Neuro-Advancements and the Role of Nurses as Stated in Academic Literature and Canadian Newspapers

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Abstract: Neurosciences and neurotechnologies (from now on called neuro-advancements) constantly evolve and influence all facets of society. Neuroethics and neuro-governance discourses focus on the impact of neuro-advancements on individuals and society, and stakeholder involvement is identified as an important aspect of being able to deal with such an impact. Nurses engage with neuro-advancements within their occupation, including neuro-linked assistive technologies, such as brain-computer interfaces, cochlear implants, and virtual reality. The role of nurses is multifaceted and includes being providers of clinical and other health services, educators, advocates for their field and their clients, including disabled people, researchers, and influencers of policy discourses. Nurses have a stake in how neuro-advancements are governed, therefore, being influencers of neuroethics and neuro-governance discourses should be one of these roles. Lifelong learning and professional development could be one mechanism to increase the knowledge of nurses about ethical, social, and legal issues linked to neuro-advancements, which in turn, would allow nurses to provide meaningful input towards neuro-advancement discussions. Disabled people are often the recipients of neuro-advancements and are clients of nurses, therefore, they have a stake in the way nurses interact with neuro-advancements and influence the sociotechnical context of neuro-advancements, which include neuro-linked assistive devices. We performed a scoping review to investigate the role of narrative around nurses in relation to neuro-advancements within academic literature and newspapers. We found minimal engagement with the role of nurses outside of clinical services. No article raised the issue of nurses having to be involved in neuro-ethics and neuro-governance discussions or how lifelong learning could be used to gain that competency. Few articles used the term assistive technology or assistive device and no article covered the engagement of nurses with disabled people within a socio-technical context. We submit that the role narrative falls short of what is expected from nurses and shows shortcomings at the intersection of nurses, socio-technical approaches to neuro-assistive technologies and other neuro-advancements and people with disabilities. Neuro-governance and neuroethic discourses could be a useful way for nurses and disabled people to co-shape the socio-technical context of neuro-advancements, including neuro-assistive technologies. Lifelong learning initiatives should be put in place to provide the knowledge necessary for nurses to take part in the neuroethics and neuro-governance discussion.

Keywords: neuro-advancement; neuroethics; neuro-governance; nurses; nursing; governance; engagement; lifelong learning; role; newspapers; scoping review; academic literature

1. Introduction

Neuroscientific and neurotechnological advancements (from now on called neuro-advancements) have a long history and continue to develop and grow [1–7]. Neuroscience is " . . . the study of how the nervous system develops, its structure, and what it does" [8] and neurotechnologies are defined for example, " . . . as the assembly of methods and instruments that enable a direct connection of technical components with the nervous system" [9], p. 1.

Applications of neuro-advancements range from therapeutic to recreational, entertainment, military, human enhancement and education. One can classify various neuro-advancements as neuro-linked assistive technologies, such as brain-computer interfaces (BCI), cochlear implants, and virtual reality.

In response to the broad applicability of neuro-advancements, neuroethics and neuro-governance discourses arose to identify potential ethical, social, and legal issues that neuro-advancements raise. Stakeholder involvement is one focus of neuroethics and neuro-governance discourses.

Health professionals in general are stakeholders of neuro-advancement discourses, as they interact with both therapeutic and non-therapeutic neuro-advancements within their occupation and daily lives [10,11]. Nursing acknowledges this interaction by having generated the specialty of neuroscience nursing [12–15].

Within their occupation, nurses uphold multiple roles, such as educator, advocate, influencer, researcher, and clinical care provider [16–18].

However, an article by Bell, Legar, Sankar, and Racine indicated gaps within the current roles of health professionals, including nurses, in relation to neuro-advancements, stating:

> *"Trainees from diverse healthcare professions (e.g., nursing, social work, physiotherapy) are not well prepared to handle many of the ethical issues associated with psychiatric DBS [deep brain stimulation] because, among other reasons, they may be unprepared to engage in ethical reflection, they have a limited understanding of issues associated with scientific uncertainty, and they may lack an interdisciplinary understanding about ethical issues"*. [19], p. 6

Another group that has a stake in how neuro-advancements, such as the socio-technical context of neuro-linked assistive devices, are discussed, are disabled people. Nurses often use neuro-advancements for assisting their clients, which include disabled people. Thus, the way in which nurses use, perceive and interact with various neuro-advancements is one factor that affects how neuro-advancements are discussed by nurses in relation to disabled people.

Given the role expectations of nurses, their interactions with clients, such as disabled people, and the gaps in ethical knowledge in health professionals identified [19], our objective was to better understand the role expectations of nurses evident in the academic literature and newspaper literature surrounding neuro-advancement, and whether the literature engaged with the topic of nurses obtaining the necessary knowledge in order to contribute effectively to the ethical and governance discussions of neuro-advancements. Although the above rationale for this study applies to other health professionals as well, we chose nursing for this scoping review because initial research indicated that nursing generated a greater amount of data we could analyze than other health professions.

1.1. Scope of Neuro-Advancements

The scope of neuro-advancements ranges from medical/therapeutic, military, education, human enhancement to recreational, including the use of mainstream neuro-assistive technologies by disabled people and mainstream society [10,11,20–24]. Some products and enabled procedures are transcranial direct stimulation techniques, neurosurgery, deep brain stimulation, artificial hippocampus, artificial brain, prosthetic memory device, cognitive enhancement and nootropic drugs [22,25–28]. As the innovation of neuro-advancements continues to grow, it has begun to converge outside the clinical and research settings, blurring the line between therapeutic and non-therapeutic use [10,11,29,30]. With the rise of "dual use" technologies of " . . . any/all applications beyond clinical care, to include

lifestyle optimization, military/warfare and political/security operations" [11], p. 12, and DIY neuro-advancements [30], international groups such as the *European Union Human Brain Project* [31] and the *Nuffield Council on Bioethics* [7] have started to shape the conversation about the use of these applications within mainstream society.

1.2. Neuroethics and Neuro-Governance

The societal discussions of science and technology advancements should be a constant endeavor [32,33]. Various terms have emerged to discuss how to govern science and technology, such as democratizing science and technology [34–38], participatory technology assessment [39–43], anticipatory governance [44–46], upstream engagement [47–50] and responsible innovation [51–55]. Neuroethics was coined as a term and further developed as a field to investigate various ethical, social, and legal issues raised by neuro-advancements as a whole [56–63] and in relation to particular neuro-advancements, such as brain computer interfaces (BCI) [64,65] and deep brain stimulation (DBS) [19]. A 2018 Organization for Economic Co-operation and Development (OECD) report on the issues of neurotechnology governance argued for the importance of understanding the ethical effects of neuroscience and that neurotechnology governances are necessary to ensure responsible advancements and innovation within the neuro field [11]. The same report said:

> *"Trust and trust-worthiness, including the development of transparent governance with inclusive participation, are important factors in ensuring public support for new approaches in science and technology and will rightly impact professional and public acceptance". [11], p. 5*

According to Racine, " . . . neuroethics has given considerable attention to topics related to public engagement, public understanding of neuroscience, and the media" [66], p. 1467. The use of media in distributing information can be a key component in the widespread release of information about neuro-advancements towards the public eye [66,67].

1.3. Role and Skills of Nurses

"Nursing is a practice discipline and it is a political act" [17], p. 1. According to the Canadian Nurses Association, the skillset of nurses ranges from providing appropriate access to health care and safe guarding human rights [68] to reading, critiquing and applying evidence-informed literature and participating in research [69]. To ensure high-quality nursing practice, nurses must apply educational, clinical, professional, ethical and social expertise through a supportive and consultative role in order to meet the needs of their patients and advocate for policy change to develop the nursing profession as an entirety [17,70]. The Canadian Nurses Association outlined eight essential nursing competencies for 2020:

1. *"A global perspective or mindset regarding health care and professional nursing issues;*
2. *A working knowledge of technology to facilitate the mobility and portability of relationships, interactions, and operational processes;*
3. *Expert decision-making skills rooted in empirical and evidence-based science and research;*
4. *prioritizing quality and safety;*
5. *Being politically astute, by understanding and appropriately intervening in political processes;*
6. *Collaborative and team building skills*
7. *Balancing authenticity and performance expectations*
8. *Coping effectively with change by proactively envisioning and adapting to a constantly variant healthcare system characterized by rapid change and chaos" [17].*

Similarly, the American Nurses Association (ANA) and the American Association of Colleges of Nursing (AACN) outlined the following responsibilities that all nurses should encompass, regardless of their specialty [18]:

1. *"1. Plans and coordinates interventions from a multidisciplinary perspective.*
2. *Functions across the healthcare system and works with diverse populations.*
3. *Initiates and facilitates quality improvement initiatives.*
4. *Facilitates, conducts, and promotes utilization of research activities in practice.*
5. *Develops education strategies and evaluates effectiveness of educational interventions.*
6. *Recommends and influences social and healthcare policies.*
7. *Provides consultation to improve care.*
8. *Applies legal and ethical standards to complex situations."*

The American Nurses Association (ANA), the American Association of Colleges of Nursing (AACN) and the Canadian Nurses Association (CNA) acknowledged that all nurses within the workforce must communicate and engage themselves at the matters of their education, and the matters of social and ethical affairs aside from their clinical obligations. With this skillset, nurses execute the role of employee/worker, advocate, medical professional, educator, and leader/expert. The proper utilization and development of these skillsets and knowledge is prompted through lifelong learning and educational initiatives [71].

1.4. Lifelong Learning and Nurses

"Learning is more process-oriented than product-oriented. More learning needs more time. The total amount of time devoted to learning over a lifespan, as well as the amount of time spent in learning activities parallel to everyday life, is increasing". [72]

Many voiced the importance of lifelong learning including the European Union (EU), the Organization of Economic Cooperation and Development (OECD) and The United Nations Educational, Scientific, and Cultural Organization (UNESCO). The OECD project, "Brain and Learning," indicated the importance of lifelong learning and the implementation of neuro background [73,74].

"Not only must individuals acquire initial training as advanced as possible in order to enhance their performance and increase their chances of entering the labour market, but once they have entered the market, they must embark upon a process of lifelong learning to preserve their position in a fiercely competitive environment. The development of the "learning society" further increases the need for individual learning". [74], p. 2

The continuation of nursing education through professional development initiatives allows for the spread of information by nurses, facilities, agencies, and institutions to help enhance nursing competencies [17,70,75]. The proper engagement of the individual nurse towards lifelong learning is reflected in " . . . quality of nursing practice" [75], p. 4. through updated patient care, awareness of new innovations and technologies, development and acquiring skillsets, and obtaining the relevant knowledge needed for change and advocacy [17,70,75,76]. Lifelong learning was also acknowledged as important for neuroscience nursing [77].

In our study, we investigated further the collaboration between lifelong learning initiatives and the exposure of neuro-advancements within the nursing field.

1.5. People with Disabilities and Neuro-Advancements

The importance of assistive technologies for disabled people has been indicated in the United Nations' Convention on the Rights of Persons with Disabilities [78] and various neuro-technologies could be classified as neuro-assistive technologies or neuro-assistive devices (e.g., cochlear implants, brain–computer interface, virtual reality) [7,79–82]. Due to this relationship, the narrative surrounding neuro-advancements has an effect on disabled people. Numerous problems have been identified in how assistive technologies are discussed, such as that the very definition of assistive technology being seen as too medical [83]. Therefore, it is important to analyze the narrative that exists for

neuro-assistive devices and neuro-advancements. Indeed, it has already been critiqued that brain computer interfaces are discussed purely within the framework of disabled people as therapeutic users of the neuro-technology and not as non-medical user of brain computer interfaces, which is reserved for non-disabled people [81].

There are many groups that interact with neuro-advancements, such as engineers and various allied health professions who often have disabled people as clients that are envisioned to be users of neuro-advancements. Nurses are one occupation covered under allied health professionals that interact with neuro-advancements and are often the first line of contact to analyze how disabled people interact with and respond to the use of diverse types of neuro-advancements. At the same time, the role expectation for nurses [17,70] includes being advocates for their client and their field and the responsibility to influence social policies [18]. These roles suggest that nurses should take part in neuroethics and neuro-governance discussions. Lifelong learning, an action expected from nurses, has the potential to be one mechanism to allow individuals to gain knowledge on neuro-advancements, including the ethical, social, legal and other non-clinical aspects. This would allow nurses to exercise a voice in increasing the benefits of neuro-advancements, to decrease the dangers of neuro-advancements for their clients, such as disabled people, and to be able to influence the sociotechnical context around neuro-advancements, including neuro-assistive technologies.

To conclude, the background section shows that nurses have a stake in neuro-advancements, including how neuro-advancements are governed. Nurses use various neuro-advancements as part of their professional practice and clients, such as disabled people, use neuro-advancements such as neuro-linked assistive technologies. As such, nurses should contribute to the socio-technical context discussions around assistive technologies and disabled people. Nurses are expected to perform many roles and these roles could be employed to engage with neuro-advancements beyond clinical service provision, such as influencing neuroethics and neuro-governance discourses. However, it has been reported that nurses lack knowledge in relation to neuroethics issues. Lifelong learning is the vehicle used by nurses to stay up to date on topics and could be used to obtain the reported missing knowledge.

2. Materials and Methods

2.1. Study Design

Academic and Newspapers

A scoping review approach was the most suitable for our study. One purpose of scoping studies is to identify the extent of research present on a given topic [84–89] and the current understanding of a given topic. As proposed by Arksey and O'Malley [87], we utilized the recommended five step process of scoping studies: identifying the review's research purpose and question, identifying databases to search, recording the descriptive quantitative results, selecting literature based on descriptive quantitative results for qualitative analysis, qualitative analysis of data, and reporting findings of qualitative analysis. We did not perform the optional step [6] of consulting stakeholders to execute knowledge translation for this study because that is part of a follow up study.

2.2. Identifying and Clarifying the Purpose and Research Questions

Academic and Newspapers

Our objective was to understand the role narrative of nurses in neuro-advancements covered by academic literature and newspapers, including the role of nurses in relation to disabled people using neuro-advancements and whether the literature engaged with the essential topic of nurses obtaining the necessary knowledge to engage in and contribute to discussions around all aspects of neuro-advancements, including neuroethics and neuro-governance discussions and the socio-technical context of neuro-linked assistive technologies.

To fulfill our objective, we first asked the following question:

How often are nurses and nursing mentioned in conjunction with the terms "assistive technology*" or "assistive device*" in academic literature and various neuro-terms in academic literature and newspapers? This question allowed us to identify data to be downloaded for the content analysis.

Our content analysis of the obtained academic abstracts and Canadian newspaper articles was guided by the following questions:

Which roles and skills of nurses are mentioned in relation to neuro-advancements? How is lifelong learning in relation to neuro-advancements and nurses engaged with? Which ethics issues are identified in relation to neuro-advancements? How are "assistive technology" and disabled people mentioned in relation to neuro-advancements? Which governance issues are mentioned in relation to neuro-advancements, if any?

2.3. Data Sources and Data Collection

2.3.1. Newspapers

It has been well reported that newspapers and other media influence discourses [90]. The media has a significant impact on individuals and is influential in creating their perspective on many issues. It sets an opportunity for flow of information and new perspective [91]. To conduct our newspaper search, we used the *Canadian Newsstream*, a database consisting of n = 300 English Language Canadian newspapers, with a complete time range from 1980–2018. We collected articles from these newspapers using the University of Calgary's ProQuest online database.

Canadian newspapers were chosen because (a) existing and potential nurses are readers of newspapers, (b) the database covers over 300 news sources covering all regions of Canada, (c) over 75% of Canadians still read newspapers [92,93] and as such, are influenced by what they read and (d) Parents, teachers, and career counselors who often give advice on career ideas to young adults are also readers of newspapers [94].

Eligibility Criteria and Search Strategies

To maintain a clear and feasible scope [89], eligible newspaper articles were identified using explicit search strategies [85]. On 28 March 2018 we employed two search strategies: first, we searched the newspaper database for the term "nurs*"in combination with "neurote*" OR "neurosc*" or "neuroen*", obtaining n = 700 results after n = 84 duplicates were removed. Secondly, we searched the database for "nurs*" in conjunction with the select 70 neuro-advancement terms (Table 1) obtaining n = 695 hits after n = 12 duplicates were removed. We downloaded the n = 1365 newspaper articles we found as two individual PDF, reflecting the two newspaper search strategies and imported the PDF into ATLAS.Ti 8™, a qualitative data analysis software application for qualitative content analysis.

The following 70 neuro-advancement-related terms, which we identified during our prior research, were used for both academic literature and newspapers:

2.3.2. Academic Literature

We searched two academic databases, namely EBSCO ALL, an umbrella database that includes over 70 other databases, itself including the nursing focused database CINAHL and Scopus, which incorporates the full Medline database collection with no time restrictions. We chose these two databases because together, they covered a wide range of topics from areas of relevance to answer the research questions, such as life science, physical science, nursing, neuroscience, disability studies, social science and technology and relevant journals, such as the journal called *Journal of Neuroscience Nursing*.

Table 1. List of neuro-advancement search terms.

1.	artificial brain	36.	HEG
2.	artificial hippocampus	37.	hemoencephalogra*
3.	auditory brainstem	38.	Hippocampus prosthesis
4.	BCI	39.	human computer
5.	bionic eye	40.	iEEG
6.	brain computer	41.	intracranial electroencephalography
7.	brain feedback*	42.	Muse headband
8.	brain imaging	43.	Neural stem cell
9.	brain inform*	44.	Neuralink
10.	brain stimul*	45.	Neurochip
11.	brain to speech	46.	neurofeedback*
12.	Brain-computer interface	47.	neuroimaging
13.	brain-to-text	48.	neuroinform*
14.	cochlear implant	49.	neuromodula*
15.	cognitive enhance*	50.	neurosens*
16.	cognitive imag*	51.	neurostim*
17.	cognitive stim*	52.	NFB
18.	cognitive tech*	53.	Nootropic
19.	collaborative cognitive simulations	54.	NSC
20.	CoriQ	55.	optogenetic
21.	cortical modem	56.	Prosthetic memory device
22.	cranial electrotherapy stim*	57.	Pulsed electromagnetic field therapy
23.	DACI	58.	Responsive neurostimulation
24.	darpa ram sensor	59.	Sacral nerve stimulation
25.	DBS	60.	Speech BCI
26.	deep brain stim*	61.	Spinal cord stimulator
27.	deep mind	62.	subvocal
28.	Ear-EEG	63.	tDCS
29.	ECoG	64.	THync mood altering headset
30.	EEG biofeedback	65.	TMS
31.	Electrocorticogra*	66.	transcranial direct current stim*
32.	Exocortex	67.	transcranial magnetic stim*
33.	Facial electromyography	68.	virtual reality
34.	fEMG	69.	VR
35.	God Helmet	70.	whole brain emulate*

Eligibility Criteria and Search Strategies

In EBSCO, we only searched for scholarly peer reviewed journals, while in Scopus, we searched for reviews, peer reviewed articles, conference papers, and editorials.

We applied two search strategies on 28 March 2019:

Strategy 1a:

We searched the abstracts of articles in EBSCO ALL and Scopus for the term "nurs*" in combination with "neurote*" OR "neurosc*" or "neuroen*".

Strategy 1b:

We searched the title of journals in Scopus for the term "nurs*"in combination with "neurote*" OR "neurosc*" or "neuroen*" in the abstracts.

In total, we obtained n = 1522 results after we removed n = 1655 duplicates.

Strategy 2a:

We searched the abstracts of articles in EBSCO ALL and Scopus for the term "nurs*" in conjunction with the select 70 neuro-advancement terms (Table 1).

Strategy 2b:

We searched the titles of journals in Scopus for the term "nurs*" in conjunction with the select 70 neuro-advancement terms (Table 1) in the abstracts.

In total, we obtained n = 597 abstracts after elimination of n = 123 duplicates.

On 1 July 2019, we performed an additional search.

Strategy 3a:

We searched the abstract of articles in EBSCO ALL and Scopus for the term "nurs*" in conjunction with the terms "assistive technolog*" or "assistive device*".

Strategy 3b:

We searched the titles of journals in Scopus for the term "nurs*" in conjunction with the conjunction with the terms "assistive technolog*" or "assistive device*" in abstracts.

In total, we obtained n = 344 abstracts after elimination of n = 193 duplicates.

We exported all abstracts into a word document and the word document was imported into ATLAS.Ti 8™, a qualitative data analysis software application for content analysis.

2.4. Quantitative Data Analysis and Qualitative Data Reporting

Newspapers and Academic Newspapers

We employed a descriptive quantitative (manifest coding) and qualitative content analysis (latent coding) to answer our research questions.

To answer the research question of which neuro-advancements are present in the covered literature, both authors performed manifest coding that involved obtaining the "frequency and location of a certain "recording unit" [75], p. 47 for the number of abstracts downloaded that contained any of the 70 neuro-related terms (Table 1).

Both authors independently performed latent coding of the downloaded academic abstracts and full-text newspaper articles to discover "underlying meanings of the words or the content" [78], p. 1284. Both authors idependently grouped related codes for content relevant to the scope of the study, namely (1) what roles of nurses are mentioned in conjunction with neuro-advancement? (2) How are disabled people mentioned in relation to nurses/nursing and neuro-advancements? (3) What ethics issues are mentioned in relation to nurses/nursing and neuro-advancements? (4) Was the role of nurses being involved in neuroethics and neuro-governance discussions present? (5) How are assistive technologies/assistive devices mentioned in relation to neuro-advancements and nurses/nursing?

Much of the content was not relevant. For example, roles were mentioned but not in relation to nurses or the role of nurses was mentioned but not in relation to neuro-advancements. In addition, content related to disabled people was mentioned but not in conjunction with nurses or nursing and in relation to neuro-advancements.

2.5. Trustworthiness Measures: Newspapers and Academic Papers

Confirmability, credibility, dependability, and transferability are four trustworthiness measures [95–97]. Confirmability deals with the overall level of confidence that the research study's findings are based on the literature narratives and words rather than potential researcher bias [97]. Using ATLAS.Ti 8™, we conducted an audit trail for the coding process by recording data of interest in the literature, recognizing concurrent themes. The authors engaged in peer debriefing on the generation of hit-counts that identified content that should be downloaded (Tables S1–S3 in Supplementary Material) and the manifest and latent coding of the downloaded material. Differences in hit counts from executing our search strategies to obtain articles for qualitative analysis did not occur and neither did differences in manifest coding. Even latent coding differences were few and differences were resolved between the authors. Transferability refers to the extent to which our finding from a study can be applied to other situations. We provided enough data, so others can decide whether to apply our search strategies and analysis to different sources or whether they want to apply different terms such as other neurotechnologies.

2.6. Limitations

Our search was limited to two academic databases and English language literature. As such, our findings are not to be generalized to the whole academic literature, non-academic literature, or non-English literature. Our findings, however, allow for conclusions to be made within the parameters of the searches.

The focus of this study was on Canadian newspapers. Sources such as social media or online only news content (e.g, Canadian Broadcast Corporation) were not the focus and therefore, were not included. Furthermore, the focus was on English-language newspapers only. Therefore, our results cannot be generalized for media in general, newspapers in Canada, and media including newspapers from other countries.

Furthermore, we used 70 neuro-advancement terms (Table 1) based on our prior research. That list is not complete, and one can use more terms if one wants to. Furthermore, new terms might appear in time in the literature as neuro-advancements continue. Therefore, the term list should be updated eventually.

3. Results

The result section was divided into seven parts:

Part One provides the summary of the results from our search strategy that led to the identification of newspaper articles and academic abstracts to be downloaded for content analysis (the full hit count results are in Tables S1–S3 in the Supplemental Material);

Part Two provides hit count for the presence of the 70 neuro-advancement terms (Table 1) in the downloaded academic abstracts;

Part Three covers the latent coding results on the role of nurses;

Part Four covers content related to ethics content and the involvement of nurses in neuroethics and neuro-governance discourses;

Part Five covers lifelong learning;

Part Six covers how disabled people are mentioned;

Part Seven deals with the terms "assistive techolog*" and "assistive device*".

All the parts were divided between academic abstracts and newspaper articles.

The results obtained for the academic abstracts and the newspaper were similar. Very few neurotechnologies were mentioned in relation to nurses. The role and skills of nurses mentioned in relation to neuro-advancements focused mostly on clinical practice, if they were mentioned at all, and lifelong learning was rarely engaged with in relation to neuro-advancements and nurses. If lifelong learning was mentioned, the focus was on clinical knowledge or using neurotechnologies (virtual

reality) as an educational tool. Learning about the societal aspects of neuro-advancements through lifelong learning initiatives was not present. Nurses were rarely mentioned in relation to ethics issues and the role of nurses being involved in neuroethics and neuro-governance discussions was absent. Disabled people were mostly engaged with within a medical/therapeutic narrative. Neurotechnologies were rarely identified as assistive technologies or assistive devices and the socio-technical context of assistive technologies in relation to neurotechnologies or in relation to disabled people was absent.

3.1. Part 1: Quantitative Results

3.1.1. Quantitative Results: Academic

We first generated hit counts for all the search terms. Tables S1 and S2 in the Supplementary Material display the results for the hit counts within academic literature using the two search methods: all search terms within the abstract (Table S1), and "nurs*" within the source/journal title and neuro-related terms in the abstract (Table S2).

In short, according to Table S1, 43 neuro-related terms had no hits. Eight of these terms had less than ten hits, including the term neurote* to indicate neurotech related words. The following had more than 10 hits: "neurosc*" (n = 1944), "Neuroen*" (n = 434), "virtual reality" (n = 438), "VR" (n = 298), "neuroimaging" (n = 180), "brain stimul*" (n = 136), "ECoG" (n = 124), "cognitive stim*" (n = 122), "deep brain stim*" (n = 120), "DBS" (n = 68), "human computer" (n = 65), "neuromodula*" (n = 64), "brain imaging" (n = 59), "cochlear implant" (n = 36), "cognitive enhanc*" (n = 29), "TMS" (n = 26), "transcranial magnetic stim*" (n = 24), "BCI" (n = 23), "brain computer" (n = 17), "brain-computer interface" (n = 16), "neurostim*" (n = 15) and "sacral nerve stimulation" (n = 11). Eight were mentioned less than 10 times and 44 were not mentioned at all.

For the search method of "nurs*" in the source/journal title, and neuro-related terms in the abstract, the following terms had more than 10 hits: neurosc* (n = 1599), neuroen* (n = 323), virtual reality (n = 204), brain stimul* (n = 74), "deep brain stim*" (n = 71), "VR" (n = 47), "neuroimaging" (n = 36), "ECoG" (n = 29), "human computer" (n = 29), "DBS" (n = 24), "cognitive stim*" (n = 24), "neuromodula*" (n = 20), "TMS" (n = 15), "cochlear implant" (n = 15), and "transcranial magnetic stim*" (n = 14). Fourteen were mentioned less than 10 times and 39 were not mentioned at all.

3.1.2. Quantitative Results: Newspaper

As for the newspaper results of search strategy number 2, the full results can be found in Table S3 in the Supplementary Material. In short, the following in conjunction with the term "nurs*" had more than 10 hits: "neurosc*" (n = 704), "virtual reality" (n = 343), "VR" (n = 146), "cochlear implant" (n = 137) "brain stim*" (n = 109), "brain imaging" (n = 103), "DBS" (n = 91), "neuroen*" (n = 82), "BCI" (n = 78), "deep brain stim*" (n = 72), "TMS" (n = 51), "transcranial magnetic stim*" (n = 21) and "neuroimaging" (n = 19). A total of 15 terms had less than 10 hits and 45 had no hits, including "neurote*".

3.2. Part 2: Neuro-Advancements Mentioned in the Downloaded Material

3.2.1. Quantitative Results: Academic

Covering the 1522 abstracts and the 597 abstracts, we found "nurses" or "nursing" mentioned 22 times in conjunction with the term "neuroen*", of which, the word was in all cases "neuroendocrine" (all within the 1522 abstracts). No hit was obtained for "neurote*", which could cover the terms "neurotechnology" or "neurotechnologies". The term "neuroscience" was mentioned frequently in conjunction with the terms "nursing' or "nurses" in the 1522 abstracts and rarely in the 597 abstracts, although the mentions were mostly a reflection of the presence of the phrases "neuroscience nurses" and "neuroscience nursing". Within the 1522 abstracts the phrase "neuroscience nurses" was present 184 times and the phrase "neuroscience nursing" was present 476 times, whereby within the 597

abstracts, the phrase "neuroscience nurses" was present three times and the phrase "neuroscience nursing" was not present.

Most of the abstracts (1522 and 597) did not engage with the 70 neuro-related terms (Table 1) in relation to nurses and nursing. The neuro-advancements found were "virtual reality" or "VR " (n = 30), deep brain stimulation or DBS (n = 22), neuroimaging (n = 14), cognitive stimulation (n = 9), cochlear implants, TMS, and transcranial magnetic stimulation (n = 6), spinal cord stimulator and cognitive stimulation (n = 2) and brain computer interface, BCI, cognitive enhancement (n = 1). The rest of the neuro-related terms in Table 1 did not generate any content related to nurses or nursing.

3.2.2. Quantitative Results: Newspaper

We then identified how often neuro-advancements (Table 1) were mentioned in the downloaded newspaper articles in relation to nurs*". Only 6 of the 70 neuro-related terms were found: "virtual reality" (n = 8), cochlear implant* (n = 2), "auditory brainstem*", "transcranial magnetic stim*", "VR", TMS (n = 1).

The newspaper coverage revealed a lack of engagement with nurses in relation to most neurotechnologies.

Our findings reported in Section 3.2 suggest a gap in the coverage of neuro-advancements in relation to nurses and nursing in both the academic literature and the newspapers covered. Most coverage did not engage with specific neuro-advancements. This is problematic because certain applications have specific issues attached to them (see for example, the ethics literature around brain computer interfaces). In addition, the term neurotechnology did not make it into the literature covered. This is a problem given the existence of a neurotechnology governance discourse [11] of relevance to nurses and nursing and that many articles of relevance use the term neurotechnology.

However, hit count does not give the whole story. As such, we reported on the data obtained through a qualitative content analysis in the remainder of the results section.

3.3. *Part 3 Qualitative Data: Scope of the Role and Skill of Nursing*

3.3.1. Scope of the Role and Skill of Nursing: Academic

Within the 597 abstracts covering the 70 neuro-related terms, the roles associated to nurses in general were occupational-specific and included patient liaisons [98], educators [98–104] and being a leader [99,105]. In turn, the skills included patient assessment [106,107] and patient care [99,108,109]. To reflect such roles and skills in practice, it was outlined that nurses should have the necessary knowledge background in order to practice effectively [98,103,107,110–113]. Outside of the occupational scope, no role of nurses was mentioned.

Within the 597 abstracts, nurses were called to build an increased understanding of different neuro-related issues and the utilization and implementation of various techniques towards appropriate client care, such as appropriate technological knowledge and support [107,109,114].

Some abstracts covering "deep brain stimulation" (DBS) and "brain stimulation" indicated the use and potential of this technology as primarily a tool to aid patients with Parkinson's disease [115–119]. In addition, abstracts covering DBS mentioned the role of patient care and client educators [118,120,121].

Within one abstract covering "spinal cord stim" (SCS), the following role of nurses was mentioned: "caring for patients receiving SCS through patient education, psychologic support, and programming the spinal cord stimulator ... Because of the active role nurses take in pain management, a knowledge of pain transmission and the techniques and efficacy of spinal cord stimulation is important" [109], p. 53. This quote concerns patient education, but the education focuses on clinical aspects, not ethical or social aspects.

The two abstracts covering roles of nurses in relation to "neurostim" both focused on clinical roles and clinical knowledge and therapeutic education [122].

"Transcranial magnetic stim" (TMS), in relation to nurses, indicated operator information [98,105, 123], treatment use [98,123–127], and safety concerns for health professionals [128,129]. One article outlined the role of the nurse in administering repetitive transcranial magnetic stimulation (rTMS) treatment, and the potential for nursing leadership [105]. However, the focus was, again, on the clinical service and not on ethical or governance issues.

Within the 1522 abstracts, if roles and skills of nurses were a topic and linked to neuro-advancements, the vast majority were linked to clinical practice, such as directly related to care services (n = 29). Other roles still linked to clinical practice were advocate for patient/client (n = 5), educator of patient (n = 8), researcher and case manager (n = 5), facilitator and assessor (n = 3), referrer and counsellor and educator of the public on the clinical condition (n = 2), administrator, outreach liaison educator of care givers and staff, enabler of communication of patient, provider for needs of families, advancing ones field, and agent of change [130] (n = 1). To give two quotes:

> "A thorough understanding of the latest concepts regarding recognition and management is essential for the neuroscience nurse to play a meaningful role as counselor, educator and clinician in the care of these patients and families". [131], p. 145

> "Neuroscience nurses can play an important role in reaching health promotion and disease prevention goals in persons with Parkinson's disease through patient education, advocacy, case management, anticipatory guidance and referrals to primary care providers". [132], p. 229

3.3.2. Scope of the Role and Skill of Nursing: Newspaper

Within newspaper literature, we found no article that covered the role of nurses and the scope of nursing in relation to neuro-advancements. We only found roles of nurses in relation to technologies in general. Interestingly, the role of the nurse as a protester/advocate was mentioned twice [133,134], but not in relation to neuro. Most of the skills mentioned were in relation to occupational obligations and general occupational skills [135–139]. Knowledge of technology was mentioned once in relation to the use of computers to help patients with depth perception [140]. Of the mentioned neurotechnologies search terms within the literature, "Virtual Reality", "Cochlear", "Auditory Brainstem" and "Transcranial magnetic stimulation (TMS)", the relation to nurses regarded occupational practice use. "Within these eight articles, it was argued that virtual reality is a useful distraction technique from pain [141,142], as well as that the use of virtual reality to improve nursing education is a good "cost-fighting tool" [143,144]. "Cochlear" in relation to "nurs*" was mentioned in two articles both covering a nurse in cochlear implantation surgery [145,146]. "Auditory Brainstem" was mentioned once, depicting the process of a nurse conducting an Auditory Brainstem Response Test (ABR) on a patient [147]. Similarly, transcranial magnetic stimulation (TMS) was mentioned once in relation to a nurse utilizing TMS as a treatment method [148].

3.4. Part 4: Ethical Implications and Involvement in Neuro-Advancement Governance as a Role of Nurses/Nursing

We found two distinct relationships between nurses and the ethics and governance of neuro-advancements: the first was the ethical implications and knowledge of such ethical issues by the nurses, and the second implication is the role of the nurse in terms of governance and policy discussion surrounding the ethical implications of neuro-advancements. The newspapers only revealed ethical implications and no governance/political involvement of the nurse.

3.4.1. Ethical Implications of Neuro-Advancements for Nurses/Nursing: Academic

Within the 597 abstracts, ethical implications in relation to nurses and neuro-advancements were rarely mentioned. Of the ethical issues mentioned in relation to neuro-advancements, only deep brain stimulation (DBS) n = 2 and Virtual Reality (VR) n = 4 were mentioned. Mentions of DBS indicated the risk of utilizing the technology upon vulnerable patients [149]. Aside from the ethics in

the use of the technology, the ethical implications stated in relation to VR outlined the potential social gaps with the use of this technology in education, particularly outlining the effects on disadvantaged populations [150]. "... major changes associated with VR will occur, and that action must be taken now to guard against the financial discrimination that will affect not only trainees, but also the institutions that treat the least fortunate populations in our society. Medical educators and practitioners should look to our medical leaders to see how we can amplify VR's benefits to patients and trainees while diminishing its adverse effects on medical education and the poorest healthcare institutions" [150], p. 326.

Apart from the ethical issues in the use of neuro-advancements, four abstracts recognized the necessity of academic background and proper ethical training to shape practicing ethics within health care occupations. "Health care trainees rely partly on their training to manage, reason, and reflect on the ethical uncertainties of innovations and new technologies" [149], p. 23. The lack of in-depth coverage of ethics issues and what to do fits with prior findings of our study. One area of ethical contemplation was raised in relation to "cognitive enhance*", "cognitive stim*," and the uses of "Cognitive stimulation therapy (CST)" [151–154] with patients and the attitudes of nursing students about the use of cognitive enhancements, where it was found that the decision to use such cognitive enhancers did not occur in isolation and there were many existing social and contextual influences that impacted the decision for nurses to use cognitive enhancers [155].

Within the 1522 neuroscience abstracts, ethics was mentioned in n = 59 abstracts. As for the relevant mentions, one stated: "the role of neuroscience nurses in relation to ethical issues has become increasingly complex. Knowledge of ethical principles and theories assists the nurse in the development of a theoretical basis for resolution of ethical issues or concerns. Additionally, the nurse must have information about practice codes or standards as well as legislative requirements. The nurse must act as an advocate for the patient and society through active participation in institutional ethics committees and legislative forums" [156], p. 621. Others argued that nurses have to be literate on ethical principles and theories [157], for example, because of their involvement in genetic-based neuroscience diseases [158] and because decision-making in nursing practice is impacted by new ways of knowing [159]. One abstract linked neuroscience nurses to ethical decision-making regarding patient advocacy [160], see also [161], and another abstract indicated that the impact of technologies and biological sciences on ethical nursing care remains uncertain [162].

Many of these mentions of ethics could indicate that nurses should be involved in neuroethics and neuro-governance discourses.

3.4.2. The Role of Being Involved in Ethics, Policy and Governance Discussion: Academic

Within the 597 abstracts, we found no content that argued for the involvement of nurses or nursing in ethics or neuro-governance discourses or discussions around the social implications of neuro-advancements. Terms such as "decision-making" [163–166], and "leader" [105] were mentioned in relation to clinical aspects and were not linked to ethics or governance discussions. "Expert" and "Responsib*" indicated the importance of expertise and occupational responsibility in relation to "neuromonitoring, neuroimaging, neurodevelopmental care" [167], p. 421 to better address the needs of their clients, as well as execute techniques [122].

Within the 1522 abstracts, the roles mentioned of nurses did not include having a role in neuro-governance, neuroethics or social implication discussions around neuro-advancements, even if ethical and social implications were acknowledged and the content suggested that nurses should have a role. To give two quote:

> *"Nursing practice is at a critical ideological and ethical precipice where decision-making is enhanced and burdened by new ways of knowing that include artificial intelligence, algorithms, Big Data, genetics and genomics, neuroscience, and technological innovation". [159], p. 1*

Covering traumatic brain injury but no neuro-advancement in particular, one abstract stated that to be a caring nurse includes "reflecting on all sociocultural factors shaping family resources and responses (knowing)" . . . ; [168], p. E2.

We found two abstracts that indicated that nurses have a role in governance and ethics discourses, although the focus was not on neuro-advancements as such. To give two quotes:

"The role of neuroscience nurses in relation to ethical issues has become increasingly complex . . . The nurse must act as an advocate for the patient and society through active participation in institutional ethics committees and legislative forums". [156], p. 621

"The nurse specialist can make a significant contribution within the context of a multidisciplinary team especially in the production of guidelines and policies to ensure and maintain high standards of practice, education for the patient, and the provision of expertise and security that the patient requires when diagnosed with a rare disease". [169], p. 487

3.4.3. Ethical Implications and Governance of Neuro-Advancements Including Role of Nurses/Nursing: Newspapers

We found not one article that engaged with the topic of governance of neuro-advancements in relation to nurses and nursing. Of the ethical implications of neuro-advancements within newspapers, none were linked directly to nurses, however, n = 8 mentions of ethics were placed as considerations within health care. These ethical considerations involved the considerations of cognitive enhancing drugs [170], the public misconception around DBS, "ethicists say patients, often carried away by glowing reports of the procedure's successes, need to be carefully briefed on DBS's unusual side effects, which have included mania, personality changes, marital discord, and increased rates of suicide" [171], p. A8; end-of life decisions for brain-dead patients [172], and technological knowledge enhancement, "how could such knowledge be conveyed through a computer wire? For Hayles, the blurring of these two kinds of knowledge can have serious ethical repercussions" [173], p. F11. Given that no hits were obtained with nurses, the reader will not be triggered to think about nurses as active agents of ethics discussions and being impacted by neuroethics issues.

3.5. Part 5: Lifelong Learning

3.5.1. Lifelong Learning: Academic

As for the 597 abstracts generated from the 70 neuro-related terms (Table 1), the main coverage of education of nurses was linked to the use of "Virtual Reality" (VR) in nursing education (n = 14). The indicated use of VR, however, placed the nurse upon the receiving end of the technology as an educational system/technique, rather than providing education/learning upon the use of virtual reality within the professional setting [100,102,112,163,174–182]. The use of virtual reality simulations was indicated to allow "students to apply and integrate knowledge newly acquired and clinical experience, in order to generate greater security and confidence prior to actual patient arrival" [174], p. 57, as well as to " . . . allow trainees to practice techniques without consequences, reduce potential risk associated with training, minimize animal use, and help to develop standards and optimize procedures" [177], p. 67. Only n = 2 abstracts were not related to the use of VR, but rather covered the role of nurses as educators towards educating the patient on deep brain stimulation before and after the intervention [121] and the need for clinical education of nurses for "adequate training both of caregivers and nursing staff in order to assist clinicians in the management of patients in the complicated stages of disease", "utilizing infusional therapies and deep brain stimulation techniques" [183], p. 434. Not one abstract indicated in-depth engagement of operationalizing lifelong learning and none linked lifelong learning as a tool to obtain a more diverse view of how to deal with disabled people beyond the medical view and to be up to date on neuroethical and neuro-governance issues.

Lifelong learning was mentioned in relation to "cochlear implant" in nursing, with the focus on being up to date on clinical knowledge [184–186]. Ethics and governance knowledge or knowledge on

the social discussions around cochlear implants within the deaf community and its implications was not a focus of knowledge.

Some "neuroimaging" abstracts indicated the need to continue nursing education in relation to this technique and provide information towards its use [187–190] but did not engage with knowledge needed to partake in neuroethics and neuro-governance discussions or how to use lifelong learning to obtain the knowledge needed.

As to the 1522 abstracts, education in general was linked to becoming more knowledgeable on the clinical aspects of neuro-advancements and neuro-diseases.

Lifelong learning as a term was not mentioned once. Professional development was mentioned eight times. To give two quotes:

> *"However, evidence suggests that neuroscience specific education provision is largely unregulated and set outside of a cohesive professional development context" [191], p. 1069 and "Clinical judgment, skills and an evidence-based approach to practice must be maintained through continuing education, training, and the ongoing evaluation of neuro-specific competencies to validate proficiency of care of the neuro rehabilitation patient. These are continuous processes that must be sought by nurses to maintain expertise in the rapidly advancing fields of neuroscience and neurorehabilitation. Professional associations, like the ARN and AANN, provide professional development through education, advocacy, collaboration and research within the specialty". [192], p. 176*

Continuing education was mentioned n = 12 times with regard to the role professional nursing organizations have to play [193], continuing education being important for neuroscience nurses [194], and technology supporting continuing education.

> *"Since its inception in 1968 the American Association of Neuroscience Nurses (AANN) has devoted the majority of its energy and resources to establishing and maintaining excellence in continuing education (CE)". [77], p. 73*

3.5.2. Lifelong Learning: Newspapers

Within the scope of our newspaper articles, numerous articles covered continuous learning in relation to nurses and nursing, such as *"Canadian Nurses Association launches national online learning network"* [195] and in [196], but there were only five mentions of learning in relation to nurses and our neuro-advancements. The relevant coverage given our focus were in relation to the use of virtual reality and simulation techniques for improving nursing education both for the pre-occupational—nursing students through postsecondary education—as well as the practicing nurse in continuous learning [143,197–199]. As such, learning initiatives was not introduced to readers as a means to learn about the ethical social and other issues linked to neuro-advancements or to indicate that the scope of lifelong learning as a tool was too small.

3.6. Part 6 Narrative of Disabled People

3.6.1. Narrative around Disabled People: Academic

Within the 597 and 1522 abstracts, all the terms that depict disabled people focused on medical and therapeutic aspects in conjunction with the terms. The term patient was the one predominantly used n = 1638. The term "client" was used only 43 times, "disabled people" 13 times and "people with disabilities" 12 times.

When placed in relation to nurses, the roles of nurses were primarily in relation to occupational roles with interacting with the disability community, such as helping to improve patient care [200] and outcomes [201], utilizing neuro-advancement for appropriate patient monitoring [163], the community learning disability epilepsy nurse specialist [202], and mental health nurses [203–205]. The abstracts did not indicate in-depth engagement with the role nurses have in relation to disabled people, especially

the social aspects of the lives of disabled people, and the potential impacts of neuro-linked assistive technologies on such social aspects were missing.

3.6.2. Narrative around Disabled People: Newspapers

Within the newspapers, the narrative around disabled persons was a medical one, whether within the use of the term "patient' or the term "impairment or how the term disability was used. Much of the language surrounding such terms was diagnostic and pertained to medical obligations such as "patient care", "protect patients", etc.

Four articles outlined the potential and use of different types of neurotechnologies by disabled people: deep brain stimulation (DBS) [206], brain control interface (BCI) [207], cochlear implants [106] and virtual reality [208].

Not one article covered disabled people (even under the term patient) in relation to neuro-advancements and nursing. Not one article thematized the relationship between nurses and nursing and disabled people in relation to neuro-advancements, something needed given the contentious debate around the neurotechnology of cochlear implant and certain controversies around brain-computer interfaces.

3.7. Part 7 Assistive Technology (AT) as Neuro-Advancements

3.7.1. Assistive Technology (AT) as Neuro-Advancements: Academic

Within the 597 abstracts, the term "assistive technolog*" (AT), obtained n = 8 hit counts, of which n = 6 classified virtual reality as an assistive technology whereby the focus was on therapeutic outcome improvement and prevention of health problems [209–214]. In the studies, the following issues were considered by some researchers in relation to assistive technologies: overall usability [209,213,215], effectiveness [211,212,214], user acceptance [213], and financial feasibility [215]. However, the only role outlined for nurses was in assisting in the use of the technology with patients and no further ethical and social implications were analyzed outside of the medical scope and purpose of such technologies.

There was one abstract that did not explicitly state the term "assistive technology" or "AT", however, the nature of the technology was to modify and further automate wheelchairs for the disability community [215]. According to the authors, the incentive of such a technology was to increase independence and empowerment of the user and will be made to integrate brain computer interfaces (BCI), and Artificial Intelligence (AI) in its modifications to perform functions such as wireless communications and avoiding obstacles [215]. The only relationship to nurses within the article was the risk of potential shortages of medical professionals, such as nurses, with the introduction of such technology.

As for the 1522 abstracts, the term "assistive technolog*" was only mentioned once in a non-relevant context. However, the term "assistive device*" was found in one abstract of relevant context that engaged with an eye-tracking device and the Psychosocial Impact of Assistive Devices Scale (PIADS) and the communication of basic needs to nurses [216].

As for the search strategy that focused on the presence of the terms "nurs*", "assistive technolog*" and "assistive device*", in the abstract (search strategy 3, 344 documents), only hearing loss-related devices, which could be seen as a neuro-linked assistive technology, were mentioned three times and one-time virtual reality was mentioned. Only one article covered a role of nurses, namely to help families to cope with hearing loss [217]. The others were not relevant as they compared the cost of a hearing devices with a nursing home [218,219]. VR was mentioned once in relation to nursing homes and not nurses [212].

All remaining abstracts used the terms to assistive devices/assistive technology (AD/AT) without any linkage to neuro-advancements. The role of nurses related to assistive devices/assistive technology (AD/AT) was mainly about nurses using them to make their work lives better and safer (n = 13), nurses involved in providing AT and use of AT on the ward/nursing home to their patients (n = 3) and how

to use AD/AT(n = 2) within their practice. The following themes were mentioned once: "emotional support, information, and access to assistive devices" [220], p. 553, researcher, discharge planning intervention, bad AD used by a nurse, promoting AD to a patient as a home nurse, encountering AD as a home care nurse, AD being needed by nursing home resident, and mandatory inclusion of AT in health professionals curricula [221].

One abstract stated,

> *"A team of Bioengineering and Nursing faculty delivered an educational and cultural summer experience with the objective to broaden students' knowledge and exposure to health care careers in engineering and nursing, while providing assistive devices and health care outreach to the local community".* [222]

3.7.2. Assistive Technology (AT) as Neuro-Advancements: Newspaper

Within the newspapers, the term "assistive technolog*" was only mentioned four times and not once in relation to nursing. This finding indicates that a gap exists between the relationship of nurses with assistive technology and therefore, the relationship between nurses and disabled people, given the impact that various neuro-linked assistive devices have on disabled people.

4. Discussion

Our results indicate similar problems for the academic literature and the newspapers analyzed. Both the academic and newspaper literature covered very few neuro-advancements in relation to nurses and did not, or rarely did, cover governance and engagement, disabled people, assistive technologies, ethics issues and lifelong learning in relation to nurses and neuro-advancements. Finally, if mentioned, the role and skills of nurses mentioned in relation to neuro-advancements focused mostly on clinical practice. We discussed our findings in the remainder of the section through the lens of the role expectations of nurses, the public and stakeholder engagement expectation evident in neuroethics and neuro-governance discourses, the literature dealing with the relationship between nurses and disabled people and the literature engaging with the lifelong learning of nurses.

4.1. The Role of Nurses in Relation to Neuro-Advancements

Nurses are expected to fill many roles and skills [17,18] and all of these roles and skills have the potential to be and therefore, should be applied to neuro-advancements. Our findings suggest that the academic and newspaper coverage around nursing expertise does not extend past the knowledge of using neuro-advancements within clinical services and does not place nurses as a body within the ethical and social implications of neuro-governance and authority of these neuro-advancements. Although the American Nurses Association (ANA) and the American Association of Colleges of Nursing (ANCC) indicate the value of recommending and influencing "social and health care policies" [18] and that the Canadian Nurses Association sees it as important to be "politically astute, by understanding and appropriately intervening in political processes" [17], for all nurses, our findings suggest a gap in the academic and newspaper role narrative of nurses. This gap hinders nurses from adhering to such responsibilities and limits their potential to influence the discussions surrounding neuro-advancements and the dissemination of knowledge of neuro-advancements.

The Canadian Nurses Association pushes for interdisciplinary and collaborative work [11,223,224] and the Framework for the Practice of Registered Nurses in Canada of the Canadian Nurses Association states that

> *"RNs lead health-care teams, conduct formal research activities, manage nursing services, develop and deliver nursing education, and contribute to the advancement of healthy public policy. They have the skill, expertise and capacity to lead, whether in enhancing client-centred care across the care continuum, directing interprofessional teams or implementing new policy. Nursing leadership is*

about critical thinking, action and advocacy—and RNs demonstrate these attributes in all roles and domains of nursing practice". [224], *p. 21*

Our findings do not suggest that neuroethics or neuro-governance is part of the interdisciplinary skill and collaborative work scope or that it is a focus of role and skills in relation to policy development, critical thinking, action and advocacy expected for nursing leadership.

Within the academic literature, much of the nurses' interactions with neuro-advancements is within the scope of their clinical practice through treatment administration [122] and proper background knowledge and expertise [107–109,114,122,167]. Furthermore, nurses retain the role of users in relation to neuro-advancements, for example, using virtual reality for educational purposes [100,102,112,163, 174–182].

Roles that would indicate that nurses should and can take part in governance and ethics discourses were absent, indicating a problematic finding.

Clause 8, "*Coping effectively with change by proactively envisioning and adapting to a constantly variant healthcare system characterized by rapid change and chaos*" and clause 2, "*A working knowledge of technology to facilitate the mobility and portability of relationships, interactions, and operational processes*'", of the nursing competencies that Huston indicated, outlined that the advancements of technological, societal and occupational aspects are inevitable and thus, nurses must adapt and develop their skills accordingly to match such a rapid ascent [71]. As such, one would have expected a substantial amount of literature, for example, around lifelong learning and how to use it, to be up to date in a continuous fashion on neuroethics and neuro-governance issues.

According to the Canadian Nurses Association, "*it is essential that RNs play an active role in the selection, design, deployment, and evaluation of information and communication technology (ICT) solutions while, at the same time, be given opportunities to acquire ICT competencies to use in their practice*" [224]. Likewise, this same sentiment should be applied beyond information and communication technologies, and into other realms of innovation and technology, such as neuro-advancements. Understanding the implications that neuro-advancements and developing technology pose not only on their professional occupation, but also daily life is important, thus, the push towards nursing engagement in governance decisions and neuro-advancement leadership.

Our findings related to the role narrative are not only problematic given the role expectation of nurses as evident by their own profession, but also in relation to other discourses.

4.2. Ethics: Governance and Public Engagement

Within both the downloaded academic abstracts and the newspaper articles, the neuroethics and ethical coverage of various neuro-advancements is limited in relation to nursing. In addition, the encouragement of nurses to take part in neuroethics and neuro-governance discussions and how to obtain the knowledge needed for such a role was not present at all in the literature. These results also seem to be in sync with other health professionals [225], raising concerns with regards to the willingness and availability of allied health professionals and their voice in the neuro-advancement field.

As indicated earlier, "*Health care trainees rely partly on their training to manage, reason and reflect on the ethical uncertainties of innovations and new technologies*" [149], p. 23. In addition, The Canadian Nurses Association acknowledges the importance of ethical awareness as "*advocating for the discussion of ethical issues among health-care team members, persons receiving care and students, encouraging ethical reflection and working to develop their own and others' awareness of ethics in practice*" [226] and the American Nurses Association (ANA) and the American Association of Colleges of Nursing (AACN) recommend that nurses influence social and healthcare policies and apply "legal and ethical standards to complex situations" [18].

As such, there should be more coverage in relation to training nurses in ethical awareness and their involvement in governance discourses.

Health care professionals/practitioners are seen as stakeholders of neuro-advancements [11]. However, our findings show a lack of engagement with the literature covered with the involvement of

nurses in the governance of neuro-advancements, despite the ongoing debate within neuroethics and neuro-governance that stakeholders should contribute [11,47,56,227–232].

There must be a communication between all as the governance is one task to be shared by all stakeholders [67]. As was argued by Illes et al., "*Indeed, the movement for public understanding is a two-way street where scientists come to understand the public, and science is communicated both in its social context and in socially just ways. This ensures that the requirements for public understanding of both the research process and the process of generating knowledge and scientific evidence are met*" [227], p. 8.

Citizen participation is seen to enable citizens to influence policies, programs, and social reforms [233]. However, in order for participation to be influential it must go hand in hand with distribution of power for all groups to benefit [233]. Nurses are also citizens and allowing nurses to take on a broader role within neuro-advancement governance will not only allow for enhanced skill capacity within their roles as professionals but allow for insightful input and opinion from nurses regarding neuro-advancement innovation as professionals and as citizens. Their current positions within their occupation as advocates, researchers, educators, patients support and medical professionals, to name a few, engulf nurses in a variety of interactions and environments, allowing them to understand and see the impact of neuro-advancements from multiple standpoints [17,70,224]. Whether it may be receiving input from patients, teaching students and other health professionals about various neuro-advancements or using these neuro-advancements in their practice, nurses have the potential to act as a useful bridge between the neurofield and the public and other non-clinical settings. Increasing the involvement within the neuroethics and neuro-governance will not only help nurses within their occupation but benefit the neuroethics and neuro-governance discourses and neuro-advancements discourses in general in return, thus enhancing the public and professional collaboration in neuro-advancement governance.

4.3. The Role of the Nurse and Disabled People

Within our findings, the interactions between the nursing field and disabled people were primarily linked to the nurse's occupational obligations, such as appropriate patient care. We did not find further considerations outside of the appropriate occupational interactions with disabled people in our literature. Our findings might not be surprising given that Scullion [234] indicated that disability as a pertinent issue is often neglected in nursing practice, although many nurses hold an obligation to uphold equity and equality in their practice. Although our findings are problematic, they also present an opportunity.

As argued earlier, nurses have the potential to actively take part in and to contribute valuable insight to the discussions and implementation of neuro-advancement governance. In addition, as health care professionals, nurses stand as the mediators between the interactions between disabled people and diverse types of neuro-advancements.

Many studies have analyzed the need for appropriate knowledge of disabled people and different models of disability to be implemented into the nursing practice [234–237]. Thus, with such background knowledge, it is reasonable to enable nurses to advocate for disabled clients and empower disabled clients to advocate for themselves. However, due to their role being so ingrained within the medical field, the conceptions of nurses around disability and the choice of what areas to advocate and empower their clients for can shift between social and medical model influences, which causes a discrepancy in the field. Thus, this poses the question: what perspective should nurses take to appropriately and effectively promote and enable advocacy for, with, and by disabled clients?

In a study conducted by Llewellyn and Northway [238], barriers for nurses towards advocacy were identified and it was found that although all nursing participants were willing to advocate for their clients, the relevance of the advocacy to their field of practice hindered this complete fulfillment [238]. In turn, it was also indicated that

"*All nurses recognised barriers to advocacy, but ability to access independent advocacy services was inconsistent, as was participants' attitude towards and willingness to use these. Nurses' received*

education in advocacy varied, but they expressed a need for ongoing support and training in advocacy related to their own work area and had specific requirements regarding how and by whom this should be provided". [238]

We submit that working on the social implications of neuro-advancements and to influence neuroethics and neuro-governance discourses is an opportunity for nurses to fulfill the role expectations already mentioned [17,18]. It also an opportunity for nurses to focus on how to engage with the topic of advocacy for, with and by disabled clients, allowing the focus to move beyond the purely medical to include societal, ethical and other aspects. There are concerns and expectations raised related to assistive technologies [80,83] that include neuro-assistive technologies, such as cochlear implants [239–243] and brain computer interfaces [81,244,245], in relation to disabled people and their involvement in the governance and ethics discussions around neuro-advancements is an opportunity to unpack certain issues, such as the identity of disabled people, the perception of disabled people (patient versus consumer) and the consequences of such identity and perception for disabled people. Neuro-assistive devices would be a good case study for revealing certain inconsistencies in the "policy-practice divide" where there is a need for appropriate advocacy and interaction with their clients, however, unfortunately, it is not always necessarily the case. Dealing with the complexities of neuro-assistive technology within ethics and governance discourses is empowering for both groups. It increases the ability of nurses to advocate for and together with disabled people as well as help to enable people with disabilities to take charge and advocate for themselves. Indeed, being part of the governance and ethics discourses will strengthen the advocacy role of nurses.

4.4. Lifelong Learning: Neuro-Advancements

"Not only must individuals acquire initial training as advanced as possible in order to enhance their performance and increase their chances of entering the labour market, but once they have entered the market, they must embark upon a process of lifelong learning to preserve their position in a fiercely competitive environment. The development of the "learning society" further increases the need for individual learning". [74]

Indeed, consistent learning and knowledge provide enhanced skills and abilities that allow employees to retain a competitive edge, however, within healthcare, the necessity for constant learning is the key between life and death [76,174,178]. Nurses are upon the receiving end of neuro-advancements, as seen with virtual reality [100,102,112,163,174–182], as well they are also considered to be the health professionals that should teach, support and administer these various neuro-advancements and innovations to patients [98–104]. Without proper exposure or knowledge, they place themselves and their patients at risk [98,103,107,110–113]. *"An RN's comprehensive knowledge base, commitment to lifelong learning and their understanding of clients and the health system, enable them to assume many different roles"* [224]. Thus, obtaining the necessary skills and awareness to practice, teach and voice their opinions and concerns is critical within healthcare.

The involvement of developing neuro-governance and neuroethical considerations is critical in guiding informed decision-making and critical thinking within their roles as healthcare professionals *"Health care trainees rely partly on their training to manage, reason and reflect on the ethical uncertainties of innovations and new technologies"* [149], p. 23. Understanding that much of the critical thinking skills, and ethical thought is fostered through educational initiatives indicates the imperative to involve these skills and thoughts into the nursing curriculum. It is suggested that due to the increased potential for the societal impact of neuro-advancements, neuroscience students should be educated in a formal way in neuroethics and public engagement [231]. This same education should be applied to nursing students and professional nurses. In turn, a proper neuro-governance and neuroethics educational background would foster fruitful discussions between nurses and, in turn, neuroscience students about their role within the neuro discourse and the ethical implications they see and face. It might be worthwhile to explore what teaching material is in this sense.

5. Conclusions and Future Research

To summarize, our findings indicate that the role narrative of nurses in relation to neuro-advancements were mostly focused on clinical practice, that the role of influencer of neuroethics and neuro-governance discourses was missing, and that lifelong learning did not engage with how to increase the knowledge of nurses on neuroethics and neuro-governance issues to allow them to take part in neuro-related discussions. These findings are problematic for several reasons but also offer opportunities for further research and actions.

It is understood that the societal discussions on science and technology advancements should be a constant endeavor [32,33]. However, our findings highlight the need to better understand why nurses were not engaged within their role of influencers of neuroethics and neuro-governance discourse. It is important to harness this potential and use it properly.

It is also warranted to understand why the impact of neuro-advancements on the relationship between nurses and disabled people was not explored. As much of the nursing clientele are individuals with disabilities, the choices that nurses have in promoting and conducting the use of neuro-advancements and types of neuro-linked assistive technologies for their clients, such as disabled people, affect disabled people and the socio-technical context of the neuro-assistive technology discussions. Thus, fostering effective communication between the opinions of the disability community and the nursing field on such technology could help to promote efficacious yet conscious interventions and provide a needed perspective for the neuro-governance and neuroethics discourses. Nurses are faced with the responsibility of teaching within the workplace to other healthcare associates as well as the public [17,71,114,118,121,224]. Our findings suggest that allowing for their involvement and leadership in neuro-governance and neuroethics engagement can allow for increased professional, client and public awareness of the ethical, legal, and social impacts that neuro-advancements can have upon the public and society. Being part of neuroethics and neuro-governance discussions can be a bridge that brings together nurses and disabled people within a discourse that is of importance to both allowing for an increase in abilities of nurses to engage with disabled people as clients and consumers and to engage and advocate for and with disabled people from a broader knowledge platform then a purely medical one. Our study provides useful data for the nursing, disability, assistive technology, neuroethics and neuro-governance, lifelong learning and policy-related academic literature. It might also be useful for magazines used to inform practitioners and used for advocacy purposes.

It may be fruitful to analyze current nursing professional development and lifelong learning programs to understand what the teaching material is and how it is taught. As for nurses, our study indicates an opportunity to reflect with nurses on our findings related to the role narrative we found and their views on lifelong learning as an instrument to increase the knowledge of nurses on neuroethics and neuro-governance. The further advancement of neuro-assistive devices could be used as a vehicle to better understand the issue of the advocacy of nurses in relation to disabled people and beyond. A recent study outlined future scenarios and trajectories for assisted devices, including neuro-assistive devices [80,82], that could be used to guide that process and to have a discourse between nurses and disabled people in relation to neuro-governance. Our findings suggest that the ethics and governance literature was not pushing for nurses to be part of their discourses, thus indicating another opportunity to better understand neuroethics and neuro-governance realities.

Furthermore, it may be fruitful to consider adapting lifelong learning programs to engage not only with the use and technical background of various neuro-advancements, but also with the ethical, legal, and social implications that these neuro-advancements pose.

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