

# **Alexa, How Do I Feel Today? Smart Speakers for Healthcare and Wellbeing: an Analysis About Uses and Challenges**

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## **Abstract**

One of the artificial intelligence applications with an increasing popularity is related to conversational agents. Indeed, the virtual assistants are conversational agents capable of handling a spoken dialogue with people providing information and various types of services. How can virtual assistants and smart speakers be used for healthcare purposes? The virtual assistant, understood as digital services designed to simulate human conversation and provide personalized responses based on input from the users, currently can be effectively exploited to realize self-care solutions for the people, who can use them to seek information, contact doctors, monitor their health parameters and adherence to therapies; but also, as a hands-free support for practitioners to optimize workflows in hospitals or small clinics. They can be used also to provide useful information for innovative health programs at large scale patient-centered.

This contribution contains an analysis about the use of virtual assistants in healthcare, conducted through the exploration of scientific studies and research dealing with the topic concerning the use of conversational agents in healthcare.

The analysis aims at systematizing current functionalities, through a new cataloging scheme based on contexts of use and end users.

The increasing use of virtual assistants in healthcare can impact society thanks to its strengths. At the same time, a number of critical points have emerged and still exist which provide ground for further challenges need to be addressed to ensure that the associated risks are reduced.

**Keywords:** *virtual assistants; smart speaker; healthcare; wellbeing; health education; adherence; social detachment.*

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## **1. Introduction**

Artificial intelligence has many applications, one with an increasing popularity is related to conversational agents, "software programs that emulate conversation with humans through natural language" (Luxton 2020).

These agents can take different forms, the simplest and most tested being a chatbot, which usually works through a written text interface. Or, they can be embodied agents, represented by avatars with the appearance of humans or animals, in order to show themselves to their users.

More complex forms of agents are now made possible by advances in speech or voice recognition, "the technology by which sounds, words or phrases spoken by humans are converted into electrical signals, and these signals are transformed into coding patterns to which meaning has been assigned" (Adams 1990) and in natural language processing, which allows machines to process and understand complex sentences given as input by humans in their own natural language.

This is how virtual assistants are born, conversational agents capable of handling a spoken dialogue with people, providing information and various types of services (Curtis et al. 2021).

In 2011, Apple launched Siri, the first virtual assistant with these features, integrated into its smartphones. Immediately after, it was followed by several IT giants (Microsoft, Amazon, Google, Samsung), who developed their own solutions, embedding them into other devices (computers, tablets, cars).

But the device that is achieving the most success is the smart speaker, a standalone tool, equipped with microphones and loudspeakers, connected to the Internet, which can be controlled by voice thanks to the virtual assistant that is installed inside.

The market of smart speakers and virtual assistants is thriving and expanding, also supported by external developers who have the opportunity to create additional pieces of software, which can extend the capabilities of devices, similarly to what happened with the iOS and Android marketplaces in the history of smartphones. Amazon calls them Skills, Google instead Actions, basically they are the same thing and there is one of them for almost every need, and there is also a wellness and health category.

The potential is high, conversational agents can play an important role in healthcare, supporting both patients and practitioners (Laranjo et al. 2018).

After all, as recalled by Bhatt (2020), the healthcare market is worth \$3.5 trillion in the United States alone (K@W 2019), and it is expected that in the future, a half of health care services will be offered via digital platforms (Basatneh, Najafi and Armstrong 2018), and therefore it is only a matter of time before producers realize the opportunities at stake.

In fact, while until recently the use of virtual assistants in healthcare has been relatively rare (Laranjo et al. 2018), in recent times things are rapidly changing, so much so as to require the birth of new terms like "digital wellness" to encompass all the uses of digital technologies in the health sector (Murthy and Kumar 2015), or the "medical Internet of Things" (Klonoff 2017), defined as "medical device connectivity to a health care system through an online network, such as a cloud, often involving machine to machine communication".

Virtual assistants can now be effectively exploited to realize self-care solutions for the people, who can use them to seek information, contact doctors, monitor their health parameters and adherence to therapies, improving health care and optimizing public health.

This contribution contains an analysis, also based on recent literature, about the possible uses of virtual assistants in healthcare, aiming at systematizing current functionalities and identifying strengths and problems that are still to be solved, in order to understand how this new channel of communication can impact society and help people taking care of their own health.

After this introduction, the contribution continues as follows: the Methods section describes how the analysis was conducted; the Results section focuses on the uses of virtual assistants in healthcare found in literature, proposing a new cataloging scheme based on contexts of use and end users; before the conclusions, the Discussion section analyzes the reasons that make such uses advantageous, together with several challenges that need to be faced to ensure that the associated risks are reduced.

## **2. Methods**

The analysis was mainly conducted through the exploration of scientific studies and research dealing with the topic concerning the use of conversational agents in healthcare.

For the purposes of the contribution, the authors have chosen to focus on studies related to virtual assistants and in particular to those integrated within smart speakers, as defined in the introduction, considering less relevant research related to chatbots or embodied agents.

For this reason, and considering the launch of Apple Siri in 2011 as the starting point for modern virtual assistants, the authors have only considered studies published in the last decade. In this regard, it is noted that despite the time span considered is 10 years, the vast majority of the articles read and selected are concentrated in the years from 2018 to the present, a sign of how the sector taken into consideration is currently prevailing and in evolution.

The two authors have conducted their searches individually, in June and July 2021, on the PubMed, ACM Digital Library, IEEE and Springer databases, using agreed and combined search terms such as "conversational agents", "virtual assistants", "intelligent assistants" and "healthcare", "wellness", "wellbeing".

The articles thus identified by each author were compared to eliminate duplicates and combined together gave rise to a corpus of over 400 publications.

The authors have then cooperated to read the abstracts of these publications, excluding the non-inherent ones, bringing the total of those taken into consideration for the analysis to just over 100. By reading the remaining articles, the authors have proceeded to a final selection, from which 40 studies emerged, which are reported in the references.

The Results and Discussion sections are based on the analysis conducted by the authors on the studies identified.

## **3. Results**

Starting from the analysis of recent literature on the subject, the authors were able to identify numerous use cases for conversational agents in health, and therefore proceeded to the categorization shown in Table 1, based on variables such as context, purpose and target users.

*Support.* The most widely detected use for this type of tools is as home support for chronic diseases.

In this case, the agent works as a "reinforcement" of the practitioner as much as possible, providing immediate and always available help, letting the doctor handle the more delicate issues, instead.

Analyses and diagnoses by a specialist doctor are generally expensive and difficult to plan. Virtual assistants can help patients, providing them with personalized suggestions, with the doctor's support, based on the data collected.

For example, the HealthAssistantBot is able "to identify the user's condition through a Symptom Checker; to find the best doctor for her by using a Recommender System; to support monitoring of treatments and health parameters; to increase the user's awareness about related symptoms and diseases" (Polignano et al., 2020).

A service of this type would allow patients to wait for the next consultation with the doctor having some advice already available, reducing costs for health care and increasing the chances of access to medical knowledge (Rosruen and Samanchuen 2018).

Zhang and Zheng (2021) analyzed the potential of conversational agents, discovering that thanks to them patients can discover many things about their health status and about specific diseases: "It gives suggestions about the different symptoms to help patients to make clear their condition. According to the user's reply, the chatbot would suggest the doctor who can be consulted in case of major disease".

When dealing with chronic diseases, having an assistant always ready to remember the therapies can be essential. In diabetes, for example, it is important to check blood sugar levels and take medications or insulin at certain times. Virtual assistants can act as a reminder and help patients with follow-up operations.

In this regard, Amazon, already in 2017, launched an initiative called "Alexa Diabetes Challenge", aimed at creating voice solutions to improve the lives of people with diabetes (Basatneh, Najafi and Armstrong 2018). Among 96 proposals submitted, the winner was Wellpepper's Sugarpod application.

Virtual assistants are much cheaper than medical tools, but also very powerful, thus they can deal with monitoring and support for diseases, as well as provide many useful services in other areas. According to Sunshine (2021), it is also expected that there is a marked advancement in the possibilities of these devices to classify diseases based on symptoms detected or listed by users, offering new opportunities for rapid and low-cost diagnostics.

However, in this scenario, the use that appears to be the most promising, albeit risky, as will be discussed later, is relating to mental disorders.

In recent years, digital psychological counseling solutions have multiplied (Abu Shavar 2015), starting with the evolution of the chatbots. When the text input is replaced by speech, then the system becomes more interactive, and may be able to recognize, for example, early signs of depression.

In fact, their use is gradually expanding to various areas, such as cognitive behavioral therapy (Hernandez 2018), suicide prevention, especially in war veterans (Gonzalez 2017), or for more specific situations (Daubney 2018).

Vaidyam et al. (2019) specify that the use of chatbots and virtual assistants can generally improve access to treatments for these disorders, but it is particularly useful "for those who are uncomfortable disclosing their feelings to a human being". In this regard, the

same study cites an experiment done with veterans showing they were more ready to open up to a virtual therapist than to a real person (Lucas et al. 2014).

The great advantage of virtual assistants is in the way they can manage communication with the patient.

The relationship between patient and specialist is irreplaceable, but for the first time, thanks to virtual assistants, there is a system that can replicate this face-to-face interaction, as long as it is always under control.

It turns out, therefore, that such systems can be customized according to needs (Bickmore, Giorgino, 2006), and can even improve the efficiency of certain treatments with the human specialist, who for example has resources limited by his/her physicality, which requires him/her to take care only one patient at a time, dedicating an amount of time that is sometimes not sufficient (Bickmore et al. 2018a).

*Health education.* Not only people affected by a pathology or who need a specialist can benefit from conversational agents, but also those who are not looking for a specific service; in fact, they can be educated to a healthy and active lifestyle.

This type of goal is pursued in particular thanks to the skills, as defined in the Introduction, where it is the main use.

Already in 2019, the Head of Alexa Health and Wellness, Rachel Jiang, invited developers to create health skills by saying: "These new skills are designed to help customers manage a variety of healthcare needs at home simply using voice" (Chen 2019).

As of July 2021, a search within the "health & fitness" skills category produced over 2000 results, almost doubled compared to what was reported by Callejas and Griol (2021), with data referring to the previous year.

The objectives of the many skills available are the most disparate, but a study conducted by Chung et al. (2018) and more recently also reported by Shin and Huh-Yoo (2020), examined over 300 among the skills of Amazon Alexa and Google Assistant, concluding that most of them are geared towards providing health education to a general audience.

Within this category of use, a specific case that has become prevalent in recent months, given the pandemic situation that the world has faced, is related to information about Covid-19 and vaccines.

The Mayo Clinic, a nonprofit American academic medical center, has developed and launched a skill to keep users informed about the developments of the pandemic, with updates also coming from the Centers for Disease Control and Prevention.

"The 'Mayo Clinic Answers on COVID-19' skill for Alexa offers the latest information on symptoms, prevention and how to cope in a hands-free way using only the voice — a fact that is especially important when we're trying to reduce the spread of a virus transmitted by physical contact", explained Sandhya Pruthi, M.D., a Mayo Clinic physician and medical director for Mayo's Health Education and Content Services (CBS Minnesota 2020).

The issue of vaccines (although not specifically Covid-related) was also used to test the validity of the answers of virtual assistants in the medical field.

The study conducted by Alagha and Helbing (2019) starts from the consideration that the vaccines topic is particularly suitable to evaluate how much virtual assistants are able to identify evidence-based sources, because a lot of inaccurate information often circulates in this regard.

The results of the comparative study show that Google and Apple's virtual assistants perform better than Amazon's, but this could be due to an implementation

choice: Siri and Assistant usually provide links to pages deemed reliable, introduced by a small voice comment, thus leaving the visual channel and the user the task of obtaining the information. "The devices primarily function as a neutral voice-initiated web search", conclude Alagha and Helbing.

Alexa, on the other hand, appears to be programmed to provide a comprehensive answer via voice, but this leads to frequent inconclusive answers. The voice-only way, even if for now grants limited results, could be a better long-term choice, given that studies on the usability of these systems show that users tend to prefer this mode (Budi and Laubheimer 2018).

A further recent study, conducted by Kocaballi et al. (2020), has extended the comparison to other virtual assistants, such as Cortana and Bixby, looking for the one that can provide the most consistent answers to health and lifestyle prompts. The results show once again that at the moment, voice-only platforms provide lower quality responses. The problem is the same: "It is possible that as conversational agents using a voice-only interface have a limited capacity to present large volumes of information, they were unable to answer lifestyle prompts, which were predominantly answered by information extracted from websites".

*Active sensing.* The third use is more innovative than the others and is linked to the opportunity that smart speakers become hubs, integrating other sensors and connecting to other devices.

In this way, these tools can be transformed into health control centers, able to monitor various parameters and provide help in situations of need.

Thus, it is possible to extend the already interesting capabilities of smart speakers, in order to exploit the principles of computer vision for purposes related to healthcare. For example, systems for the detection of falls can be easily integrated, but also for monitoring physical activity, as long as a camera is available.

This concept can be pushed further, by integrating sensors for biometric or environmental parameters, already used today in several monitoring systems, into the ecosystem, taking advantage of voice interaction.

Moreover, smart speakers themselves have some important potential. Since they are equipped with microphones and speakers, they can be used in numerous sonar- and radar-based active sensing modalities, with interesting healthcare applications for situations such as sleep disturbance, breathing problems or epilepsy (Sunshine 2021).

The same study also analyzed other situations in which sounds can be relevant at a diagnostic level, so much so as to suggest the possibility of using smart speakers as a classifier of disease signals: not only changes in the voice can be early symptoms of Parkinson's or dementia, but by analyzing inflection and speech it is possible to detect signs of mental disorders or depression.

The scenario described here is futuristic, of course, much development and research will still be needed to make it feasible without risk.

Instead, an easier and currently achievable goal is to take advantage of these devices, based on the hearing channel, for hearing control.

The study conducted by Ooster et al. (2019) showed how the current systems for measuring hearing deficits can be reproduced effectively and optimizing the resources thanks to virtual assistants and conversational interfaces, compared to GUI-based systems.

*Visit scenario.* Smart speakers can be useful not only for the patients at home, but also for health practitioners in other contexts, like the classic medical visit, in a specialist's consulting room or in a small clinic.

Shaughnessy, Slawson and Duggan (2021) depict a scenario that at first sight seems futuristic and difficult to achieve, but on closer analysis it consists of a set of practices that can now be implemented: the doctor, before seeing the patient for the first time, can consult a lot of data on his/her state of health, coming from smart speakers and all related tools, but also from social media, from the websites visited and from the researches made. An artificial intelligence analyzes them and makes them available to the doctor, with the patient's consent.

The hypothesized scenario continues with the use of additional technologies embedded in the room used for the visit, but it is not necessary to go that further.

The amount of data collected even before the visit may be sufficient to help the doctor make a more accurate diagnosis, but also to identify certain problems before the patient realizes that something is wrong, optimizing health care results.

Actually, this kind of use is related to the support mentioned above: if this information is made available to the doctor in the context of the visit, the patient can take an active part in the collection of data by answering questions in the home environment, saving time and resources. That could be convenient above all for older adults, as they are usually homebound (Ponathil et al. 2020).

Finally, always within the visit scenario, these tools can help the doctor make a diagnosis based on symptoms and suggest similar situations based on rare cases, relying on a huge database. That suggestion is then validated by the doctor.

*Hospital scenario.* In medium and large hospitals, where patients are cared for by multiple practitioners, virtual assistants can prove very useful in helping physicians to keep track of patient care, complementing or replacing current reporting systems, which require a high expenditure of time resources by the doctors themselves.

Although there are still no studies analyzing the impact of these technologies in such an environment, the premises seem interesting and speech recognition could become a pillar of support to the patients (Kadariya et al. 2019).

In fact, according to Farr (2017), "doctors are spending up to two-thirds of their day on busywork, namely clicking fields in their electronic health record system".

In such a scenario, virtual assistants can translate the sentences spoken by doctors and physicians into commands and database entries, optimizing the process.

In addition to being useful to doctors, smart speakers in hospitals can also benefit patients. Cedars Sinai has conducted an experiment providing its patients with the ability to control the environment and have an always-on line of communication with the staff via Alexa (Cedars Sinai, 2019). The pilot showed that patient satisfaction with the care received improved, while staff saved a lot of time spent monitoring patients.

#### **4. Discussion**

Through the analysis conducted and thanks to the results illustrated above, the authors were able to collect the main positions in favor of the use of conversational agents in medicine, together with some doubts and challenges yet to be addressed.

Among the advantages, the most cited seem to be:

- Better adherence to therapies
- Support for self-education
- Immediate availability of information, at home

- Low cost
- Non-stigmatizing
- Usability of voice interaction

*Adherence.* Better adherence to therapies thanks to the use of virtual assistants is the advantage most often detected, also because it helps solving a complex and costly problem.

The theme is so important that the term adherence has earned a specific definition by the World Health Organization (WHO 2003), according to which it is the "extent to which a person's behavior - taking medication, following a diet, and / or executing lifestyle changes, corresponds with agreed recommendations from a healthcare provider".

Just to give an estimate of the value of the matter, the report by Hagan (2015) evaluates the cost faced by the health system for the United Kingdom alone at about £ 500 million per year.

According to Beaney, Kalirai and Chambers (2020), the problem of non-adherence can be divided into two categories: "intentional, where a patient decides not to follow the treatment recommendations; and unintentional, where the patient wants to follow the treatment recommendations but faces practical problems doing so".

While in the presence of an intentional choice it is necessary to act with other techniques to stimulate motivation, virtual assistants can help in cases of unintentional non-adherence, in which patients simply forget to follow the therapy, thanks to alert functions.

*Support for self-education.* As mentioned in the previous paragraph, virtual assistants can be an excellent health education tool and contribute to the empowerment of the patient, but also of the general audience: being able to make people learn the techniques for a healthy life-style, through specific recommendations, as made for example in the research by Gardiner et al. (2017), can be helpful to both clinical and non-clinical populations, with beneficial effects on national health systems.

*Immediate availability of information, at home.* Being connected to the Internet, smart speakers give immediate access to an enormous amount of information.

Not only is information readily accessible, but also many services. Thinking about mental health, for example, we can agree on what Kretzschmar et al. (2019) said, that thanks to the digital revolution, interventions become accessible to anyone with a device and a connection, solving the problem of the lack of specialists in certain areas.

But even where there is no shortage of specialists, accessing certain services from the comfort of home is an opportunity that makes the process easier and less stressful.

*Low-cost.* The devices on the market are sold at extremely low costs, and at the moment there are no subscription strategies, although this may change.

These tools therefore become an excellent access point to certain services. In general, as explained by McCrone et al. (2004), digital technologies are significantly less costly than face-to-face interventions. Smart speakers are even cheaper than computers or smartphones, so they can take this concept even further.

*Non-stigmatizing.* Virtual assistants can be used in a habitual context with no interaction with other human beings and no risk of being judged.

Such an advantage becomes even more important in situations of mental disorders, where fear of stigma can lead people to avoid seeking help, as reported by Bickmore et al. (2010) and Gulliver, Griffiths and Christensen (2010).



People, especially youngsters, may tend to feel more comfortable interacting with an artificial intelligence, rather than with a human being. This leads to a reflection on the trust people are willing to place in virtual assistants. Leaving aside for a moment the privacy issues, that will be discussed shortly, evidence shows that some people prefer to manage certain situations through online conversations (Livingstone and Bober 2004).

*Usability of voice interaction.* The last advantage found is due to the structure of smart speakers: tools with a vocal interface and that make use of natural language are generally considered to be easier to use than products with graphical interfaces that require learning metaphors and other dynamics.

As evidence of this, we can cite the study conducted by Qiu et al. (2021), according to which half of the people involved to test a tablet-based application called Nurse AMIE refused because they were overwhelmed by technology, a motivation that prompted researchers to create a version of the same application which can be executed by smart speakers.

As suggested by Følstad and Brandtzæg (2017), voice interaction can significantly improve the accessibility of technologies for digital non-natives.<sup>45</sup> Virtual assistants can be inclusive tools, helping especially people with limited hand dexterity or limited vision in the realization of tasks (Sciarretta and Alimenti 2021).

This simplicity seems to be appreciated even among the elderly population, as numbers show that people over 55 are the majority among the "first adopters" of smart speakers (NPR, 2018).

The penetration rate of these systems among the elderly population is very encouraging for their use in healthcare, where older people are the main target. Therefore, a solid base of users who learn to exploit the potential of such a tool emerges, this creates a positive impact for anyone who wants to provide for social and health services.

As for the challenges, instead, the authors were able to group what emerged into the following categories:

- Privacy & data protection
- Safety
- Over-reliance & personification
- Risks for behaviour
- (Un)constrained language
- Technical challenges

*Privacy & data protection.* The most relevant challenge, cited in almost every contribution on the subject, seems to be relating to how virtual assistants process personal information.

Given that the presence of Alexa-enabled devices is now found in many homes and offices, around the world, as noted by Sanchez (2020), the question of how our data is processed affects almost everyone, since it is enough to enter a room where there is a smart speaker to be intercepted.

As also mentioned by Pierantoni (2020), these devices can record, through their microphones, everything we say. In theory they are activated only when the wake-word is said, but they are always listening, and they can also mis-interpret the wake-words, causing unwanted recordings.

The issue of privacy becomes even more important when dealing with healthcare services and health data, which are sensitive.

The problem seems to be the acceptance by people, worried that their data could be used illicitly or improperly, since they end up on the servers of commercial companies.

Still, currently there is no agreement on what information to protect. Privacy, in fact, takes on different meanings depending on the person (Sunshine 2020). Would we all be willing, for example, to allow a smart speaker to monitor the sound of our breathing during the night to analyze the quality of our sleep and detect whether we snore or cough?

Undoubtedly, however, there are situations, such as those related to mental disorders (Miner, Milstein and Hancock, 2017) or medical conditions, that must be protected to prevent them from becoming stigmatizing (Bickmore et al. 2018a), and therefore it becomes essential to identify solutions and set limits.

Even if some countries are applying specific rules, like the Health Insurance Portability and Accountability Act in the United States, still there is no international regulation. Luxton (2020) suggests that this situation can lead to problems for the development of conversational agents, given that, as for the telehealth services market (WHO 2010), the laws can vary greatly from country to country.

*Safety.* If the purpose is to show that these tools can be useful in healthcare contexts, the first goal should be to do no harm.

Bickmore et al. (2018a) rightly believe that considerations on the risk of harm are the most important and the most difficult to address in the design of automated systems that can advise people on medical issues,<sup>20</sup> because people tend to trust them and consider them as authoritative sources.

Unfortunately, this risk is concrete, as pointed out by several studies.

Among others, Luxton (2020) found that the ability of conversational agents to make autonomous decisions can lead to safety risks, and that virtual assistants should recognize dangerous situations and suggest people to consult human professionals.

Wrong advice clearly should be avoided, but there is a more subtle risk: over-information.

As said before, there is a skill for almost any type of problem we would like to examine. But so much information available can lead to uncertainty and anxiety, when dealing with different and perhaps opposite advice. Thus, problems are overestimated and usually solved through drugs and medications (Slawson, Shaughnessy, 2019), which can cause addiction and other troubles.

“Making decisions better means discerning between the right amount of care and too much” (Shaughnessy, Slawson and Duggan 2021).

Once again, the only solution to such problems seems to be based on the awareness that in the most delicate cases people should not rely exclusively on virtual assistants for issues concerning healthcare, but it is necessary to ask a doctor for confirmation. As also said by Polignano et al. (2020), in the creation of HealthAssistantBot, “an automatic system cannot reliably replace an experienced doctor”.<sup>9</sup>

*Over-reliance / personification.* The risk that people consider conversational agents as friends and confidants, and therefore tend to over-rely on them, comes from a psychological issue, which applies also to other technologies, but it becomes more pressing with virtual assistants that can show a sort of behavior, willingness to listen and caring personalities, but without the predisposition to judgment.

It becomes too easy for people to reveal their secrets to them, risking creating an emotional dependence. In fact, several cases of statements about depression told to smart speakers, up to even suicidal intentions, have been reported (Shulevitz 2018).

Being too dependent on something, be it a human being or a technology, paves the way to a related problem, the risk of losing contact with reality (social detachment).

Since smart speakers are always available, people can think they don't need friends, with detrimental effects on the quality of their interpersonal bonds.

Finally, a reflection on the economic consequences of this over-reliance emerges. Currently the services available through smart speakers are mostly free of charge, but we do not know if this business model will be maintained later on or if it is due to the startup phase.

If services become paid, it might be convenient for producers to develop solutions that encourage over-reliance, in order to engage people more and have higher profits.

*Risks for behavior.* Interaction with virtual assistants risks changing our behavior, increasing impoliteness and aggressiveness (Pierantoni 2020).

In fact, there is no need to be polite when talking to a machine, since it is programmed to respond in any case.

Research shows that people don't want to be rude to smart speakers (Auxier 2019). However, avoiding too complex formulas becomes a necessity due to the current state of technology, which struggles in their presence; so being impolite and giving orders is an effective strategy in this case (Biele et al., 2019).

On the other hand, being excessively kind to smart speakers would lead to overestimating their abilities, with the same risks of personification mentioned above. The problem is therefore widely debated and arises from the peculiar modality of interaction, based on speech, with these devices. After all, none of us say thank you to their oven.

The question then has to be reversed: "we should not be polite to our voice-activated assistants for their benefit, but for ours" (Gratenberg 2017).

Aggressiveness, instead, derives from the consideration that, because of the state of technology, virtual assistants make mistakes, and these errors sometimes are apparently foolish, so much so as to irritate people, who are therefore led to exacerbate their behavior. As mentioned before, smart speakers are programmed to respond in any case, with a submissive tone, showing no reaction to such behavior, and this may encourage people.

In both cases, the problem is that such behavior can be replicated towards other human beings, as if it were normal, especially in impressionable subjects such as children.

*(Un)constrained language.* Several studies have focused on whether it is preferable to operate virtual assistants through unconstrained language, where the user can say what he/she wants and the assistant makes the effort to understand correctly, or instead opt for constrained language, where the assistant offers to the user some specific choices, and does not answer to other prompts.

Of course, unconstrained language is much more fascinating, as it fulfills the dream of speaking to a machine with natural language and getting proper answers.

However, research has shown that these systems are not mature enough to allow free interaction without any risk, especially in the healthcare field, where decisions with dangerous consequences can be made.

For example, the makers of HealthAssistantBot (Polignano et al. 2020) explain that "in domains such as health, where accuracy is essential, it is preferable not to leave the dialogue totally free, but to constrain it through alternative methods of interaction in order to reduce ambiguity on the input".

This greatly facilitates the recognition of intents, in order to minimize errors and to have validated and accurate data, necessary when monitoring chronic conditions.

Actually, the accuracy of smart speakers' understanding skills is constantly growing and is now comparable to that of people (Jeffs, 2018). But in healthcare contexts

nothing can be left to chance, so even the smallest mistake must be eliminated before being able to rely on automatic systems. The advice, therefore, is always to ask for further advice from a human specialist.

Bickmore et al. (2018b) ran an experiment to understand the effectiveness of systems that use unconstrained language in similar situations. The results obtained suggest that in 30% of cases the responses of smart speakers can lead to some kind of harm in people, up to death. The study also revealed that the main problem is when the system answers to an incomplete request and ends up providing partial advice.

The research by Kocaballi et al. (2020) reaches the same conclusion, that “using unconstrained natural language input is currently unsuitable for getting advice on safety-critical health topics”.

However, there are a few positions that lukewarmly encourage the use of unconstrained language, as long as certain rules are respected.

The same Bickmore et al. (2018a), for example, give a chance to the use of unconstrained language, provided that the system offers "complete information to patients regarding what it thinks the patient has said, what it understands the patient's intentions to be, and how its response addresses those intentions".

Probably it is a matter of expectations about the devices and the services. If it is made extremely clear that virtual assistants are indeed assistants, and that their answers must always be validated by a human professional, then it is also reasonable to use unconstrained language for health care support or education functions.

To this end, some measures need to be applied to avoid running into dangerous situations.

Unconstrained language can only be used in the presence of a very robust error recognition and prevention system, with recovery strategies such as explicit and implicit confirmations (Skantze 2007) for cases of mis-understanding, or re-prompting or repeating/rephrasing for cases of non-understanding.

*Technical problems.* Finally, the authors of the contribution have identified a significant number of challenges that can be categorized under the “technical problems” label.

Timing: providing input to the device within specific time limits is a common problem in virtual assistant applications, not just in healthcare. However, there may be situations related to this precise area that lead to further difficulties.

Shin and Huh-Yoo (2020), for example, show how numerous skills related to healthcare and wellness require users to follow step-by-step instructions (for physical activities or particular procedures).

Timing is therefore essential, but it is not always designed properly, as many users complain of not being able to complete tasks.

And the problem becomes even more complex when people with cognitive disorders or sensory disabilities use smart speakers (Sciarretta and Alimenti 2021).

Transparency: voice interaction can facilitate use by people with less technological skills; on the other hand, smart speakers that use only the voice channel have more difficulty in showing their capabilities or simply their operational status.

According to Kocaballi et al. (2020), designers should focus on improving the level of transparency of devices, working on the responses of virtual assistants. When the device fails to respond to a request, it must be clear whether it is "because of

misrecognized prompt, natural language understanding failure, inability to find a response, system failure, or a deliberate choice to not respond to a particular type of prompt".

However, numerous manufacturers have begun to release smart speakers that are also equipped with a screen on the market. In this way, the feedback provided to the user can be multi-modal (Sciarretta and Alimenti 2021) and promote transparency.

Consistency: the same prompt should generate the same response, but that's not always true. This can happen due to the context of use, the skill used, the geographical area and of course, depending on the type of device. But it may also happen that the assistant is programmed to answer the same question differently, to avoid repetition.

However, this should be avoided, so as not to confuse the mental model created by users on the functioning of a specific device.

Indeed, according to the study by Kocaballi et al. (2020), which recalls how consistency is fundamental for usability, virtual assistants should provide similar, if not the same, answers even when they work on different platforms, explaining the differences which can be due to different configurations (presence of the screen or not).

Another type of consistency that must be considered and kept is over subsequent interactions after some time.

Bickmore et al. (2018a) argue that "maintaining continuity over multiple conversations is important in such situations and in healthcare", because continuity of care has a positive impact on care (Walraven et al. 2010). To grant this type of consistency, it is necessary to equip smart speakers with a memory capable of remembering previous interactions.

Length of conversation: what is the optimal duration of a conversation with a smart speaker? In healthcare scenarios, as short as possible.

If persons with a chronic disorder want to use a virtual assistant to get help in certain situations, it's easy to imagine that during the interaction they will not be at their best, and therefore will prefer a less lasting interaction.

In addition, long conversations can be easily interrupted, forcing the user to start over.

## **5. Conclusions**

In this paper, the authors showed that smart speakers with virtual assistants can be useful in the field of healthcare, creating a catalog of the different types of uses based on the context (home, clinic) and the end user (patient, practitioner): thanks to this, they discovered that virtual assistants can offer information to patients, in order to educate them, or support the management of chronic diseases and therapies to be followed, also thanks to connected sensors that can extend the functionality of smart speakers.

Furthermore, if entrusted to practitioners, they can be a valuable aid in collecting data about the patients and can streamline the hospital processes related to compiling health records.

The authors then analyzed the main advantages that can derive from the use of these tools, as noted in literature: in this regard, summarizing the results in a single sentence, virtual assistants can be considered as a valid support for the health self-education (Gupta et al. 2018) of people and for adherence to therapies, offering several services in a way that is immediate, simpler than other technologies (Meier et al., 2019), directly in the person's home, low cost (Davis et al. 2020) and without risk of stigmatization.

However, they also found a relevant number of problems that still exist and challenges that need to be addressed in order to ensure that the associated risks are minimized.

In particular, apart from a series of technical issues related to the maturity of current solutions (timing, transparency, consistency), the most relevant problem is related to the safety of these systems, and specifically to the risk that partial or incorrect advice may cause harm to people. In this regard, the authors found that many studies indicate the use of unconstrained language as the main cause of this risk, and suggest that only constrained language should be used for healthcare applications, at least until it is certain that error prevention and correction systems are reliable, for example by providing mechanisms for confirming the understanding of the input.

The authors agreed with this, but also added that unconstrained language can be used for low-risk situations, while focusing attention on user expectations: it is necessary to make them understand they're talking to a machine and that the advice obtained must always be validated by a human specialist.

In fact, another problem detected is the personification of these tools, which leads users to over-rely on the responses received.

Furthermore, it is also necessary to consider the interaction dynamics established between the person and the assistant, because some behaviors observed in their dialogue, such as impoliteness and aggressiveness on the part of the human, could also be reflected in the interaction with other people, in the long term.

Finally, the issue of personal data security and privacy obviously takes on great importance: in some cases, this problem is so strong that it can cause people to reject such technologies.

That would really be a huge shame, because virtual assistants and smart speakers are proving they can improve everyone's health, thanks to cost-effective and wide-reaching interventions. Furthermore, practitioners can obtain great benefits in their work thanks to these tools, limiting the risks of wrong advice thanks to their knowledge, thus being able to validate the results.

In general, however, further research is needed to find a solution to the problems highlighted and in the meantime it is necessary to remind users of healthcare services on smart speakers that the recommendations provided come from non-authoritative sources and therefore must be confirmed by professionals.

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**Tables**

Table 1. A new scheme for virtual assistants uses in healthcare

<b>Context</b>	<b>Purpose</b>	<b>Users</b>
Home	Support	Patients / Caregivers
	Education	Generic
	Active sensing	Patients / Caregivers
Visit	Pre-consultation	Doctors
Hospital	EHR	Physicians

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