. Thematic analysis is a way to develop, analyse, and interpret patterns across a qualitative data sample while recognising the researcher's subjective perspectives. It typically involves using domain expertise to label content in the survey and then developing themes around the most commonly used content labels. Thematic analysis was used for the questions where the survey respondents' thoughts were asked, while other questions were analysed using statistical inference models.

5. Results

The primary objective of this research is to explore doctors' perspectives on the use of DTDs in clinical settings in India, and all findings will be focused on this.

Benefits of DTD, Technological Feasibility and Desired Features

To evaluate the technological feasibility of integrating digital twin avatars into existing clinical systems, we analysed respondents' perceptions of this technology's most significant benefits and challenges. Figure 1 illustrates the distribution of perceived benefits. Using medical doctors as digital twin avatars in clinical settings in India yielded good insights. This section presents the findings based on the primary research objectives.

The research indicates that digital twin avatars have potential. The most frequently cited benefits include improved time management (374 responses), enhanced patient education (373 responses), enhanced patient engagement (356 responses) and better data analysis (284 responses). Other responses indicate that data integration capabilities for healthcare systems, seamless access to patient records, and sophisticated

language processing algorithms should be critical priorities when cementing DTDs for clinical settings in the Indian context.

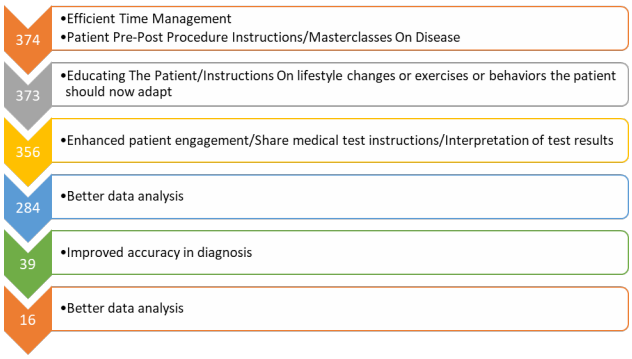

Fig. 5. Bar chart showing "most significant benefits of using digital twin avatars"

The results indicate that respondents see considerable potential in digital twin avatars. The survey responses point to a few factors for a reliable implementation of DTDs in clinical settings in India. The first factor is the Integration of patient data into other existing hospital systems and EMR systems. Equally important will be easy access to patient records and natural language processing capabilities so patients can easily converse and understand what a DTD states and responds to.

However, implementing this technology is challenging. Figure 2 presents the distribution of perceived challenges associated with digital twin avatars. One of the biggest challenges will be exploring human-centred design-based user experiences since the survey responses have highlighted the same. Resistance to staff adoption (358 responses), Technical difficulties in implementation (335 responses), High implementation costs (328) and questions about privacy concerns (326 responses) were highlighted. Future researchers can use these benefits and challenges to build operational plans better when exploring DTD's use in India in a clinical setting.

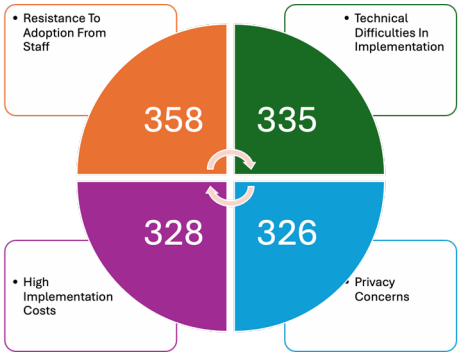

Fig. 6. Bar chart showing most significant challenges in using digital twin avatars

Developing patient perceptions and acceptance of digital avatars should be based on the humanistic design of user experiences. This will be important as the other challenges reflected in survey responses included: (a)The issue of loss of human touch and empathy, (b) Over-algorithmisation and (c) Complexity Adaptable Cases.

A. Patient Perception and Acceptance

To understand the patient's acceptance and willingness to use DTDs and the willingness to accept recommendations made by a DTD, the survey responses indicate a mixed bag, with some patients saying they are not too sure while some stating that it is okay. It is also interesting to note that there was a weak relationship between a doctor or a patient role and their trust in DTDs (correlation coefficient: 0.026374).

Familiarity with the concept of DTDs will help acceptance, which is the inference we can draw from the correlation analysis based on responses (Question 9). There was a slightly positive correlation with familiarity with the concept of DTDs (correlation coefficient: 0.050818).

B. Using DTD's and the Ethical and Legal Issues

Privacy and security were noted 133 times in Question 8 responses. They emerged as long-standing requirements for solid measures in data protection and explicit rules regarding the ethical use of digital twin avatars in healthcare. Data management was named 134 times, and technical issues 108 times. (see Table 1).

Table 1
Word cloud thematic analysis of open-ended questions

Word Cloud	Count
Desired Features in a Digital Twin Avatar System	
clinical'	541
'emr'	280
'(NLP)'	277
Thoughts on Digital Twin Avatars in Healthcare	
'human'	240
'algorithms'	138
'management'	134
'privacy'	133
'24/7'	132
'technical'	108
'complex'	104

C. Clinical Use and DTD's

Another crucial insight is that Careful Integration into existing clinical workflows is necessary to maintain the quality of care; this refers to Integration with existing EMR and HIMS solutions. The survey indicated a preference for 24/7 availability (132 mentions) and improved data management (134 mentions), along with concerns over excessive dependence on algorithms (138 mentions).

According to the word cloud visualisation, respondents feel that this technology has an enormous latent ability to optimise clinical processes and knowledge-based decision support, as explicitly observed through the words used: "clinical," "knowledge," "integration," and "monitoring."

D. Patient Outcomes and Satisfaction

A correlation analysis was done to understand if patient outcomes were related to patient satisfaction when DTDs were used. This shows there is a weak positive correlation (correlation coefficient: 0.011389) between respondents' expectations of when AI-driven avatars would have a noticeable impact on general medicine (Question 10) and their

agreement that the field of general medicine will improve with the introduction of AI (Question 13). The outlook for digital avatars in clinical care seems optimistic.

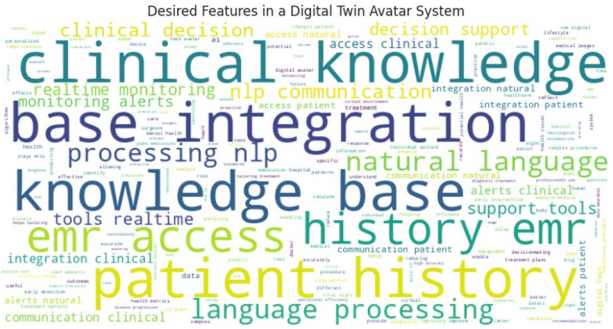

Fig. 7. Word cloud visualization on desired features in a digital twin avatar system

E. Impact of Society and Culture on the Use of DTDs

A word cloud (Figure 5) was generated based on responses to Question 8 to identify the social and cultural aspects of implementing and adopting DTDs. Words included overreliance on algorithms, a need for empathy, touch, and a human connection.

One of the survey's points is that technology solutions like DTDs can only assist doctors and cannot be paramount; the other is that there is still immense value in a physical meeting and establishing a human connection.

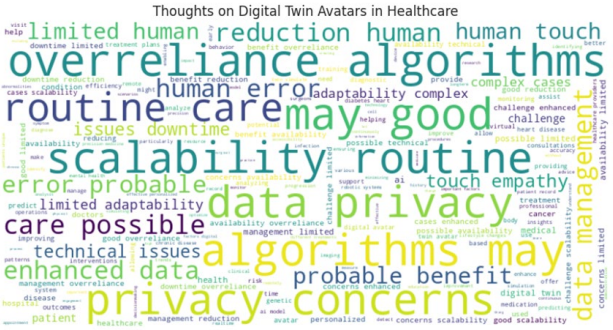

Fig. 8. Thoughts on digital twin avatars in healthcare

F. Cost and Impact of DTD Implementation

There were no specific questions in the survey around costing, but the responses indicated that using DTDs will increase efficiencies in the clinical setup. This suggests that the respondents see costs as insignificant compared to improved patient data management, 24/7 availability, and increased knowledge of various clinical aspects being integrated into the DTD.

G. Doctor Usage of DTD's

The majority of Doctors (310) see good potential benefits in DTDs. A few of them (20) said they would use DTDs immediately if made available to them.

H. Qualitative Analysis - Additional Features Desired and Usage of DTD's

Additional features users would like to see in a digital twin avatar system.

Critical analysis of the open-ended question revealed the following themes. There was a clear preference for using DTDs in clinical settings; Integration with existing healthcare systems would be a game changer. This was elaborated using words like "Clinical Knowledge Base Integration" and "Patient History and EMR Access". (b). There were also interesting points about using natural language processing for more human-like communication and DTDs to provide real-time insights by Integrating clinical decision tools. This was clear from the use of words like "Natural Language Processing (NLP) for Communication" and "Clinical Decision Support Tools and Real-time Insights". (c). Some respondents also indicated that DTDs could be used to automate routine patient engagement tasks, which may help improve patient engagement and efficiency.

I. Feedback on Using Digital Twin Avatars in Healthcare

Critical analysis of the open-ended question revealed the following themes: (a). There were concerns about human touch and empathy because words like "Limited Human Touch and Empathy could be challenging" (b). There were also concerns about technology and its overuse and dependence. This was because words like "Over-reliance on Algorithms may not be good (c)—potential Benefits of Digital Avatars for Doctors.

DTDs in clinical settings offer an excellent opportunity to improve patient care quality and efficiency. They can specifically help reduce errors in diagnosis by being linked to the latest clinical knowledge systems and improve the scalability of clinical practice by being used as a primary screening tool before doctor consultations.

J. Comparison Between Doctors' and Patients Views of DTDs

Comparing the opinions of doctors and patients presents exciting data; for example, both doctors and patients believe DTDs will bring efficiencies, but patients also feel that technical difficulties in setting up and using DTDs and high implementation costs may also bring inefficiencies as shortcuts may be taken in operationalising DTD's. These factors could lead to potential challenges in adopting DTDs in clinical settings. Another area where doctors and patients agree and disagree is the benefits of clinical data integration, insights gained using DTDs, and concerns around data privacy. There is also a concern about the lack of human-centred care while using DTDs as compared to improved clinical outcomes due to DTDs. This comparison reflects differing priorities between patients and doctors when using DTDs.

K. Ethical and Legal Issues to be Considered

Patients, doctors and healthcare administrators have shared significant concerns about data privacy, consent, accountability, and the need for robust regulatory frameworks. The ethical and legal concerns highlight the need for clear guidelines and stringent regulatory measures to protect patient data and ensure the ethical use of digital twin technology. This aligns with the findings of Thomas et al. (2020) on the importance of ethical and legal frameworks in healthcare innovations. Addressing these concerns is essential to building trust and compliance with national and international standards.

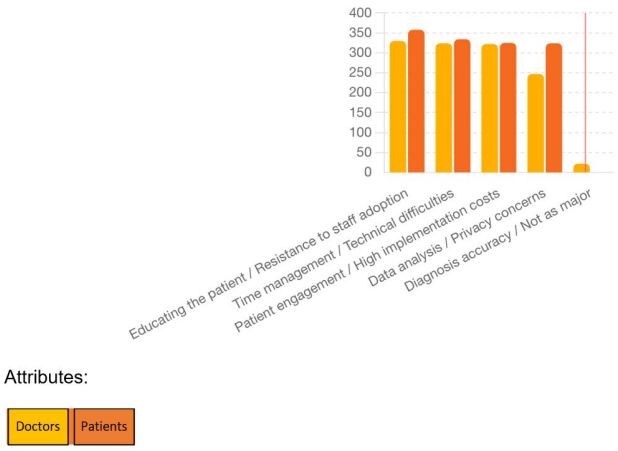

Fig. 9. Patients vs. Doctors perspectives On DTDs

Healthcare administrators perceive more ethical challenges compared to doctors which suggests that administrators focus more on broader ethical considerations, such as data privacy, fairness, or compliance, which impact organisational policies and operations. However, doctors focus more on immediate patient care and clinical outcomes. Addressing these ethical concerns will ensure smooth adoption and trust in new healthcare technologies.

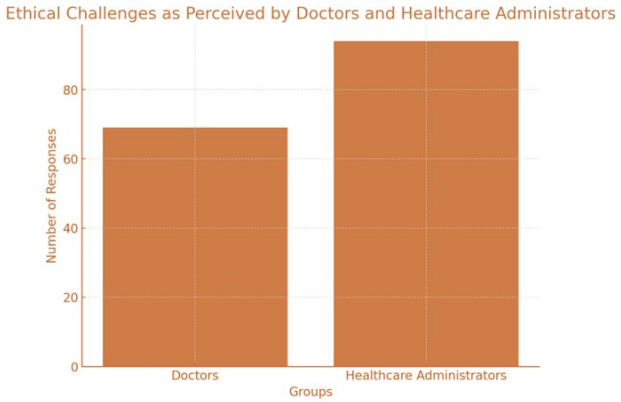

Fig. 10. Ethical challenges as perceived by doctors and healthcare administrators

L. *Impact on Clinical Workflow*

Integrating DTDs will increase efficiency and improve patient outcomes is the view shared by doctors and patients alike. They also believe there will be challenges in adapting to the clinical workflow as it exists presently. The expected improvement in efficiency and patient outcomes suggests that DTDs can significantly enhance clinical operations. However, the challenges in adapting workflows indicate a need for comprehensive Training and support models for healthcare providers, as emphasised by (Heyn et al., 2023). Successful Integration will require careful planning and continuous monitoring to address operational issues in a clinical setting.

Both doctors and healthcare administrators prioritise better patient engagement (143 mentions) and better time management (134 mentions) due to the usage of DTDs. At the same time, doctors and healthcare administrators (122 mentions) also emphasise that a more significant benefit of using DTDs is significantly better data analysis. Doctors believe DTDs will help improve patient engagement and care aspects, while healthcare administrators believe that using DTDs will enhance decision-making by making it more data-driven. However, doctors and healthcare administrators believe that DTDs will improve time management and patient education. At the same time, a smaller number see that using DTDs will improve the accuracy of diagnosis.

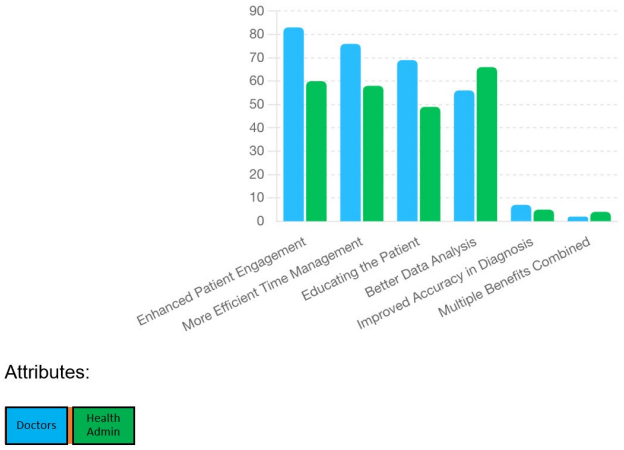

Fig. 11. DTDs impact on clinical workflow as perceived by doctors and healthcare administrators

M. *Cost-Effectiveness*

The relevant stakeholders believe there could be a positive cost-benefit ratio, with significant savings in patient travel and operational costs for healthcare providers, especially in rural India. Long-term savings could offset the initial high-technology implementation costs, making it a viable option for improving healthcare delivery. This economic benefit can encourage broader adoption and investment in digital twin technology.

Doctors and healthcare administrators view high implementation costs as a significant economic challenge, with healthcare administrators expressing slightly more concern about the financial burden of implementing digital twin avatars in Healthcare. Both recognise the importance of economic impact, with healthcare administrators giving it slightly more attention. This suggests that administrators are more focused on the financial feasibility of adopting digital avatars, while doctors also acknowledge the cost aspect but prioritise other operational or patient-related factors

N. *Cultural and Socioeconomic Factors*

Cultural acceptance will vary significantly across different regions of India, with higher acceptance in urban areas than in rural areas. The variation in acceptance highlights the influence of cultural and socioeconomic factors on technology adoption. Efforts to promote digital twin avatars must consider these differences and tailor strategies to address specific regional and cultural contexts. A first step in this direction will be enhancing digital literacy for broader acceptance and use.

Many doctors are optimistic about patient acceptance; many believe it is situational, reflecting variability based on context

or individual patient preferences. Some scepticism is also evident, with a considerable portion expressing doubts about acceptance.

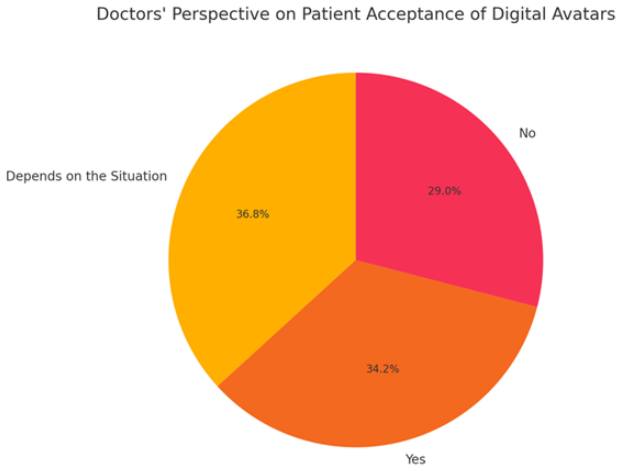

Fig. 12. Patient's acceptance of DTD's as per doctors

Many patients are open to the idea of DTDs, but acceptance is highly context-dependent. Many patients are supportive, though a noteworthy group is reluctant, emphasising the importance of thoughtful implementation tailored to individual needs and circumstances.

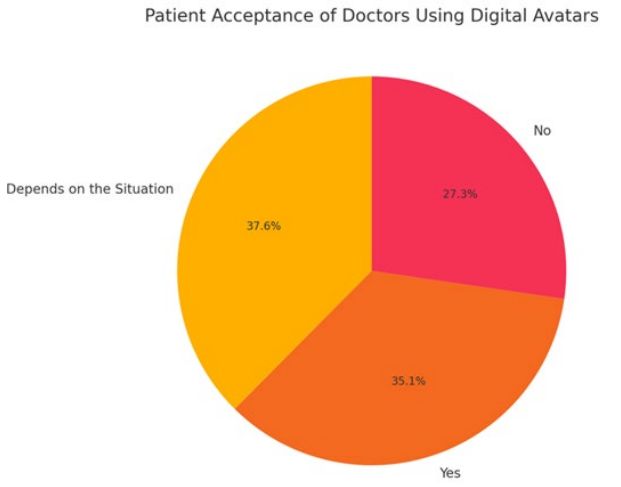

Fig. 13. Patient's acceptance of DTD's as per patients

O. Analysis and Interpretation

The Study indicates a generally positive outlook towards using digital twin avatars in clinical settings in India, with notable improvements in efficiency and patient satisfaction. However, ethical, legal, and cultural considerations require careful attention. Tailored strategies that consider regional differences and provide robust support for healthcare providers and patients are essential for the sustainable adoption of digital twin avatars.

6. Implications of the Study

A. Healthcare Delivery and Access to Care

Healthcare delivery and access to care will be improved due to 24x7 technology access. Digital twin avatars can significantly enhance access to healthcare services, particularly in remote and underserved areas of India. These avatars can bridge the gap between healthcare providers and patients who lack easy access to medical facilities by providing virtual consultations. Digital twin avatars can also ensure continuity of care by maintaining comprehensive patient records and providing consistent follow-up, which is crucial for managing chronic conditions and improving overall health outcomes.

1) Efficiency and Cost-Effectiveness

The healthcare infrastructure will improve operational efficiency as integrating digital twin avatars can streamline clinical workflows, reduce administrative burdens, and enhance the efficiency of healthcare delivery. This can lead to faster patient processing times and improved resource utilisation. It can reduce patient travel costs, minimise in-person visits, and optimise resource use; digital twin technology can make Healthcare more affordable and sustainable.

2) Patient Engagement and Satisfaction

Digital twin avatars will improve patient care and engagement by providing interactive and personalised healthcare experiences. Patients can access health information, receive tailored advice, and engage in proactive health management, leading to higher satisfaction levels. The convenience and accessibility of virtual consultations can improve patient satisfaction, particularly among those with mobility issues or those residing in remote areas. This can lead to better adherence to treatment plans and improved health outcomes.

3) Ethical and Legal Frameworks

Robust legal and ethical guidelines and frameworks will need to be put in place to address concerns related to data privacy, Consent, and accountability. Clear guidelines and regulations are essential to ensure the fair and ethical use of digital twin technology and protect patient rights. Policymakers must prioritise establishing regulations that govern the use of digital health technologies. This includes creating standards for data security, defining the scope of use, and ensuring compliance with national and international laws (India Data Privacy Act).

4) Cultural and Socioeconomic Considerations

DTDs adoption will have to consider the diversity of India's culture and social mores, as well as the varying levels of literacy and digital literacy. Tailored strategies that address regional and cultural differences are crucial for achieving widespread acceptance and effective implementation of digital twin avatars. Educational initiatives and Training programs can help bridge the digital divide and ensure all stakeholders can use and benefit from the technology.

7. Research Summary Notes

Doctor's and Healthcare Administrators View on DTDs

The study findings on doctors using DTDs revolve around a few themes: (a) accuracy and appropriateness of information

shared by DTDs, (b) using DTDs only for information sharing, (c) selective utilisation of DTDs during patient engagement, and (d) transparency around usage of DTDs. One of the other types of feedback received was that for better patient acceptance and engagement, it would be important that the DTD resembles the doctor closely.

A. Using Digital Twins for Doctors as an Information Sharing Mechanism

The information shared by DTDs should follow all prescribed medical standards and guidelines, and information quality has to be maintained. Doctors felt that the accuracy of information generated automatically needs to be managed, and hence, pre-scripted content for DTDs could be a way forward. The challenge with this approach is the time demands placed on the doctors to develop this, and it may challenge the time-saving benefits that DTDs are supposed to bring to the clinical setting. Similar concerns were around DTDs sharing information from sources that doctors disagree with. There was a strong view that DTDs could be used for information sharing only as that would help avoid any legal issues concerning using DTDs and sharing information.

B. Digital Twins for Doctors Should be Used in Only Selective Use Cases

The other perspective doctors have shared is the need to use DTD in selective cases. This is because they believe certain patient information must be shared empathetically and humanely, and DTDs cannot do the job. DTDs will not fit into certain areas of medical care, especially in cases where patient sharing information will be specific to the patient and unique in terms of content. This was another feedback that was shared.

C. Digital Twins for Doctors Usage Should be Clearly Defined

Transparency about the information-sharing process will be essential, especially when done by DTDs. Doctors believe that the accuracy and appropriateness of the information provided to each patient need to be vetted by a doctor and shared with them so that they are aware of what information the DTD has shared with the patient.

D. Digital Twins for Doctors and Patient Perspective

New Technology always takes time for patients to adjust and get used to, which doctors feel is essential to be aware of. Some doctors felt that patients might have a negative opinion about DTDs, especially during the early adoption phase, as it shortens the time spent with doctors and requires using technology. Another reason could be the fear that doctors could overuse this technology and significantly limit patient interaction time. Some other doctors believe that patients may appreciate the convenience and accessibility it provides, given that doctors are extremely busy and offer short-duration face-to-face interactions. The general belief is that DTDs will positively influence healthcare systems once the technology matures.

E. Willingness to Use DTD's

Doctors were open about their willingness to use DTDs in clinical practice, provided costs and implementation challenges, and created patient awareness. The broad idea was that DTDs would supplement doctors' efforts in patient engagement and care, leading to better patient care and better medical treatment due to the Integration of DTDs with clinical systems.

8. Discussion

The present research study is amongst the first to explore doctors' and other stakeholders' perceptions of using DTDs in healthcare in clinical settings in India.

The findings from this study will expand the work done in the past on exploring doctors' views and perceptions of conversational technologies, a similar type of technology assist tool using chatbots and conversational agents (20).

This research study's findings also address typical challenges in a developing country like India, where the doctor-patient ratio is skewed. Building tools to help doctors balance their work will be extremely helpful and will lead to changes in community medicine models. Future research will use this work to focus on critical issues raised in this study to further research and implement DTDs in India.

The findings from this study will broaden existing literature on using AI in healthcare and will specifically help build empirical implementation models in developing countries. As discussed in the research findings, There is a good chance that the credibility of information shared with patients for their care is a significant benefit and may reassure patients about their medical care. There are also specific opportunities for personalised care, as DTDs can mimic the doctors' physical attributes and voice and help patients receive information.

However, another approach could be using a non-familiar DTD to share basic medical and care information, given that a DTD with sufficient personalisation of a human should be able to replace a human doctor in certain aspects of patient engagement and care. For example, prior work has used conversational agents to perform similar patient care tasks in the healthcare domain, such as explaining healthcare processes or guidelines or discussing preventive care procedures (21). Hence, reviewing if a doctor's DTD is better than a random humanistic DTD is essential to research. There are also challenges around DTDs sharing incorrect information due to wrong sources or interpretation of clinical systems, which could pose legal challenges that must be evaluated.

Defining specific use cases for implementing DTDs may be necessary as sources of information, and sharing unverified information may lead to many operational challenges for a doctor's health, care administrators, and patients. Past research has shown that in the healthcare sector, there are various issues with the content and information shared by chatbots and other similar software, and current practices to address these information issues involve using credible health and medical information sources and involving healthcare experts and practitioners [22].

This also applies to using LLMs in healthcare [23], where data generated by an LLM may not be verified, which may be a challenge, especially in medicine. Healthcare ecosystem stakeholders' perspectives should be considered when

designing authoring and content management tools for developing content to be used by large language models for generative AI or Digital Twins.

Much research and study has been done on creating and adopting software agents and artificial intelligence-generated software characters [24]. However, stakeholders' reactions to using AI-generated characters vary, ranging from curiosity, interest, and amusement to fear and distrust.

Our findings expand on this by comparing the current state of sharing SMS messages or using phones or paper to share medical care information with a more personable approach of using a familiar-looking DTD, which patients may benefit from. The flip side is the overuse of DTDs, which may reduce doctor-patient communication and is already a concern in existing patient care [25]. In addition, some patients may need more knowledge of technology, and some may mistake DTDs for real doctors. Researchers must develop guidelines for creating awareness to avoid confusion and manage patients' expectations. There has to be a focused study on perceptions and challenges with DTDs from a patient stakeholder standpoint [26], and the findings should be used in the design and development of DTDs.

9. A Proposed Approach Towards Implementing DTD's in India

Implementing digital twins of doctors to support clinicians in clinical settings in India involves several key steps that address both the technical and operational challenges unique to the healthcare landscape in India. A digital twin in this context would be a virtual representation of a doctor, incorporating their medical expertise, decision-making patterns, and clinical history to assist in patient care, reduce administrative burden, and improve clinical outcomes and help in patient care and patient management.

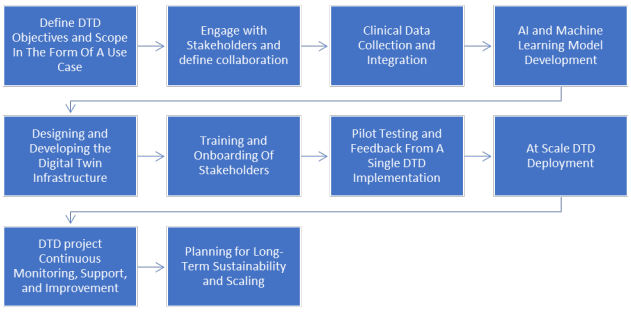

Fig. 14. A proposed approach towards implementing DTD's in India

1) Define DTD Objectives and Scope in The Form of a Use Case

- *Objectives*: Clearly define the objectives of using digital twins. For example:
  - Assist in decision-making by providing real-time recommendations.
  - Reduce burnout by automating repetitive administrative tasks.
  - Enhance training and continuous learning for medical professionals.
- *Clarify Scope of Implementation:* Decide the scope of the initial rollout (e.g., specific specialties, urban vs. rural, public vs. private hospitals).
- *Define Outcomes in form of Metrics:* Establish clear metrics for success (e.g., improvements in patient outcomes, reduced errors, improved doctor-patient communication, reduced workload, etc.).

2) Engage with Stakeholders and define collaboration

- *Engage with Healthcare Providers:* Work closely with hospitals, healthcare systems, and doctors to understand their needs, challenges, and expectations from the digital twin system.
- *Collaboration with Government and Regulators:* Partner with health authorities (Ministry of Health and Family Welfare, NITI Aayog) to ensure compliance with health regulations, data privacy laws (e.g., India's Personal Data Protection Bill), and standards.
- *Partnerships with Technology Providers:* Collaborate with tech companies (AI, machine learning, cloud computing providers) to develop the required infrastructure.

3) Clinical Data Collection and Integration

- *Clinical Data Acquisition:* Collect data on doctor's past clinical decisions, diagnoses, treatments, patient interactions, and performance metrics. This can be gathered through doctor logs, discharge summaries, electronic health records (EHR) and clinical decision support systems if available.
- *Data from Wearables and IoT Devices:* Incorporate real-time data from wearables and medical devices that monitor patient health metrics (e.g., vital signs, lab results) to feed into the digital twin.
- *Medical Knowledge Database:* Integrate medical guidelines, research, and clinical protocols from trusted sources (e.g., medical journals, best practice guidelines).
- *Patient Data:* Collect anonymized patient data (subject to privacy concerns) to create profiles that are consistent with the doctor's usual practice.

4) AI and Machine Learning Model Development

- *Knowledge Model:* Create an AI model that represents the doctor's clinical expertise, decision-making processes, and personal preferences. This can include:
  - Diagnostic patterns (e.g., how a doctor diagnoses diseases based on symptoms, tests, and medical history).
  - Treatment approaches (e.g., prescribing patterns, decision thresholds).
  - Communication styles (e.g., preferred ways of explaining medical conditions to patients).
- *Training the Digital Twin:* Use supervised learning from historical data (clinical records) to train the AI to replicate the doctor's decision-making. Reinforce this model with continuous learning to reflect evolving medical practices.

- *Data Privacy and Security:* Implement robust security measures to protect sensitive health data, complying with Indian data privacy laws (e.g., the Personal Data Protection Bill).
- *Informed Consent:* Ensure transparency with patients about the use of digital twin technology in their treatment process.
- *Bias and Fairness:* Ensure that AI models are free from bias, reflecting diverse patient demographics and reducing the risk of algorithmic discrimination.
- *Regulatory Compliance:* Ensure compliance with Indian healthcare regulations, medical device laws, and AI ethics standards.
- *Simulation and Testing:* Before full deployment, test the digital twin on anonymized patient cases to verify that it accurately mimics the doctor's clinical decisions.

5) Designing and Developing the Digital Twin Infrastructure

- *Cloud Infrastructure:* Set up a secure cloud-based platform for hosting the digital twin, ensuring scalability and data security (following Indian data protection laws).
- *Real-Time Data Integration:* Ensure the digital twin can integrate real-time data from patient records, clinical systems, wearables, and other medical devices.
- *Interactive Interface:* Develop user-friendly dashboards for doctors to interact with the digital twin. This could include:
    - Clinical decision support tools (e.g., treatment recommendations, alerts for potential misdiagnosis).
    - Workflow support tools (e.g., automated reminders for patient follow-up, administrative task automation).
- *Mobile Application or Integration:* Enable mobile access for doctors, especially in remote areas where hospital infrastructure may not be as robust.

6) Training and Onboarding of Stakeholders

- *Doctor Training:* Provide training programs for doctors to understand how to effectively use the digital twin. This may involve hands-on training and e-learning modules.
- *Medical Staff Awareness:* Train other medical staff (nurses, technicians) on how the digital twin can be used to improve patient care, streamline workflows, and reduce administrative burdens.
- *Patient Communication:* Introduce patients to the concept of the digital twin (i.e., how their treatment may be supported by AI models, ensuring trust and transparency).

7) Pilot Testing and Feedback from a Single DTD Implementation

- *Pilot Deployment*: Conduct pilot testing in a controlled environment (e.g., one hospital or clinic) to assess the digital twin's performance, user adoption, and impact on clinical outcomes.
- *Monitor Effectiveness:* Use feedback from doctors and patients to evaluate the success of the system and identify areas for improvement (e.g., accuracy of diagnosis, reduction in errors, time savings).
- *Iterative Improvement:* Use iterative cycles to refine the model based on real-world performance, adding new data and improving AI algorithms.

8) At Scale DTD Deployment

- *Gradual Rollout:* Expand the digital twin system to more hospitals, clinics, and specialties, gradually scaling based on the feedback from the pilot phase.
- *Address Regional Variations:* Customize the system for regional variations in medical practices, available resources, and patient demographics.
- *Support for Rural Areas:* Ensure that rural healthcare systems are supported through telemedicine integration and lightweight versions of the digital twin that work on low-bandwidth networks.

9) DTD Project Continuous Monitoring, Support, and Improvement

- *Ongoing Evaluation:* Continuously monitor the system's impact on patient care, doctor performance, and system efficiency.
- *Medical Guidelines Updates:* Regularly update the digital twin's knowledge base to reflect the latest clinical guidelines, research, and technology advances.
- *User Feedback:* Maintain open channels for feedback from both doctors and patients to enhance the system further.
- *AI Monitoring and Ethical Oversight:* Ensure that the digital twin is ethically aligned with medical standards and monitored for any biases in decision-making.

10) Planning for Long-Term Sustainability and Scaling

- *Funding and Partnerships:* Explore funding models (government grants, partnerships with NGOs, public-private partnerships) to ensure long-term sustainability.
- *Scalability:* Plan for scaling the system across India's healthcare system, keeping in mind the resource challenges in rural areas.
- *Integration with National Health Infrastructure:* Eventually, integrate the digital twin with India's national health platforms like Ayushman Bharat or the National Health Stack.

This process will help develop and implement digital twins for doctors in India, making clinical decision-making more efficient and supporting doctors in their everyday work. This approach can help reduce healthcare disparities, enhance doctor-patient relationships, and improve overall healthcare delivery across the country.

10. Limitations of the Research Study on DTDs and Future Consideration

This research study on the use of DTDs in clinical settings in

India is a unique undertaking, but it has limitations around the scope of work. Firstly, the video in the interview was not a digital replica of a doctor; doctors and other stakeholders were asked to imagine if a similar video was created using the doctor. Given that the study was done using a survey, the approach included creating an awareness video on DTD and then creating two use cases of a DTD addressing a pre-diabetic case and a patient fall case; there could still be gaps in terms of understanding the holistic engagement and impact of DTD's for the survey participant.

Participants may view DTDs as applicable for similar use cases or may view them based on their past knowledge of DTDs, either through their research or their learning. Hence, this video approach will need to be validated from a sentiment and prior bias standpoint as well into the future. A more concerted effort using the findings from this study could be used to do a more well-rounded study around the content shown and its impact on the use of DTDs as well.

11. Conclusion

In conclusion, DTDs have many benefits and can significantly improve healthcare systems by improving clinical outcomes, patient engagement and care. They can also free up doctors' time by enabling using of DTDs as primary screening tools before doctor consults and performing the role of an able assistant to the medical doctor. Some challenges need to be addressed. They include being diligent in-patient privacy, confidentiality, and ethics around using AI by obtaining all stakeholders' consent. Integration with existing healthcare systems and easy access is another significant operational challenge that must be overcome.

This study also showcases that doctors, patients, and healthcare administrators must be involved in designing, developing and deploying DTDs in clinical settings. It is also clear that the same stakeholders must be involved in designing and developing content that large learning models and conversational agents could use in healthcare settings.

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