Trends in Neonatal Dysphagia Research: Insights From a Text Mining Approach

Les tendances de recherche au sujet de la dysphagie chez le nouveau-né : un aperçu résultant d'une exploration de texte

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Abstract

Meta-research is an emerging field that can provide valuable insights into research trends. This preliminary meta-research study aimed to trace and describe the research patterns in the area of neonatal dysphagia from 1970 to present using the technique of text mining. It also aimed to compare the amount of published research in the last 5 decades, identify journals that published the most research papers on neonatal dysphagia, and provide insights into the most common research topics. We utilized a combination of text mining and bibliometric–scientometrics techniques. The titles and abstracts of various scientific articles were analyzed for word frequency and relationship between them using hierarchical cluster analysis and co-occurrence network techniques. A total of 1819 research articles were published across various journals under the Scopus database. Research themes centred around feeding problems in neonates, clinical evaluation, and management, and a few studies focused on treatment outcomes. Findings of this study emphasize the need for unification of terminologies, wider adaptation of the International Classification of Functioning, Disability, and Health framework (World Health Organization, 2001), interprofessional education, and more evidence to support the practice of neonatal dysphagia.

Abrégé

La métarecherche est un domaine de recherche en émergence et pouvant fournir de précieux renseignements sur les tendances de recherche. La présente métarecherche préliminaire avait pour objectif de retracer et de décrire les tendances de recherche au sujet de la dysphagie chez le nouveau-né (depuis 1970), en utilisant une technique intitulée « exploration de texte » (*text mining*). Cette métarecherche avait également pour objectif d'examiner la quantité d'études ayant été publiées dans les cinq dernières décennies, d'identifier les revues qui ont publié le plus d'articles de recherche au sujet de la dysphagie chez le nouveau-né et de fournir un aperçu des sujets de recherche les plus fréquents. Une combinaison de techniques d'exploration de texte et de bibliométrie-scientométrie a été utilisée. La fréquence des mots, ainsi les relations entre ceux-ci, des titres et résumés d'une variété d'articles scientifiques ont été analysées à l'aide de techniques de classifications hiérarchiques et de réseaux de cooccurrence de termes. Un total de 1819 articles de recherche ont été publiés dans les diverses revues indexées dans la base de données Scopus. Les thèmes de recherche de ceux-ci étaient axés sur les problèmes d'alimentation des nouveau-nés, ainsi que sur l'évaluation clinique et la prise en charge de la dysphagie. Le thème de recherche de quelques études portait également sur les effets des interventions. Les résultats de la présente étude soulignent la nécessité d'unifier les terminologies utilisées, d'adopter de façon plus généralisée le cadre proposé dans la *Classification internationale du fonctionnement, du handicap et de la santé* (World Health Organization, 2001), d'offrir des activités de formation interprofessionnelle et de disposer de davantage de données probantes pour soutenir la pratique auprès de nouveau-nés dysphagiques.

The prevalence of dysphagia is estimated to range from 25% to 45% in children who are typically developing (Bryant-Waugh, Markham, Kreipe, & Walsh, 2010), 33% to 80% in children with developmental disorders (Burklow, McGrath, Valerius, & Rudolph, 2002; Field, Garland, & Williams, 2003; Linscheid, 2006; Schwarz, Corredor, Fisher-Medina, Cohen, & Rabinowitz, 2001), and about 27% among preterm infants (Zimmerman & Rosner, 2018). This rise in the prevalence of dysphagia may be because of considerable technological advances in perinatal care during the last 5 decades. These advancements have resulted in an increased survival rate among neonates with histories of low birth weight, prematurity, and a wide array of medical conditions (Hamilton et al., 2007; Martin et al., 2003; Newman, Keckley, Petersen, & Hamner, 2001; Rommel, De Meyer, Feenstra, & Veereman-Wauters, 2003). Medical and surgical advances have shifted the lower limits of viability to shorter gestational periods. This shift in viability has been associated with accelerated neonatal morbidity rates and prolonged need for mechanical ventilator support, thereby increasing the overall duration of hospitalization (Lefton-Greif & Arvedson, 2016). The most critical factor that prolongs hospitalization in neonates is dysphagia (Bakewell-Sachs, Medoff-Cooper, Escobar, Silber, & Lorch, 2009).

Speech-language pathologists (S-LPs) have played a central role in the assessment and management of infants and children with feeding and swallowing disorders for more than 5 decades (Lefton-Greif & Arvedson, 2016). For S-LPs involved in feeding and swallowing rehabilitation, this change in focus from infants and children to neonates poses a new challenge. Lefton-Greif and Arvedson (2016) have highlighted that S-LPs are underprepared to handle the high-risk practice in the area of neonatal dysphagia as there are no opportunities for formal education or uniform protocols. National governing bodies, such as the American Speech-Language-Hearing Association, have taken several steps towards addressing the issue of lack of trained workforce. The American Speech-Language-Hearing Association's (2007) technical report, "Graduate Curriculum on Swallowing and Swallowing Disorders," highlighted the need for education and training of students with knowledge and skills to evaluate and treat dysphagia across a variety of populations and settings. Even with these necessary steps, most S-LPs who did not complete a course on pediatric dysphagia reported feeling unprepared to handle this population (Zimmerman, 2016). These reports further highlight the need for formal training, focused research, and dissemination in this area.

Lefton-Greif and Arvedson (2016) have highlighted the population demographics, advances in evaluation and

management over the past decade, and future directives that might influence the practice of pediatric dysphagia. Although the gaps Lefton-Greif and Arvedson identified are appropriate, infants and neonates present with unique considerations. The present study was carried out to trace the evolution of research in neonatal dysphagia.

We believe that there exists much-hidden information in the scientific literature that cannot be studied from a purely statistical viewpoint. The technique of data mining attempts to bridge this gap by uncovering and analyzing information inaccessible to statistical treatment, especially when the magnitude of data is vast (Gaber, 2012; Gonzalez, Tahsin, Goodale, Greene, & Greene, 2015). Witten, Frank, Hall, and Pal (2017) defined the term *data mining* to be a computational process of extracting new information from existing large amounts of data. Data mining is often used as an umbrella term to refer to classification algorithms (e.g., decision trees and other classifiers), frequent pattern algorithms (e.g., association rule mining, sequential patterns mining and others), clustering algorithms, graphs, and networks (Che, Safran, & Peng, 2013; Herland, Khoshgoftaar, & Wald, 2014). Data mining also includes text mining, image mining, web mining, predictive analytics, and big data techniques (Piatetsky-Shapiro, 2012).

Text mining is a subfield of data mining that aims to extract valuable new information from existing sources of data (Feldman & Sanger, 2007). Text mining, as an interdisciplinary approach, analyzes data in natural language text through the use of specific algorithms (Cohen & Hunter, 2008; Nie & Sun, 2017). Thus, when a set of documents are given the text mining technique extrapolates unique patterns, relationships, and trends contained within the documents.

Existing databases, such as Scopus, PUBMED, and Web of Science, consist of scientific literature that is massive but also fragmented and often nontransparent. These databases consist of several important works of research and equally irrelevant attempts at replication and reduplication. An understanding of patterns among existing research is necessary to avoid wasted effort, optimize resources, and provide the right directions to prioritize research. A relatively new discipline called meta-research aims to provide a bird's eye view of current research by studying research itself. It is interdisciplinary and can benefit from better tools and methods in statistics and informatics. The present meta-research study is a combination of text mining and bibliometric techniques that will allow us to investigate the journal-wise distribution of neonatal dysphagia research over the last 5 decades to trace the evolution of research trends during this period. We believed

that these efforts would shed light on the identification of major academic branches and trends in the area of neonatal dysphagia.

Method

The present study can be described as an attempt towards "research on research" in the area of neonatal dysphagia. It utilized techniques of text mining in the background of scientometric and bibliometric analyses. Given the limited space and scope of the article, the techniques of text mining are not discussed here in detail and could be found elsewhere (see Herland et al., 2014; Krishnamurthy & Balasubramanium, 2019).

Source Selection and Search Strategy

The authors searched the Scopus database using the keywords *neonatal, dysphagia, swallowing problems, swallowing difficulties, feeding problems, feeding difficulties,* and *feeding issues.* The Boolean operations of AND, OR, and AND NOT were used in combination with the keywords mentioned. Further, search filter settings (see Appendix) were limited to subject areas of medicine, nursing, and health professions. Other disciplines, including engineering, chemistry, and social sciences were intentionally removed to maintain the relevance of the search. A complete list of omitted disciplines is mentioned in the Appendix. The document type was restricted to articles, reviews, and articles in press. Source type was limited to journals, and only those articles in the English language were considered.

The present study aimed to investigate changes in the research trends over the past 5 decades. An initial pilot study was carried out to determine the appropriate period to analyze the trends. When a time frame of 10 years was considered, and search queries were made, the results of this pilot study revealed very few articles. Hence, a minimum time frame of 3 decades was fixed to provide better insights and to get a broader perspective of research trends. Based on this, the time frames between 1970 to the present were divided into two. The first time period was considered to be between 1970 and 2000, whereas the second time period was considered to be between 2001 and 2018.

Information Extraction

Search results from the Scopus database were handled in two ways. First, the information on indexation data was imported into an excel sheet (.CSV format) and the text was transformed into columns. Only information pertaining to the title, journal, year of publication, and abstract was retained. Second, data with respect to title and abstract from the last 5 decades (1970 to 2018) were imported into a text (.txt) file.

Handling of Data

The first aim of the study was to investigate the journal-wise distribution of research over the last 5 decades. Frequency tables were generated for journal data and published research in the area of neonatal dysphagia using SPSS, version 23.

The second aim of the study was to investigate the evolution of research trends in neonatal dysphagia. For this purpose, the text mining approach was utilized to identify and compare the predominant research themes in the last 5 decades. Data mining was carried out using K H Coder version 3, which is an open source software for computer-assisted qualitative data analysis, mainly quantitative content analysis and text mining. Based on the search operations described in the earlier section, the title and abstract data retrieved from the Scopus database as text (.txt) files were fed into K H Coder for further analyses, which are described below.

A co-occurrence network for words was generated for the title and abstract data. This method of analysis provides a graphical representation of the association between the words through connected lines. Closely associated themes are colour-coded with the size of each node representing the frequency of occurrence. Sentences were considered to be the unit of analyses, and the filter edge was set to 30 words. We also used hierarchical cluster analysis. This method of text analysis examines word combinations with similar appearance and groups them into patterns, which are represented in the form of a dendrogram. Both these methods allow for the transformation of text data into a visual representation based on the nature of words.

Results

Results are presented under the following headings to provide better insights into the publication and research trends across the first and the second time periods.

Amount of Published Research

From 1970 to 2018, 1819 research articles were published across various journals in the Scopus database.

For the first period (1970 to 2000), 395 published research articles were found in the Scopus database under the search term *neonatal dysphagia* and accounted for 21.7% of the total publications. A graphical representation of publication distribution over the first time period is depicted in **Figure 1**. For the second period (2001 to 2018),

1424 published research articles were found in the Scopus database and accounted for 78.3% of the total publications. A graphical representation of publication distribution over the second time period is depicted in **Figure 1**.

Journals That Published the Most Papers

From 1970 to 2000, more than 30 journals published research studies on neonatal dysphagia. A ranking based on number of research articles published was created, and the top five research journals publishing on neonatal dysphagia are presented in **Table 1**.

From 2001 to 2018, more than 50 journals published research articles on neonatal dysphagia. A ranking based on number of research articles published was created, and the top five research journals publishing on neonatal dysphagia are presented in **Table 2**.
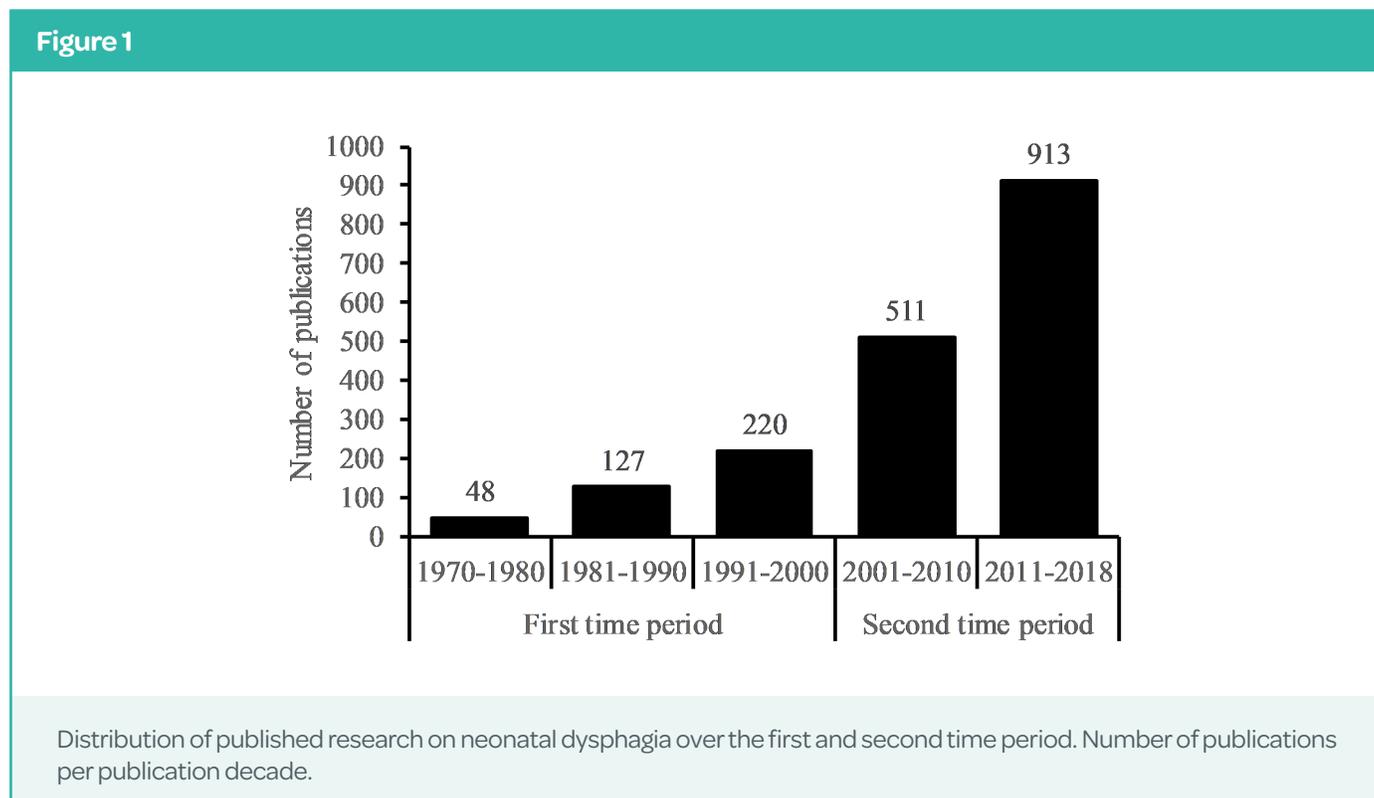
Figure 1

Distribution of published research on neonatal dysphagia over the first and second time period. Number of publications per publication decade.

Table 1

Top Five Journals Publishing Research Articles on Neonatal Dysphagia During the First Time Period (1970–2000)

Rank	Journal	Number of publications	%
1.	Pediatrics	16	4.7
2.	American Journal of Medical Genetics	12	3.5
3.	Journal of Pediatric Surgery	11	3.2
4.	American Journal of Diseases of Children	8	2.3
5.	Journal of Obstetric, Gynecologic & Neonatal Nursing	7	2.1

Note. A total of 395 articles were published during the first time period.

Table 2

Top Five Journals Publishing Research Articles on Neonatal Dysphagia During the Second Time Period (2001–2018)

Rank	Journal	Number of publications	%
1.	Journal of Perinatology	29	2.8
2.	Advances in Neonatal Care	23	2.2
3.	American Journal of Medical Genetics Part A	23	2.2
4.	International Journal of Pediatric Otorhinolaryngology	20	1.9
5.	Pediatrics	20	1.9

Note. A total of 1424 articles were published during the second time period.

To know the specific contribution of the speech and hearing field to the study of neonatal dysphagia, we limited the search results to the *health professions* category, as speech and hearing is a subcategory within health professions in the Scopus database. A Scopus search within the subcategory of health professions for the terms mentioned earlier revealed just 24 research articles from 1984 to 2018. A ranked list of the top five journals publishing on neonatal dysphagia within the health professions category is presented in **Table 3**.

Most Frequently Researched Themes

To identify the most frequently researched themes, hierarchical cluster analysis and co-occurrence network analysis were used. These techniques examine the word combinations in the abstract and group them into patterns based on their association with each other while providing a graphical representation through connected lines. The hierarchical cluster analysis is a dendogram, whereas a co-occurrence network is a concentric representation of word association.

The hierarchical cluster analyses generated for the research data from 1970 until 2018 revealed six different groups, and the bars on the left-hand side of the dendrogram represent the term frequency of each word (see **Figure 2**). When these six groups were visually inspected, the highest frequency was observed for the term *infant*; hence this was considered to be the first group along with the associated words that are grouped under the same colour code. The term infant was frequently associated

Table 3

Top Five Journals Under the Health Profession Category That Published Research Articles on Neonatal Dysphagia During 1984 to 2018
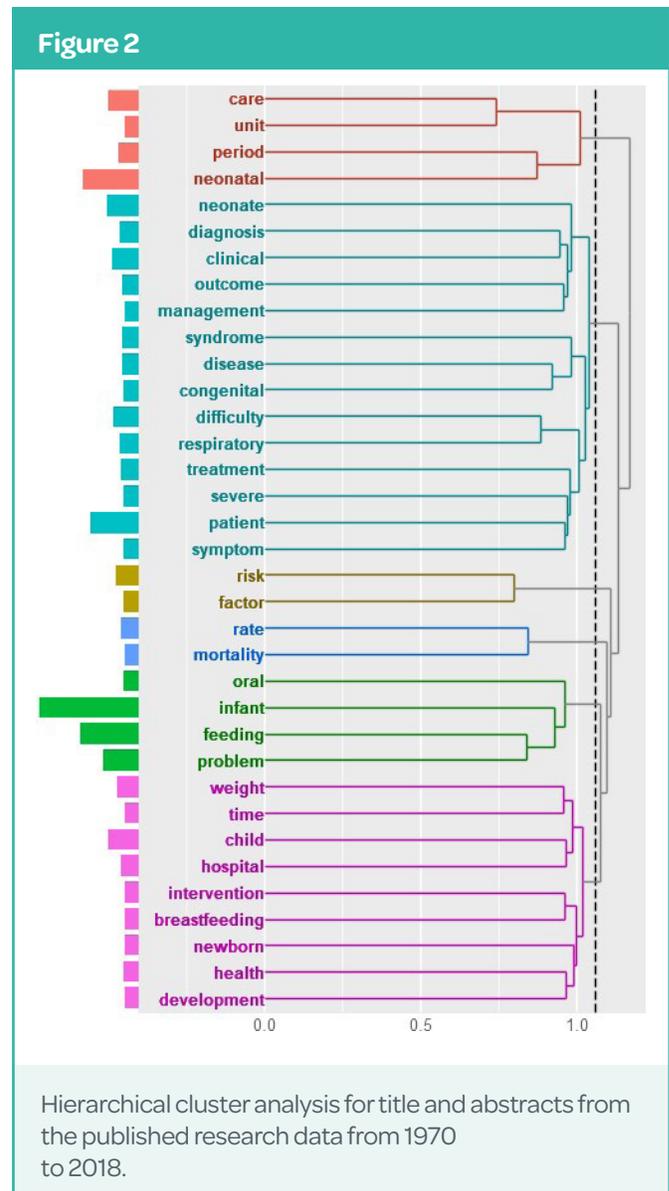
Rank	Journal	Number of publications	%
1.	Dysphagia	9	37.5
2.	Seminars in Speech and Language	5	20.8
3.	International Journal of Speech-Language Pathology	2	8.3
4.	Physical & Occupational Therapy in Pediatrics	2	8.3
5.	Acta Radiologica	1	4.2

Note. A total of 24 articles were published under the health professions category between 1984 and 2018.

with *feeding* and *problems*. Moreover, these two words are in close association with the term infant. Thus, feeding problems in infants was the first theme.

The second group was identified by the next highest frequency of word occurrence. It was found that the term *neonatal* was the second frequently occurring word and was in close association with the terms *period, unit,* and *care*. Therefore, dysphagia among neonates in the neonatal intensive care unit was considered the second theme. The third cluster showed the most frequent word *patient*, which is in close proximity with terms like *treatment, management, diagnosis, clinical,* and *outcomes*. Hence, the third major theme was identified to be evaluation and management outcomes in neonatal dysphagia. The fourth cluster was comprised of *child* and *weight*, which are in close association with the terms *intervention* and *development*. This association of word combinations gives an impression that intervention among low birth weight neonates may be the fourth theme. The terms *risk, factor, mortality,* and *rate* constituted the fifth and the sixth cluster. Therefore, the fifth and sixth themes together can be considered risk factors associated with neonate mortality.

Our co-occurrence network (**Figure 3**) showed 35 of the most frequent words in published research data from 1970 until 2018. These words were grouped into colour-coded clusters with the connecting line representing the association among them. The first cluster (represented in light green) was identified as the most prominent node, representing the highest frequency words *infant* and *feeding*. Other terms including *problems, difficulty, neonate,* and *oral* revealed a strong association with the main terms *neonate/infant feeding problems*. The yellow community was considered the second node as it had a dual connection to the first community. The terms *diagnosis, management, clinical,* and *outcome* were very close to each other. The purple community was identified as the third node and included the terms *mortality*, *rate*, and *breastfeeding*, and was in single direct connection with the term *neonate*. This combination of words gave the impression that the central theme of this cluster may be feeding and swallowing factors associated with a high rate of mortality among neonates. The red community was considered the fourth node with terms like *unit, care,* and *health* indicating that the common theme may be dysphagia among neonates in intensive care units. The fifth community (blue) showed common appearing terms to be *disease* and *congenital*, which were connected to terms *respiration* and *feeding* through the term *severe*. This combination of words gave us the impression that the dominant theme of this community could be feeding


Figure 2

Hierarchical cluster analysis for title and abstracts from the published research data from 1970 to 2018.

and respiratory problems among neonates with severe congenital anomalies.

Discussion

An inspection of the number of publications in the area of neonatal dysphagia revealed a definite increasing trend from 1970 to 2018. This shows the increased attention that the area of neonatal dysphagia has received over the last 5 decades. Even though the present study did not aim to compare the research outputs of adult and pediatric dysphagia, an earlier study by Krishnamurthy and Balasubramanium (2019) reported a higher number of research articles in the area of adult dysphagia. While there is increased attention in the area of neonatal dysphagia, the amount of articles is significantly lower than the adult dysphagia population.

Figure 3
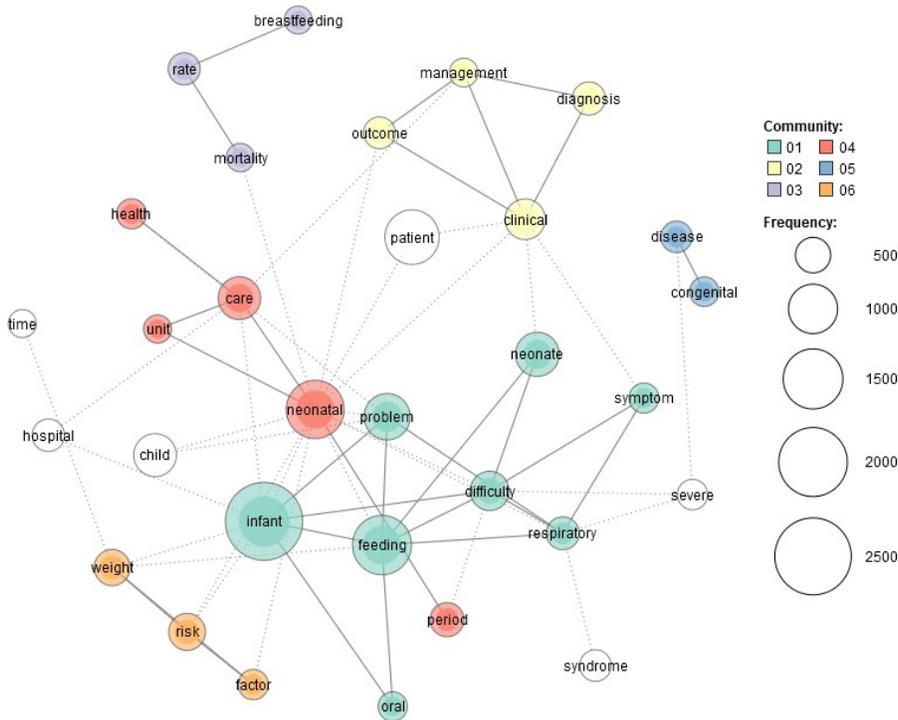
Co-occurrence network analysis for title and abstracts from the published research data from 1970 to 2018.

During the first time period examined in this study (i.e., 1970 to 2000), the journal *Pediatrics* published the most research articles, which accounted for 4.69% of total publications. For the second time period (i.e., 2001 to 2018), *Journal of Perinatology* published the most research articles, accounting for 2.78%. It can be observed from **Table 1** that most of the journals that published articles about neonatal dysphagia had a medical background, especially pediatric medicine and surgery. For the second time period, even though journals from pediatric medicine and surgery remained prominent, we observed other specialties, such as neonatology, nursing, and otorhinolaryngology, contributing a significant share. This trend can be interpreted as a paradigm shift in medical care from the first to the second time period. During the first period, pediatric medicine and surgery was the predominant profession to be involved in neonatal dysphagia; whereas for the second time period, a wide variety of professionals ranging from nurses to S-LPs to gastroenterologists could be seen involved in neonatal dysphagia research. Also, it is possible that the nature of the approach used towards patient care has evolved to be multi-disciplinary with various professionals serving patients' needs.

Hierarchical cluster analysis and co-occurrence network analysis examine word combinations with similar appearance and group them into patterns while providing a graphical representation of the association among the words through connected lines. The results of the present study revealed five important research themes in the area of neonatal dysphagia since 1970. These themes centred around feeding problems in neonates, clinical evaluation, and management, and a few studies focused on treatment outcomes. We believe this limited output may be due to two reasons that are described in-depth below.

First, there are naming differences within the S-LP field and terminologies used during dissemination. Often, *feeding* is used rather than *pediatric dysphagia* to indicate the array of swallowing difficulties exhibited by infants and children. Even though we have included the terms like *feeding*, the results from the present study signify a strong need for unification of terminologies to enhance dissemination. Despite the apparent increase in the number of research articles, due to the lack of unified terminology there exists fragmentation of research output for the scientific literature on neonatal/pediatric dysphagia. These factors may be responsible for clinicians

and researchers not looking in correct journals for these articles, and therefore, not obtaining this critical scientific literature. A possible solution to this issue could be the uniform implementation of the International Classification of Functioning, Disability, and Health (ICF) framework, developed by the World Health Organization (2001). Lefton-Greif and Arvedson (2007) suggested that the ICF framework may provide a common context for establishing a standardized language for describing and studying health and health-related domains. In relation to the trends revealed in the present study, there is a need for better sensitization and broader adoption of the ICF framework by clinicians and researchers. Uniform implementation of the ICF framework may help in developing and evaluating outcomes for interventions, predict health care delivery needs, and influence policies and allocation of essential resources towards the area of neonatal dysphagia.

Second, as shown in **Table 3**, there were only 24 research articles under the *speech and hearing* subcategory of the Scopus database. This low number may be because most S-LPs involved in neonatal intensive care units are predominantly practicing clinicians—not researchers—and time constraints hinder these S-LPs from playing an active role of clinician–researchers. In addition, it might be the case that speech and hearing journals are not prioritizing pediatric dysphagia articles resulting in fewer accepted manuscripts within this subcategory.

The cluster analysis and co-occurrence network consist of terms like *respiratory, congenital, syndrome, preterm, low birth weight,* and all these terms are in close association with the term *feeding*. This combination of terms suggests that existing studies have focused on feeding/swallowing problems commonly occurring in settings of medical, health, and developmental conditions. However, terms like *randomized control trials*, which indicate high-quality research studies, did not appear among our co-occurrence network analysis or hierarchical cluster analysis. This finding suggests that there may be fewer or no randomized control trial studies in the area of neonatal dysphagia. Evidence-based practices in pediatric/neonatal dysphagia have not kept pace with the recognition of these problems. High-quality investigations are needed to identify the best clinical practices for optimal outcomes in this population.

The findings of the present study also revealed that several disciplines, such as nursing, neonatology, pediatrics, and speech language pathology, are emerging to be involved in the practice of neonatal dysphagia; this calls for an emphasis on interprofessional education among practicing S-LPs. Introducing interprofessional education as part of the graduate curriculum would prepare future S-LPs to function

as full members of interprofessional collaborative practice and demonstrate the added value contributed by S-LPs. Current practices in the evaluation and management of pediatric/neonatal dysphagia may immensely benefit from the interprofessional collaborative practice.

Limitations and Future Directions

The present study is a preliminary report that summarizes the research in pediatric dysphagia from 1970 to 2018. The authors limited their search only to the Scopus database; further studies could include databases such as PubMed and Web of Science. Even though the present authors have rigorously and carefully examined the articles before their inclusion in the study, a selection bias may persist. The discipline of dentistry was omitted and can be considered a drawback. Some of the reported topics can appear out of its original context and may induce interpretation errors. Further research should consider stringent selection criteria using the same methodology. A similar methodology could be used to investigate the funding trends for pediatric/neonatal dysphagia using the National Institutes of Health reporter. It would be interesting to investigate if these trends carry over for research funding support.

Conclusions

The present study summarizes the research that has been carried out from 1970 to 2018 in the area of neonatal dysphagia using the text-mining technique. Findings emphasize the need for unification of terminologies, wider adaptation of the ICF framework, and interprofessional education. There is a pressing need for evidence-based practice in the area of neonatal dysphagia. It is essential that we become proactive in both clinical practice and research domains as we lay a foundation for S-LPs' involvement with neonates and infants who have a wide range of feeding and swallowing difficulties.

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Authors' Note

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Disclosures

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