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Gen AI in Healthcare Technology: Crafting Virtual Health Assistants for Patient Engagement

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Generative Artificial Intelligence (Gen AI) is rapidly altering the world, and healthcare technology is no exception. Gen AI applications are potentially poised to provide patients and providers with varied interactive experiences through accurate and scalable patient-facing virtual health assistant platforms. This paper investigates the design and development of patient-facing virtual health assistants to assess whether Gen AI can facilitate patient engagement. We also constructed use cases for the combined use of Gen AI and virtual health assistants to stimulate and aid further research and development in the field. Despite the rapid evolution of technology in healthcare and its growing use across the globe, it is not well known, let alone properly understood, how virtual health assistants can be designed and developed. In a scoping review, we find that virtual health assistants are feasible, provide promising patient engagement, are accepted by providers and patients to a certain extent, and that further research should focus on gamification, integration, intelligent responses, synchronized patient/emergency and health record information, and analytics incorporation to commence the move towards more advanced, user-friendly, and intelligent virtual health assistants. Recommendations for future virtual health assistant development were made following the findings. Of particular interest, dual studies of virtual health assistants and Gen AI operating in unison will ensure virtual health assistants can develop meaningful and relevant additional capabilities to facilitate patients' understanding, communication, and engagement in making their shared decisions with providers. By focusing on healthcare, we provide a blend of clinical and business perspectives to shape the future of Gen AI innovation and ethics in a meaningful, conscious, and pragmatic way for human well-being. We are discussing the various digital virtual assistant uses for patients across the continuum of care.

Keywords: Generative AI, Healthcare Technology, Virtual Health Assistants,

Patient Engagement, Scalable Platforms, Interactive Experiences, Gamification, Intelligent Responses, Emergency Synchronization, Health Record Integration, Analytics Incorporation, Design and Development, Shared Decision-Making, Clinical Perspectives, Business Perspectives, Ethical Innovation, Patient Communication, Unison Studies, Technology Evolution, Continuum of Care.

1. Introduction

Matá, Slovak Republic, 24 June 2021

In recent years, virtual health assistants have progressively entered the area of healthcare technology. They connect AI technology with patients to achieve better patient engagement and improved access to healthcare services. Advanced patient participation is possible due to digitalization and virtualization in healthcare. Virtual health assistants contribute by enhancing patient uptake and involvement in participating in different service offers or products within healthcare more easily, as there are no physical or geographical limits. There are five generations of AI workforces – Gen AIs (termed Generation AI) aimed at different targets. The focus is on Gen AI type III, virtual assistants to engage patients and clients in their healthcare, i.e., improving patient-opted services nowadays.

Despite the knowledge about the knowledge-based society, salutogenesis, or the e-health society that increases service participation and is a key goal of e-health services, it is still valid that healthcare is one of the industries many years behind those enabling these transformations. The research question is, then: "Can we use the latest Gen AI technology VHA to provide complex healthcare using the skills available within the industry mixed with natural speech to engage patients and offer them a new way of participating in their healthcare by opening a new type of healthcare-oriented industry?" The role of such VHAs is still a matter of interpretation. The existing literature provides an overview of the various approaches and limitations identified in this area because VHAs can be built in many ways, ranging from providers of medical data and helping to find health facilities to psychological applications that interact with patients and can follow up with them. The number of such types of approaches is limited.

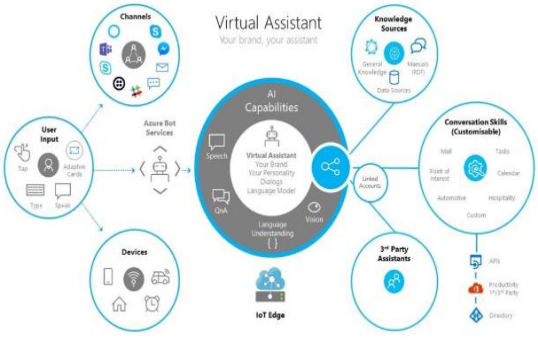

Fig 1 : Generative AI in Healthcare Technologies.

1.1. Background and Significance

Growing demand for quality healthcare, particularly for chronic condition management, has encouraged more stakeholders in the health sector to invest and innovate in the field of healthcare technology. In line with the increasing preference for patient-centered care, AI technologies rely on large volumes of data to offer just-in-time communication with patients in real-time. Semantic processing has been applied to sentiment analysis of patient data from social networks. AI chatbots help patients diagnose and treat common health problems. Many apps are available that use chatbots for patient care. New mobile health applications utilize chatbots to assist people who want to quit smoking, manage their weight, reduce stress levels, improve sleep patterns, and maintain a healthy diet. More chatbots are likely to join the ranks of virtual health coaches to provide remote patient care. The technology blurs the line between human relationships and patient-clinician digital encounters in healthcare, allowing for more connected and continuous care.

Patient engagement is a vital component of successful healthcare delivery and a driver of both health and care outcomes. Industry stakeholders are investing significantly in the development of evidence-based digital solutions that support the full patient journey within specific therapeutic areas. These digital platforms and devices enable constant touchpoints with patients and routine monitoring, and the data they yield offer valuable patient insights and opportunities for strategic market advancements. Such customized interactions with patients, delivered at a scalable level, address demands not currently being met within the healthcare industry. As the management of long-term conditions and focus on outcomes increases, so do tech firm purchases of health tech brands. Among the brands the public thinks are changing the health landscape, new entries are illustrating a well-known move of the tech industry into healthcare. Technology has the power to revolutionize the healthcare experience by improving the ability of those who provide care to personally engage with actual or potential patients. It also has the power to proliferate the concept of an integrated and multidisciplinary healthcare team to a much larger population of patients. Actual patient experiences from such programs show that just-past or even real-time communication is not just informational but provides emotional support as well.

1.2. Purpose of the Research

From a patient-centric standpoint, a relevant question has come to the fore, related to the contribution of Gen AI through virtual health assistants to facilitate the engagement of patients in healthcare services. The purpose of this research inquiry is to answer the subsequent overarching question: What role does Gen AI have in making patients engage more with the logical health interface of virtual health assistants? Furthermore, the study has the following specific objectives: 1) To investigate the influence of AI on delivering technology and the interactivity functionalities to patients in healthcare delivery institutions of the present times; 2) To understand the real use of digital technology with AI functioning by the existing engaged patients in healthcare delivery settings; 3) To share clear and strong usability suggestions to design the virtual health interfaces of health tech apps based on human-centric values.

AI has now become an essential tool in healthcare operations, helping to process an enormous amount of data containing signal and non-signal information. In addition, the delivered patient interactions are adding benefits beyond patient diagnosis as the front-line receiver. Effective

factors explain why virtual AI health services are dexterous in managing patient engagement effectively and statically since patient engagement has become an ultimate utility to forging a solid healthcare delivery system. Gen AI works with an application of AI healthcare by making embedded technology with an AI backend. Nonetheless, embedded virtual health assistant technology meets the satisfaction of health services delivery since it offers a quick in-and-out experience for the medical health player. Therefore, for managers of health tech, it has become a new frontier to understand the real patient attitudes, either as satisfaction or needs, that should be shared since the experience should inform good and wise practices to run AI innovative practices. To exhibit informed insights, the investigation has embraced medical patients with data gathered through a systematic survey period. The results extracted will offer practical gaps and value activities that can be exploited beneficially by researchers and managerial staff within a healthcare setting. The recommendations will focus on the precise actions required to reconstruct the AI elements inside and outside a new health interface.

Equation 1 : Intent Recognition in Patient Interaction (Natural Language Processing)

$$I = \text{argmax}\left(W_{\text{intent}} \cdot \text{Emb}(S) + b_{\text{intent}}\right)$$

I: Predicted intent,

W_{intent}: Weight matrix,

$\text{Emb}(S)$: Embedded input sentence,

b_{intent}: Bias term.

2. Understanding Gen AI in Healthcare Technology

Generative AI is a rapidly evolving field in its conception and has gained prominence in recent years. The idea of general intelligence among artificial beings harkens back to science fiction narratives, already holding notoriety before the era of omnipresent AI. While we might think of "general intelligence" as encompassing all cognitive functions employed by humans, in the context of Generative AI, this term has a rather specific implementation. Generative AI encompasses the generation of complex systems and can be applied to generate data. Potentially, powerful tools may expand the limited capabilities of current data extractions. Currently, many tools designed to sort, generate, and analyze data have limited decision-making and learning capabilities. Newer tools offer forms of data generation: recurrent neural networks, generative adversarial networks, long short-term memory networks, and query-based language models. As these systems mature, a limited few are designed for or maturing into functional tools within healthcare technology. Applications range from assisting with diagnostics, clinical evidence generation, treatment planning, and patient management. Several trends separate Generative AI from simply using AI to generate data. There are significantly longer time requirements for development, often requiring massive data sets along with large computational power, hybrid technologies, and crowdsourcing efforts. Research has shown some level of skepticism regarding utility as the return on investment can potentially be limiting. Despite this, real-world use cases of Generative AI show striking

results. Generative AI has been used in genomics to assess potential future outbreaks, long-term weather predictions, and the assessment and behavioral analysis of organs. When applied to healthcare technology, these tools have shown themselves to be influential and powerful adjuncts to the traditional dataset and information management systems often in use today.

The outcome of AI in the sphere of healthcare improves at different rates. Arguably, the placement of various AI implementations depends on the complexity and usefulness of the tools, but also on the demand for when such tools can be woven into health technologies. The very limited set of tools used is conceivable as more mature and useful: population analytics and decision frameworks, chatbots, scheduling, and logistics. Recently, significant strides in Generative AI have started to enter the healthcare space in the form of the Virtual Health Assistant. While not fully understood, virtual health assistants have the potential to reshape operational efficiencies and communications with patients. Traditional chatbots can only do so much. They require new programming modules, scripts, or backing to engage and present themselves as human-adjacent. These systems depend on conversation trees or path points to direct interactions. Matching NLP and AI allows architectures to parse, understand, and suggest diagnoses. In several cases, these tools are seen as functioning as complex scheduling and logistics optimization tools. Barely any health assistants and Generative AI-designed tools exist in the world, but the transformation and impact are only now felt as applications begin to reach the general public. Even in its relative infancy, relatively mature uses of Generative AI in a healthcare setting yield points of truth for the positive consumer sentiment and efficacy of the tools in virtual health assistant systems. These complexities emerge from systems that are no longer one-off profitable case bases but are beginning to iterate and diversify with applications moving beyond simple data generation into more complex experience management.

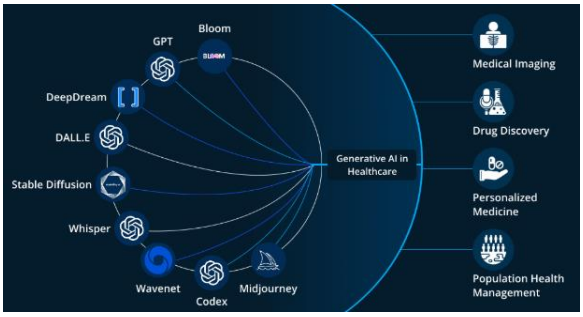

Fig 2 : Generative AI in healthcare applications.

2.1. Definition and Characteristics of Gen AI

Generative AI can be thought of as the following: it creates content, either textual, visual, audio or a combination. It can learn and create from interactions with humans and can use data to make insights and predictions. Existing algorithms of Generative AI in the healthcare space have mostly been in the literature using patient interviews and in hospitals providing patient options. However, virtual assistants that utilize Generative AI have not been integrated into healthcare systems as a main resource. These virtual assistants for healthcare provide significant opportunities as they can serve as the first point of contact, providing each patient with the attention and individualized assistance they need. This review focuses on defining

and understanding the use of Generative AI in the context of healthcare and freeing up human resources.

Generative AI is capable of personal content creation. It does not rely heavily on programming, nor does it follow merely pre-designed data pathways. It is multi-vetted and can be unsupervised, supervised, or semi-supervised. Generative AIs have the characteristics of being an adaptable system or plan, adjusting to new, differing, or opposed conditions either in materials or devices. The priority of the system changes when needed. They also have the capacity for something to be changed or enlarged but still be able to function well. Moreover, with a set of resources that reach quickly and easily to a larger scale, efficiency and cost are maintained. In healthcare, Generative AI allows for efficient tailoring to patients' needs. Knowledge gained from patient interactions can be easily transcribed and adapted as the system learns. Data can be collected and analyzed in various aspects of tasks. It further allows for insight into patient volumes, patient options, patient preferences, and in real-time as decisions occur.

2.2. Applications of Gen AI in Healthcare

Gen AI encompasses a wide array of tools, platforms, and techniques that can be used to harness and produce medical data, content, and features. Some applications include:

● Diagnostic support - This cluster positions Gen AI to diagnose diseases, distill a differential diagnosis, and suggest clinical actions.

● Treatment recommendations - Gen AI models can propose therapies, medications, or even generate treatment regimens.

● Personalized or tailored patient interactions - Chatbots and conversational agents that enable the possibility of the "virtual health assistant."

● Exploiting EHR data - Applications that create, synthesize, or query structured data leveraging existing repositories of patient information or queries.

Of note, ongoing work has demonstrated the efficacy of using medical content generated using deep learning across medical imaging as well as medical text, also making the benefit of "fast prototyping" easier to demonstrate for contextual simulation. There are many benefits of using these forms of AI in healthcare. Gen AI can provide an efficient, effective way to add context to a patient encounter. Chatbot use in the healthcare sector is of interest, particularly in the empowered consumer era. There is uncertainty around the technology. The ability to perform more real-time conversational AI research into patient experience in updated electronic health record environments is of growing interest for new research and development. The details and specifics of patient interactions, and how chatbots can support these activities, are of keen interest and unexplored territories in healthcare.

3. Virtual Health Assistants: The Evolution of Patient Engagement

At first, these AI virtual assistants appeared as chatbots embedded in healthcare providers' websites, asking patients if they would like to subscribe to the clinic's newsletter or to book an appointment. However this digital trend has evolved, and virtual health assistants, or virtual

nursing companions, are now part of several companies' digital health strategies. They can serve as wellness coaches, help patients manage chronic diseases, monitor their health status, or answer clinical questions about patients' conditions. They also provide follow-up and medication adherence nurturing, or even scheduling aftercare services. They are conversational technologies people use, naturally, enabling true quality conversations. This new set of digital healthcare resources makes clinical advice available at patients' fingertips, easily accessible, promoting engagement and stimulating health risk management initiatives.

The top five technology systems that can drive patient engagement are e-learning systems, mobile health monitoring devices, customer relationship management tools, virtual health assistants, and patient data analytics technology. It is commonly included in patient outreach systems, together with pre-visit communications, post-visit feedback surveys, lead management systems, care path tools, and reminders. As organizations engage more with digital healthcare services, incorporating telemedicine technologies and wearable monitoring tools, the virtual assistant will become key in coaching patients to adopt these remote healthcare systems. These digital staff are part of digital health transformation plans that can bring down costs, humanize care, enhance patient outcomes, and help providers achieve real scale in a booming market.

Fig 3 : Virtual Healthcare Assistants.

3.1. Definition and Functions of Virtual Health Assistants

Patients' need for around-the-clock information and support can be addressed using AI-driven tools. Virtual health assistants, often referred to as chatbots, conversational agents, or digital health companions, are holistic software systems with healthcare competence, able to empower individuals by providing personalized, reliable, text-based information and reminders. Virtual health assistants can inform, support, encourage, and empower patients in disease monitoring or management. They can provide pertinent, evidence-based health information and education, serve timely personalized reminders or notifications, recall patient information and records, or digital care plans, support health behavior change, offer personalized feedback, and assist in self-management. Furthermore, they can support referrals to the appropriate care levels or healthcare providers, serving as patient navigators, scheduling appointments, preparing or activating patients before their scheduled visits, and advancing patient-provider communication. They also embody patients' emotional and social factors that greatly impact health, providing emotional and mental support, and encouragement to reduce

loneliness during crisis periods. As a new generation, chatbots are conversational and contextual; these virtual personalized assistants tailor information to users' concerns and reply to users' specific inquiries. In summary, chatbots go beyond providing information and become digital health and well-being care partners available 24/7.

Support for Patient Engagement

Patient engagement is an individual's meaningful involvement in self-motivated health-related tasks, including not just informed decision-making, communication, and action, but also informed behavior change and informed partnerships with health professionals. Health assistants can support patient engagement and satisfaction in multiple roles: they educate, inform, empower, activate, and coach patients and serve as patient portals, patient navigators, and scheduling assistants. Patients appreciate talking to conversational agents, accept the accuracy of the given information, and find the use of chatbots suitable within electronic health systems. Provided key functions are serving as patient-centric health information sources and personal assistants. However, such intelligent systems have their limitations, as some feel uncomfortable with the robot-like approach and others find it time-consuming, while concerns are also expressed about patient health literacy. Additionally, the development of ICT and the advancement of AI allowed the introduction of a subcategory of health assistants: virtual personal assistants or conversational agents. Minimum ICT competencies required are the possession of an electronic device and Internet connectivity, while most virtual health assistants are integrated into existing eHealth, telemedicine, telehealth, proactive and predictive medicine, telecare, and telemonitoring or self-management/support IT solutions. The target user groups include patients, family members, informal caregivers, and health and care professionals. It is noted that no specification of the target population is given in a significant portion of the available studies that introduce conversational agents in healthcare. Additionally, no inclusive design principles were reported by the available studies. Also, available evidence comes in the form of published literature, with the newest articles dating from 2022. Its objective is to identify conversational agents that have been proposed and developed for use in healthcare as well as summarizing the potential settings where they could be utilized. A secondary aim of this review is to identify the functionalities of these conversational agents and to describe the different settings and target user populations.

Equation 2: Response Generation (Seq2Seq Model for Dialogue)

$$\hat{y} = \text{Decoder}\left(W_{\text{dec}} \cdot h_{\text{enc}} + b_{\text{dec}}\right)$$

$\hat{y}$: Predicted response,

h_{enc}: Encoder hidden state,

W_{dec}: Decoder weights,

b_{dec}: Bias term.

3.2. Benefits of Virtual Health Assistants in Healthcare

1. Enhancing patient engagement

- Facilitating access to health information, which, for inpatients, is more necessary than for patients seen in outpatient care.

- Empowering patients to make decisions about their health.

- Although not all eHealth solutions offer a perfect substitute for in-person healthcare delivery, VHAs may serve to enhance healthcare delivery, thereby furthering the intent to transform the current model of inpatient care to a patient-centered model focused on ensuring patients have the necessary data to inform their decisions about their desired level of quality and resource use.

2. Saving time

- For patients: The ability to communicate with a VHA at a time that is convenient for patients is likely to streamline the exchange of health information between patients and clinicians.

- For clinicians: VHAs can ensure that standardized information is obtained without consuming valuable clinician time, leverage limited clinician time, and focus clinicians and other healthcare workers' time with patients on what they need.

- Clinicians using a VHA may spend less time documenting health information and calling the multidisciplinary team for an inpatient discharge. This may result in freeing up clinician time, reducing clinical frustration, and even increasing patient throughput.

4. Design and Development of Virtual Health Assistants

There are inherent principles to be considered during the development of virtual patients and virtual health assistants to guide patient engagement and interaction with virtual assistants, such as user experience, accessibility, and cultural sensitivity. If these traits are absent from the design of virtual assistants, we position individuals with decreased proficiency with technology, low digital literacy, those with disabilities, or individuals from diverse racial or cultural backgrounds as marginalized individuals. Conducting user testing and development iterations is a key principle that dictates that the development of virtual health assistants should be iterative, where the relevant consideration factors are updated based on user feedback: language and voice user interfaces; the sophistication, relevance, and capacity of conversations; extra functionalities and characteristics; and dissemination and testing.

Efforts required for ideal user testing and further development reinforce suggestions to conduct development using a multidisciplinary team of constructive opinions. Developers who are healthcare specialists must be present in conversations and contribute to the prototyping of such innovations. Furthermore, there is a requirement to include the corresponding data specialists in the process of developing virtual health assistants for the structurally compelling application of natural language processing for conversation and investigation of information in text. Along with the availability of other technological components relevant to the ideal conversation, a virtual health assistant’s personnel or personal identity will be distinctly presented in line with the overall aim of any conversational agent. In interaction with chatbots, virtual assistants, or digital health, there is an understandable concern for the privacy of user information. Patient information ought not to be expected to remain private, secure, and non-identifiable unless explicit measures are present to ensure security.

4.1. Key Considerations in Designing Virtual Health Assistants

Stakeholders interested in deploying virtual health assistants should carefully consider the design, content, and target demographic of users when crafting a user-centered virtual health assistant. Patient profiles offer useful insights into defining specific target user groups and adopting user-centered design. The first target demographic, "Next-Gen Nurturers," refers to adults aged 20-40 who are responsible for taking care of children. The second group, "Smart Gen Xers," includes adults aged 45-59 who take care of both children and older adults. The final category, "Wise Baby Boomers," caters to older adults over the age of 60 who manage to care for an older adult. This demographic range expands across both caregivers and care recipients, recognizing the importance of matching the age ranges to offer the most personalized support.

It is important to design virtual health assistants with an easy-to-use interface that allows the in-depth interaction required for conversational interfaces. In addition, designers need to consider cultural and linguistic variables and determine how much and what kind of customization virtual health assistants can offer, despite the eventual target population varying by region or healthcare provider. Virtual assistants can be designed to service a wider population as an outcome of their information-based service, which is independent of local or organizational regulation. Stakeholders responsible for deploying virtual health assistants should focus on creating technology that can gain traction across multiple systems. The virtual health assistants can be tailored to specific healthcare organizations and other systems simply by inputting those unique data into the system.

Additionally, the agents should be able to indicate to human users when conversational variables are operating in dynamic or static modes. Virtual health assistants need to be scalable and applicable in various healthcare settings. In addition, this technology needs to be flexible and cost-effective. Lastly, users need the assurance that using virtual health assistants will not compromise their sensitive medical information and related data. Assuring data security will prevent users from using these online services once their sensitive personal medical or healthcare information is at stake. Stakeholders should pay special attention to ensuring data security to maximize valuable virtual health assistant opportunities. Together, these considerations will enable stakeholders to optimize the design of virtual health assistants for a given healthcare setting and patient population.

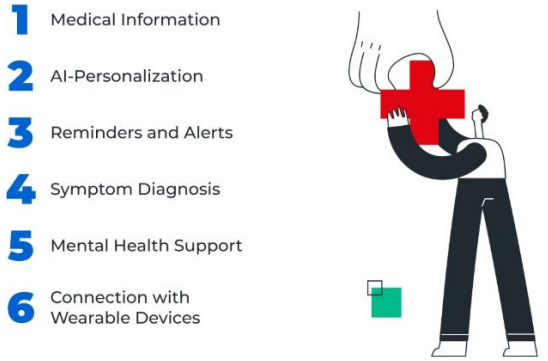

Fig 4 : AI-powered Virtual Healthcare Assistant

4.2. Technological Components and Features

Technological components and features. Technically, a virtual health assistant relies on numerous software and hardware technologies. The software technologies emerging in this field include artificial intelligence, machine learning, deep learning, cloud computing, and natural language processing. The hardware devices used in virtual health assistants include sensors, biosensors, actuators, and so on. The core of virtual health assistants involves AI and ML technologies. Unlike programming that deals with hard decision-making abilities with 'if-then' rules, ML utilizes annotated datasets to train statistical models, while AI simulates human cognitive functions like reasoning, problem-solving, learning, and understanding natural language.

One of the AI technologies used in virtual health assistants is NLP because it enables the assistant to interact with users in their natural language. Furthermore, NLP combines several computer science disciplines comprising AI, ML, linguistics, computer science, and logical philosophy. Besides, the virtual health assistant can exhibit the ability to perform multitasking, bringing about an impeccable personal experience in user engagement. In addition, the focus is on data analytics in refining user experience through personalization. Normally, the virtual health assistant's user response time is fast because of cloud computing. Furthermore, security features are similar for both virtual health assistants and common chatbots despite the privacy concerns regarding health information. Overall, novel drugs or technologies may weaken patient engagement; therefore, both interest and innovation in virtual assistants are only on the rise.

5. Challenges and Ethical Implications

The success and acceptance of intelligent conversational agents into the healthcare value chain can depend on and foster close cooperation across multiple disciplines such as human-computer interaction, software engineering, health psychology, cognitive science, consumer behavior, and medicine. Currently, healthcare is performed in data silos, and the lack of healthcare system interoperability is causing many barriers to the adoption of new technologies. An analytical framework is needed to guide software engineering to conceptualize, design, build, evaluate, and validate generic conversational agents across different digital healthcare ecosystems.

Getting healthcare workers and patients to trust technology against real-world concerns is also challenging, and this might further be complicated by professional resistance. The failure to protect patient privacy and to fortify the technological solution against data security concerns could have a detrimental effect on the image and reputation of companies and healthcare establishments. A lawsuit is often brought against doctors, but increasingly, it is hospitals and service developers that are blamed for data breaches and privacy concerns. The ethical implications of technology-related approaches cannot be overlooked, and the creation of mechanisms to ensure safety alone is not sufficient. The same is true for technologies used across the broader spectrum of the care pathway. Codes signpost and regulate the organization and its response to the ethical frameworks required to function within a digital health context. According to the ethical framework required to functionalize technology in a healthcare

setting.

5.1. Privacy and Security Concerns

1. Introduction 5.1. Privacy and Security Concerns All stakeholders of virtual health assistants (VHAs) in healthcare, including developers, care providers, caregivers, patients, and family members, have a vested interest in privacy and compliance with security standards. Embedded with regulations that protect the sensitivity of health and illness-related personal information, the healthcare domain demands both legal and ethical attention to patient privacy from all of its service providers. Protecting the privacy of VHAs, human agents, caretakers, relatives, friends, and casual bystanders is crucial. If widespread breaches occur, compromising the confidentiality of patient information, such incidents would darken the layperson's impression of virtual health assistants. Although there is no shortage of complexity in either privacy or security, best privacy practices can consolidate as an adequate determination regarding the relevance of health information that is stored in the nation's virtual health assistants and that can be considered permanently detached from the long-term storage that is used for the system's personalization. Best security practices can coalesce as designing storage and communication according to current commercial standards and practices in encryption, reported in system documentation and security advisories for the public record. Healthcare providers, too, have obligations to protect the privacy of patient data according to national health information portability and accountability acts rules in the United States and similar data protection regulations in most developed countries. Moreover, the technical requirement that VHAs maintain compliance with entitled patient-controlled authorization would require both healthcare providers and virtual assistants to comply with technical and policy standards and comes from the desire to offer the greatest possible choice in healthcare decision-making to patients. Failure to protect data security as well as patient privacy could lead to decompensation of one's reputation and significant liabilities. Those who work in healthcare also have to follow national private health information regulations and guidelines. Employees must provide ongoing proof of compliance to the oversight organizations.

5.2. Ethical Considerations in AI-driven Healthcare

Artificial intelligence, a powerful technology, is making its way into the healthcare sector. The moral questions surrounding AI-human relationships in healthcare become more grave. We have to find answers to several such ethical questions to ensure this relationship is harmonious and ethical. Some of these questions are: Should the creators, deployers, or users of virtual health assistants, or the VAs themselves, be held responsible when decisions taken on their recommendations go wrong? What kind of role makes us feel more comfortable with the decisions these tools make? Should we be involving humans in the loop at all times? And finally, how might regulatory frameworks provide new guidance in this brave world? Algorithmic decision-making causes several shifts in the ways of the decision-making process: they are opaque and hard, if not impossible, to scrutinize or criticize; as such, one loses the ability to understand, question, or appeal against decisions that may impact one's life. The ethical implications of neglecting this responsibility in healthcare are massive.

Another concern commonly discussed is algorithmic decision-making systematically leading to biases of all sorts. Be they gender biases, racial biases, or otherwise, these biases tend to systematically benefit or penalize certain categories of people and disfavor or advantage

others. There is a concern, no different in healthcare, that machine learning systems are designed on datasets or use algorithms that are implicitly and inherently biased in different ethnicities and minorities, for instance. To address this fairly widespread issue, regulations impose strict accountability and transparency duties on the developers of the technology to reduce information asymmetry and minimize the risk faced by the end user. The duty to ensure the non-discriminatory development and deployment of technologies should be taken even more seriously in the context of healthcare, where the costs of excluding a significant or marginalized portion of the population are indeed of the highest social importance. Legal responsibilities can, as such, harmonize technological development with societal needs and ethics and offer a framework for greater transparency and scrutiny. Civil society, patient bodies, and National Health Systems need to question these issues at all digital health summits to cultivate an ecosystem for the proliferation of ethical technologies of the future. Only ongoing, interdisciplinary dialogue and transparency can ensure that Gen AI, as a universal concept, promotes and ensures diversity, equity, and access and breeds confidence in the digital healthcare consumers of today and tomorrow.

Fig 5 : Conversational AI in Healthcare

6. Future Directions and Conclusion

We foresee several future directions of research in the area of Gen AI virtual health assistant technology. It is expected that virtual health assistant systems will be improved with additional problem-solving capabilities to articulate a health concern or diagnose a health condition. It would also be valuable to explore the capability, ethics, violation potential, and other dimensions of the use of non-anonymous virtual health assistants in processes to recruit and screen potential participants for clinical trials and/or research studies; in interventions to facilitate behavior or lifestyle change; or in other direct-to-patient communications for commercial or research purposes. As Gen AI continues to develop into increasingly advanced capabilities, it is anticipated that VHAs will also have more sophisticated abilities, including a natural language interface, adaptive logic, and real-time interaction with surrounding human beings. The use of VHAs in healthcare settings will assist in serving as a platform for improving patient engagement and enhancing patient-centered care delivery, while the role of VEAs in the market as consumer engagement or customer service tools continues to expand. With appropriate mechanisms to satisfy all related regulatory requirements and ethical obligations, healthcare alternatives may be adjusted to property, throughout the house, especially, and healthcare amenities, research, and delivery channels on many of them. An in-depth study of these burgeoning trends is required given the extensive room for growth in

VHA use in healthcare settings as Gen AI systems develop more broadly in the commercial sector and throughout everyday consumer in-home entertainment use. This project covers the background work done with Gen AI and people's experiences as well as the capability and application-related conditions necessary to effect a change in engagement strategies and the impact of new tools like the VHA on patients in a healthcare setting. It is not meant to cover the privacy implications or consumer consent necessary for a VA to work in a healthcare setting. This project also concludes with some suggested strategies for healthcare companies involved in healthcare delivery or related research to get involved in how and where they would bring this kind of Gen AI-based technology into their services and product lines.

6.1. Emerging Trends in Gen AI and Healthcare Technology

Generation AI (Gen AI) is beginning to reshape healthcare, offering a bridge to more efficient and meaningful patient-provider connections. Though in its early stages, Gen AI's future casts what the blending of algorithm development and increasing availability of healthcare data could mean for patients and providers. Here, we provide insight into some of the emerging trends in Gen AI and healthcare technology that will influence patient engagement over the next decade.

In response to some people's preferences for a conversation, an SRI has been developed for building VHAs with natural language. Recent advances in data analysis have even made waste, redundant, or unhelpful VLAs somewhat obsolete: for instance, realized through algorithms that do some combination of real-time data integration, big data, or machine learning, a report can now be more personalized than not, based on individual preferences and behaviors. Moving one step further, a report after a VOI conversation or series of conversations may soon be highly predictive or prescribed, just by overhearing command tables. Naturally, while incredibly useful, flagging these people or configuring silent environments in the hospital generally involves contextual illness background information—like the decline in the length of phone calls to your GP—leading to an increased likelihood of attendance. Perhaps instead, the VLA could be given a to-do list in these instances if it concluded the person was not intending to fully engage in a mutually beneficial conversation. Further developments in this space are already happening, and increasingly, people are being encouraged or incentivized to interact with their wearable technologies for both physical and psychological benefits.

Equation 3: Personalized Health Recommendation

$$R_{\text{patient}} = \sigma\left(W_{\text{rec}} \cdot X_{\text{patient}} + b_{\text{rec}}\right)$$

R_{patient}: Personalized recommendation,

X_{patient}: Patient data,

W_{rec}: Recommendation weights,

b_{rec}: Bias term,

σ: Activation function.

6.2. Summary of Findings and Recommendations

Summary of Key Findings This research, involving expert interviews, literature reviews, and

an analysis of online user reviews of the Babylon technology, explores the role of General Artificial Intelligence (Gen AI) in healthcare settings as a tool for and an object of patient engagement. Gen AI-enabled healthcare involves both AI as a set of patient engagement tools, such as virtual health assistants and other AI-driven applications, and AI as an object of patient engagement. In the latter, the increased use of AI in healthcare services is predicted to foster patient engagement, making patients more informed and health literate. Trust is the bedrock on which any well-functioning healthcare system must be founded. Artificial Intelligence (AI) is already transforming healthcare, with the development of General Artificial Intelligence (Gen AI) promising to take this one step further. Trust in new technologies, therefore, is important and may impact the likelihood of their usage. This study offers a patient-oriented perspective for policymaking, healthcare delivery, and technological development on the impact of General Artificial Intelligence (Gen AI) on patient engagement and the effectiveness of virtual health assistants.

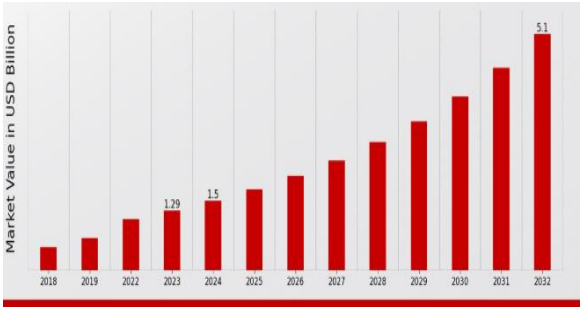

Fig 6 : Health Intelligent Virtual Assistant Market Growth 2032

The main benefits resulting from patient engagement often include improved health outcomes and quality of care. The main challenges relate to the siloed perspectives that are in tension with one another. These include the different views of the benefits and risks of using AI as a tool and the tensions between minimizing costs and maximizing safeguarding mechanisms. Providing recommendations on what constitutes good standards for the use of Gen AI is intended for a consultative multi-stakeholder group to achieve regulatory momentum aimed at an EU cross-border adoption of Gen AI. The group includes healthcare providers, academics, and technologists who develop virtual health assistants and AI applications. For those working in healthcare and developing new technologies: practitioners developing AI applications in healthcare; and patients and citizens involved in the further development of Gen AI in healthcare. These good practices have been created in the area of health tech token design. In conclusion, the main findings can be derived from the fact that Gen AI has great potential, but only if implemented as real general consultation guides. Given all the above, we propose that health tech start-ups and investors conduct comprehensive tokenomics analyses and account for a potential segmentation of their patient base. This can encourage stakeholders to adopt best practices and help decision-makers who move developments forward in a responsible way. The patient engagement sub-group focuses on providing recommendations on guidelines for EU-wide standards. They decide to evaluate what is good or workable. From the stakeholder-driven discussions, two important criteria for evaluation remain concerning the impacts. These are the remaining benefits per patient or carer representatives, and safety is chosen.

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