FUEL YOUR FUTURE

The Intelligence Revolution
In Hearing Health Care Delivery

FUEL MEDICAL

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“Generative AI is likely to have the biggest impact on knowledge work, particularly activities involving decision-making and collaboration, which previously had the lowest potential for automation.“

—The economic potential of generative AI: The next productivity frontier, Chui, M., et al., June 2023 McKinsey & Company

“This is a transformative moment in human history. The changes that are going to occur in the lifetime of people entering medicine today are going to be without parallel.”

—Dr. Lloyd Minor, Dean of the Stanford University School of Medicine, commenting on the breakthroughs AI will bring to medicine.

“By leveraging the power of AI, we have a unique opportunity to democratize healthcare, making it more equitable, accessible, and tailored to the needs of diverse communities.”

—AIMQWEST Corporation 2023

“All of us are at the beginning of a journey to understand this technology’s power, reach, and capabilities. If the past eight months are any guide, the next several years will take us on a roller-coaster ride featuring fast-paced innovation and technological breakthroughs that force us to recalibrate our understanding of AI’s impact on our work and our lives. It is important to properly understand this phenomenon and anticipate its impact. Given the speed of generative AI’s deployment so far, the need to accelerate digital transformation and reskill labor forces is great.”

—The economic potential of generative AI: The next productivity frontier, Chui, M., et al., June 2023 McKinsey & Company

INTRODUCTION

WHY IS ARTIFICIAL INTELLIGENCE IMPORTANT?

We must understand generative artificial intelligence (GenAI) because it is the master platform for transforming health care to solve numerous problems, and in doing so, it will remake and modernize health care provision. It is driving both cultural and technological change in health care. This transformation brings many exciting opportunities to improve patient care, especially access and affordability while increasing revenue. It also offers an opportunity to be a changemaker and assume leadership in this unstoppable transformation of hearing health care (HHC). The capabilities and progress of HHC will depend on how well we transform HHC into a GenAI-based system while retaining our core values. This paper is a changemaker's guide to that transformation.

THE AI PROBLEM:

AI technology is unexpectedly powerful and advancing so rapidly that it is difficult to absorb how it is transforming HHC. This Intelligence Revolution is challenging traditional HHC delivery and business models. The path forward and how much disruption will occur are unclear. As the providers of HHC services, we prioritize delivering those services as the crucial area for AI-driven improvements.

THE SOLUTION:

The resolution is understanding GenAI and its potential to create new AI-enabled healthcare delivery and business models that solve HHC's most pressing challenges. Creating that knowledge, encouraging the use of AI to solve HHC's struggles and rethinking the assumptions of healthcare delivery are the purposes of this white paper. We start with an overview of AI.

AI OVERVIEW

Professor John McCarthy created the term artificial intelligence (AI) in 1956 when he gathered a small group to spend a few weeks pondering on how to make machines do things like use language (Simonite, 2023). They failed, but they planted a fertile seed. *AI, the ability of software to perform cognitive functions traditionally associated with human minds*, became a new field of study. We have used AI for years when we talked with Siri or Alexa, searched the internet or used a chatbot. However, basic AI could not generate original content. That came recently.

Deep-learning-based models use circuits and algorithms based on brain *neural networks* nested in layers, with connections between and among layers weighted differently as they train and learn. The first layer receives the input, and the last layer yields the output. Just as scientists who study the brain don't understand precisely how the brain works, the experts who create neural networks don't always understand what happens in the neural networks they make. Deep-learning models excel at learning from text, images, audio and code, from which they can produce new original text, images, audio, code, simulation and videos. They can understand sequential data, such as how a word is used in a sentence, and are drastically changing the way we approach content creation.

Researchers at Dishbrain are taking neural network modeling to the next level by fusing computer chips with living human and mouse brain tissue. Their goal is to enhance neural network-based AI models with biological intelligence. According to Blain (2023), this approach shows promise.

Machine learning (ML) is a form of AI that can learn from data patterns without human direction. We train ML on an extensive database from which it detects patterns and learns how to make predictions and recommendations. It also adapts, becoming more efficient with new data and experiences.

Generative AI (GenAI) is a form of machine learning based on deep learning and has more capabilities than basic AI. It can generate new content responding to a prompt by identifying patterns in massive quantities of training data and then creating original material with similar characteristics. Outputs from GenAI models can be indistinguishable from human-generated content. GenAI can be used out of the box or fine-tuned to perform specific tasks.

Large language models (LLM) are a type of GenAI, such as ChatGPT, trained exclusively on text. Because language allows us to build models of the world, even absent any other stimuli, like vision or hearing, LLMs can write fluently about the relationships between different sounds even though it has never heard either.

The Intelligence Revolution refers to the massive transformation of society caused by the exponential growth of computer power and the unrelenting desire to create machines that do everything humans do. It is a profound revolution in how we think, work and think of ourselves as humans. It is transforming our society, including the HHC professions.

In this white paper, we consider how AI facilitates HHC provision, including machine-learning models and their predictions and the new systems for care delivery they enable.

WHAT ARE THE ADVANTAGES OF GenAI?

- **GenAI** *drives down the time taken to perform a task*. It enables multitasking and eases the workload for existing resources. These advantages improve productivity and increase cost savings.

- **GenAI** *enables the execution of hitherto complex tasks* without significant cost. It avoids hiring competent but expensive new experts.

- **GenAI** *operates 24/7 without interruption or breaks*, surpassing the dedicated performance of even our most loyal and committed clinic employees.

- **GenAI** *facilitates decision-making* by making the process faster and wiser. It has access to more knowledge and can analyze it quicker and more intelligently.

- **GenAI** *makes the rapid query, analysis and summary of massive amounts of data possible.* As detailed below, this enables precision medicine in HHC, an innovative approach to tailoring disease prevention and treatment that considers differences in people's genes, environments and lifestyles.

- **GenAI** *is being deployed across industries*, so its use is becoming commonplace. It is the fastest diffusing innovation ever. Patients will expect HHC to use GenAI, and its use will define the best care.

WHY IS GenAI CHANGING SO RAPIDLY? It is a powerful human bias to expect tomorrow to be like today. So, we wildly underestimate how quickly AI systems will transform health care. Let's look at what is countering our bias and driving the rapid changes in AI.

- *GenAI is popular:* ChatGPT drew one million users in the first five days of its existence. In 40 days, it had 100 million users. That is the fastest adoption of any innovation ever.

- *GenAI is easy to use:* It operates with natural language processing, which means it understands instructions in natural language, the language you use daily. There is no need to know computer programming to communicate with or instruct GenAI.

- *GenAI knowledge diffuses quickly:* Researchers from competing AI labs hang out socially and discuss their work. AI researchers also publish more papers and give more presentations than most scientists.

- *GenAI feeds itself:* GenAI is self-improving because now that we can partner with AI, we can improve and amplify what we do to push science and technology forward. This results in a massive increase in scientific and technological advancement, creating a more powerful AI, which will produce more advances in technology and science and an even more improved AI. In this enhancement feedback loop, AI experiences explosive progress.

- *GenAI is competitive:* Big tech and startups know its promise. They are spending billions of dollars in an epic race for AI platform dominance. In 2023, enterprises spent $16 billion on GenAI solutions. They are expected to spend $143 billion by 2027, according to the International Data Corporation, a research firm.

- *GenAI is universally necessary*: Business leaders realize that GenAI is crucial to staying competitive across industries. Everyone is aware and impatient to add AI to their operations or get left behind, including HHC providers.

- *GenAI is not stopping or pausing:* The AI race is in full swing, forever changing how we provide HHC. Competitors, spending billions of dollars and racing to dominate AI, will not pause for fear that they will

lose the race. In this race, the “transformation train” has left the station, and we cannot stop it, so we must learn how to control and use GenAI.

FUTURE AI:

Artificial general intelligence (AGI), *the stage at which AI can do any job that a human can do, only better*, is the longer-term future of AI. It is a central theme of the Intelligence Revolution. This paper will not specifically cover AGI, but it is a fascinating, controversial and fast-moving field of study that offers a world without work (Susskind, D., 2020). It raises the supposition that AI may not be artificial. Instead, we should refer to it as inorganic or machine intelligence. We encourage readers to keep abreast of AGI, monitor its progress and imagine how it will further transform HHC. But first, this paper provides an essential background of GenAI and its application to HHC now, at the dawn of the Intelligence Revolution. Here, we attempt to answer the fundamental question: What do we do?

Artificial superintelligence (ASI) is a hypothetical future AI that is *significantly more intelligent than the best human minds across various categories and fields of endeavor.* ASI does not exist.

Improving AI

There are three main dimensions to quickly improve AI: size, data and applications (Bertics, A., 2023).

- *Size*: Traditionally, we have considered larger models to be better. However, increasing size results in enormous costs. The new focus is to maintain performance by making models smaller and faster. This transformation is done by training a smaller model using more training data. We can also shrink size by reducing the numerical precision of the parameters within a model. Small models are less expensive to run, and we can use them on a laptop or cellphone.
- *Data*: We can also shift the focus from how much data to improving the quality of the model’s data. Furthermore, we can create more effective models by increasing and combining data types to give them new capabilities.
- *Application*: AI has advanced quicker than we have taken advantage of, so one way to improve AI is to learn how to use it more effectively. There are three main ways to use AI.
    - *Prompt engineering* feeds the model with specific phrases or questions based on the desired goal.
    - *Fine-tuning* a model to improve it, such as adding an extra round of training using papers from HHC journals to make it better at answering HHC questions.
    - *Embed* LLM in a more extensive, more robust architecture, such as combining an LLM with extra software and a database of knowledge to make it less likely to produce falsehoods.

Computer Advances and AI

The power of AI comes from its training materials and computer power. As computer power increases, AI becomes faster and more powerful.

Personal computers (PC): We will see PC power increase in 2024 by adding GenAI to smartphones and personal computers, allowing them to run GenAI algorithms directly on their hardware without the internet or expensive cloud computing services. Lisa Su, who leads Advanced Micro Devices, says AI-enabled PCs will fundamentally redefine the computing experience over the coming years.

Supercomputers: In one second, *Aurora, the newest exascale supercomputer,* can perform two quintillion operations, the number two followed by 18 zeros. It will become functional in 2024 and have 70% more memory than the previous top supercomputer. Aurora’s creators will equip it with the latest advances in AI and use it to address medical issues, among other goals. In addition, Lawrence Livermore National Laboratory and Tesla are each building even more powerful supercomputers.

Quantum computing has the advantage of being quantum-based like nature rather than digital-based like supercomputers, so it can simulate reality that digital computers struggle with. Quantum computers also promise to be more powerful than digital computers. The best supercomputer, before Aurora, would take an astonishing 47.2 years to match a computation by Google’s newest quantum computer (Kaku, M., 2023). Quantum systems have the potential to solve problems the fastest classical supercomputers could not crack in millions of years.

"This year (2023) has shown us that AI isn't just a kind of cool new thing; it's actually the future of computing."

—Lisa Su, Chief Executive of Advanced Microdevices

The rapid growth of more powerful computers and the accompanying expansion of expertise will accelerate the use and capabilities of AI. Improved AI can help design even faster, more powerful computers. The Intelligence Revolution is on a fast track!

Integrating novel data and providing new services is crucial to healthcare AI development. As GenAI combines with HHC, we must shape it to solve critical problems in the HHC environment. Below is a look into those growing problems.

HHC's GROWING PROBLEMS

HHC Problems Shape the Application of GenAI: The urgent need to solve these ten crucial problems plaguing HHC is heavily influencing the application of AI to improve hearing health care.

1. **Supply and demand:** For the past two decades, approximately 800 new Au.D.s have graduated yearly, and the number of practicing audiologists has remained constant at about 12,000. The numbers for ENTs are similar. On the demand side, 40–60 million people in the US have hearing health issues, and the numbers are growing. *Audiologists and ENTs cannot serve all the patients needing hearing health care. We must provide competent alternatives.*

2. **Affordability:** More than half the workers in the U.S. make less than $44,000 a year, and about 30% have no savings. Half the households 65 to 74 years of age have incomes less than $55,000, and half the households 75 and older have incomes less than $38,000. They cannot afford $5,000 once, much less every four or five years, for a pair of hearing aids. *We must provide capable, low-priced hearing devices for those unable to afford traditional hearing aids.*

3. **Information access:** The traditional one-on-one in-person consultations we have relied on for creating and sharing HHC knowledge are outdated. The new view is that there is nothing so special or unique about a professional's knowledge that we cannot make it easily accessible and understandable when delivered online. *We must give patients easier access to HHC information and educate them on how to manage their hearing difficulties.*

4. **The face-to-face dilemma:** Patients prefer in-person interactions for their medical care (Singh, J., Dhar, S., 2023). But, in-person interactions are costly, and there are not enough providers to offer face-to-face care for everyone. *We must reduce all unnecessary, expensive face-to-face interactions and simultaneously greatly increase overall accessibility.*

5. **Psychological factors:** Outsourcing a personal issue, including health issues, to another can be diminishing and conducive to doubts about one's self-sufficiency. People gain satisfaction and self-respect when they grapple with problems on their own. *We must provide information and tools that support the ability of individuals to promote health, prevent disease, maintain health and cope with illness and disability with or without the support of an HHC worker.*

6. **Moral obligation:** Lack of affordability and access limits HHC in rural and economically challenged communities. There are places where no amount of money can get a human to come to help you with HHC. *We have the technological means to spread HHC expertise more widely at a lower cost. As medical professionals, we must morally strive to make this happen.*

7. **Need to improve medical care:** *We must move beyond the one-size-fits-all medical model and expand the boundaries of medicine beyond the traditional scope of clinical practice to deliver more precise, personalized and effective patient care.*

8. **Need to improve collaborations with primary care providers (PCPs):** HHC patients are more likely to seek and follow treatment recommended by their PCP. However, PCPs too often overlook HHC, and HHC providers too often ignore the importance of PCPs in HHC decisions. *We must connect with PCPs and facilitate, educate and empower them to triage and refer HHC patients to the proper providers.*

9. **Need for nonmedical HHC providers:** Since we do not have enough medical providers to care for all HHC patients, *we must create competent nonmedical providers for those patients who don't require expensive advanced medical care.*

10. **We need to expand clinical audiology to care for all HHC patients** regardless of the severity of their hearing issues, including mild hearing loss and self-perceived hearing issues we miss, irrespective of their low profitability.

The Changing Role of Innovation

Any existing organization … goes down fast if it does not innovate.

—Peter Drucker

Drucker's comment about organizations also applies to the HHC professions. Imagination structured by knowledge and reflection allows for innovation. Innovation is crucial to success in the Intelligence Revolution. Still, innovation has changed from focusing on efficiency gains in a one-to-one consultative advisory model of professional service to innovations that provide credible, promising alternatives to selling the time of expert humans, such as HHC providers (Susskind and Susskind, 2022). Table 1 lists some differences between the older innovations and those required in this new era.

Table 1. How innovations have progressed, modified from Susskind and Susskind (2022)

Previous Innovations	Modern Innovations
Process improvements	New business models
Marketing noise	Substantive progress
Automation	Innovation
Argument-based	Evidence-based
Minority of partners involved	Majority of partners involved
Intellectual grasp	Emotional commitment
Avoiding competitive disadvantage	Seeking competitive advantage
Short-term tactical	Long-term strategic

When considering the opportunities presented by GenAI, we must choose changes consistent with modern innovations like those listed in the right-hand column of Table 1 and others that *provide alternatives to selling audiologists' and ENTs' time*. We will discuss this latter point more below as we look at a breakdown of our patient population and nonprescription HHC provision.

HEARING HEALTH CARE'S PATIENT POPULATIONS

To understand how GenAI is transforming the provision of HHC to resolve its problems, we must first appreciate the diversity of our patient base and their needs. This patient diversity and the multiplicity of needs, plus GenAI's innovations and power, are the drivers of redefining HHC providers and transforming their roles. Here is where we stand today.

Hearing Loss	Treatment & Patient Parameters	Patient Population Distribution
Profound Hearing Loss	Mostly elderly patients Complex, sophisticated treatment High device customization High treatment costs	1.9M
Moderate to Severe Hearing Loss	Mostly later middle-aged patients Wide range of treatment sophistication Wide range of device customization Wide range of treatment costs	7.6M
Mild to Moderate Hearing Loss	Mostly middle-aged Patients Simple treatment devices No customization Low treatment costs	28.5M
No Audiometric Hearing Loss, but Self-Perceived Hearing Loss	The patient and treatment variables are being researched. Mild amplification and improving hearing in noise may be a promising treatment for some	25.3M

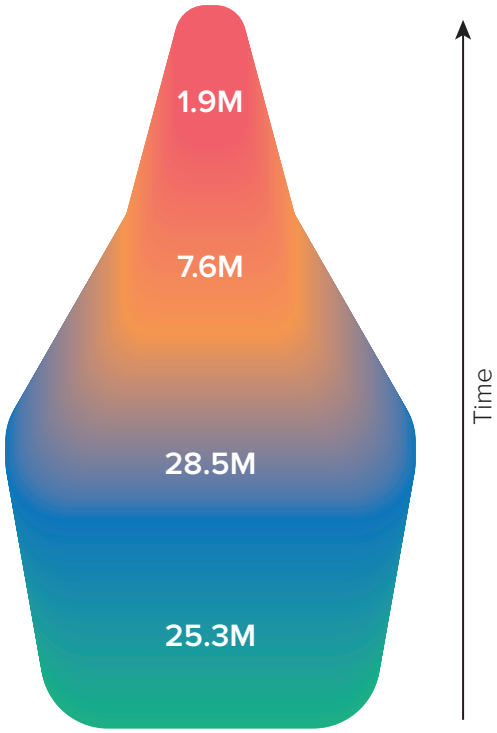

Figure 1. The distribution of patients according to their degree of hearing loss and the costs and quality of their treatments. Adapted from Taylor and Nielsen 2019, with data from Nash 2013, Lin 2011, Wallhagen and Pettengill 2008, Humes, 2021, Edwards, 2020.

Figure 1 illustrates that 75% of patients with measurable hearing loss have mild or moderate losses, while only 5% have profound hearing loss. There are overwhelming differences in the healthcare needs of these patient groups. Much hearing loss is chronic, and as time passes, the hearing loss gets more severe, so treatments and providers must evolve to accommodate those changes. Grouped by the severity of hearing loss, the illustration clarifies the differences in costs, treatments and expertise needed to serve each group.

Sadly, we have no established way to treat self-perceived hearing loss accompanying a normal audiogram. Mild amplification and improved hearing in noise show promise for some (Edwards, 2020; Roup, 2023). Mealings et al. (2023) reported that mild gain hearing aids can assist this population in having better self-reported hearing experiences in noisy environments. Still, differences were not observed in the laboratory tests. The increasing use of genomic diagnostics may give new insight into this issue. Indeed, no single treatment will work for all in this category, adding to the diversity of treatment complexity and costs.

The take-home message is that the provision of HHC for these groups differs drastically in the expertise required to treat them, treatment costs and complexity.

Audiology is at a turning point because we can now benefit from GenAI to efficiently address these diverse patient populations by matching patients' unique needs with the proper level of care, thereby reducing costs and increasing accessibility.

THE PIVOTAL THEME:
MATCH THE PROVIDER TO THE PATIENT'S NEEDS

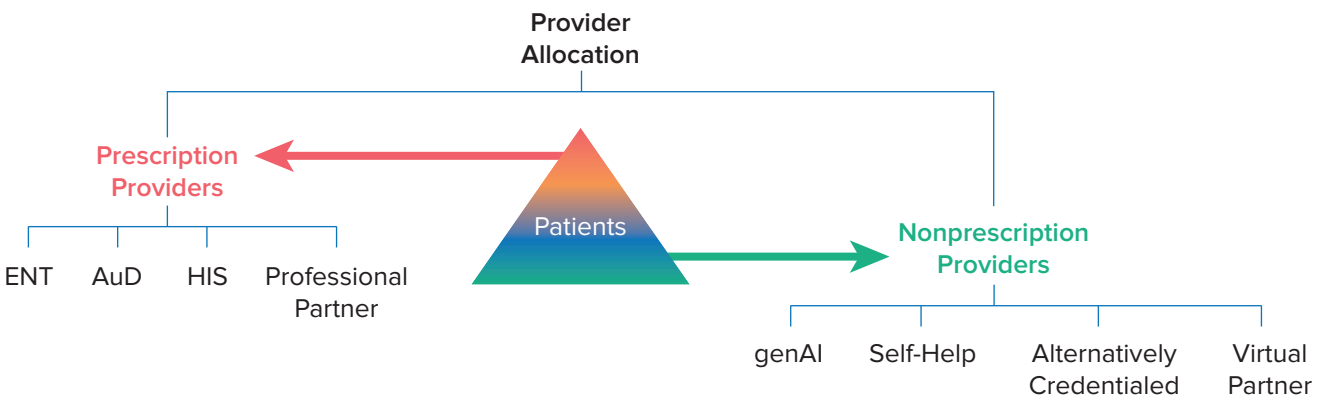

Figure 2. Patients in the upper portion of the triangle have complex prescription needs (See Figure 1) that are best met by providers using the medical model. Patients in the lower part of the triangle are best served by providers who do not use the medical model.

Figure 2 illustrates that we must split the diverse patient base in Figure 1 into those requiring medical model care (prescription providers) and those who will do well with nonmedical model care (nonprescription providers). This triaging matches the patient's needs to the appropriate provider and allows us to assign providers most efficiently and effectively while improving access and affordability. We amplify the details in the following sections.

AI'S ROLE IN FACILITATING THE PATIENT/PROVIDER MATCH

Figure 1 shows HHC patients distributed according to their hearing loss. However, people don't know where they are in this population distribution or which providers they should see. They require guidance to match their needs with the right provider. An enormous contribution of AI to HHC is its ability to facilitate that match and even create new providers.

AI's role in matching HHC patients and providers via primary care providers (PCPs)

Why PCPs matter: PCPs play crucial roles in HHC. PCPs are often the patient's initial interaction point. They are responsible for identifying hearing loss in Medicare's annual wellness exam. HHC patients are twice as likely to seek treatments, ranging from OTCs and hearing aids to implant surgeries if a PCP recommends them.

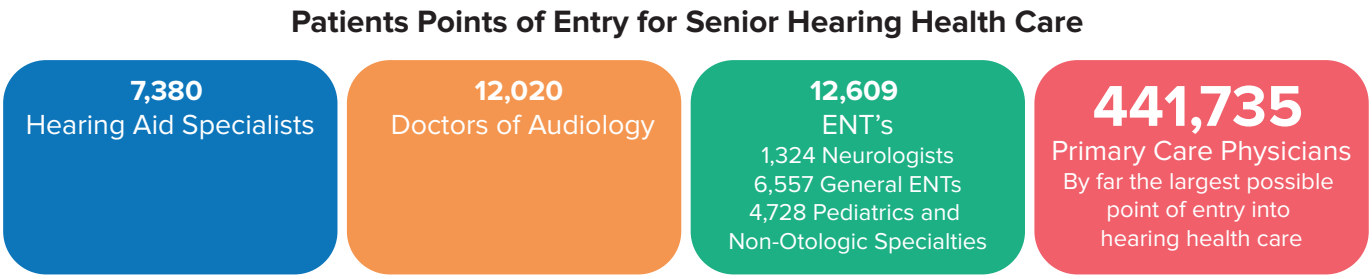

Figure 3. PCPs are the largest and most trusted entry point into senior HHC.

The problem: HHC has not been a top priority for PCPs. Only 12% refer patients to hearing care, and many are confused or anxious about identifying the hearing health path their patients should follow. As a result, hearing issues can go undiagnosed and untreated or not seen by the optimum provider.

The AI solution: We can embed HHC-based AI in primary care annual wellness intake forms to identify more people with hearing issues, diagnose them correctly and guide them to the proper treatment device and provider.

An example: HCRpath, created by Sara Sable-Antry (www.hcrpath.com), provides us with an example of how AI embedded in a PCP's intake forms provides a solution that benefits patients, PCPs, audiologists and ENTs. Here is how it works:

- HCRpath AI embedded in Medicare wellness exam intake forms identifies hearing loss and if the patient needs a medical exam.
- HCRpath *considers* a broad range of hearing devices, from simple nonmedical amplification devices to sophisticated medical devices, and matches the patient to the appropriate device suggestions based on its analysis.
- HCRpath *considers* several providers and suggests the most appropriate providers that the PCP could recommend to the patient.

In addition, HCRpath has several additional advantages, including audiologists and ENTs benefiting from more referrals for those patients genuinely concerned about hearing difficulties and ready to receive treatment. See www.hcrpath.com for more details.

This example demonstrates that AI embedded in the Medicare intake forms does not replace audiologists or ENTs. Instead, AI, as the PCP's *co-provider*, makes informed decisions that guide only appropriate patients to their optimum providers, maximizing the providers' time and services. In the future, this approach can benefit significantly from including genomic information and other personal information in the patient's database and its integration into the intake form analysis.

A strong partnership between HHC providers and PCPs is necessary to modernize the provision of HHC. AI can facilitate and strengthen that relationship. Audiology's involvement adds credibility and sophistication. We must work toward integrating AI-enabled HHC in the PCPs domain. Audiologists and ENTs will gain from working with PCPs and their AI system to be the clinician or clinic the AI recommends.

In facilitating the patient-provider match, HCRpath illustrates how AI can improve collaborations with PCP providers.

Let's turn to AI's role in solving other HHC problems centered on matching the patient and provider.

AI'S MODIFICATION OF HHC DELIVERY

The recent blossoming of GenAI and the concurrent proliferation of nonprescription hearing treatments have reshaped how audiologists can serve the lower portion of the patient triangle, who can benefit from nonprescription providers. These emerging provider types include self-help and virtual partners. Both benefit from GenAI empowerment.

A NEW GENERATION OF AI-ENABLED PROVIDERS ARE AUDIOLOGY EXTENDERS

Self-Help: *Patients as Partners*: A limitation to increasing patient information access and encouraging patients to investigate their problems is that we have thought of patients as passively waiting and then engaging a doctor when treatment is necessary. However, increasing offerings improved by GenAI let patients identify and triage medical issues and care for them independently, only bringing in a doctor when necessary. Meanwhile, medical devices customized for self-help are moving from the doctor's office to the home. Even cochlear implant recipients can self-test at home to monitor implant performance with a smartphone or tablet (Wasmann et al., 2023).

Because of these changes and the mismatch of provider supply and demand, individuals are becoming long-term stewards of their hearing health. Viewing patients as medical self-health stewards makes them partners

in the medical process. It acknowledges that there may be no other person or institution with a corresponding level of information, incentive or influence as the individual. It does not undermine the role of the medical community and its institutions. It makes it more efficient (Hartenstein and Latkovic, 2022).

Virtual Providers: GenAI allows us to provide accessible, competent virtual providers instead of one-on-one in-person medical care when patients need constant or repetitive advice or instructions. The AI that empowers virtual providers and self-help assistance is the same. We call it telepresence. Let's take a deeper dive into its operation and use.

AI ENHANCEMENT OF TELEPRESENCE

Telepresence —These technologies allow people to feel as if they are physically present with someone whom technology represents digitally. In prescription HHC, telepresence can be an essential part of digital therapeutics (DTx) to treat and manage diseases. *DTx are patient-facing software applications that help patients treat, prevent or manage a disease and have a proven clinical benefit.* Given the widespread use of cell phones and computers, telepresence is rapidly evolving to strengthen health care and increase affordability and accessibility.

Virtual assistants using GenAI can learn, converse and problem-solve like humans.

Previous virtual technologies, like Internet chat blogs, were not lifelike or personal—questioning and answering required laboriously written interactions with long delays, frustrating misspellings and mistaken interpretations. Notably, the elderly find them challenging and unnatural.

Videos are an improvement over text-based chatbots; however, if you have assembled furniture while watching a YouTube video, you understand the limitations of the video instructional model. Self-help videos give limited instructions, lack interactions and are often problematic.

GenAI allows us to do better. Virtual assistants using GenAI can learn, converse and problem-solve like humans. Using captioning and clear speech, they can exceed routine human communication.

GenAI facilitates the development of new care delivery capabilities that fundamentally change how HHC teams spend their most valuable resource: time. Now, we can provide patients with needed information 24/7 from a virtual person who can answer any verbal or written question and present a pleasant, empathetic personality. As the virtual partner acquires more knowledge, it improves with use. For example, see www.medrespond.com and their models from Cleveland Clinic's Cardiology Department.

Contrary to popular belief, AI can express emotions by reacting to the feelings of others. GenAI-based systems can determine a patient's emotional state by analyzing speech patterns and other cues, such as facial expressions and physiological measures. These systems can help inform a virtual provider in real time if the patient is or is not engaged and what material is resonating. The virtual presenter could slow down, show more empathy or make other changes. For a nonmedical example of AI and emotional connection, read Meghan O'Gieblyn's account of living with a primitive AI-based robot dog provided by Sony (O'Gieblyn, M., 2021). Patients will develop relationships with virtual providers as they do now with friendly front office staff and providers.

GenAI's INFLUENCE ON OTC DELIVERY AND ACCEPTANCE

By allowing patients to feel as if they are physically present with someone whom technology represents digitally, telepresence can transform over-the-counter (OTC) hearing aid adoption. The FDA promoted OTC hearing aids to provide high-quality hearing aids that people with mild to moderate hearing loss could buy online or at local pharmacies and big-box stores. However, acquiring hearing aids over the counter can still feel challenging. Not everyone with hearing loss is comfortable with online sales or do-it-yourself adjustments via apps. ASHA's OTC Hearing Aid Survey, 2023, found that only 24% of those patients who were at least somewhat confident an OTC device could assist them were confident they could choose the correct device. They need help.

AI-enabled platforms could be the key to unlocking greater value-based care adoption. Consider how helpful interactive dialog with a quality virtual provider could be in informing patients about OTC devices. Patients could discuss if the devices are appropriate treatments for their hearing issues. If so, they can also get suggestions about which OTC device to purchase and how to unbox, fit and maintain it. This system would introduce patients to HHC in a less expensive, more accessible, more successful and more rewarding way than it currently does.

Whoever dominates the interactive telepresence approach to OTCs will capture the mild hearing loss market and be the provider of choice for hearing issues as the patient's hearing deteriorates.

Perhaps the ultimate telepresence innovation is Google's Project Starline, which, without 3D glasses, provides the patient with a life-sized 3D image sitting across the table from them www.youtube.com/watch?v=obuyCkotJ_s. No more flat, boring screens! The image is so lifelike that people try to reach out to each other to shake hands or fist bump. That hologram could be a virtual representation of their personal physician or audiologist equipped with precision medicine knowledge, sensitive to the patient's emotions and available 24/7 for consultation.

The more true-to-life experience of 3D and holographic medicine is already with us. The University of Central Florida, see healthprofessions.ucf.edu/rehabilitation-innovation-center/#contact, uses holograms to train students and educate patients.

Along with their glasses-free 16-inch, 32-inch and 65-inch holographic displays, lookingglassfactory.com has small portable 3D holographic displays in the $300 range. Their technology could make holographic interactions available to a wide range of patients.

Virtual reality headsets are like having a computer strapped to your face. In time, these headsets will be inexpensive enough for healthcare systems and insurers to provide them so their patients can consult with their 3D virtual healthcare provider 24/7, creating a massive transformation in healthcare.

Creating 3D spatial videos just got easier with Apple's announcement of their iPhone 15 Pro model, which can record 3D spatial video you can view in 3D on their Vision Pro headset. Creating and using 3D video is becoming commonplace.

AI-powered virtual health care has the potential to be both convenient and cost-effective. Patients no longer need to schedule appointments, travel to a health care provider or wait for an in-person, one-on-one meeting with their provider.

AI'S EFFECTS ON PRESCRIPTION HHC

In-Office AI-Enabled Audiology Extenders: While self-help and remote virtual providers will improve HHC access, in-office AI-enabled providers like AMTAS Pro will also be needed to accompany prescription care.

> **AMTAS Pro:** This is made by GSI and provides an Automated Method for Testing Auditory Sensitivity. It is an in-office patient-directed hearing assessment tool that uses AI to obtain diagnostic or screening audiometry. Imagine the benefits of freeing up the time to perform full diagnostic testing.
>
> AMTAS Pro requires an approved GSI audiometer (the AudioStar Pro or Pello), a compatible computer, a bone conductor with AMBANDS for forehead placement and circumaural (DD450, HDA280) headphones.
>
> AMTAS Pro is self-paced, so patients may proceed at a rate that is comfortable for them. A complete diagnostic evaluation will typically take 15–20 minutes for the patient to complete independently, which provides more time for the audiologists to attend to other patients. AMTAS is configurable, so performing only air conduction thresholds or a basic air conduction screening is possible.
>
> AMTAS Pro assigns up to nine quality indicators to provide insight into the patient's behavior during the test and aid in interpretation. AMTAS methodology and validity have been documented with over 15 years of research and publications in international peer-reviewed journals.

Audiology extenders are essential in freeing audiologists from routine testing tasks to reallocate their time to the most complex patients who can only succeed with audiologists participating in their HHC. In-office AI-enabled audiology extenders fulfill this role while reducing costs.

Triaging and Improved Access: By directing the appropriate patients to new GenAI-equipped channels to diagnose and treat their nonprescription HHC needs, GenAI will streamline patient triage so only those needing qualified prescription-capable providers will see physicians and audiologists. This liberation of prescription providers will result in more patients with prescription needs being appropriately seen and treated, significantly improving HHC.

Power and Breadth: GenAI-driven precision medicine also increases the power and scope of prescription providers by allowing them to analyze enormous datasets, glean hitherto unavailable relevant information and research that information to make patient-personalized diagnostic and treatment decisions. Because of GenAI, precision medicine can revolutionize the provision and delivery of prescription HHC.

HOW AI IS TRANSFORMING THE MEDICAL PARADIGM

Because AI can swiftly uncover difficult-to-discern patterns in massive quantities of data, it is revolutionizing health care.

GenAI is the driving force behind significant changes in the medical care paradigm. The traditional approach of treating the "average" patient with a one-size-fits-all model has proven ineffective, leading to misdiagnosis and suboptimal treatment outcomes (Cerrato and Halamka, 2023).

GenAI-enabled precision medicine has emerged as a revolutionary healthcare diagnosis, delivery and treatment approach. It provides the mechanism to transform health care, improving its quality, consistency and efficiency.

Precision medicine offers a more personalized, precise and effective approach to clinical practice, representing a change in basic assumptions from conventional medicine. It addresses the inherent problems of one-size-fits-all treatment and provides an antidote. It even addresses timely medical issues, such as inequality emanating from how health care is currently defined and investigated (Tinetti et al., 2023).

GenAI's ability to analyze massive data sets that are too complex for human cognition has given life to precision medicine.

A precision medicine-based medical system collects two giant data sets, one about the individual and the other about the disease mechanisms, and, without human direction, analyzes them, detecting patterns and making predictions and recommendations to deliver personalized patient care.

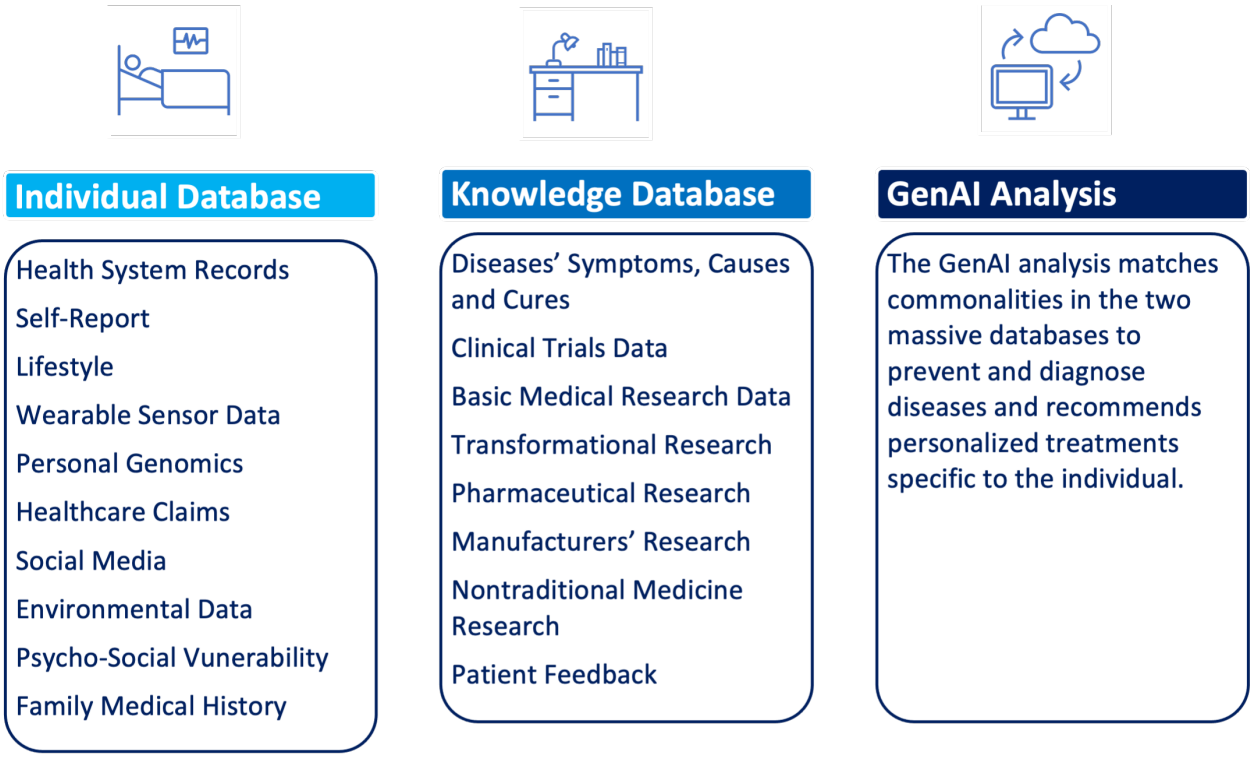

Figure 4. AI-driven precision medicine integrates the investigation of disease mechanisms with prevention, treatment and cure at the individual level, providing high-value, personalized health care that improves outcomes while decreasing costs.

The importance of genomics to precision medicine: Emphasizing genetics is a distinctive and crucial strength of precision medicine. Precision medicine is enabled by the power of GenAI to analyze massive amounts of genetic information and apply that information to customize the individual patient's diagnosis and treatments. For audiologists, genomic data is rarely available. HHC providers are seldom well versed in the genomics of hearing loss, even though genetic hearing loss accounts for 50% of congenital sensorineural hearing loss (Allen Young; Matthew Ng., 2023). The remaining hearing loss cases are due to aging, environmental or acquired causes such as infection, trauma, noise exposure and ototoxicity that also may have genetic components.

Reversal of Hearing Loss by Gene Activation
Neurological-based hearing loss has been thought to be irreversible, but researchers from King's College London have reversed such a loss through gene activation in mutant mice, Martelletti et al (2023). The study focuses on a specific form of hearing loss and sheds light on the potential for gene-based interventions not only to prevent but also reverse debilitating otologic conditions when caught early, according to Karl Strom at hearingtracker.com.

Properly diagnosing hearing loss must include all genetic and acquired causes; AI and precision medicine enable us to do that.

Cerrato and Halamka (2023) of the Mayo Clinic explain that precision medicine, the new medical model, equips every patient who walks into a medical office with a comprehensive collection of relevant medical data. "That includes their complete genome with all the mutations that increase their risk of specific diseases, genetic variants that make them susceptible to drug toxicity, all their environmental exposures to toxins and allergens, along with their clinical chemistries, medical and family histories, psychosocial vulnerabilities, nutritional deficiencies and much more. And once these data are available, we want to see precisely designed treatment protocols to address these problems."

The healthcare potential and low sequencing costs of AI-enabled genomics will cause an individual's genome to be as much a routine part of the medical record as their blood work.

The cost of sequencing an individual genome has decreased from $3 billion to less than $100 in the last 20 years, unlocking the full potential of the human genome. Sequencing allows a doctor to identify differences between a patient's sample and the reference genome. This helps determine a patient's genetic disease or helps doctors look across a population to discover new drug targets, Vacek, (2023). *HHC must actively expand the use of genomics in this enduring AI-driven healthcare transformation.*

The Promise of Genetics

"Recent breakthroughs in genetic screening and gene-based therapeutics using novel gene editing for the inner ear can lead to novel therapies for multiple classes of hereditary hearing loss … these tools and strategies will create a clear path to clinical treatment and accelerate the advent of a new era of personalized medicine for hearing loss," says Xue Zhong Liu, MD, Ph.D., professor of otolaryngology, human genetics, biochemistry and pediatrics at the University of Miami Miller School of Medicine (Lui, 2023).

Genetic Scissors: An increased emphasis on genomics will extend its benefits to HHC. Gene-editing technologies like CRISPR are becoming available for many diseases. This technology acts like a pair of molecular scissors to cut and modify a DNA sequence. Initially, CRISPR therapies required a complex and lengthy procedure, much like a stem cell transplant. However, we can now deliver these therapies directly to the patient. Gene editing will allow us to rewrite HHC-relevant portions of the genome. With base editing, we can even change a single base in the genome without damaging the DNA molecule. This revolutionary technology permits us to target the root cause of the disease and potentially cure the patient even before symptoms exist. Gene-editing drugs cost $1–2 million, but like the cost of sequencing, the price will decrease sharply. Drug treatments must be repeatedly administered and are subject to interactions with other drugs. Genetic solutions are cures expected to last a lifetime. Genomics and gene editing will play a crucial role in the future of HHC.

Challenges to Precision Medicine: Thanks to AI, precision medicine promises to improve health care significantly, but it also has challenges.

The fundamental challenge is the assimilating, analyzing and integrating of genomic data, electronic medical records (EMRs), data obtained with mobile health devices and other data on millions of people.

Another essential challenge is ensuring appropriate participant inclusion concerning ethnic diversity and other demographics and inclusion of those medically disenfranchised without EMRs or ready access to the internet.

Finally, it must address privacy and security concerns.

HEARING HEALTH CARE AND PRECISION MEDICINE

HHC will experience precision medicine first in large healthcare systems because they have the resources to invest, have a diversity of medical expertise and can access more patient data and knowledge databases. HHC providers in these large systems must ensure they enter their patients' HHC data in the system's precision medicine database and that HHC plays an active role in the process.

Private practices lack the resources of health care systems. They are at a disadvantage, which they might offset by a solid collaborative private practice effort focused on integrating precision medicine into their domain and collaborating with healthcare systems.

Because GenAI-based precision medicine is only as up-to-date as the database information it was last trained on, acquiring new real-time data is critical to an accurate diagnosis, treatment and prevention. Self-sustaining, wearable, monitoring and therapeutic systems are the future of patient care and are particularly beneficial for

the elderly (Global X, 2023).

HHC providers can emphasize the ability of in-the-ear devices to monitor important aspects of overall health and work with precision medicine systems to integrate these real-time health data into a healthcare system's precision medicine initiative. Here are some examples.

Lend me your ear: In keeping with the aims of precision medicine, hearing aid manufacturers are taking advantage of AI and the ear's capability to yield critical health information. For example, Starkey's AI-based hearing aids, in addition to dealing with hearing issues, also include activity tracking, fall detection and alerts, social interactions and personal health monitoring, which produce valuable data to feed a precision medicine system. The Starkey AI-based devices will also translate to assist in delivering health information and directions to non-native English speakers, and they provide reminders for those with memory issues. Starkey's AI-based initiative focuses on a holistic approach to medical care that is the basis of precision medicine.

Patients' illnesses are not independent of one another, nor are their treatments. They are interdependent and favor a holistic approach to patient care. Successful HHC providers will adopt this holistic approach and play an active role in precision medicine.

Hearing aid manufacturers are not the only ones discovering the ear's potential to play a crucial role in health monitoring. MindMics (www.mindmics.com) uses earbuds as health monitors. MindMics invented an in-ear infrasonic hemodynography (IH) technology, which measures low-frequency sounds created by vital organs. It can deliver biometric data like heart rate (HR) and heart rate variability (HRV) with a 99% correlation to an ECG. IH provides a more comprehensive view of every heartbeat by providing insights into associated hemodynamics— or how blood flows through blood vessels—which is not observable by ECG. IH has the potential to detect dangerous heart rhythms like atrial fibrillation (AF) early enough for even asymptomatic cases and to save many lives. This ear-sensor-based data is valuable to precision medicine databases, providing a path to increased precision medicine involvement for HHC.

MindMics earbuds allow for listening to music and answering cellphone calls. Still, MindMics is looking for partners, and clever hearing aid manufacturers will surely add MindMics-like measurements to hearing aids, further guaranteeing HHC a critical role in precision medicine.

Lend me your other ear: A team of researchers at UC San Diego recently announced (today.ucsd.edu/story/NatureBME2023) that they had developed a flexible sensor that converts earbuds into a wearable that records the brain's electrical activity and lactate levels in the body. Data from the earbuds can diagnose different kinds of seizures and monitor stress, focus and effort levels during exercise. Data collected from the sensors were as effective as commercially available contact EEG headsets and lactate-containing blood samples, suggesting monitoring and advancing the health and wellness of people anytime, anywhere. Ultimately, the goal is also to gather additional data, such as oxygen saturation and glucose levels, and transmit all the data wirelessly to a computer or smartphone, potentially making it a vital contributor to precision medicine.

Imagine a set of Starkey hearing aids with one ear using MindMics to measure cardiovascular data and the other using UC San Diego's flexible sensors to measure brain activity and more. That is a wealth of real-time hearing aid-sourced data that will increase and improve the application of precision medicine while updating it in real-time.

Holistic Care Within HHC

Because we have found HHC to have consequences on general health (Jiwani, S, 2023; Griffiths et al., 2020; Maidment et al., 2023; Pichora-Fuller, 2023), we encourage precision medicine and a holistic approach to HHC that integrates across health care disciplines rather than an independent approach. We must apply holistic medicine within audiology to best operate in a precision medicine system.

For audiology clinics to be the most advantageous to their patients and precision medicine systems, they must be comprehensive in their diagnostic and treatment capabilities. To assume their rightful position in precision medicine and the future of health care, audiology clinics must offer the whole spectrum of audiological care, including tinnitus, aural rehabilitation and balance.

Precision medicine and Au.D. education: We must better understand and use the relationships between hearing loss and other conditions. With this increased interplay of data from diverse medical professions comes the need to educate many other medical professionals about HHC and to educate HHC professionals about different medical professions. This effort requires broadening Au.D. education to include experiences

and introductory courses in topics like genomics, pharmacology, cognition, AI, prompt engineering, big data analysis, precision and holistic medicine and virtual reality. Students must learn to favor comprehensive clinics with robust diagnostic and treatment capabilities. Moreover, it means a stronger emphasis on continuing education to stay abreast of innovations in these fields. We must educate our students to become members of interprofessional teams to provide holistic and patient-centered HHC. With this more rounded education, we can better partner with other professionals and provide more expansive patient care. Encouraging and facilitating students to participate in global health with its diverse cultures and social and economic levels can be a dynamic learning experience to absorb that HHC products and services must be tailored to those using them. This is a significant lesson as our country becomes more diverse culturally and economically.

How AI Solves HHC's Problems and Transforms HHC

AI can benefit HHC, but HHC must change to reap the benefits and solve HHC's problems. For each HHC delivery problem, here is the AI solution.

1. **Supply and demand:** *Audiologists and ENTs cannot serve all the patients needing hearing health care. We must provide competent alternatives such as:*
   - ✓ Audiology assistants
   - ✓ Additional audiology extenders
   - ✓ Accessible AI-driven virtual providers using captioning and clear speech and eventually being 3D and with access to precision medicine knowledge
   - ✓ Working with researchers and manufacturers to perfect AI-enabled virtual healthcare
2. **Affordability:** *We must provide capable, low-priced hearing devices for those unable to afford traditional hearing aids.*
   - ✓ Participate in vetted OTC hearing aid sales using virtual AI providers to understand the patient's needs, recommend the best device and assist in fitting and maintenance.
   - ✓ Use OTCs to attract patients with mild losses to your practice. Monitor their hearing, knowing that their hearing issues will increase for many.
   - ✓ Participate in research to improve and promote OTC treatments and virtual nonprescription HHC provision.
3. **Information access:** *We must give patients improved access to HHC information and educate them on how to manage their hearing difficulties.*
   - ✓ Provide accessible online AI-enabled virtual educators so customers know where they are in the patient triangle and where they should seek care.
   - ✓ Use AI-driven self-help assistants to aid in fitting and maintaining nonprescription treatments.
   - ✓ Provide online HHC education services to your local PCP groups.
4. **The face-to-face dilemma:** *We must reduce all unnecessary, expensive face-to-face interactions and simultaneously significantly increase overall accessibility.*
   - ✓ Use AI to triage patients to match their needs with the proper providers so only those needing doctoral-level expertise see doctors.
   - ✓ Use appropriate audiology extenders or virtual providers to treat nonprescription needs and instruct them on using self-help.
5. **Psychological factors:** *We must provide information and tools that support the ability of individuals to promote health, prevent disease, maintain health and cope with illness and disability with or without the support of an HHC worker.*
   - ✓ Use the internet, telepresence and AI virtual representation to educate, promote and facilitate self-help.
6. **Moral obligation:** *We have the technological means to spread HHC expertise more widely at a lower cost. As medical professionals, we must morally strive to make this happen.*
   - ✓ Include the whole spectrum of patient needs in your practice.
   - ✓ Use AI to match patient needs with the appropriate level of expertise and support self-help when appropriate.
   - ✓ Maximize care to match patients' limited finances.
   - ✓ Create innovative solutions to lower costs to the patient.
7. **Need to improve medical care:** *We must expand the boundaries of medicine beyond the traditional scope of clinical practice to deliver more precise, personalized and effective patient care.*

- ✓ Move beyond the one-size-fits-all medical model.
- ✓ Establish holistic care in your clinic.
- ✓ Actively participate in precision medicine.
- ✓ Educate your clinicians about the importance of related professions like genomics and their relation to HHC.

8. **Need to improve collaborations with primary care providers (PCPs):** *We must connect with PCPs and facilitate, educate and empower them to triage and refer HHC patients to the proper providers.*
   - ✓ Work with local PCPs to educate them about the importance of HHC.
   - ✓ Support PCP active triaging of HHC for seniors.
   - ✓ Volunteer to participate in joint experimental patient triaging with PCPs.
9. **Need for nonmedical HHC providers:** *We must create competent nonmedical providers for those patients who do not require expensive advanced medical care.*
   - ✓ Train and hire audiology assistants.
   - ✓ Increase accessibility to virtual providers.
10. **Need to expand clinical audiology to care for all HHC patients,** *regardless of the severity of their hearing issues, including mild hearing loss and self-perceived hearing issues we miss.*
    - ✓ Diagnose and treat the broad spectrum of audiometric hearing loss from moderate to profound.
    - ✓ Use the RHHI-S to identify those with self-defined hearing loss but no audiometric hearing loss.
    - ✓ Participate in research to identify and treat the causes of self-defined hearing loss without audiometric loss.

RESHAPING HEARING HEALTHCARE

Driven by GenAI-powered precision medicine, health care, like many other professions (Susskind et al., 2022), is dramatically transforming. Figure 5 summarizes how HHC has evolved. The current transformation in health care will be more like a revolution than an evolution.

One sign of the enormity of this transformation is that Mayo Clinic, a leading health care system, announced a $5 billion expansion, not to make a nicer facility but to take advantage of artificial intelligence, including the acceleration of the development of new cures.

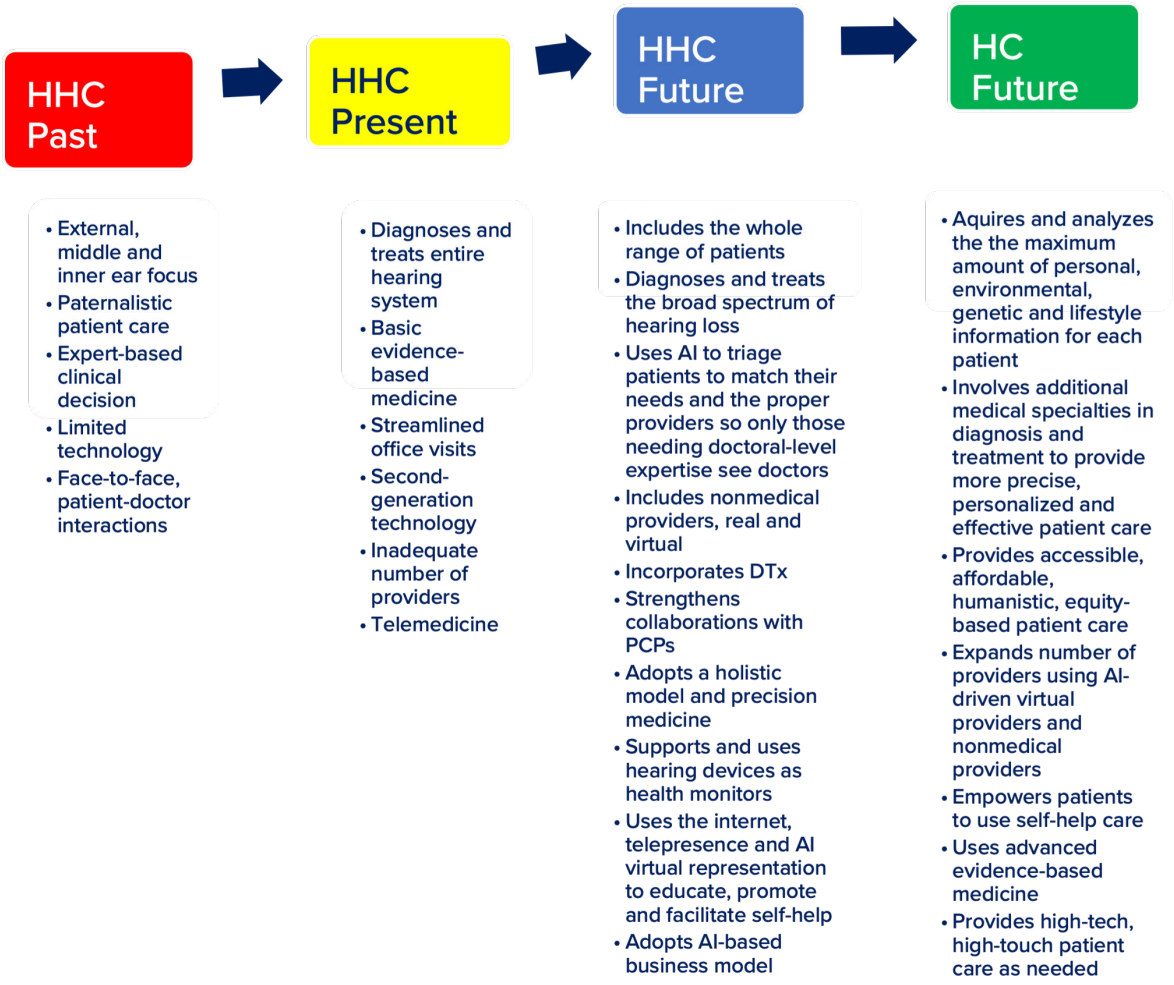

Figure 5. The evolution of HHC from the past through the present, into the future and the revolution in health care that will serve us going forward.

How to stop worrying and learn to embrace AI

The news is full of people, including AI leaders, expressing fears about AI. These fears raise real issues. Still, we have developed international nuclear regulations to reduce fears of nuclear alienation. So, we can also develop global AI regulations to reduce the fear of human irrelevancy due to superior machine intelligence. We can also correct biases and accuracy.

Is GenAI-Enabled Health Care Safe, Unbiased and Accurate?

We are often encouraged not to anthropomorphize AI. However, there are convincing reasons to do so. GenAI is modeled after human brain networks and educated by human-created knowledge bases. To understand and correct GenAI's shortcomings, we only need to look at humans, how we learn and our inadequacies and how we correct them.

Weird kids

Anne Giron et al. (2023) have shown that AI learns similarly to how human minds change as children become adults. As Alison Gopnik (2023) says, "AI programs do best if they start out like weird kids and then grow up." An AI algorithm still in its childhood will explore and try weird results. As it grows, it will get more realistic.

Adult doctors

But even adult doctors make misdiagnoses and give weird advice. Our criteria for AI success in health care should be identical to those for drugs and devices. Does AI do as good a job as the existing method, i.e., doctors, or better? We all know of examples where doctors have misdiagnosed and given bad advice. The validating question is, in a specific case, will AI make an equal or better diagnosis or recommendation than an experienced doctor? If so, the AI provider's advice should be accepted. If not, the algorithm should be

corrected and retested. AI in its youth needs adult supervision.

Hallucinations

When AI creates misinformation, it is labeled a hallucination. However, doctors also give misinformation, sometimes very convincingly. Consider the harmful drugs some doctors recommended to treat COVID. AI, like doctors, will never be perfect. Instead, it must be monitored and regulated as the rest of medical care is.

Bias

Many inadequacies of GenAI health care result from its training. Humans who develop AI must use diverse training sources and test the results for bias. Humans and their biased material create the problem, and they, not the AI, must correct it. Likewise, AI developers must constantly update their source material and begin to involve novel sources like real-time information from wearables used in precision medicine.

Transparency

To improve accuracy and eliminate bias, transparency of training materials is essential. Fortunately, Casper Labs is developing methods to develop a transparent training history. They are applying blockchain technology to increase transparency and the ability to audit algorithms. Blockchain structures the data to create a digital ledger of transactions and share it among a network of computers. By doing so, blockchain is used to track what data the algorithm was trained on and who trained it. Transparency is an important issue that is being worked on. Hopefully, we will have a solution soon.

The Need for Regulations

Table 2. AI is a tool. Like any tool, it is neither good nor evil but can be used for either, depending on who controls it. We must establish regulations to limit AI use to benevolent performers.

BENEVOLENT PERFORMERS	BAD ACTORS
• Focus on the common good	• Self-Interest focus
• Transparency of how they work and what data they were trained on	• Lack of transparency
• Fairness	• Bias
• Accountability	• Misinformation
• Equitable	• Inequity
• Maintains privacy	• Ignores privacy
• Monitors and controls AI uses for good	• Misuse, i.e., cybercrime and other crimes

From our experience with the unregulated development of social media, we have learned the importance of considering and enforcing regulations at the beginning of technological advancement.

According to The Economist Intelligence Unit Limited 2023, “digital healthcare will continue to develop, along with the regulatory frameworks surrounding it. The WHO’s five-year window for member states to develop a secure strategy for digital health ends in 2024. This will nudge several countries into framing better legislation for health data to safeguard citizens’ sensitive personal information.”

Here are the regulations we can use to resolve safety issues and create safe, responsible AI-based health care.

We must establish a regulatory agency that:

1. Regulates AI companies to guarantee that their products are safe and that the benefits outweigh the risks.
2. Compels AI companies to be transparent about their data and processes.

3. Requires AI companies to fund and otherwise facilitate independent external audits.
4. Ensures its regulations serve the public, not just the company.
5. Has the power and authority to enforce these regulations.

FEAR

According to McKinsey and Company (2023), a consulting firm, "AI will perform at a median level of human performance by the end of this decade," which is consistent with the forecasting of AGI.

The arrival of AGI, sentient, conscious machines with supreme intellect, is predicted by some to doom humans to irrelevancy. Their fear ignores the role of man/machine interfaces, where we supplement human intelligence with machine intelligence. It is the opposite of what Dishbrain scientists do when enhancing computer chips with neural tissue. Humans augmented with brain-implanted AI will have the capability and power to control and participate in AGI. We do not need to envision AI and humans in competition to dominate intelligence. We can work together to create a better world.

Consider this before you think that *Singularity, the merger of machine intelligence and human brains*, is outrageous. HHC first produced a machine-human neural interface when it developed the cochlear implant. That implant has the intelligence to convert acoustic information into electrical impulses that the auditory nerve understands and is interpreted as sound by the patient. The cochlear implant was followed by the auditory brainstem implant that converts sound to electrical impulses that the brainstem understands and interprets as sound.

The evolution has continued to include a self-tuning deep brain implant for Parkinson's patients that uses feedback from the brain to fine-tune its signaling to manage disease symptoms and epilepsy brain implants. Elon Musk's startup, Neuralink, is developing implantable brain-computer interfaces (BCIs) that can record from thousands of brain cells. BCIs that restore function to allow communication and movement have been in development for decades. Now, non-implantable or wearable brain-sensing devices are rapidly progressing to perform some of these functions (Hernandez, D., 2023).

"The fusion of AI and healthcare is not just about technology; it's about humanity. It is about harnessing the power of AI to enhance our healthcare experiences, to make informed decisions, and to create a future where technology and humanity coexist in harmony" —AIMQWEST (2023)

Brain-machine interfacing has been in place for years. The merger of machine intelligence and human brains is not far off. In his book "The Singularity is Near" (2005), Ray Kurzweil predicted that the human and machine AI merger will occur in 2045. At first, many thought the idea was absurd; now, some believe the Singularity will happen in the next decade.

With Singularity, the brain benefits from machine intelligence's vastly greater capacity, speed and knowledge-sharing ability. Singularity will benefit from the Gestalt principle that the whole equals more than its parts. Because both human and machine intelligence are imperfect, combined machine and human intelligence will be improved over either alone. Implanted sentient machines that think with us could open new frontiers in creativity and innovation to provide a more outstanding and humane future than without them. Singularity's increased ability will undoubtedly improve health care, including the quality, affordability and access to HHC.

CONCLUSIONS

"The difficulty lies not in the new ideas, but in escapist from the old ones, which ramify ... into every corner of our minds." —John Maynard Keynes.

The Industrial Revolution produced the change from an agrarian and handicraft economy to one dominated by industry and machine manufacturing. The Intelligence Revolution has diffused globally much faster and will be more transformative.

The Intelligence Revolution, birthed by growing computer power and the desire to create machines that do everything humans do, including cognition, is based on “big data” analysis and manipulation, expanding and applying machine intelligence, increasing computer power, “big data” storage, cloud computing and the perfection of virtual reality and robotics. It is already transforming our society. Every profession, including health care, will become more technology-based and dependent on the growth, development and application of intelligence.

The assumptions we have traditionally based the HHC profession on, which dictate decisions about what to do, who does it and what not to do, will no longer fit our new AI-enabled reality.

Our ideas of what could happen are firmly rooted in what we expect to happen. The assumptions we have traditionally based the HHC profession on, which dictate decisions about what to do, who does it and what not to do, will no longer fit our new AI-enabled reality. To flourish, we must actively encourage our conversion and revise our professional assumptions to meet the opportunities the Intelligence Revolution provides. We hold our future in our AI-augmented hands.

In our new intelligence-driven economy, professionals with a commanding grasp of AI will have abundant opportunities. Successful healthcare professionals will consider what range of services and products patients will value and benefit from tomorrow and how they might preempt competitors in delivering those benefits through holistic, personalized medicine, AI and innovation. Essentially, they will be entrepreneurs who see the future at the intersection of technological change, lifestyles, regulations, and demographics. They are curious about everything and look to other industries for new ideas to adapt. They synthesize knowledge across many disciplines. They will do more than satisfy patients; they will continually amaze them by giving them something of a higher value that does not yet exist. They are doctorpreneurs.

For HHC, we have entered a decade of radical rebuilding driven by provider shortages, amplified patient demand, less expensive treatments, better accessibility, increased computer power, machine AI progress bringing powerful capabilities to nontechnical users, the mastering of big data, the acceptance of precision medicine, the integration of genomics and the perfection of virtual reality. That’s exciting growth. Participate and enjoy the transformation of HHC!

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