Research Paper ■

Structural Validation of Nursing Terminologies

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Abstract **Objective:** The purpose of the study is twofold: 1) to explore the applicability of combinatorial terminologies as the basis for building enumerated classifications, and 2) to investigate the usefulness of formal terminological systems for performing such classification and for assisting in the refinement of both combinatorial terminologies and enumerated classifications.

Design: A formal model of the beta version of the International Classification for Nursing Practice (ICNP) was constructed in the compositional terminological language GRAIL (GALEN Representation and Integration Language). Terms drawn from the North American Nursing Diagnosis Association Taxonomy I (NANDA taxonomy) were mapped into the model and classified automatically using GALEN technology.

Measurements: The resulting generated hierarchy was compared with the NANDA taxonomy to assess coverage and accuracy of classification.

Results: In terms of coverage, in this study ICNP was able to capture 77 percent of NANDA terms using concepts drawn from five of its eight axes. Three axes—Body Site, Topology, and Frequency—were not needed. In terms of accuracy, where hierarchic relationships existed in the generated hierarchy or the NANDA taxonomy, or both, 6 were identical, 19 existed in the generated hierarchy alone (2 of these were considered suitable for incorporation into the NANDA taxonomy and 17 were considered inaccurate), and 23 appeared in the NANDA taxonomy alone (8 of these were considered suitable for incorporation into ICNP, 9 were considered inaccurate, and 6 reflected different, equally valid perspectives). Sixty terms appeared at the top level, with no indenting, in both the generated hierarchy and the NANDA taxonomy.

Conclusions: With appropriate refinement, combinatorial terminologies such as ICNP have the potential to provide a useful foundation for representing enumerated classifications such as NANDA. Technologies such as GALEN make possible the process of building automatically enumerated classifications while providing a useful means of validating and refining both combinatorial terminologies and enumerated classifications.

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The recent trend toward developing a more rigorous foundation for nursing terminologies brings with it a number of potential benefits, including greater expressiveness and more extensive reuse of data from heterogeneous sources.[1,2] However, exposing the formal properties of nursing information also exposes a complexity that has remained concealed in more traditional terminologies. Features such as the decomposition of pre-coordinated expressions into more elementary components and the shift toward multi-axial hierarchies are hard for people to handle. Support is needed to make the terminologies easier to develop and maintain and to deliver the terminologies in a usable form.

Users of contemporary nursing systems typically enter and retrieve structured data using so-called "interface terminologies"—terminologies that are optimized for

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end-user utilization, such as menu-driven data entry.[3] These terminologies generally take the form of enumerated classifications in which enumerated terms are related by hierarchic and other associative and pragmatic relations.* One example of an enumerated classification for nursing is the North American Nursing Diagnosis Association Taxonomy I (NANDA,† the NANDA taxonomy).[5]

As far as they go, enumerated classifications may be useful for data retrieval and analysis, for helping manage resources more effectively, for identifying nursing input to the care process, and for formalizing knowledge about nursing practice.[6,7] Enumerated classifications are also seen as useful for statistical evaluation.[4] NANDA in particular claims to provide "a useful way of conceptualizing nursing science and focusing for clinical decision making."[8] The underlying enumerated approach makes this possible by providing a relatively stable agreed-on conceptual framework from which to "hang" key components of the diagnostic process.

Despite the widespread use of these terminologies, it is now recognized that the approach is inherently problematic. As a result, the terminologies may not be able to represent clinical information in sufficient detail,[9–11] nor are they able to provide sufficient coverage.[12] The beta version of the International Classification for Nursing Practice (ICNP),‡ a combinatorial terminology, represents one attempt to address some of the problems associated with these traditional representations. The development of ICNP has exposed part of the complexity that is implicit in more traditional nursing terminologies. The combinatorial nature of ICNP makes it awkward for direct use. This is now proving to be a barrier to acceptance. For example, in the European TELENURSE program, the trend has been to abandon direct use of ICNP in applications; instead, more traditional enumerative approaches have been used for data entry and analysis (with mappings to ICNP).[13–15] The TELENURSE experience suggests that combinatorial terminologies require different interfaces. Until such support becomes available, traditional approaches will continue to play a dominant role in the process of entering and retrieving structured nursing data, by providing the means to "hide" rather than "tame" the awkwardness.

Work in progress by the North American Nursing Diagnosis Association includes a proposal for a new multi-axial taxonomy.[5] The proposed taxonomy§ shares many features with ICNP. Although this will address many of the problems with the more traditional approach used in the NANDA taxonomy, the TELENURSE experience demonstrates that users of the proposed taxonomy will need significant support if they are to use it directly. It is unlikely that this support will be available in the near future. This will necessitate a move back to more traditional techniques, i.e., using the proposed taxonomy to derive a more traditional taxonomic structure. (See Rossi Mori et al.[16] for a description of how advanced terminological systems might assist in the development and maintenance of more traditional systems). However, existing problems with constructing and maintaining the current taxonomy will be compounded by the use of the proposed taxonomy, and support will also be needed in deriving and maintaining any new taxonomy.

The purpose of this article is to describe how GALEN technology|| can provide that support, i.e., by modeling ICNP, by representing terms from the current NANDA taxonomy, and by using the structure of ICNP to derive a new taxonomic structure for NANDA. In this way it will provide a means of validating ICNP in terms of the utility, content, and structure of each of its axes, and the existing NANDA taxonomy in terms of the accuracy its constituent relationships. A similar study has been carried out in medicine.[17] The focus of this study is on nursing; more specifically, nursing diagnosis. In addition, a key motivation behind this work is not the integration of terminologies but rather examination of the practical use of combinatorial terminologies as a basis for deriving and validating enumerated classifications. This is important as NANDA and other terminologies move toward more advance representation techniques.#

* What we term in this article "enumerated classifications" are referred to by Ingenerf [4] as "systematic taxonomic vocabularies."

† In this article, to prevent confusion, references to the terminology will be indicated by the abbreviation NANDA, whereas references to the association itself will be indicated by the full name North American Nursing Diagnosis Association.

‡ See http://www.icn.ch/icnpupdate.htm for further details. The designation ICNP is copyright © 1999 by ICN International Council of Nurses, 3 place Jean Marteau, CH-1201 Geneva, Switzerland.

§ In this article, any reference to the NANDA taxonomy should be taken as a reference to the existing NANDA taxonomy unless "proposed taxonomy" is stated explicitly.

|| See http://www.opengalen.org/ for further details.

A similar study is planned using the proposed NANDA taxonomy in place of ICNP to generate a new taxonomic structure for comparison with the existing NANDA taxonomy. This study will serve as a validation of the proposed taxonomy.

Background

NANDA

As mentioned previously, the NANDA taxonomy is an example of an enumerated classification. Such terminologies are constructed by enumerating all the possible terms that are to be represented and by organizing the terms into a hierarchy. For example, in NANDA the notion of a "state in which an individual experiences pain that continues for more than 6 months"[8] is represented by the term "Chronic Pain." This term represents a "Nursing Diagnosis." Nursing diagnoses may be viewed as "agreed-on labels for diagnostic concepts." Each of these "labels" or diagnoses in NANDA has an associated set of components. This set includes a definition, defining characteristics, and related or risk factors. These components are seen as useful elements in the diagnostic process.[8]

In the NANDA taxonomy, the term "Chronic Pain" has been classified manually (i.e., by people) as a "Pain," a more general term. The NANDA taxonomy also includes certain organizing categories in the form of human response patterns, e.g., Feeling. These categories have been excluded from this study, as they do not in themselves represent nursing diagnoses.

As indicated previously, the enumerated classification approach has fundamental limitations. To avoid combinatorial explosion, developers must limit the number of terms to include in any enumerative terminology, so that the terminology remains manageable, in terms of both development and practical application.[18] Because of this, enumerated classifications tend to be both narrow and shallow.[2]

In addition, arranging terms into hierarchies is problematic. This is borne out in practice by the apparent mixture of relations that have been used to construct the NANDA taxonomy. This is typical of such informal taxonomies, which Rector terms "thesauri."[19] For example, "Chronic Pain" is classified as a "Pain," i.e., a relatively straightforward "is-a" relation (the generic relation). "Impaired Swallowing" is classified as a "Feeding Self-care Deficit," i.e., a much more complex relation. Since the relations in NANDA are not labeled explicitly, the possibility of processing formally the hierarchy is restricted.

Despite these limitations, as an organizing framework for elements of the diagnostic process, NANDA has found utility particularly in education and research.

International Classification for Nursing Practice

The ICNP uses a different approach from enumerated classifications. The ICNP is an example of a combinatorial terminology.** By decomposing complex concepts such as "Chronic Pain" into primitive concepts—e.g., "Pain" and "Chronic", such terminologies attempt to address the problems associated with enumerated representations.

The ICNP classification of nursing phenomena is multi-axial. It consists of 8 axes: Focus, Judgement, Frequency, Duration, Topology, Body Site, Likelihood and Bearer. Complex nursing concepts are represented by selecting appropriate elements from these different axes as appropriate.

For example, in ICNP "Chronic Pain" might be represented as:

Focus	Duration
Pain	Chronic

The combinatorial nature of ICNP permits the representation of a vast number of highly detailed concepts. However, the lack of specific rules for determining which combinations are clinically sensible means that applications that use ICNP cannot prevent the creation of clinically meaningless concepts. It is true that paper-based health record systems share this problem—users are free to write anything they wish. However, to enter structured data into computer-based health records, structured terminologies must be "delivered" to users for selection. The direct use of combinatorial taxonomic terminologies for data entry introduces an increased "look up" burden on users; in the context of a traditional menu-driven user interface paradigm, to enter a single concept into the record they must search for and select elements from several lists.

A further limitation of combinatorial terminologies such as ICNP, and one which is of greater concern in this study, is related to classification. In each axis of ICNP, elementary concepts are classified according to the generic "is-a" relation. However complex concepts are not classified, and any hierarchic relationships between complex concepts must be inferred. For example, Pain is classified as a Sensation. However, in ICNP, combined concepts, such as the representation of "Chronic Pain," are not classified. Therefore, although it might be possible to use ICNP

** What we term in this article "combinatorial terminologies" are referred to by Ingenerf[4] as "combinatorial taxonomic vocabularies."

to represent complex terms from NANDA, it would not be possible to use ICNP alone to represent any hierarchic relationships between those terms.

GRAIL

A third approach is the use of formal systems.[2,11] GRAIL (GALEN Representation and Integration Language) is a language for representing concepts and their interrelationships—the source materials for constructing terminology models. It is one of a family of tools known as "description logics," which are closely related to Sowa's conceptual graphs.[20] This family also includes KRSS, which underlies SNOMED-RT.

Two integrated sets of tools are used in the construction of a GRAIL model—a modeling environment and a terminology server. The modeling environment facilitates the formulation of models. This includes the specification of an initial hierarchy of elementary concepts and the definition of compositional rules to decide how concepts might be combined. The terminology server performs the actual construction of the model. This involves the combination of concepts according to the compositional rules and the automatic classification of composite concepts into the hierarchy. For example, "Chronic Pain" might be represented in GRAIL by:

(Pain which ††
hasDuration Chronic).

This composite concept is a specialization of the more general concept "Pain," and as such it would be classified automatically by the terminology server as a "Pain."

Further detail is beyond the scope of this paper. A more detailed discussion of GRAIL may be found in Rector et al.[21]

Methods

Representing ICNP

In each axis of ICNP, the hierarchic relationships between concepts are indicated by associated "codes." For example the concept "Pain" (1A.1.1.1.13.1) is classified as a "Sensation" (1A.1.1.1.13). In this study, ICNP "codes" were used to create automatically, in GRAIL, an individual explicit hierarchy of atomic-level ICNP concepts to reflect the hierarchic structure of ICNP. This process revealed several minor problems, including erroneous numbering and ambiguity. For example, the concept "Law Dissent" is associated with the ICNP code 1A.2.2.4.3, but according to its place in the Focus hierarchy, this code should read 1A.2.2.5.3. As an example of ambiguity, the concept "Perception" appears as a modifying Judgment, with descendants such as "Perceived." "Perception" also appears as a base Focus, with descendents such as "Hallucination." These are clearly two separate concepts. Such problems were identified and rectified as part of the process of creating the hierarchy.

For the interrelationships between concepts, the ICNP axes provided the potential linkages between elementary GRAIL concepts, e.g., previous examples show how the Duration axis transforms into a hasDuration link.

Representing NANDA

Terms from NANDA were represented using only atomic-level ICNP concepts and derived links. (Consistency was ensured by the use of a tailor-made representation building tool.) For example, the NANDA term "Chronic Pain" was represented unsurprisingly as:

(Pain which
hasDuration Chronic) name §§ *ChronicPain*

The result was a set of GRAIL representations for NANDA terms. These composite GRAIL concepts were classified automatically by the terminology server into a new hierarchy.

The formal properties of GRAIL ensure that concepts are classified in a principled way. It should be noted that the organization of the new hierarchy is a reflection of the hierarchic organization of the individual axes of ICNP; it should not be taken as an indication of the adequacy of the GRAIL classifier.

A small experiment to assess potential inconsistency between two modelers was performed in collaboration with the Danish Institute for Health and Nursing Research. A random selection of 30 NANDA terms (26 percent of total terms represented) were represented separately by the two modelers, using only atomic-level ICNP concepts.

Comparing Hierarchies

The resulting generated hierarchy was compared with the NANDA taxonomy to assess coverage and accuracy of classification. Coverage was measured in terms of

†† The operator *which* is used for the creation, normalization, and classification of composite concepts.

§§ Composite GRAIL concepts may be named using the *name* operator.

whether it was deemed possible to represent NANDA terms using the GRAIL model of ICNP concepts. Accuracy of classification was judged by comparing the generated hierarchy with the NANDA taxonomy; any differences were taken as cues for further investigation.

Results

Coverage[||||]

A total of 114 NANDA terms were represented, out of a possible 149—i.e., a coverage of 77 percent. This represents the test set for the study.

A breakdown of individual representations revealed that concepts from the ICNP Focus axis were used in all 114 representations; concepts from the Judgment axis were used in 62 representations; concepts from the Likelihood axis were used in 27 representations; concepts from the Bearer axis were used in 15 representations; and concepts from the Duration axis were used in 4 representations. No concepts from the remaining axes—Body Site, Topology, and Frequency—were needed to represent the test set.

The experiment to assess potential inconsistency between modelers showed that inter-modeler reliability was relatively high (93 percent) with only two differences in representation.

Accuracy

The complete generated hierarchy is given in Table 1. A full account of the similarities and differences between the generated hierarchy and the NANDA taxonomy is given in Tables 2, 3, and 4. The generated hierarchy includes a total of 25 hierarchic relationships; i.e., 25 terms are indented while 89 terms appear with no indenting, at the top level. Of these 89, the generated hierarchy is identical to the NANDA taxonomy in 60 cases; i.e., 60 terms appear with no indenting both in the generated hierarchy and in the NANDA taxonomy.

In terms of the 25 hierarchic relationships, the generated hierarchy is identical to the NANDA taxonomy in six cases. These hierarchic relationships, shown in Table 2, are assumed to be accurate.

Of the 19 hierarchic relationships that appear only in the generated hierarchy (Table 3), 2 relationships are deemed to be accurate, 6 reflect problems with the internal structure of ICNP, and 11 reflect problems with the mapping between NANDA and ICNP. They include the majority of concepts that are modified by the couple "hasLikelihood Risk for."

Twenty-three hierarchic relationships appear in the NANDA taxonomy only (Table 4). Eight of these relationships are deemed to be accurate, 7 reflect causal and other associative relationships, and 2 are contradictory. Six represent particular world views.

Discussion

In terms of coverage, 35 NANDA terms could not be represented using the GRAIL model of ICNP. Reasons include:

- *Structural peculiarities of NANDA.* Four NANDA terms could not be represented using the GRAIL model of ICNP concepts, as they contained either a conjunction or a disjunction—e.g.,"Altered Growth and Development" and "Sensory/ Perceptual Alterations." These constructs are problematic for combinatorial terminologies, because they map onto more than one concept. The GALEN code-mapping tools provide a straightforward solution, but this was not used in this preliminary study.
- *Limitations in the content or organization of ICNP.* A larger number, 31 terms, could not be represented for a different reason—either the content of ICNP or the organization of concepts into axes was too limited to capture accurately the essence of the NANDA rubric. Examples are Delayed Surgical Recovery, Death Anxiety, Rape Trauma Syndrome: Compound Reaction, and Risk for Peripheral Neurovascular Dysfunction.

As indicated in the results, no concepts from the axes Body Site, Topology, and Frequency were needed to represent the test set. This brings into question the utility of these three axes. This finding is borne out by the proposed NANDA taxonomy, which contains no axes pertaining to Body Site, Topology, or Frequency. Further work involving a range of terminologies is needed.

It is not surprising that concepts from the ICNP Focus axis were used in all 114 representations. The particular modeling style used reflects to a large extent current guidelines for constructing in ICNP a nursing diagnosis; i.e., a nursing diagnosis must include a term from the Focus axis.[##]

[||||]Any assessment of coverage should take into account the fact that NANDA was included in the original list of sources for the development of ICNP.[22]

[##]See "Composing a Nursing Diagnosis" at http://www.icn.ch/icnpupdate.htm#Guidelines for for further details.

Table 1 ■

Hierarchy of 114 NANDA Terms Automatically Generated from a GRAIL Model of ICNP

- Activity Intolerance
  - Risk for Activity Intolerance
- Acute Confusion
- Adult Failure to Thrive
- Altered Family Process
  - Altered Parenting
    - Risk for Altered Parenting
      - Risk for Altered Parent/Infant/Child Attachment
- Altered Nutrition: Less Than Body Requirements
- Altered Nutrition: More Than Body Requirements
  - Altered Nutrition: Risk for More Than Body Requirements
- Altered Oral Mucous Membrane
- Altered Role Performance
- Altered Sexuality Patterns
- Altered Thought Processes
- Altered Tissue Perfusion
- Altered Urinary Elimination
- Anxiety
- Body Image Disturbance
- Bowel Incontinence
- Caregiver Role Strain
  - Risk for Caregiver Role Strain
- Chronic Confusion
- Chronic Low Self-esteem
- Constipation
  - Perceived Constipation
  - Risk for Constipation
- Decisional Conflict
- Decreased Cardiac Output
- Diarrhea
- Disorganized Infant Behavior
  - Risk for Disorganized Infant Behavior
- Diversional Activity Deficit
- Dysfunctional Grieving
- Dysreflexia
- Effective Breastfeeding
- Family Coping Potential For Growth
- Fatigue
- Fear
- Feeding Self-care Deficit
- Fluid Volume Deficit
  - Risk for Fluid Volume Deficit
- Fluid Volume Excess
- Functional Urinary Incontinence
- Health Seeking Behaviors
  - Altered Protection
  - Effective Management of Therapeutic Regimen: Individual
  - Ineffective Management of Therapeutic Regimen: Community
  - Ineffective Management of Therapeutic Regimen: Families
  - Ineffective Management of Therapeutic Regimen: Individuals
  - Non-compliance
  - Risk for Violence: Self-directed
    - Risk for Self-mutilation
- Hopelessness
- Hyperthermia
- Hypothermia
- Impaired Gas Exchange
- Impaired Home Maintenance Management
- Impaired Memory
- Impaired Physical Mobility
  - Impaired Ability to Transfer
  - Impaired Walking
- Impaired Social Interaction
- Impaired Swallowing
- Impaired Verbal Communication
- Inability to Sustain Spontaneous Ventilation
- Ineffective Airway Clearance
- Ineffective Breastfeeding
- Ineffective Breathing Pattern
- Ineffective Community Coping
- Ineffective Denial
- Ineffective Family Coping: Compromised
- Ineffective Family Coping: Disabling
- Ineffective Individual Coping
- Ineffective Infant Feeding Pattern
- Ineffective Thermoregulation
- Interrupted Breastfeeding
- Knowledge Deficit
- Nausea
- Pain
  - Chronic Pain
- Parental Role Conflict
- Personal Identity Disturbance
- Post-trauma Syndrome
  - Rape Trauma Syndrome
  - Risk for Post-trauma Syndrome
- Potential for Enhanced Community Coping
- Potential for Enhanced Organized Infant Behavior
- Potential for Enhanced Spiritual Well-being
- Powerlessness
- Reflex Urinary Incontinence
- Relocation Stress Syndrome
- Risk for Altered Body Temperature
- Risk for Altered Growth
- Risk for Aspiration
- Risk for Disuse Syndrome
- Risk for Infection
- Risk for Injury
- Risk for Loneliness
- Risk for Suffocation
- Risk for Trauma
- Risk for Violence: Directed At Others
- Self-esteem Disturbance
- Sexual Dysfunction
- Sleep Deprivation
- Sleep Pattern Disturbance
- Spiritual Distress
  - Risk for Spiritual Distress
- Stress Incontinence
- Toileting Self Care Deficit
- Unilateral Neglect
- Urge Incontinence
  - Risk for Urinary Urge Incontinence
- Urinary Retention

ABBREVIATIONS: NANDA, North American Nursing Diagnosis Association taxonomy : GRAIL, GALEN Representation and Integration Language; ICNP, International Classification for Nursing Practice.

Table 2 ■

Hierarchic Relationships That Appear in Both the Generated Hierarchy and the NANDA Taxonomy

Parent	Child
Impaired Physical Mobility	Impaired Ability to Transfer
Impaired Physical Mobility	Impaired Walking
Pain	Chronic Pain
Post-trauma Syndrome	Rape Trauma Syndrome
Constipation	Perceived Constipation
Risk for Altered Parenting	Risk for Altered Parent/Infant/ Child Attachment

A varying degree of creativity was needed for certain representations, from the use of relatively simple synonyms (e.g., "Trauma Reaction" in ICNP to represent "Post-Trauma Response" in NANDA) to more complex substitutions (e.g., "Self-reliant Action" in ICNP to represent "Behavior" in NANDA). Such substitutions were made to provide sufficient scale to the study. However, they were permitted only if it was felt that they would have little or no effect on the overall results. A more comprehensive set of recognized synonyms for ICNP concepts would have made these substitutions easier.

The results of the experiment to assess variability between modelers suggest that inter-modeler variability is unlikely to be a serious issue, but a more extensive study is needed.

In terms of accuracy, of the 25 hierarchic relationships in the generated hierarchy, 6 are identical to those in the NANDA taxonomy (Table 2). For example, "Chronic Pain" is classified as a "Pain." In a more complex example, "Risk for Altered Parent/Infant/ Child Attachment" is classified as a "Risk for Altered Parenting."

Both the generated hierarchy and the NANDA taxonomy are relatively flat. This suggests that NANDA has a relatively broad coverage. The fact that 60 non-

Table 3 ■

Hierarchic Relationships That Appear in the Generated Hierarchy Alone

	Parent	Child
3.1 Relationships that are deemed accurate:	Risk for Violence: Self-directed	Risk for Self-mutilation
	Altered Family Process	Altered Parenting *In NANDA, Altered Parenting is a child of Altered Role Performance.*
3.2 Relationships that reflect problems with the internal structure of ICNP:	Health-seeking Behaviors	Altered Protection *In NANDA, Altered Protection appears in a different Functional Health Pattern (Exchanging) than Health-seeking Behaviors (Choosing)*
	Health-seeking Behaviors	Effective Management of Therapeutic Regimen: Individual *In NANDA, these are siblings.*
	Health-seeking Behaviors	Ineffective Management of Therapeutic Regimen: Community *In NANDA, these are siblings.*
	Health-seeking Behaviors	Ineffective Management of Therapeutic Regimen: Families *In NANDA, these are siblings.*
	Health-seeking Behaviors	Ineffective Management of Therapeutic Regimen: Individuals *In NANDA, these are siblings.*
	Health-seeking Behaviors	Non-compliance *In NANDA, Non-compliance is a child of Ineffective Management of Therapeutic Regimen: Individuals.*
3.3 A relationship that reflects problems with the mapping between NANDA and ICNP:	Urge Incontinent	Risk for Urinary Urge Incontinence

Table 4 ■

Hierarchic Relationships That Appear in the NANDA Taxonomy Alone

	Parent	Child
4.1 Relationships that are deemed accurate:	Self-esteem Disturbance	Chronic Low Self-esteem
	Altered Urinary Elimination	Functional Urinary Incontinence
	Altered Urinary Elimination	Reflex Urinary Incontinence
	Altered Urinary Elimination	Stress Incontinence
	Altered Urinary Elimination	Urge Incontinence
	Altered Urinary Elimination	Risk for Urinary Urge Incontinence
	Altered Urinary Elimination	Urinary Retention
	Altered Family Process	Caregiver Role Strain *According to NANDA, the caregiver performs the "family caregiver role."*
4.2 Relationships that represent causal and other associative relationships:	Activity Intolerance	Fatigue
	Ineffective Management of Therapeutic Regimen: Individuals	Non-compliance
	Feeding Self-care Deficit	Impaired Swallowing
	Inability to Sustain Spontaneous Ventilation	Ineffective Breathing Pattern
	Ineffective Individual Coping	Ineffective Denial
	Altered Role Performance	Sexual Dysfunction
	Sleep Pattern Disturbance	Sleep Deprivation
4.3 Contradictory relationships:	Risk for Violence: Directed at Others	Risk for Violence: Self-directed
	Risk for Violence: Directed at Others	Risk for Self-mutilation
4.4 Relationships that represent a particular world view:	Risk for Injury	Risk for Aspiration *NANDA uses a broader definition of Injury than ICNP.*
	Risk for Injury	Risk for Disuse Syndrome *NANDA uses a broader definition of Injury than ICNP.*
	Risk for Injury	Risk for Suffocation *NANDA uses a broader definition of Injury than ICNP.*
	Risk for Injury	Risk for Trauma *NANDA uses a broader definition of Injury than ICNP.*
	Altered Thought Processes	Impaired Memory *In ICNP, Memory is classified as a Self-awareness rather than as Thought Process*
	Ineffective Breastfeeding	Interrupted Breastfeeding *ICNP separates notions of Interruption and Ineffectiveness.*

hierarchic (i.e., top-level) relationships are also identical is significant, and it reveals a much greater level of agreement between the generated hierarchy and the NANDA taxonomy.

Two of the 19 hierarchic relationships that appear only in the generated hierarchy are deemed to be accurate and should perhaps be considered for inclusion in the NANDA taxonomy—e.g., "Risk for Self-Mutilation" is classified as a "Risk for Violence: Self Directed" (Table 3, part 3.1).

However, in 6 cases the generated hierarchy appears to be less accurate—e.g., "Non-compliance" is classified as a "Health-seeking Behavior" (Table 3, part 3.2). This reflects the hierarchic structure of ICNP and suggests that some refinement of the ICNP Focus axis hierarchy might be necessary.

The generated hierarchy reveals problems associated with the way in which "risk" is handled in ICNP. Risk is what might be called a contextual qualifier.[23] Other examples include negation and certainty. Contextual qualifiers differ from simple qualifiers in that, rather than refine the meaning of a statement, they radically alter it. For example, "Risk for Post-trauma Syndrome" has a very different meaning from "Actual Post-trauma Syndrome." In 11 cases in the generated hierarchy, if a concept is marked as "at risk," then it is classified as a child of the base concept, e.g., "Risk for Urinary Urge Incontinence" is classified as an "Urge Incontinence" (Table 3, part 3.3). This would appear to be inaccurate, as "Risk for Urinary Urge Incontinence" is a potential state, whereas "Urge Incontinence" implies an actual state. (ICNP has no term to indicate an actual state.) This suggests that if ICNP is to find application as the basis for more formal terminological systems, the way in which it handles "risk" should be refined.*** The two exceptions to this are themselves children of concepts marked as "at risk" (Table 2 and Table 3, part 3.1).

Of the 20 hierarchic relationships that appear in the NANDA taxonomy alone, six are deemed to be accurate and should perhaps be accommodated in ICNP—e.g., "Functional Urinary Incontinence" is classified in NANDA as an "Altered Urinary Elimination" (Table 4, part 4.1). These result from the fact that ICNP is actually a hybrid of enumerated terms and more elementary concepts. For example, "Altered Urinary Elimination" is decomposed into the Focus "Urinary Elimination" and the Judgement "Altered," whereas "Functional Urinary Incontinence" is fully enumerated. The notion that the latter concept might necessarily be "altered" is locked in the term and cannot be used in automatic classification. GRAIL includes a construct that deals with this situation, but this was not used in this preliminary study.

Seven relationships in the NANDA taxonomy appear to be nonhierarchic—e.g., "Sexual Dysfunction" is classified as an "Altered Role Performance" (Table 4, part 4.2). This may be symptomatic of the potential use of NANDA as an interface terminology, in which users are more interested in grouping together terms in a pragmatic way than in classifying concepts according to more formal properties. Highlighting such relationships makes debate and informed decision possible.

The NANDA taxonomy contains two hierarchic relationships that appear to be contradictory and should perhaps be reconsidered—e.g., "Risk for Violence: Self-directed" is classified as a "Risk for Violence: Directed at Others" (Table 4, part 4.3).

The NANDA taxonomy contains six further hierarchic relationships that do not appear in the generated hierarchy (Table 4, part 4.4). These remaining differences appear to be an indication of different valid views—e.g., "Interrupted Breastfeeding" in NANDA is classified as an "Ineffective Breastfeeding." ICNP separates notions of interruption and ineffectiveness.†††

As both views could be considered equally valid, to harmonize these views would require debate.

Conclusion

Until software support for the direct use of combinatorial terminologies (such as ICNP and the proposed NANDA taxonomy) becomes available, traditional approaches will continue to play a dominant role in entering and retrieving structured nursing data.

This study has demonstrated that, subject to appropriate refinement, combinatorial terminologies may have a role in providing the basis for representing enumerated classifications, as evidenced by the representation in ICNP of NANDA terms.

This was a preliminary study and, as such, it did not exploit the full power of GRAIL, nor did it exploit any aspect of the broader GALEN terminology framework. Nevertheless, this study has demonstrated that technologies such as GALEN make possible the process of building automatically enumerated classifications by providing a framework for recombining individual elements into more complex concepts and a mechanism for classifying those concepts automatically and in a principled way, as evidenced by the generated hierarchy of NANDA terms.

Finally, this study has demonstrated the usefulness of the approach for validating and refining both combinatorial terminologies and enumerated classifications. It might also contribute to larger efforts, for example by preparing source terminologies for inclusion in reference terminologies such as SNOMED-RT.

In particular, the study highlighted:

***The proposed NANDA taxonomy includes the concept "actual," which is given as a sibling to "risk for." The application of "actual" to all actual states would resolve this problem.

††† To "force"" this classification according to the NANDA taxonomy would require a more intricate hierarchic structure in the Judgment axis; i.e., Interruption would need to be classified as an Ineffectiveness. This process would result in a richer taxonomic structure for any generated hierarchy.

- Potentially accurate hierarchic relationships that are currently not included in the NANDA taxonomy
- Nonhierarchic and possibly inaccurate relationships in NANDA
- Problems in the content and structure of individual axes in ICNP
- Questionable utility for three entire ICNP axes
- Problems in the overall handling of "risk" in ICNP

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