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Attributing Fuzzy Values to Nursing Diagnoses and Their Elements: The Specialists' Opinion

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PURPOSE: To test the viability of to use specialists' opinions to establish degrees of membership between nursing diagnoses and its elements (defining characteristics or risk factors), based on the concepts of fuzzy sets theory. This strategy may feasibly mapping the specialist's knowledge on the diagnostic task.
METHODS: Specialists were invited to reflect on the relationship between diagnoses and elements using linguistic variables, with a numerical representation.
FINDINGS: We generated four matrices of 28 diagnoses and 62 elements. Out of 905 possibilities, we identified 286 relationships, represented in graphs.
CONCLUSIONS: The strategy was able to identify degrees of membership between nursing diagnoses and elements.
IMPLICATIONS: It seems that this method, if expanded, would contribute to refining and mapping the NANDA-I terminology.
OBJETIVO: Testar a viabilidade de utilizar a opinião de especialistas para estabelecer graus de pertinência entre diagnósticos de enfermagem e seus elementos (características definidoras ou fatores de risco), baseado nos conceitos da Teoria dos Conjuntos Fuzzy. Esta estratégia poderá viabilizar o mapeamento do conhecimento do especialista na tarefa diagnóstica.
MÉTODOS: Especialistas foram convidados a refletir na relação existente entre diagnósticos e elementos, utilizando variáveis linguísticas, com representação numérica.
RESULTADOS: Foram geradas quatro matrizes de 28 diagnósticos e 62 elementos. Dentre 905 possibilidades, foram identificadas 286 relações, representadas em grafos.
CONCLUSÕES: A estratégia foi adequada para identificar graus de pertinência entre diagnósticos de enfermagem e elementos.
IMPLICAÇÕES: Vislumbra-se que esta metodologia, se expandida, contribua ao refinamento e mapeamento da classificação NANDA-I.

Leaders in nursing computing (Marin, 2007) have, in recent years, stimulated the development of systems to help nurses make decisions and held up these systems as a step toward improving the quality of care. This topic is also part of the list of Brazil's health research priorities (Brazil, 2008). Using a standardized nursing terminology in electronic systems is another challenge for nursing computing (Marin, 2007).

The NANDA-I nursing diagnosis terminology (NANDA International, 2010) introduces the diagnostic task as nursing competency, matching Brazilian legislation (Brazil, 2009) and the opinion of studies on the subject (Lunney, 2001). NANDA-I defines the nursing diagnosis as a clinical judgment on the part of the nurse that provides the basis for interventions and their results (NANDA International, 2010). Its structural components have, as their basis, the title (which establishes a name for the diagnosis), the defining characteristics (signs and symptoms, clinical manifestations), the risk factors, and other related factors.

The nursing diagnosis is a complex task and one with a high risk of low accuracy between nurses, because it requires the interpretation of human behavior related to health (Lunney, 2001). A nonaccurate diagnosis can lead to a not sufficiently accurate intervention, directly affecting the quality of health care provided. In light of the complexity of this diagnostic task, developing models or diagnostic support systems for nursing can be a way to contribute to diagnostic accuracy and to the quality of care.

Fuzzy sets theory (FST; Zadeh, 1965), used in the development of models to support decision making (Lopes, Ortega, Massad, & Marin, 2009; Marques, Barbosa, Basile, & Marin, 2005), allows the specialist to demonstrate how s/he arrived at a determined decision, attributing a weight to each rule used in the process of making a decision (Rolfe, 1997). This strategy could have implications for teaching nursing diagnosis, construction of decision support systems as to the refinement of NANDA-I terminology, allowing to be mapped the specialist's knowledge during the diagnostic task.

FST (Zadeh, 1965) deals with rather unclear limits between sets, representing vague concepts and working with imprecise linguistic variables. The elements of a universal set can pertain to a fuzzy set with degrees of membership ranging from 0 to 1, unlike classic sets, or crisp sets, in which each element completely relates to or does not relate to the set, that is, with degrees of membership equal to 1 or 0, respectively. Thus, FST allows for a gradual transition between sets based on a concept of partial truth, or degree of membership. This is represented by the function $\mu_A: U \rightarrow [0,1]$, where U is the universal set, and each element $x \in U$; $\mu_A(x)$ indicates the degree to which x is a member of set A, or whether x is compatible with the characteristics that define A, or in an equivalent way, how much x is compatible with the characteristic properties of set A. It is important to explain that [0,1] means: the U (universal) set includes values that range from 0 to 1. This situation of uncertainty is present in many diagnostic procedures, in which a defining characteristic may pertain to various diagnoses, with different degrees of membership.

For example, the concepts of health and disease are considered opposites in the classical logic perspective, where disease is absence of health and vice versa. Hence, the existence of health and disease in the same individual is contradictory. In the fuzzy logic, as in the real word, these concepts are complementary (Sadegh-Zadeh, 1999). In clinical practice, we have patients that live with a chronic pathology and present good quality of life. In the fuzzy logic perspective, this person may be more pertinent to the set of healthy individuals with a tenuous degree of pertinence to sick individuals set.

Based on the concepts of FST, this study's objectives were to test the viability of using specialists' opinions to establish membership degrees (relationship values) between nursing diagnoses and defining characteristics/risk factors, and to verify whether this method could be reproduced.

Methods

This study was a methodological one. We enlisted the participation, as specialists, of members of the DIREnf research team (Research Team for the Study of Nursing Classifications [*Grupo de Estudos sobre Diagnósticos, Intervenções e Resultados de Enfermagem*]), led by teachers from the School of Nursing at the University of São Paulo, in Brazil, at two points in time: in the years 2008 and 2012.

At meetings of the research group, we invited participants to reflect, in consensus, on the relationship (degree of membership) between nursing diagnoses and defining characteristics/risk factors (signs and symptoms). The guiding question was: what degree of relationship does each defining characteristic or risk factor has to this diagnosis? The idea was to analyze a set of nursing diagnoses and defining characteristics/risk factors one by one, identifying how much power a defining characteristic/risk factor had to lead to a determined diagnosis.

At first, as a pretest, the specialists established the relationships using numerical values, determining the relationship's level of relevance, in a range from 0 to 1.

However, the group found it difficult to use numerical values to determine relational values, and, therefore, we redefined the strategy, opting to use natural language, which the participants easily accepted. Thus, we used linguistic variables, which represented numerical variables, as follows: strongly related (1); related (0.75); moderately related (0.50); weakly related (0.25); and not related (0).

We collected data at two points in time:

- The first point (2008): 10 participants analyzed the relationship between 19 different nursing diagnoses and 34 defining characteristics/risk factors (NANDA International, 2008), divided into three data sets, generating three matrices of relationships.
- Second point (2012): we proposed the same activity to the group, in this moment with 27 participants, but with a new set of nursing diagnoses and defining characteristics/risk factors, this time involving 15 nursing diagnoses and 36 defining characteristics/risk factors (NANDA International, 2010), in a single data set, generating a single matrix of relationships.

In total, we analyzed 28 nursing diagnoses and 62 different defining characteristics/risk factors, which belonged to 10 domains from the NANDA-I terminology.

We proposed the activity corresponding to the first point in time to define the parameters of the relationship between nursing diagnoses and defining characteristics/risk factors, to a model supporting decision making (Lopes, 2008) used in an educational software (Jensen, Lopes, Silveira, & Ortega, 2012). Then, at the second point in time, the activity was performed so as to define the parameters of the second version of this software. Thus, in the first period, the specialists defined parameters for the relationship between a data set (nursing diagnoses and defining characteristics/risk factors), which were used in case studies of the first version of the software. During the second period, the specialists defined the parameters of a new data set, for new case studies, from the second version of the software. We should emphasize that during the second period, we presented new diagnoses and new elements, but some were repeated.

The institution's Ethics Committee approved the data collection process (Process n. 594/2008 e 778/2010).

We used graphs to represent the degrees of membership established by the specialists. A graph could represent the existing relationships between objects of a determined set and infer new relationships. The size of the objects or nodes (PageRank value) within this set is indicated in the graphs by an algorithm that identifies the incoming nodes, an algorithm developed by the founders of Google to determine the importance of sites (Brin & Page, 1998). It is also possible for the graph to analyze a grouping or cluster (identifier of modularity), indicated by a community detection algorithm, grouping the nodes according to affinities of relationships (Blondel, Guillaume, Lambiotte, & Lefebvre, 2008). Gephi software (Gephi, 2012) was used to perform the study's graphs and analyses.

Results

The specialists who participated in the first period of data collection (Table 1) spent 5 hr to analyze the data sets (Table 2). In the second period, the specialists (Table 1) needed two meetings to analyze the data set (Table 2), making a total of 8 hr of work. It should be noted that only three specialists who had participated in 2008 participated again. There was some variation in the number of participants, with 19 people present on the first day and 18 on the second day, in the second period. There was also a variation in the composition of the group between the two meeting days in the second period, meaning that only 10 specialists were present at both meetings.

Out of 905 possible relationships between the nursing diagnoses and the defining characteristics/risk factors shown in Table 2, the specialists indicated 286 relationships (Figure 1).

The graph of relationships (Figure 1) shows the diagnoses and defining characteristics/risk factors. The nodes (circles), in the light color, represent the diagnoses and, in the dark color, the defining characteristics/risk factors; the lines connecting the circles are the relationships as attributed by the specialists. The thickness of each relationship indicates the value attributed by the specialists to the relationship; the thicker it is, the stronger the relationship. The larger nodes represent more important diagnoses, that is, those that have a stronger relationship to the defining characteristics/risk factors (e.g., in clinical practice, if the more important diagnoses are eliminated, it can favoring the resolution of other diagnoses).

Based on the relationships identified, we were able to analyze the association between the defining characteristics/risk factors, according to the relationships that were shared with the diagnoses (Figure 2). In this graph, each relationship was created between two defining

Table 1. The Characteristics of the Specialists Who Participated in the Study, Distributed by Group

		Group 1 (2008)			Group 2 (2012)		
		n	%	Average (±SD)	*n*	%	Average (±SD)
Sex	Male	0	0		03	11	
	Female	10	100		24	89	
Training	Doctorate	01	10		03	11	
	Master's	05	50		06	22	
	Specialization	03	30		13	48	
	Undergraduate	0	0		02	07	
	Enrolled as an undergraduate	01	10		03	11	
Time since graduation				11.4 years (±9.22)			9.8 years (±9.25)

SD, standard deviation.

Table 2. The Number of Diagnoses, Defining Characteristics/Risk Factors, and of Relationships, Analyzed According to Group and Data Set

		Data set 1	Data set 2	Data set 3
Group 1 (2008)	Nursing diagnoses	11[b]	07[b]	07[b]
	Defining characteristics/risk factors	16[b]	14[b]	13[b]
	Total number of relationships[a]	176	98	91
Group 2 (2012)	Nursing diagnoses	15		
	Defining characteristics/risk factors	36		
	Total number of relationships[a]	540		

[a]Value obtained by multiplying the number of nursing diagnoses by the number of defining characteristics/risk factors.
[b]Some diagnoses and defining characteristics/risk factors are repeated in the sets, yielding a higher total obtained based on the tables.

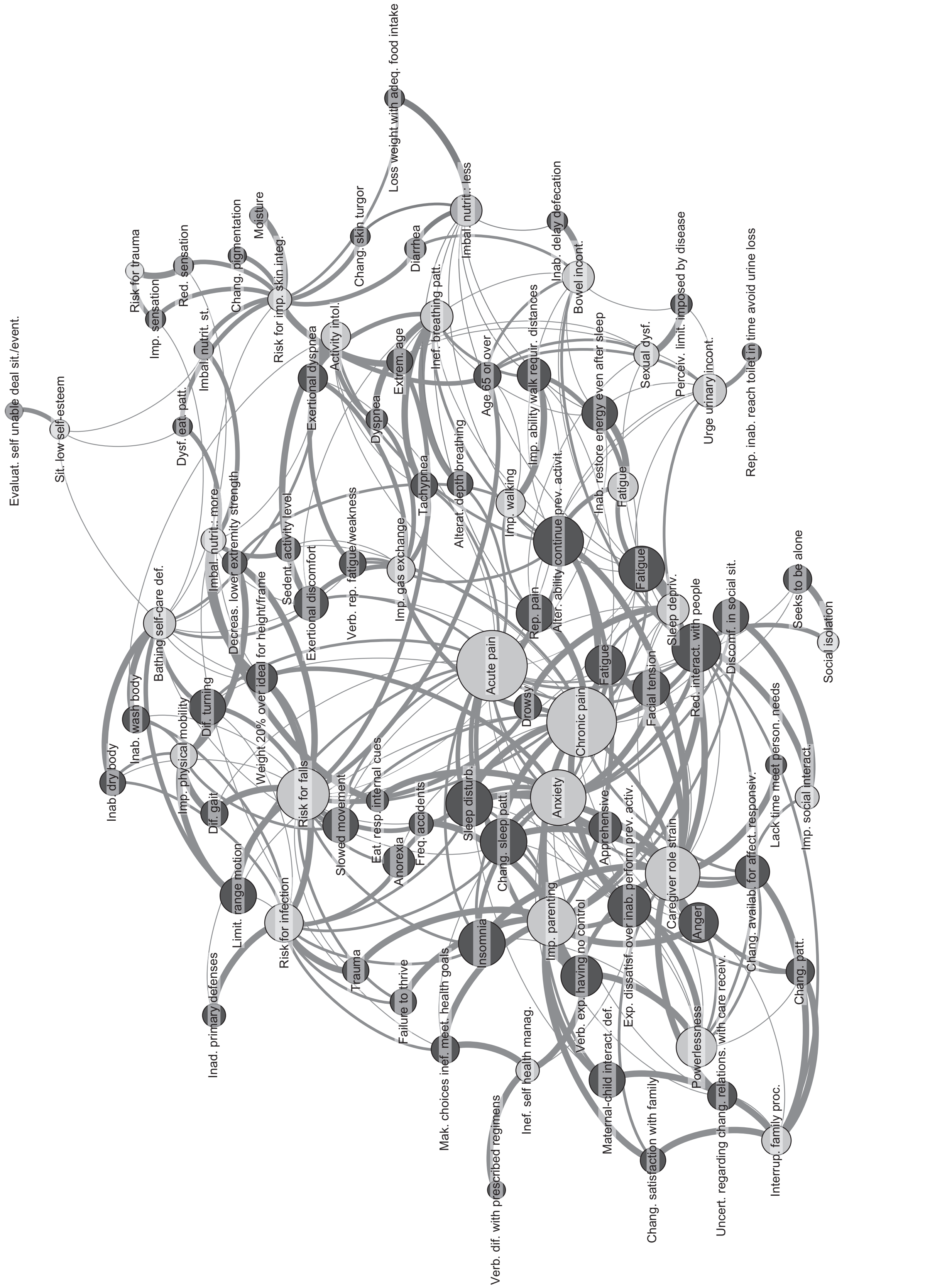


Figure 1. Graph Showing the 286 Relationships Between the 28 Nursing Diagnoses and the 62 Defining Characteristics/Risk Factors

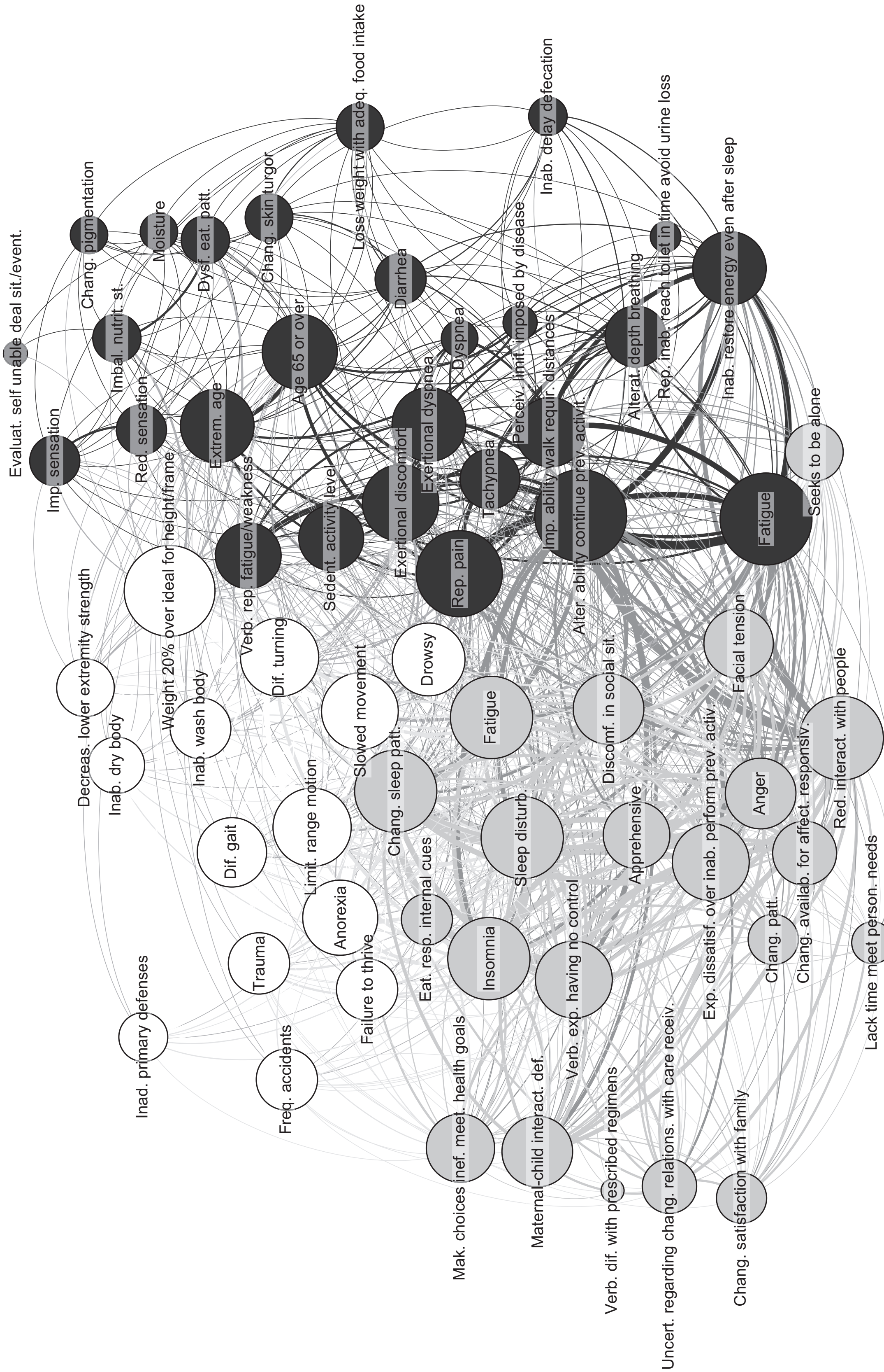


Figure 2. Graph of the 952 Relationships of Association Between the 62 Defining Characteristics/Risk Factors

characteristics/risk factors when they shared an association with a diagnosis—equivalent to an initial bipartite graph projection onto a monopartite graph. In the case of multiple diagnoses in common, we codified the occurrences based on the weight of the relationship (e.g., three relationships in common equaled a greater thickness for the relationship). As in the previous graph, the size of the nodes indicates their importance within the group. The software statistically identified three clusters of defining characteristics/risk factors, labeled: physical aspects (white), emotional aspects (light grey), and functional capacity (dark grey).

The data set presented to the specialists, at the two different time periods, shared five diagnoses and eight defining characteristics/risk factors. Thus, we were able to analyze the agreement between the specialists over the two time periods, considering the 27 relationships common to both groups (Figure 3). We found an intergroup agreement of 78% (21/27).

Discussion

The research group participants were considered specialists in this study, given the group's 12-year trajectory, their action in conjunction with NANDA-I, the participants' level of training (in 2008, 60% had master's or doctorate degrees, and in 2012, 33%), and the fact that they had studied the theme. In addition, the heterogeneity of the group (researchers, educators, nurses, clinicians, and students) was a positive aspect in terms of the results of research on diagnostic accuracy (Lunney, 2001).

We subsequently used the values for the relationships (degrees of membership) indicated by the specialists between the diagnoses and NANDA-I's defining characteristics/risk factors for academic purposes, in an educational simulation software (Jensen, Lopes, et al., 2012). For use in the care field, we recommend that it receive the scrutiny of specialists who evaluate diagnoses specific to their area of knowledge.

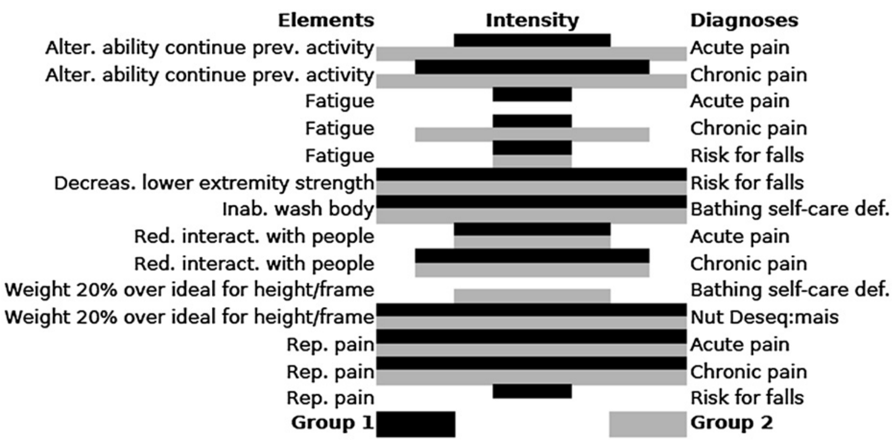
Nursing has already made use of FST (Jensen & Lopes, 2011); this study proved the theoretical value of the method, making it possible to use natural language to express the uncertainty and subjectivity involved in the diagnostic task. Based on this experience, we emphasize that in the context of nursing diagnosis, FST has the potential to motivate theoretical discussions about the diagnostic task, diagnostic accuracy (Jensen, Lopes, et al., 2012; Jensen, Silveira, Ortega, & Lopes, 2012), the mapping and refinement of the NANDA-I terminology, and the development of models to support diagnostic decisions (Lopes et al., 2009).

Using graphs to represent the relationships indicated between NANDA-I's diagnoses and elements (defining characteristics/risk factors) is a potential instrument for studies of an epidemiological nature and for mapping the terminology.

We were able to identify three groupings of elements that had a greater level of association, based on the relationships with the diagnoses. The three groupings shown in Figure 2 were generated based on the relationships indicated by the specialists in the graph shown in Figure 1. Thus, we named the groupings found, considering the characteristics of their elements, as: physical aspects, emotional aspects, and functional capacity. Probably, if all the diagnoses and elements in the NANDA-I terminology had been included, we might have made other groupings, allowing for the validation or refinement of the present terminology of nursing diagnoses in domains. This would be a way to validate the relationship between the diagnoses and the elements in the NANDA-I terminology.

The methodology proposed in this study could be used as a strategy to refine the NANDA-I terminology, to be reproduced with renowned specialists who evaluate diag-

Figure 3. Comparison of the Values Attributed by the Specialists in Group 1 and Group 2, Considering Equal Relationships to Both (Lines Completely Filled in Indicate a Strong Relationship, While Lines in White Indicate No Relationship)



noses specific to their area of knowledge, indicating the membership degrees (relationship values) between the diagnoses and the defining characteristics/risk factors of the NANDA-I terminology. These specialists would be organized according to the classes in which they would insert the diagnoses (e.g., nutrition, sexual health, cardiac function, and respiratory function). As a result, we would be able to map the major or minor defining characteristics for each nursing diagnosis, according to the force of the evidence for the diagnosis, in the specialists' opinion. This database, in turn, could facilitate the construction of systems to support the diagnostic decision with greater accuracy.

The 78% agreement rate for the specialists in the two periods (2008 and 2012), when analyzing the same diagnoses and defining characteristics/risk factors, nearly reached the 80% recommended by the literature (Rubio, Berg-Weger, Tebb, Lee, & Rauch, 2003). Therefore, the strategy used seems to fit because it produced reproducible results, even though the composition of the group varied.

This study's execution made it possible to reflect on subjects relating to the structure of the NANDA-I terminology. Moments of discomfort with the terminology emerged in the group discussions because: (a) there were NANDA-I defining characteristics/risk factors that needed clarification and were difficult to interpret (e.g., *changes in patterns*); these, when considered in isolation, sometimes made it impossible to understand the diagnostic context. (b) Certain elements of the terminology shared the same meaning, making them potentially redundant (e.g., *damaged sensations* × *reduction in sensations*). (c) The specialists indicated that defining characteristics/risk factors were strongly related to certain diagnoses even though there was no relationship according to the terminology, and they gave a lesser weight to the same defining characteristic, in relation to the diagnosis to which it pertained (e.g., to the defining characteristic *reduced interaction with people*, which concerned the terminology to the diagnosis of *chronic pain*, the value attributed was *related*, or 0.75. When the same defining characteristics were analyzed considering the diagnoses of *damaged social interaction* and *damaged paternity or maternity*, although they are not associated to these diagnoses in the NANDA-I, the value attributed to the relationship was strongly related, or 1, the maximum possible value).

In light of these findings, we would like to raise the following questions: are studies that propose a conceptual and operational definition of the elements of the terminology relevant? Should the redundant elements in the terminology be described in a single way? That is, if these elements were mapped by codes, would they have the same code in an electronic system? Would it be possible to propose to the NANDA-I council a revision of the defining characteristics/risk factors of the terminology in order to standardize them? Should the defining characteristics/risk factors follow standardized criteria for naming them, like that used for diagnoses?

These questions should not cast doubt on the consistency and relevance of the NANDA-I terminology, but they prompt reflection in terms of seeking strategies to refine it. These questions are relevant to the development of models or systems to support diagnostic decision making, and the NANDA-I council should consider them in their search for proposals to make the terminology more fit for use in electronic systems.

The initiative envisaged would be a great step toward mapping the terminology; although, at first, there must be a revision of the defining characteristics/risk factors and related factors of the NANDA-I that have not yet been standardized, a move that would make this strategy more viable.

This study's limitations are as follows: (a) at the second period, there was a variation in the group's participants between the first ($n = 19$) and the second ($n = 18$) meeting, with some members present on both meeting days ($n = 10$). (b) The analysis of the agreement between the groups of specialists from the first and second time periods (2008 and 2012) was based only on the 27 relationships that were equal to both. (c) To improve the construction of more robust graphs, there should be a single matrix to analyze the sets for the diagnoses and defining characteristics/risk factors and also the related factors, with a single data set, where the relationships between all the diagnoses and all the elements cited should be indicated.

Conclusion

This study proposed to analyze the relationships (degrees of membership) between the nursing diagnoses of the NANDA-I terminology and the defining characteristics/risk factors by means of a research group; the theory of reference was the FST. If expanded, the methodological strategy adopted by this study could make an important contribution to refining and mapping the terminology.

This study made it possible to reflect on the structure of the NANDA-I terminology, leading to the inference that standardizing the elements of terminology would favor its use in models to support decision making and electronic systems.

Graphs proved to be a potential instrument to map the terminology and future analyses of an epidemiological nature. In sum, FST has the potential to motivate theoretical discussions about the diagnostic task, diagnostic accuracy, mapping and refining the NANDA-I terminology, and developing models to support diagnostic decision making.

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