Data on Financial Toxicity Concerns for Patients as Neurotechnology Use Increases: Where We Are and Where We Need to Go

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INTRODUCTION

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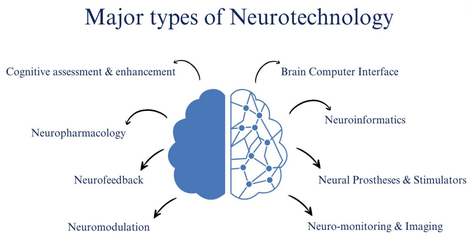
- The global market for neurotechnology was 12.82 billion USD in 2022 and is expected to reach 17.1 billion USD in 2026 and 38.17 billion USD by 2032.[1,2] These projections parallel a time where neurological and psychiatric diseases are the leading cause of disability and the second leading cause of death worldwide.
- The applications of neurotechnology continues to expand, from its uses in describing brain functions to the development of implantable closed-loop deep brain stimulation (DBS) systems.[3,4]

OBJECTIVES

- The global market for neurotechnology is expected to increase significantly over the next decades, paralleling the growing prevalence of neurological and psychiatric diseases worldwide. While the applications of neurotechnology continue to expand, the financial impact on patients and caregivers remains understudied.
- This study explored the extent of existing financial toxicity that patients using neurotechnologies endure, emphasize challenges in identifying relevant data and completed studies on financial toxicity in neurotechnology use, and recommend improvements for future research.



METHODS

- A systematic literature search was conducted from February-March 2023 of the PubMed database, using MeSH terms (Medical Subject Headings), to identify relevant articles exploring the financial costs of neurotechnologies. Two reviewers independently screened titles and abstracts, extracted data, and assessed quality using predetermined criteria.

PubMed MeSH Terms Used

Query	Search Details	Results
((implantable) AND (neuro technology)) AND (financial toxicity)	("drug implants"[MeSH Terms] OR ("drug"[All Fields] AND "implants"[All Fields]) OR "drug implants"[All Fields] OR "implant"[All Fields] OR "embryo implantation"[MeSH Terms] OR ("embryo"[All Fields] AND "implantation"[All Fields]) OR "embryo implantation"[All Fields] OR "embryo implantations"[All Fields] OR "implantation"[All Fields] OR "implant s"[All Fields] OR "implantability"[All Fields] OR "implantable"[All Fields] OR "implantables"[All Fields] OR "implanted"[All Fields] OR "implanters"[All Fields] OR "implantations"[All Fields] OR "implanters"[All Fields] OR "implanting"[All Fields] OR "implantion"[All Fields] OR "implantology"[MeSH Terms] OR "implantology"[All Fields] OR "neurology"[MeSH Terms] OR "neurology"[All Fields] OR ("neuro"[All Fields] AND "technology"[MeSH Terms] OR "technology"[All Fields]) OR "technologies"[All Fields] OR "technology s"[All Fields]) AND ("financial stress"[MeSH Terms] OR ("financial"[All Fields] AND "stress"[All Fields]) OR "financial stress"[All Fields] OR ("financial"[All Fields] AND "toxicity"[All Fields]) OR "financial toxicity"[All Fields])	2
((implantable) AND (neurotechnology)) AND (cost)	("drug implants"[MeSH Terms] OR ("drug"[All Fields] AND "implants"[All Fields]) OR "drug implants"[All Fields] OR "implant"[All Fields] OR "embryo implantation"[MeSH Terms] OR ("embryo"[All Fields] AND "implantation"[All Fields]) OR "embryo implantation"[All Fields] OR "embryo implantations"[All Fields] OR "implantation"[All Fields] OR "implant s"[All Fields] OR "implantability"[All Fields] OR "implantable"[All Fields] OR "implantables"[All Fields] OR "implanted"[All Fields] OR "implanters"[All Fields] OR "implantations"[All Fields] OR "implanters"[All Fields] OR "implanting"[All Fields] OR "implantion"[All Fields] OR "implantology"[MeSH Terms] OR "implantology"[All Fields] OR "neurology"[MeSH Terms] OR "neurology"[All Fields] OR ("neuro"[All Fields] AND "technology"[MeSH Terms] OR "technology"[All Fields]) OR "technologies"[All Fields] OR "technology s"[All Fields]) AND ("economics"[MeSH Terms] OR "economics"[All Fields] OR "cost"[All Fields] OR "costs and cost analysis"[MeSH Terms] OR ("costs"[All Fields] AND "cost"[All Fields]) AND "analysis"[All Fields]) OR "costs and cost analysis"[All Fields])	8
(neural implants) AND (financial toxicity)	("neural"[All Fields] OR "neuralization"[All Fields] OR "neuralize"[All Fields] OR "neuralized"[All Fields] OR "neuralizes"[All Fields] OR "neurally"[All Fields]) AND ("drug implants"[MeSH Terms] OR ("drug"[All Fields] AND "implants"[All Fields]) OR "drug implants"[All Fields] OR "implant"[All Fields] OR "embryo implantation"[MeSH Terms] OR ("embryo"[All Fields] AND "implantation"[All Fields]) OR "embryo implantation"[All Fields] OR "embryo implantations"[All Fields] OR "implantation"[All Fields] OR "implant s"[All Fields] OR "implantability"[All Fields] OR "implantable"[All Fields] OR "implantables"[All Fields] OR "implanted"[All Fields] OR "implanters"[All Fields] OR "implantations"[All Fields] OR "implanters"[All Fields] OR "implanting"[All Fields] OR "implantion"[All Fields] OR "implantology"[All Fields] OR "implants"[All Fields]) AND ("financial stress"[MeSH Terms] OR ("financial"[All Fields] AND "stress"[All Fields]) OR "financial stress"[All Fields] OR ("financial"[All Fields] AND "toxicity"[All Fields]) OR "financial toxicity"[All Fields])	20
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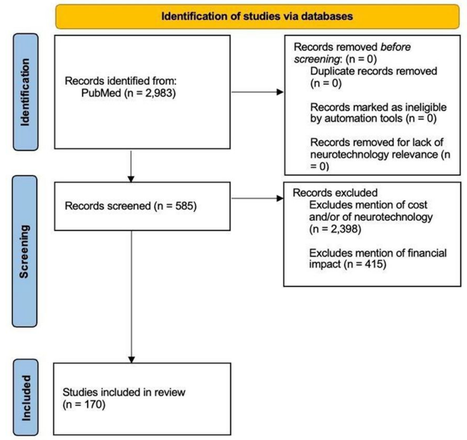
(deep brain stimulation) AND (cost)	("deep brain stimulation"[MeSH Terms] OR ("deep"[All Fields] AND "brain"[All Fields] AND "stimulation"[All Fields]) OR "deep brain stimulation"[All Fields]) AND ("economics"[MeSH Subheading] OR "economics"[All Fields] OR "cost"[All Fields] OR "costs and cost analysis"[MeSH Terms] OR ("costs"[All Fields] AND "cost"[All Fields]) AND "analysis"[All Fields]) OR "costs and cost analysis"[All Fields])	415
(cost) AND (neurotechnology)	("economics"[MeSH Subheading] OR "economics"[All Fields] OR "cost"[All Fields] OR "costs and cost analysis"[MeSH Terms] OR ("costs"[All Fields] AND "cost"[All Fields] AND "analysis"[All Fields]) OR "costs and cost analysis"[All Fields]) AND ("neurotechnologies"[All Fields] OR "neurotechnology"[All Fields])	103
(financial toxicity) AND (neurotechnology)	("financial stress"[MeSH Terms] OR ("financial"[All Fields] AND "stress"[All Fields]) OR "financial stress"[All Fields] OR ("financial"[All Fields] AND "toxicity"[All Fields]) OR "financial toxicity"[All Fields]) AND ("neurotechnologies"[All Fields] OR "neurotechnology"[All Fields])	20

Of the 170 studies reviewed, *only 16* examined the financial cost of various neurotechnologies, while *none* investigated the socioeconomic burdens patients may face in accessing these vital interventions, highlighting a crucial gap of understanding in current neurotechnological research.

International Neuroethics Society



RESULTS

- Of 170 articles reviewed, existing research is infrequent and sparse, using vague words e.g., “cost-effective,” “low-cost,” and “affordable” to describe neurotechnologies, which fail to capture patient costs. Only 16 articles examined the cost of various neurotechnologies. The extent of insurance coverage for existing and emerging neurotechnology varies and is unclear. In epilepsy studies conducting healthcare cost analyses, direct-to-patient costs spanned $11,276/year, with total-lifetime-indirect-costs of $385,505.58 (Begley et al, 2000).[8] Other studies found rTMS cost-effective to antidepressant medication for major depressive disorder, but savings depended on early use (Voight et al, 2017).[9]
- Electronic Health Record (EHR) and claims data may shed light on insurance coverage and out-of-pocket costs, but there are barriers to their use. Furthermore, the lack of transparency in reimbursement streams by the Center for Medicare and Medicaid Services (CMS) impedes patients/caregivers’ ability to consider costs in decision-making.

STRATEGIES TO ADDRESS FINANCIAL TOXICITY FOR PATIENTS USING NEUROTECHNOLOGIES

Category	Strategies	Description
A. Solutions to curb increasing COI	Culture of transparency and placing patients first	Emphasize transparency and prioritize patients to curb the increasing cost of intervention with neurotechnology.
	Federal mandate for insurers to be transparent about price	Ensure insurers are transparent about their payment for neurotech implantation and fees patients will face. Promotes healthy competition and reduce prices.
	Re-evaluate policies for early neurotechnology intervention	Policies requiring patients to fail multiple pharmacotherapies before starting neurotechnology intervention should be re-evaluated in dire and/or rare disease circumstances. Allows for early intervention and longer-term tech use, which can be financially beneficial to neurotech companies.
	Stricter FDA regulations on emerging DTC technologies	FDA should establish stricter regulations on emerging direct-to-consumer (DTC) technologies to prioritize patient safety and ensure quality.
	Development of a public facing database to compare costs	Developments of a database to compare costs of diagnosis and implantation performed by hospital and covered by insurance plans to empower patients to find more affordable care without compromising on necessary treatments.
B. How to improve data collection	Improve transparency of costs in claims data and EHR data	Claims data and electronic health record (EHR) data can be made more transparent to collect patient out-of-pocket costs, which can be achieved via a federal mandate to collect this data.
	Improve cross-talk and data-sharing	Cross-talk and data-sharing between patients, insurers, and neurotech companies should be improved to ensure transparency in the cost of the device, insurance bills, and cost to the patient, which can be achieved via a federal mandate.

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