The Promise and Potential Hazards of Artificial Intelligence (AI) for Neuropathy

The NAF would like to express their sincere gratitude to M2 Health Care Consulting for their invaluable contribution to this white paper.

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Artificial Intelligence: Hopes and Hazards for Patients with Neuropathy

Artificial Intelligence (AI) seems to be everywhere, but what is it exactly and how might it affect patients with neuropathy? Could it be used to find new treatments? To improve the speed of diagnosis? To further scientific research in neuropathy? Yes, the hopes for AI for patients living with neuropathy are that AI could do all of these things and more. Still, AI also poses some hazards for people with neuropathy, especially when AI is used to restrict access to care.

Researchers and clinicians are already using AI to revolutionize research and interventions for patients living with neuropathy bringing some of the hopes of AI to real life. AI-based algorithms are being used to analyze medical imaging, patient data, and symptoms to help diagnose neuropathy at earlier stages. AI helps predict the progression of neuropathy based on patient data, such as blood tests, genetic information, and lifestyle factors and it is being used alongside precision medicine to create personalized treatment regimens. AI is also being used to identify biomarkers, accelerate drug discovery, and optimize clinical trials, as well as enhance the education and training of health care professionals in diagnosing and treating neuropathy.

There are possible hazards in the use of AI for patients with neuropathy, however. AI tools are usually based on retrospective data. If that data underrepresents certain kinds of patients, or patients with newly identified types of disease or deterioration, the AI model will perform poorly. Additionally, if the data is biased, for example, has only been collected in certain clinical settings, the AI model will replicate that bias. Additionally, AI is being used by insurers to inform coverage determinations and possibly to deny claims. While these AI hazards could affect all people interacting with the health care system, patients living with neuropathy are more likely to confront diagnostic uncertainty, encounter limited or inadequate treatment options and grapple with barriers to access to care, such as step therapy requirements and claims denials. Ongoing awareness and advocacy by patients, families, providers, and policymakers will be necessary to balance the hopes and hazards of AI in the research, diagnosis, treatment, and management of neuropathy.

What is AI and How Can It Help Patients with Neuropathy?

AI is a machine-based system that uses input it receives to generate outputs, such as inferences, predictions, recommendations, or decisions influencing physical or virtual environments. Essentially, AI tries to mimic how humans think and act but does it faster and in a more in-depth way than humans. It is as though an AI system has the benefit of millions of human brains working together at once to see patterns and solve problems. Some of the most promising uses of AI generally are the automation of repetitive tasks and faster, deeper analysis of expansive amounts of data. In the field of health care, AI might be better described as augmented intelligence, instead of artificial intelligence, as it is frequently implemented by a health care professional to support scientific or clinical decision making. For patients with neuropathy, AI is increasingly being used in diagnosis, treatment, and management of the condition, as well as in research. Neuropathy, particularly peripheral neuropathy, involves damage to the nerves outside the brain and spinal cord and can result from various causes, including autoimmune diseases, chemotherapy, diabetes, genetic disorders, and infections.

AI applications in neuropathy fall into 6 broad categories:

1. Early Detection and Diagnosis of Neuropathy
2. Predicting the Progression of Neuropathy
3. Managing and Monitoring Symptoms
4. Personalized Treatment Plans
5. Clinical Trials and Drug Discovery

6. Education and Training for Health Care Providers

Each of these categories is described in Table 1 and explained in more detail below.

1. Early Detection and Diagnosis of Neuropathy

As an example, AI-based algorithms can analyze medical imaging and other test results to help diagnose neuropathy at earlier stages:

- **AI in Medical Imaging:**
  - AI models are being used to analyze MRI scans and other imaging techniques to identify patterns in nerve damage. For instance, machine learning can identify abnormalities in the structure of peripheral nerves that might indicate the presence of neuropathy.
- **AI for Electromyography (EMG) and Nerve Conduction Studies (NCS):**
  - AI can automate and enhance the interpretation of EMG and NCS results, which are commonly used to assess nerve damage in neuropathy. Machine learning models can be trained to detect subtle abnormalities that might be missed by human clinicians, providing faster and more accurate results.
  - AI models have been developed to analyze complex data from these tests to predict the severity of nerve damage and help identify the underlying cause of neuropathy (e.g., diabetic neuropathy vs. chemotherapy-induced neuropathy).

2. Predicting the Progression of Neuropathy

AI can help predict the progression of neuropathy based on patient data, such as blood tests and genetic information:

- **Predicting Diabetic Neuropathy:**
  - For patients with diabetes, AI models have been developed to predict the likelihood of developing neuropathy based on factors such as blood sugar levels, duration of diabetes, and the presence of other complications. This allows for earlier interventions that could slow down or prevent nerve damage.
  - A combination of machine learning and clinical data, including biomarkers, can help predict the development and progression of diabetic neuropathy, enabling personalized treatment strategies.
- **Genetic Algorithms for Hereditary Neuropathy:**
  - In hereditary neuropathies, such as Charcot-Marie-Tooth disease (CMT), AI can be used to analyze genetic data and family histories. By identifying genetic markers and patterns, AI can assist in predicting which patients are at higher risk of developing more severe forms of the disease, allowing for early interventions and tailored therapies.

3. Managing and Monitoring Symptoms

AI can help improve the management of neuropathy symptoms, such as pain and sensory disturbances, by providing real-time monitoring and personalized treatment plans.

- **Wearable Devices and AI for Pain Management:**
  - AI-powered wearable devices are being developed to monitor neuropathic pain and sensory changes in real-time. These devices use sensors to track temperature sensitivity, vibration perception, and other parameters related to neuropathy. The collected data can

then be analyzed by AI algorithms to adjust pain management strategies dynamically, providing patients with more personalized care.
    - For instance, AI can help optimize transcutaneous electrical nerve stimulation (TENS) therapy by learning from the patient's pain response patterns and adjusting the treatment parameters accordingly.
- **Virtual Assistants and Symptom Tracking:**
    - Virtual health assistants powered by AI can help patients track symptoms like tingling, numbness, and pain over time. This data can be analyzed to adjust medications or suggest lifestyle changes, and it can be shared with health care providers for more informed decision-making.

4. Personalized Treatment Plans

AI helps to tailor treatments based on the individual characteristics of each patient, improving outcomes, and minimizing side effects.

- **Precision Medicine and AI:**
    - AI is being used to analyze genetic, biochemical, and lifestyle data to create personalized treatment regimens for patients with neuropathy. For example, for diabetic neuropathy, AI can help determine the best drug or intervention based on a patient's specific genetics, medical history, and the severity of their condition.
    - In chemotherapy-induced peripheral neuropathy (CIPN), AI models can help predict which patients are most likely to experience severe neuropathic pain or motor dysfunction, guiding the selection of more targeted treatment options.

5. Clinical Trials and Drug Discovery

AI is also being applied in the field of drug discovery for neuropathy treatments and for optimizing clinical trials.

- **AI in Drug Development:**
    - AI is accelerating the development of new drugs and devices for treating neuropathy by predicting which drug compounds are most likely to be effective in treating nerve damage. Machine learning algorithms can analyze vast amounts of data on drug interactions, side effects, and molecular mechanisms to identify potential candidates for neuropathy-related conditions.
    - AI models can also help identify biomarkers for neuropathy, leading to more targeted therapies and more efficient drug development pipelines.
- **Optimizing Clinical Trials:**
    - AI is being used to improve the design and recruitment processes of clinical trials for neuropathy treatments. By analyzing patient data, AI can help identify individuals who are most likely to benefit from a specific drug or intervention, improving the efficiency of clinical trials and reducing costs.
    - Additionally, AI can help monitor patient responses during trials, allowing for real-time adjustments and ensuring that the treatments are working as expected.

6. Education and Training for Health Care Providers

AI is being used to enhance the education and training of health care providers in diagnosing and treating neuropathy, ensuring that health care providers are equipped with the latest knowledge and

tools. For example, AI-powered simulations are being used to train clinicians on recognizing the early signs of neuropathy and understanding the complexities of different neuropathic conditions. These simulations can present a range of case scenarios, allowing health care providers to practice their diagnostic and treatment skills in a risk-free environment.

Table 1: Examples of AI Applications in Neuropathy

Benefit	AI Application	Description
Early Detection and Diagnosis of Neuropathy	• Disease classification • Image enhancement • Lesion detection	AI systems can analyze medical imaging, patient data, and symptoms to help diagnose neuropathy at earlier stages
Predicting the Progression of Neuropathy	• Pattern recognition • Predictive modeling	Neuropathy progression can be predicted by AI analysis of patient data, such as blood tests, genetic information, and lifestyle factors
Managing and Monitoring Symptoms	• Efficient data management • Neurostimulation • Sensory feedback	Neuropathy symptom management can be improved through real-time monitoring and personalized treatment plans
Personalized Treatment Plans	• Risk prediction • Treatment optimization	AI can analyze patient responses and adjust therapies or tailor treatments based on each patient's unique characteristics to improve outcomes and minimize side effects
Clinical Trials and Drug Discovery	• Data analysis • Modeling and simulation	AI can accelerate the research process by simulating molecular interactions and predicting potential drug candidates
Education and Training for Health Care Providers	• Interactive diagnostic training • Simulations and immersive training	Simulations and immersive training can help clinicians improve their ability to recognize signs of neuropathy and understand the complexities of these conditions

Can AI Be Used in Ways That Are Hazardous to Patients with Neuropathy?

There are many hopeful uses of AI for patients with neuropathy, but there are also potential hazards. In everyday uses, AI is accessing immense amounts of data and learning to put that data together in novel ways, which can then be used to create fake or deceptive information and images. Additionally, AI built on incomplete, biased, or discriminatory data sets can make biased or unfair systems even worse. There are many aspects of health care that need to be protected from AI hazards. To focus on patients with neuropathy, it is essential to safeguard two primary aspects of patient interaction from potential AI risks: uses by clinicians and uses by payers.

Potentially hazardous uses of AI in clinical settings

AI can be used *in health care* for administrative functions such as clinical transcription or automated appointment reminders, and it can be used *for health care* to guide medical decision making, such as using an AI system to read medical images and identify anomalies for further review by a human

clinical expert. When it comes to AI in health care, both administrative and clinical uses pose potential risks to patients, though the clinical risks are higher.

Hazards in health care administrative uses of AI

The most common hazards in administrative uses of AI in health care relate to privacy, security, and transparency. Federal laws such as the Health Insurance Portability and Accountability Act (HIPAA), alongside state laws protecting personal health information, are already in place to safeguard sensitive patient information. AI itself does not inherently pose an administrative health care risk; rather, it has the potential to amplify vulnerabilities in the security of patient data already held by clinicians. For patients living with neuropathy, privacy and security concerns take on additional risk as, "The transmission and storage of sensitive neural information for AI analysis raise ethical questions regarding patient consent, data ownership, and the potential for breaches." Clinicians must be vigilant in protecting their patients' data, when they are using AI systems that interact with this information, such as automated appointment scheduling or chatbots.

Transparency of the use of AI is another important aspect to consider. For administrative tasks, it is imperative that clinicians are transparent about their use of AI so people interacting with their practice, whether patients or other consumers, are aware they are not talking or messaging with a human. Disclosure of the use of AI in consumer-facing tools such as chatbots should be considered the bare minimum for clinical practices offering these tools.

Hazards in health care clinical uses of AI

There are several common hazards in clinical uses of AI in health care, the most concerning of which for patients with neuropathy is bias. The idea of gender or racial bias is broadly familiar. AI systems are built on large data sets that may already contain outdated or discredited medical information based on gender or race, which has created clinical AI tools that perpetuate this kind of bias. In the case of neuropathy, bias in AI data sets and clinical uses can take other forms as well. Published research and medical literature that might be used to inform the diagnosis, treatment, management, or research of neuropathy is disproportionately focused on a handful of well-known neurological conditions, and neuropathic disorders, while rare and complex conditions are less frequently explored. AI's ability to recognize patterns and make predictions is only as good as the data it is trained on so a bias towards more common neuropathies in datasets could be hazardous to patients looking for medical insights for their less common neuropathic conditions.

Explainability and hallucinations are two other well-known hazards of AI tools in clinical practice. Explainability refers to how the end-user understands how AI generates its output. It can be challenging for patients, consumers, and clinicians to understand how an AI system works. In the case of clinical health care AI uses, the immense complexity and size of the data sets and modeling algorithms that move from inputs to outputs in the form of predictions or decision trees can be extremely difficult to understand, if not impossible. As such, this is closely connected to another potential AI hazard: hallucinations. Sometimes an AI tool is asked to generate an output, for example, the summary of past diagnoses for a patient, and the answers it generates are factually incorrect, illogical, or nonsensical. This type of mistake is commonly referred to as a hallucination because it appears to be based on the AI's training data instead of the specific patient data provided to it. This type of hazard is precisely why it is essential for a human clinical expert to be involved in medical decision making with a patient. If the AI tool has provided a nonsensical response, it will be immediately obvious to a patient and hopefully the provider as well. This "human in the loop" concept is one of the most important protections against some of the hazards of the use of AI in health care.

Potentially hazardous uses of AI in by payers and insurers

Payers determine whether, under what circumstances, and at what price to cover medical interventions. In theory, payers such as the state (e.g., Medicaid or state employee health plans) and the federal government (e.g., Medicare or Veterans Affairs), and health insurance companies make coverage decisions based on up-to-date medical evidence and the specific circumstances of patients. In 2023, however, one of the largest health insurance companies in the U.S., Cigna, had its coverage and payment review process exposed for rapidly dismissing claims in bulk. According to an investigative report by ProPublica, "The company has built a system that allows its doctors to instantly reject a claim on medical grounds without opening the patient file…Over a period of two months last year [2023], Cigna doctors denied over 300,000 requests for payments using this method, spending an average of 1.2 seconds on each case…" While Cigna's review system has been in place for more than a decade, the speed at which it is able to "review" and deny claims only seems possible with AI.

The fight between health insurers and providers is an old one. Insurers are trying to spend as little money as possible; clinicians are trying to provide the best care, and patients are caught in the middle. This back and forth applies not just to outright claims denials, but also to utilization management tools such as fail first, step therapy and higher cost sharing requirements for treatments or interventions health plans don't want to have to provide. The introduction of AI tools to this struggle is being called the "Battle of the Bots." The Healthcare Financial Management Association (HFMA) describes it as a technological battle where "both payers and providers lean into AI for claims management." According to HFMA, health plans have made significant investments in AI over the past few years building sophisticated AI algorithms that speed up the review and denial of claims. Providers, including hospitals, clinics and office-based practices are responding by building or buying AI technology that can assist them in responding to prior authorization requests and claims denials. As with the hazards posed by clinical uses of AI, patients living with neuropathy will need to remain vigilant in asking for prior authorization overrides and support from their medical team in fighting claims denials regardless of whether AI is being used by their health insurer.

Advocacy Opportunities in Health Care AI

The hopes for AI for patients living with neuropathy will likely only grow as these tools are able to be used in more ways and novel ways to diagnose, manage and treat neuropathic conditions. The hazards for AI for patients living with neuropathy present advocacy opportunities at the state and federal level to ensure AI is being used ethically and transparently. Some of this work has already begun. For instance, the American Medical Association (AMA) is advocating for greater regulatory oversight of the use of AI by health insurance companies to speed up medical claim and prior authorization decisions. The AMA recommends regulators review "whether insurers are using a thorough and fair process," and "require such reviews [to] include human examination of patient records prior to a care denial."

At the federal level, in late 2023 more than 30 Members of Congress urged the Centers for Medicare & Medicaid Services (CMS) to enhance oversight of AI and algorithmic software tools used in Medicare Advantage (MA) plans' coverage decisions. The letter asked for CMS to continue its efforts to curb inappropriate use of prior authorization in Medicare, particularly when AI or algorithmic software is involved. Related to the use of AI in health care decision making more broadly, the U.S. Department of Health and Human Services (HHS) finalized the *Health Data, Technology, and Interoperability: Certification Program Updates, Algorithm Transparency, and Information Sharing (HTI-1) rule* in December 2023. The rule established first-of-its-kind transparency requirements for AI, including requirements to assess whether AI algorithms are appropriate, fair and valid.

States are also working to create guardrails to protect consumers from the inappropriate use of AI by

insurance companies. At the state level insurance commissioners across the country have been issuing guidance on how insurance companies can use AI. The guidelines are based on a model written by the non-partisan National Association of Insurance Commissioners (NAIC) that emphasizes accountability, fairness and transparency, and reminds insurers that compliance with all other state and federal laws is still required even if AI tools are employed. Before 2024, Colorado was among the first states to pass legislation prohibiting discrimination, specifically targeting the use of algorithms and predictive models by insurers that result in unfair bias (SB169 in 2020). Additionally, California (SB1001 in 2018) and New Jersey (A4563 in 2020) enacted laws banning the use of undisclosed bots, although these measures were not specifically focused on health care.

In 2024, more than 40 states introduced bills broadly addressing AI in health care. Of the bills that passed, most created AI Taskforces, but a handful of states were more aggressive in their efforts to protect patients and consumers from the hazards of AI. Utah passed the AI Policy Act (SB149) mandating that health care professionals and other regulated occupations disclose the use of generative AI in oral or electronic communications, ensuring transparency between deployers and end users under consumer protection regulations. Colorado's SB205 establishes stringent requirements for developers and deployers of "high-risk" AI systems, including health care stakeholders, to mitigate algorithmic discrimination and ensure transparency.

The most notable state law, however, is specific to the AI hazard described above as the Battle of the Bots. In addition to passing several other health care and non-health care AI bills, in September 2024, California became the first state to pass a law requiring not just a human in the loop of AI decision making, but a clinician familiar with the specific patient's medical needs when insurers are considering health care services claims. SB 1120 says:

> ***"The artificial intelligence, algorithm, or other software tool shall not deny, delay, or modify health care services based, in whole or in part, on medical necessity. A determination of medical necessity shall be made only by a licensed physician or licensed health care professional competent to evaluate the specific clinical issues involved in the health care services requested by the provider…by reviewing and considering the requesting provider's recommendation, the insured's medical or other clinical history, as applicable, and individual clinical circumstances."***

AI is rapidly transforming the way neuropathy is diagnosed, treated, and managed. By enhancing early detection, improving symptom management, personalizing treatment plans, and accelerating drug development, AI has the potential to significantly improve outcomes for patients with neuropathy. However, much of this technology is still in the experimental or early implementation stages, so ongoing research and clinical validation are crucial for widespread adoption. Concurrently, patients need to be vigilant in advocating for uses of AI in health care that are fair, transparent and maintain a human in the loop of decision making.

The Neuropathy Action Foundation (NAF) is a 501(c)(3) nonprofit dedicated to ensuring neuropathy patients obtain the necessary resources to access individualized treatment to improve their quality of life. The NAF increases awareness among providers, the general public and public policy officials that neuropathy can be a serious, widespread and disabling condition, which may be treatable when appropriate medical care is provided. The NAF's goals include:

Patient Empowerment
Educates and assists neuropathy patients on how to become informed advocates.

Public and Physician Awareness
Supports programs that create public and physician awareness of neuropathy, the use of IVIG and other treatments to improve patient care.