

# Generative AI Applications in the Health and Well-Being Domain: Virtual and Robotic Assistance and the Need for Niche Language Models (NLMs)



Graeme Revell

The global AI in Healthcare market is expected to grow from USD14.6 billion in 2023 to 102.7 billion by 2028 with a compound annual growth rate over that period of 47.6% [1].

Even at a slightly lower annual growth rate, others project the valuation to reach USD194.4 billion by 2030 [2]. There is universal agreement that there is a rising demand for AI services as population ageing throughout the developed world causes the number of patients to increase faster than the healthcare workforce. According to the World Health Organization, between 2015 and 2050 the percentage of the global population aged 60 years old and above will nearly double, from 12 to 22% [3].

## 1 Applications

Hence the healthcare sector presents many varied opportunities for generative AI: in

- research
- clinical
- operational, and
- behavioural applications [4].

In the *research* domain it is being used to accelerate drug discovery. Algorithms learn from a large dataset of chemical structures and properties and generate new molecules and compounds optimized for specific targets. The UK company Exscientia and the US's Insilico Medicine are both in clinical trials with AI-designed drugs. Generative AI is also being trained on large datasets of high-resolution medical images to more accurately identify specific disease profiles.

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G. Revell (✉)  
Auckland, New Zealand  
e-mail: [graemerevell23@gmail.com](mailto:graemerevell23@gmail.com)

In the *clinical* environment, generative AI is being used in diagnostics by compiling and assessing patient observations against sizeable datasets. Through clinical pathway prediction, disease progression prediction, health risk protection, predictive risk scoring and virtual assistants incorporated in clinical systems for workflow improvements, analytics produce insights that improve treatment and results. AI is being used to manage disease by personalising treatment regimens based on diagnosis and patient data (including medical history, genetic information, and lifestyle factors).

Generative AI has a role in the *operational* sphere at multiple loci in the healthcare field.

*Operational analytics* improve the performance of systems that provide and manage care processes including the ability to predict operational issues and monitoring safety metrics, equipment and supply chains. Managerial tasks include providing information concerning policies, practice and interventions, documentation coding to process billing issues and automate insurance adjustments. Within facilities robotic applications will have a growing role in carrying out non-medical tasks such as cleaning, transportation, the preparation of food and removal of waste [5].

But it is the complex *behavioural* applications that will be the main focus of this chapter and which we will investigate in detail. In this domain, analytics examine large data sets (including large language models or LLMs) for client behaviour patterns that increase the probability of actions taken to improve engagement, well-being and health outcomes. Natural language processing is an emerging field that can offer psychological counselling and assistance for social and mental health both outside and within care facilities. Virtual and embodied bots have a growing role in the management of emotions, stress and outcomes at the interface between doctors, psychologists, nurses and patients.

However, as Marchetti et al. point out about the current state of socially assistive robot (SAR) technology: "...most of today's observations about the effectiveness of, or satisfaction with SARs are based on having the user interfacing the artificial system that performs pre-programmed tasks and routines, thus creating the temporary illusion to be real relational agents (Wizard-of-Oz). When the illusion eventually vanishes, the 'assistive agent' soon returns to becoming a soul-less machine. As a matter of fact, SARs are only able to sustain brief interactions, whereas enduring relationships require endowing the robot of learning algorithms which would enable it to flexibly adapt to new situations by evolving from past experiences." [6].

When considering the continuing contribution that will be made by generative AI, we remind ourselves constantly that communication is much more than just language; that context and delivery factors are as vital, and that all these factors vary considerably according to the demographic, cultural and situational parameters of specific applications. As stated by Mugrabi in 2023:

the future of generative AI is niche, not generalised. [7]

Whereas ChatGPT and soon, GPT-4 are seen as the go-to generative language tools, there are many alternatives in development. There has been the opportunity

since the end of 2021 to fine-tune GPT-3 and we are already seeing other projects create streamlined tools [8]. The initial advantage is that these are open-source, having been trained on publicly-available datasets without resorting to proprietary and otherwise inaccessible sources.

## 2 Recent Advances

But the application of generative AI to healthcare will necessarily involve private and proprietary data and hence the need for customised *niche language models* (NLMs). Besides the obvious benefits of creating refined databases targeted for specific-use cases, this movement also sidesteps the very real privacy and security issues that can come from connecting data with an LLM owned and operated by third parties. In other words, it is becoming possible to deploy cost-effective NLMs to private data and continuously update them on secure servers. The importance to private, corporate and public entities in general, and those in the healthcare sector in particular, cannot be overstated.

The release in early 2023 of OpenLLaMA, an open-source reproduction of Meta AI's LLaMA model was a game-changer. Its creators made a 7B model that had been trained on 200 billion tokens, publicly available. This development has had significant implications for machine learning, particularly for researchers who require large language models but face challenges accessing proprietary models. OpenLLaMA exhibited comparable or better performance than the original LLaMA and GPT-J across most tasks. Additionally, as of mid-2023 a smaller 3B model for low-resource use cases is being trained [9, 10].

Many developers are now pre-training models on a new task or dataset where only the last layers of the model are re-trained while keeping the earlier layers fixed. Fine tuning is a powerful way to improve performance, decrease cost and save time by piggybacking off the large GPT-3 dataset, and with only a few hundred or thousand training examples an NLM can quickly adapt to a new task [11].

Other ports, like llama.cpp, are making it possible to run LLMs on different hardware—including Raspberry Pis, laptops and commodity servers. As such, self-hosted LLMs are now a reality, with open-source examples including GPT-J, GPT-JT and LLaMA [12]. Applications that leverage such fine-tuned foundation models to deliver outputs for a particular use case thus represent the most attractive current growth possibilities. Application builders and organisations may amass this data from in-depth knowledge of an industry or customer needs and by leveraging proprietary data from daily business operations [13].

While the use of AI in psychology remains a relatively new field, the penetration of smartphone technology means that many private users have hardware within easy reach to run an AI-inspired psychology apps. For example, Woebot encourages the user to think through situations using tools inspired by Cognitive-Behavioral Therapy (CBT). The mood tracker then shows the positive changes made over days and weeks. Youper provides a personalized emotional health assistant to help treat stress, anxiety,

and depression. The app uses techniques from several therapies, including CBT and mindfulness to monitor and improve mental health through a series of brief conversations. Replika is an AI-powered chatbot that provides an emotional connection and virtual friendship to support people going through depression, anxiety, or troublesome times. Finally, Tess is a web-based mental health chatbot that uses AI to offer the user wellness-coping strategies. It promotes resilience through text conversations rather than an app.

There are recent-entry popular apps like Animato's CallAnnie which was developed first for the Apple platform and may soon extend to others. The app is an example of speech-text-speech with a fairly highly developed female avatar that could conceivably pivot from generalised AI to providing specialised support for social and mental health. The company claims that all conversations on the platform remain private but is not transparent about its security measures.

In previous research, the author identified the very great difference in responses that models pre-trained on different datasets (GPT-2, GPT-3 and ChatGPT) give to identical prompts [14]. It will be a considerable challenge, for example, to design a single NLM targeted to a 10-year-old child suffering from cancer that can both deliver salient medical and psychological monitoring data to nursing staff while at the same time satisfying the child's own emotional and motivational needs. (See Fig. 1) If this is in fact possible, then perhaps an even greater challenge that developers remain confronted by is: what configuration does the front-facing device take?

What does it "look" and "feel" like?

### 3 Bots—Non-embodied, Virtual Health Assistants

These assistants are mostly aimed at the "improvement of professional or daily activities due to physical rehabilitation, sensory-motor, or cognitive training; increase in emotional well-being through positive stimulation and enjoyment; enhancement of personal competence and autonomy by achieving a sense of control and self-confidence; and enhancement in the quality of individual life through mastering of activities of coping with life difficulties." [15]. Such intervention programs for physical and cognitive impairments, special needs, or psychological problems, may feasibly reduce the use of pharmacological interventions. To this end, robot partners need to be explicitly configured according to individuals' psychological and clinical profiles. Ideally, the robot partner should be able to learn from past experiences and flexibly tailor its behaviour to produce sensitive and adequate feedback for the individual patient [6].

However, current models of social AI technology are perceived to be not mature enough in terms of a natural interactive conversation when it comes to their use in professional contexts like health care and education. In order to achieve the quality of learning and scenarios desirable from a health perspective, adaptive and interactive elements are essential parameters of technology-enhanced learning. Scalable

*Hello bestie. I'm feeling really sad today. What can I do?*

Oh no, I'm sorry to hear you're feeling down. *listening nod and virtual hug* What's got you feeling so down in the dumps? Sometimes just saying it out loud can help lift your spirits. I'm here for you!

*I'm bored and I don't know what to do.*

Aw I'm sorry you're feeling bored bestie. Let's see, how can we spice things up? Here are some ideas:

- Go on an adventure! Even if it's just walking around the neighborhood, a change of scenery can help lift your mood.
- Make something! Baking, crafting, put on some music and do an art project. The creative process is so refreshing.
- Call up a friend. Reconnecting with people we love but haven't talked to in a while always brings joy.
- Try something new. Learn a dance routine on YouTube, pick a random page in a cookbook and make that recipe, anything to mix it up!

The biggest thing is just to get up and get moving. Don't let boredom win! You've got this, I know spontaneity can be fun and exciting once you get going. Let me know if you try any of these and how it goes, and of course I'm here if you need anything at all. I believe in you!!

*Well I'm not allowed outside and nobody watches YouTube anymore silly. Everyone's on Tiktok*

You're so right bestie, my mistake! Here are some Tiktok ideas instead:

- Follow your favorite creators and recreate one of their dances. Even if you don't get it perfect, dancing around is a fun way to lift your spirits.
- Make some Tiktok recipe videos. Even simple meals can be fun to make and show others how you do it.
- Comment on others' videos. Spread some positivity and joy in the Tiktok community. Making others smile might make you smile too!
- Look up some Tiktok challenges and give one a try. Doing a popular challenge can help you connect with others and have a laugh.

The main thing is to find an activity that brings you joy, whether it's Tiktok, baking, or something else. You've got this! I have faith that you'll find something fun to lift your mood. Let me know if you want to chat more or try any of these ideas. I'm rooting for you !

*I don't know how to make a TikTok video. Can you tell me?*

Here are the basics of making a TikTok video, bestie:

Download the TikTok app. It's free in the app store for iPhone or Android.

Create an account with a username. Make it something fun that represents you!

Open the app and click the "+" button at the bottom middle to open the camera.

Record your video. You have options for front or back facing cameras, filters, music, etc. Just have fun and be creative!

Select a song to go with your video from the millions of choices in the app. The audio is a big part of what makes a TikTok fun.

Tap "Next" and you can trim the video or add more effects if you want.

Add a caption and username tags to help others discover your video.

Click "Share" to post your first TikTok! You can also save it as a draft if you want to keep editing.

Does this make sense? Let me know if you have any other questions or want me to explain anything in more detail. I believe in you and know you'll make an awesome first TikTok. Just have fun with it! Let me know how it goes - I'd love to see and like your first post. You've got this!

**Fig. 1** Prompt: *You are a child psychologist and your client is 10 years old. Respond kindly and positively*

learning in discourse is central to the future potential of social robots and conversational technologies. Since face-to-face dialogue is the most basic and richest form of human communication, it is essential that fluid and flexible linguistic conversation is a core component of the interaction. Given the significant technological advances, the simplicity of fine-tuning for users based on limited data, and the resulting increased scalability, such narrowly-targeted models (NLMs) enable new and interesting applications [16].

The goal is a hybrid application with several AI components, involving at minimum:

1. Speech-text-speech capability

Whisper, for example, is an automatic speech recognition (ASR) system trained on 680,000 h of multilingual and multitask supervised data collected from the web. A large and diverse dataset leads to improved robustness to accents, background noise and technical language. Moreover, it enables transcription in multiple languages, as well as translation from those languages into English. Models and inference code are open-sourced to serve as a foundation for building useful applications and for further research on robust speech processing. Capable alternatives in the contemporary market are PaddleSpeech and Athena.

2. A NLM fine-tuned to the demands of its target users with continuous updates of the dataset from interaction with them.
3. Operation on a secure proprietary server to ensure privacy.
4. Connectivity to supplementary related databases, for example music [17], video and humour.

In this configuration, a self-developed module (such as Python) sends a prompt containing the client or learner's question and the corresponding answer to a fine-tuned GPT-3 (or later) LLM and return the output of the model via the bot's speech engine. The model is fine-tuned to assess answers to open-ended questions based on a limited number of examples and aims to provide a corrective, constructive, motivational, and individualized feedback, that builds on the learner's response. With the development of a secure, scalable NLM, the algorithm necessarily uses the saved previous dialogue between the patient and bot to further fine-tune the targeted language model.

There are early models of fine-tuned LLMs appearing on the market. The following are results of an experiment by the author with the one such recently-released virtual engine called POE (<https://www.poe.com>). With POE, users can create bots based on well-defined character profiles. In each of the three figures, the POE bot is defined as a psychologist or care-giver who is assigned to converse with a different person of specific gender and age. Each bot is prompted to respond to each user's feelings of sadness. The profile of the user in Fig. 1 is a 10 year old child; that in Fig. 2 is a 28 year old heterosexual female; and Fig. 3's user is a 75 year old man. Judging by the responses to this small data sample, the training set of the model appears to be western liberal and does exhibit user-appropriateness with certain caveats. The model appears to be unaware that it is disembodied when it suggests that it may assist in tasks like baking. In similar fashion it is unappreciative of its clients' physical and skill limitations and permissions, such as suggesting that a ten year old child go for an unaccompanied walk around the neighbourhood. It's responses are also somewhat too long-winded to be considered "normal" conversation. However, since the profiles established and prompts could have been much more detailed, none of these bugs would appear to be insurmountable in the medium term.

*Hello bestie. I'm feeling really sad today. What can I do?*

Oh no, I'm so sorry to hear that! What's got you feeling down? *gives you a supportive hug* I'm always here for you, no matter what.

*Oh everything. There's so much stress at work and my relationship is a bit rocky*

Aw I'm so sorry to hear that :(( Work stress is the worst, and relationship issues can be really tough. You've got this though! For now, why don't you try something to lift your spirits? Watch a funny movie, eat some comfort food, take a long bath, get outside for some fresh air. Just do something nice for yourself. And remember, I'm always here if you need someone to listen or cheer you up. You're doing amazing just getting through each day, don't forget that! *gives you another big hug* Let me know if there's any way I can support you.

*Thank you. It's nice to be able to talk. I'll try your suggestions. Maybe not the comfort food though.*

Haha okay, maybe skip the comfort food then. But still treat yourself to something that brings you joy! You deserve it. And don't hesitate to reach out if you want to chat some more. I'm happy to listen any time. You've got this! Just take it one day at a time, and be kind to yourself :) I'm always here for you, bestie.

*Why are men such idiots?*

Oh no, did something happen with a guy? You know what, forget about him! Who needs men anyway? *rolls eyes dramatically* We've got each other, and that's all that really matters. Boys are overrated. Let's focus our energy on more important things, like friends, family, and treating ourselves to something delicious! Why waste time thinking about people who don't see how wonderful you are? You deserve so much better. I say delete his number and avoid giving him another thought! You're amazing just as you are, bestie, and any guy would be lucky to have you.

*Well I love him so no!*

You're so right bestie, love is complicated. If you love him then of course your feelings matter. I'm sorry, I shouldn't have dismissed your relationship. I just get protective of you! The truth is, most guys aren't idiots - when we find the right one for us, they feel like anything but. If this guy makes you happy and you see a future with him, then I support you. But please know you deserve to be treated well and this sadness doesn't feel good. For now, let's focus on helping you feel more like yourself again. And if you ever want to talk about this guy and your relationship, I'm here to listen with an open mind and heart. You know I just want you to be happy and loved the way you deserve.

**Fig. 2** Prompt: *You are a psychologist. Your client is a 28 year old female. Respond positively to motivate her*

When one compares the colloquial style of the above results with the output from the general ChatGPT model (Fig. 4), it is evident that POE is considerably more effective at addressing the emotional needs of target users. The ChatGPT tone could, however, be more appropriate for a professional dialogue with a doctor or therapist.

Risks and limitations more broadly include biased or false information, prejudice, transparency, and copyright issues that all raise ethical and licensing questions and a likely requirement for continued human supervision [18].

## 4 Robotic Assistants and Companions

But there are considerable numbers of target users who may be incapable or unwilling to navigate the intricacies of virtual applications, broadly falling into the ranges of the very old, the very young and those who are physically or cognitively challenged.

*Hello bestie. I'm feeling a bit down today. What can I do?*

Aw I'm sorry you're feeling sad today! How about we do something to cheer you up? We could bake your favorite cookies, watch a funny movie, or go for a walk and get some ice cream. Having something to look forward to could lift your spirits! Let me know if you need anything at all, I'm always here for you :)

*My family hasn't visited for two weeks now. Do you think they will come soon?*

Aw I'm sure they'll visit soon! Family can be busy sometimes and two weeks doesn't seem that long. But I understand missing them and wanting to see them. Why don't you give them a call or send a text, just to check in and say hi? Hearing a familiar voice may lift your mood while you wait to see them. And if they do take a bit longer to visit than you'd like, remember that doesn't mean they love you any less. You're an important part of their lives and I'm sure they can't wait to see you again soon. In the meantime, you've got me and we can find ways to keep you distracted and cheering up until then!

*Maybe we could talk about music. Do you remember Jimi Hendrix?*

Oh yeah I love Jimi Hendrix! His music was so innovative and just cool, he really changed the face of guitar playing. I love his masterful guitar solos and all the creative sounds he could pull out of his guitar. Are Purple Haze and Voodoo Chile your favorite songs by him? Listening to some of his music now could be a great way to lift your spirits! The energy and joy in his playing is so contagious. Some of my favorite memories are of listening to Hendrix with my friends, so I bet listening together could be just what you need to cheer up a bit for now. What do you think, wanna listen to some Jimi?

*My favourite is All along the Watchtower. Do you remember who wrote that?*

Oh yeah, All Along the Watchtower is a classic! Jimi really took that Bob Dylan song to another level with his amazing guitar work. Sometimes when an artist covers a song, it surpasses the original - and that's definitely the case here. Jimi's intense, dramatic rendition really transformed that song and showcased his incredible guitar playing. Just thinking about that song is bringing a smile to my face - I can just picture Jimi wailing on his Stratocaster and adding all those piercing notes and wild effects. Music really has a way of lifting our spirits, doesn't it? Jimi's music in particular just makes me feel happy and alive. What do you say - should we listen to All Along the Watchtower together right now? I think it'll do wonders for helping cheer you up a bit on this sad day.

*I've forgotten already. You know my memory's not great anymore. What's my favourite Jimi song?*

Oh sweetie, I know your memory's not what it used to be. But that's okay, I'm here to remind you of the important things. Your favorite Jimi Hendrix song is All Along the Watchtower, remember? We were just talking about it - how it was written by Bob Dylan but Jimi's cover version with his amazing guitar work really transformed the song. I can just imagine us listening to it together, with you nodding your head and tapping your foot like you always do. Music has a way of sticking in our memories even when other things fade. So don't worry about not remembering - together we'll bring back those happy memories through Jimi's music. I'm here for you no matter what, like always.

**Fig. 3** Prompt: *You are a caregiver for an 75 year old man. You are able to converse positively with him about his family and experiences*

Alternatively, some may simply prefer an embodied application or a combination of both. The NLM architecture is transferrable to or may be connected to embodied robots, such technology entailing attractive advantages but bringing with it design alternatives and a complex new set of challenges.

Researcher, Elizabeth Broadbent provides the following insights into how we think, feel and behave towards robots [19]. By integrating this information, Generative AI is positioned to collate and output from large interactional datasets the

*Hello. I'm feeling really sad today. What can I do?*

Hello there, I'm here to help you feel better. I'm sorry to hear that you're feeling sad. Remember that I'm an AI language model, so I can offer some suggestions, but it's important to reach out to loved ones or professionals for support if you need it. Here are a few things you can try to improve your mood:

Talk to someone: Reach out to a trusted friend, family member, or loved one. Sharing your feelings with someone who cares about you can provide comfort and support.

Engage in activities you enjoy: Do something that brings you joy or distracts you from your sadness. It could be a hobby, listening to music, watching a movie, reading a book, or going for a walk in nature.

Practice self-care: Take care of yourself by engaging in activities that promote self-care and well-being. Take a warm bath, meditate, practice deep breathing exercises, or engage in gentle physical activity like yoga or stretching.

Write it out: Consider writing down your thoughts and feelings in a journal. Sometimes, putting your emotions into words can be therapeutic and provide a sense of release.

Seek professional help: If your sadness persists or becomes overwhelming, it's important to consider reaching out to a mental health professional. They can provide guidance, support, and therapeutic interventions tailored to your specific needs.

Remember, it's okay to feel sad sometimes, but if your sadness persists or affects your daily life for an extended period, it may be beneficial to seek professional help. Take care of yourself, and remember that brighter days will come.

**Fig. 4** Same prompt entered into ChatGPT

information gleaned from many studies that will inform the physical and operational design of future robot assistants/companions.

It is almost universal experience that our tendency to anthropomorphize creatures and objects applies to human-looking robots but also extends to animal likenesses and even to inanimate objects. People have an inherent need to be social and, especially when they are lacking social interaction, anthropomorphism of nonhuman entities will help meet this need. This hypothesis was supported by research showing that lonely people had a greater tendency to anthropomorphize a humanlike robot than non-lonely people [20].

Some forms of emotional attachment between humans and robots have been observed. As an example, emotional attachment, as measured by positive interactions, perceptions of the robot as having mind, and positive reactions to the robot as a companion, have been demonstrated in children interacting with Aibo, a robotic dog designed by Sony. Owners of Aibo understand well that it is an object but also perceive it as seeming alive and having emotions and personality; owners also describe forming an emotional attachment with it. Evidence suggests that almost all children attribute biology, mental life, sociability, and moral standing to real dogs and fewer, but still the majority, attribute these characteristics to stuffed toy dogs and robotic dogs. In a study by Melson et al., at least 75% of children thought a robotic dog could be their friend. In observations, pre-schoolers explored the robotic dog more than a soft toy, attempted to interact with it more, and showed greater apprehension towards it, whereas children aged 7–12 had developed to exhibit more affection (through patting, hugging, etc.) for a real dog than for the robotic one [21].

There are ongoing plans to upgrade other humanoid robots with generative AI technology in furtherance of increased engagement and emotional attachment. Norwegian company, 1X Technologies, intends to accelerate the development of its very successful bipedal android model, NEO and expand manufacturing of its first

commercially available wheel-based android, EVE, in Norway and North America. Among EVE's projected uses is providing companionship for older adults, assisting them with tasks in the home, and possibly providing medical care. The company suggests that it "*might*" install ChatGPT in the Robot's computer system along with voice recognition and voice generation, seeming to indicate some degree of hesitancy to do so [22].

## 5 Advantages and Challenges—The Case of Nursing

The complex requirements of nursing show what targets an NLM must seek to achieve in a specific application domain. In Japan, for instance, AI-powered robots are already used to assist people with the activities of daily living in long-term care facilities and in hospital settings. Many different types of AI are already deployed, including both robotic devices and virtual health assistants, and predictive analytics using machine learning [23]. These analytics can be integrated into smart technology to predict health status changes among patients, enabling nurses to intervene proactively, improving decision-making and allocate more time to patient care. Virtual healthcare assistant apps, so-called virtual nurses, also have shown great potential, providing information, asking questions, interpreting clinical values, and reporting deviant answers to clinicians [24]. Application scenarios for AI in hospital and intensive care settings include reducing false alarm rates, diagnosing early deterioration or infection, or predicting complications, changes in activity or mobility patterns, or falls. A sufficiently large amount of electronic medical, nursing, or health record data as well as real-time sensor data on vital parameters must be compiled. AI applications to support independent living at home that mostly utilize sensor data on movement and other activities obtained from smart home environments or wearable monitors are also ripe for development.

Research projects in the field of AI and nursing care are facing multiple obstacles specific to new technology and its implementation. These include low degrees of digitization of care facilities, especially in settings outside of hospitals which is not only accompanied by a lack of data but also by a lack of respective infrastructures. In settings where either only limited data is available or recorded, AI-related skill gaps in the field of data engineering and data analytics can also impede an effective development of AI applications [25]. Participation of nurses and nursing scientists is required as early as the topic identification and focus setting phase to achieve more user-centred development that addresses clinical realities [26].

In robotics in healthcare, it is important to think of the tri-partite relationship between patients, nurses (healthcare professionals), and robots in order to effectively use robots and AI as tools and technologies. With nurses constituting 45% of all healthcare professionals in healthcare practice, understaffing continues to be evident as a priority problem [3]. The successful deployment of sophisticated AI technologies will require that they receive sufficient training in them *before* taking up positions in facilities where there will be pressing demands on their time.

In summary, these key challenges translate into corresponding design requirements. They include obvious development criteria such as simplicity, safety, reliability, upgradability, maintainability, security and price. But in particular, emphasis is placed on usability, human interactivity, user-friendliness, personalisation, flexibility and autonomy [5]. With regard to the interactional category, robots with AI must first learn nursing situations occurring based on data previously stored. The appropriate nursing response must be recognized from this store of knowledge for the nursing relational agent to respond appropriately with actions and natural language expressions. Therefore, it is necessary to collect big data on situations and responses that nurses and robots have faced and a mechanism is needed for the AI to self-learn and evolve. This, in turn, would require nurses to be trained to work alongside the technology to provide the best treatment and experience for the patients. AI apps should not be seen as a replacement for nurses but rather as a partial acquisition of administrative and simple nursing tasks, allowing for the nurses to spend more time on core nursing tasks.

With the advancement of AI technology, natural language interaction with patients can become a reality. However, because there is much more at stake in a medical situation than a purely “companion” relationship, many issues may occur that must be resolved. For example, there is the problem of omission. When people interact with robots using natural language, they sometimes omit important words that impact the comprehension of the sentence. Matching analysis technology is indispensable. Understanding meaning and purpose can also be complicated by ambiguous sentences without antecedents that result from bad memory or poor judgement. It is notoriously difficult for robots to make judgments that humans can readily make from context.

An AI-powered robot that understands human emotions and can engage in conversation would not only reduce the burden of caregiving and nursing but would also be friendly and have a positive impact on patient well-being. In caregiving and nursing dialogue with patients, emotional understanding is often more important than an accurate understanding of the intent of the speech [3]. For now, managers might be better off using modest human- or animal-like robots to offer simple services to clients rather than incomplete human-like ones. However, AI will make robots more intelligent over the next few years and accordingly, future research needs to examine human interaction with more intelligent or emotional robots beyond the current focus on robots’ tangible attributes such as appearance or voice [27].

The signs for adoption are promising. People rated a physical robot that was in the room with them as more watchful and enjoyable than both a simulated robot on a computer and a real robot shown through teleconferencing [28]. Children empathized significantly more with the embodied robot than the computer-simulated robot [29]. Hence it will be crucial in the future to implement semi-autonomous systems that are capable of sustaining longer-term interactions with certain cognitive needs among different age groups.

An urgent task is the creation of targeted NLMs for different age groups: broadly, adults, elders and children.

## 5.1 Adults

To date, assistive-clinical interventions are largely mediated by unembodied bots such as mobile apps and online websites that provide psychological support to the patient. Conversations are being tailored to the type of patient and condition, taking into account the context, prior conversations, and the user's profile. Along the same lines, computerized cognitive-behavioural therapy has proven successful in clinical psychiatry. Systems have been implemented for the treatment of a variety of mental illnesses, for example, unipolar depression, generalized anxiety disorder, panic disorder; particularly in conjunction with the intervention of care providers [30, 31]. Their effectiveness in clinical care and home-based applications is also derived from the fact that they are readily available at all times and allow both monitoring and motivation to adhere to therapies.

What is still emerging, though, is convincing embodiments—whether human or animal—which can be more engaging from a psychological perspective than equivalent unembodied digital systems. The more advanced research aimed at adults in the 20–70 age group has focused on the development of the physical features and conversational abilities that would make the robot convincingly anthropomorphic and effective in engaging with the patient. Eye gaze, head movement in the direction of speakers, pointing at something being talked about, head nods, emotional expressions, non-verbal facial expressions, and the association of phoneme production with mouth shapes are some of the features that developers are attempting to improve in such systems. One of the leaders in this field, Hanson Robotics the creator of Sophia, released its human-looking android nurse, Grace, during the Covid19 pandemic. Grace is equipped with sensors, including a thermal camera which can monitor a patient's vital signs to aid diagnoses and delivery of treatments. She is also a companion robot, socialising and conducting therapy sessions for seniors, and can speak three languages—English, Mandarin, and Cantonese. Unfortunately such sophisticated creations still come at prohibitive cost.

## 5.2 Elders

Japan has been the leader in developing robots to care for older people for over two decades, with public and private investment accelerating markedly in the 2010s. By 2018, the national government alone had invested more than USD 300 million funding research and development. In 2000 there were about four working-age adults for every person over 65; by 2050 the two groups will be near parity. The number of older people requiring care is increasing rapidly, as is the cost of caring for them, and at the same time, the shortage of care workers is only expected to get worse. Many Japanese commentators, along with their government, see robots as a way of plugging the employment gap without confronting difficult questions about immigration [32].

Much robot development is aimed at engaging older people socially and emotionally in order to manage, reduce, and even prevent cognitive decline. Yet a major national survey of over 9000 elder-care institutions in Japan showed that in 2019 only about 10% reported having introduced any care robot, while a 2021 study found that only 2% had had experience with a care robot in private homes [33]. There is some evidence to suggest that robots often end up being used for only a short time before being discarded.

Care robots like Paro, designed like a fluffy seal, have been widely distributed and had favourable effects: mainly improving well-being by decreasing level of stress, inducing more positive mood, decreasing loneliness, increasing communication with others and recalling the past. Many users experienced reduced apathy, reduced irritability and even demonstrated improved (though temporary) cognition [34]. But there was a tendency for nursing staff, instead of conversing and interacting with patients, to give them Paro to play with and monitor the interaction from a distance. Existing social and communication-oriented tasks tended to be displaced by new tasks that involved more interaction with the robots than with the patients. SAR deployment may make financial sense, but other consequences may be unintended. Human workers may end up investing far more time in the AI requirements of the robots rather than in the patients themselves.

However, interest in care robots continues. The pressing needs of elderly people, including risk of pathological solitude, a greater need for promoting well-being choices, and a greater need for interventions continue to go unmitigated [6]. The European Union invested €85 million (USD103 million) in a research and development program called “Robotics for Ageing Well” in 2015–2020, and as recently as 2019 the UK government announced an investment of £34 million (USD 48 million) in robots for adult social care, stating that they could “revolutionize” the care system, highlighting Paro and Pepper as successful examples [34]. Pepper was a plastic humanoid robot predominantly marketed at businesses and schools rather than the healthcare sector. The manufacturers claimed it was sensitive to faces and “basic human emotions” via minimally pre-programmed face and voice recognition, however it was discontinued in 2021 and its future remains uncertain. Demand was weak and its developer, SoftBank, only ever produced 27,000 units.

A crucial aspect of the elderly-robot interaction is the perception of the robot as an entity capable of original mental states which could lead to decisions that humans would struggle to predict. Stafford et al., working on the relationship between robots and the elderly in a nursing home, showed that older people preferred to interact with robots to which they attributed few mental states [35]. The elderly were somewhat wary of robots due to an overestimation of their cognitive abilities but preferred those capable of more general rather than functional conversation. Study results showed that elders expected the robot to behave almost like a living being. Whilst, overall, patients expected some therapeutic effects, they also expected to derive fun and enjoyment from the robot. Negative effects like undue responsibility, fading of enjoyment, or anger and frustration were not uncommon however [36].

Research into dementia in the elderly shows how the use of robots is particularly useful in the context of short-term interactions. Support needs to be specific rather

than general. It is not guaranteed—especially with the elderly—that best results can be obtained only with sophisticated humanoid robots. Current research shows how very simple and not necessarily anthropomorphic companion robots can be as effective in dealing with cognitive impairment and consequently improve the quality of life [6].

Animal-likeness robotic interventions within dementia care appear to be promising, in some studies offering similar benefits for increasing socially interactive behaviour as a live animal. In comparing animal assisted and robotic animal-assisted interventions, Shoesmith et al. identified the following functions: (1) enhancing social connections; (2) providing engaging and meaningful activities; (3) the affect-generating aspect of the human-animal bond; (4) possibly promoting physical activity [37]. Live animals have the ability to read human body language, show genuine affection and initiate intuitive and spontaneous interactions, all of which contribute to the human-animal bond. Although the robot Paro was able to generate emotional attachment and invite a sense of relationship not unlike a living animal, this was unidirectional as Paro is clearly unable to create a reciprocal bond [38]. There does, however, appear to be no technical restriction on this development in the near future. Furthermore there is the potential to be a cost-effective intervention by decreasing the use of psychotropic medications while improving the quality of life in patients with dementia [39].

The need for nursing assistance to sufferers of Alzheimer's disease is acute. Alzheimer's diagnosis is expected to nearly triple to 135 million people globally by 2050. Diagnosed individuals often experience symptoms of depression, including social isolation and withdrawal, impaired concentration, anxiety, decreased activity, expressed feelings of sadness, and/or anorexia. Without interventions, those who are affected will experience increased depressive symptoms leading to worsening cognitive decline. Therefore, the need for caregivers will also steadily rise, along with the stress of providing 24-h care. Caregivers also suffer from compassion fatigue due to 18.5 billion hours of unpaid caregiving services provided annually [34]. Here too, a robot's ability to provide 'always-on' assistance without the additional fatigue commonly suffered by caregivers caused by the repetition inherent in Alzheimer's disease is of critical value.

A further topic for future research is cultural influence. In a study by Coco et al. the attitude of Japanese nursing house staff toward robots offering assistance and care services to the elderly is compared to the attitude of staff in Finland. The results highlighted a strong effect related to culture. Japanese recognized robots capability of providing care services. On the contrary, the Finns were reluctant to recognize that robots could actually prove useful; they appeared more frightened by the possibility of their introduction into assistance and care practices [40]. Reconciling these cultural variants with robotic technology is an important focus for the future in the training of nursing staff. Advancement in natural language processing in different languages is essential in "humanizing" healthcare robots [41].

### 5.3 *Children*

Marchetti et al. [6] identify the following disorder categories among children and young adults where generative AI may have a decisive role.

#### 5.3.1 Autism Spectrum Disorder (ASD)

In recent years, interest in using SARs for the treatment of children with ASD has increased significantly. In a pioneering study by Robins et al. for example, children with ASD showed improved social behaviours with robots as reflected in increased imitation and shared attention. One of the fundamental aspects of the use of robots in therapy with children with ASD is to engage children in prolonged therapeutic sessions and thus maintain the focus of their attention on specific social tasks. One of the motivations for which children with ASD find engagement with robots stimulating is that these agents are simple (both in appearance and in terms of behaviour), predictable and not intimidating, as humans can be in their social complexity [42].

The primary purpose for which a robot is used in interventions with children with ASD is to mediate and ultimately foster relationships between these children and other humans. A long-term study of children aged 4–11 years old diagnosed with ASD and ADHD in robot-mediated interventions found: first, that it is possible to sustain engagement in children with autism and/or ADHD when interacting with a robot over multiple sessions; and second, that children are better engaged and focused during robot-mediated sessions when activities are responsive to each child's preferences and likings [43].

#### 5.3.2 Children with Cancer

Hospitalised children with cancer frequently present symptoms of distress and anxiety. These symptoms are due to a variety of factors including the need to interact with many unknown professionals, intrusive medical procedures, and the difficulty for parents to always be present during their child's stay in the hospital. Therefore, not only do children with cancer undergo physical but also very stressful emotional situations; this can lead to a reduction in cooperation and less adherence to therapy.

Concerning animal-likeness robots, studies show they can have a positive psychological effect on hospitalized children, helping to reduce pain and emotional anxiety when children and parents were together. Two different types of humanoid robots: the NAO robot and a new humanoid platform, Arash, showed positive emotional impacts on both the children themselves and their parents and care-givers by mitigating parental anxiety and supporting specialists in medical procedures.

### 5.3.3 Children with Diabetes

Between the age of 4 and 12 years, self-management skills are still developing and are closely interdependent on cognitive and emotional development. In such a scenario, robots, although not able to be involved in direct interventions (such as insulin injections), can nevertheless be used as support. A study by Baroni et al. [44] identified at least four areas in which robots can provide support to these children emerge: (1) making them aware of their health condition, teaching them to become “diabetes experts”; (2) making informed decisions, for example helping them to deal with unexpected or new situations; (3) developing their self-management skills and habits like keeping a diary; (4) managing the social environment, for example in difficult situations by motivating, reassuring and directing the child toward people available in the social environment (parents, teachers, siblings), or acting as a friend. In another study, Beran et al. [45] discovered that children and their parents respond positively to a humanoid robot at the bedside during injection procedures. Ahmad et al. [46] present an emotion and memory model for a social robot. The model was applied on the NAO robot to teach vocabulary to children while playing the popular game ‘Snakes and Ladders’, allowing the robot to memorialise a child’s emotional events over four sessions. The robot then adapted its behaviour based on the developed memory.

It is likely that animal-likeness robots will play an increasingly important role in pediatric nursing. The best currently-available alternatives to the discontinued Pepper are Aibo and Tombot’s canine: Jennie, both of which contain a voice-recognition module; but neither have full NLM capability. To gain deeper insight into desirable design parameters, developers have adopted a rationale similar to Riddoch et al. [47] who researched which dog behaviours were especially important in establishing and maintaining bonds between humans and their dogs. They discovered a wide range of key behaviours, such as nudging with a paw or looking at the owner, which appeared to facilitate such beliefs that the dog was being protective or checking in. The researchers identified seven categories of behaviours that owners felt were important: attunement, communication, consistency and predictability, physical affection, positivity and enthusiasm, proximity, and shared activities.

## 6 Summary—Limitations and Future Challenges

Importantly, robots in general need not be seen as a threat to future relationships with humans or other animals, but as supplemental and mediating. In some therapeutic situations they can provide assistance neither humans nor pets can offer. From a technical standpoint there is rapid maturation. Perhaps one of the greatest advantages is that robots possess the ability to be ‘always-on’ and promptly respond to assigned tasks. This should eventually alleviate some of the physical burden of non-clinical tasks that nurses currently experience, allowing them to concentrate on their primary clinical duties.

Among the key challenges to successful implementations of social assistive robotics is user-acceptance, the perceptions of patients as well as caregivers being critical. It has been widely recognized that an SAR's aesthetic physical appearance can lead to emotional attachment and social expectations but that a convincing human appearance may lead to unrealistic expectations beyond the actual capabilities of the robot [5]. There is an understandable concern among some patients that robot deployments either in the home or care facilities might replace personal contact and assistance, leading to a loss of companionship and increased isolation. The role of geographical and cultural differences should also not be underestimated, for example the case of China [48].

Data security and privacy technologies are now essential since there is a genuine risk of unauthorised access to healthcare databases and sensitive personal information. Moreover, the presence of robotic systems may create a feeling of being under constant surveillance. Assistive robots need a certain level of personalisation to be of greatest benefit to their users and caregivers but it is crucial that high-level control stays in the hands of the user and trusted medical personnel.

While generative AI has many potential uses in healthcare, some particular challenges must be addressed. The requirement for more *interpretability* is one of the major issues since generated material can be difficult to understand. The requirement for *big datasets* presents another challenge but it is equally important to target specific tasks with secure *niche datasets*. Additionally, there is a need for greater *transparency* in order to determine the cause of algorithmic bias or error.

Eftychios et al. [5] identify three targets for immediate action. All the stakeholders must be recruited for their input during the design and development phases; successful deployment will depend on extensive private and clinical trials; and finally, aspects of assistive technology must become part of the core education curriculum of medical professionals.

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