Use of Clinical Data from EHR for Nursing Research

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• Introduction to Bundang Seoul National University Hospital
• Background
• Three studies that used clinical data from EHR
Introduction to ICNP
International Classification for Nursing Practice

• A product of the International Council of Nurses (ICN)
• A dictionary of terms and expressive relationships that nurses can use to describe and report their practice in a systematic way.
Definition of 7 Axes

• Client: Subject to which a diagnosis refers and who is the recipient of an intervention (e.g., newborn, caregiver, family, community)
Elements of ICNP

• 7 Axes (client, focus, judgment, means, action, time, location) model

• Pre-coordinated terms
  – Nursing diagnoses and nursing sensitive patient outcomes (ex: acute pain)
  – Nursing interventions (teach about managing pain)
ICNP 7-axis Model

Terms from multiple axes can be combined to form nursing diagnoses, outcomes, and interventions.
Definition of 7 Axes

- Focus: The area of attention that is relevant to nursing (e.g., pain, homelessness, elimination, life expectancy, knowledge)
- Judgment: Clinical opinion or determination related to the focus of nursing practice (e.g., decreasing level, risk, enhanced, interrupted, abnormal)
Definition of 7 Axes

• Means: A manner or method of accomplishing an intervention (e.g., bandage, bladder-training technique, nutritionist service)

• Action: An intentional process applied to or performed for a client (e.g., educating, changing, administrating, monitoring)
Definition of 7 Axes

• Time: The point, period, instance, interval or duration of an occurrence (e.g., admission, child birth, chronic)

• Location: Anatomical and spatial orientation of a diagnosis or intervention (e.g., posterior, abdomen, school, community health center)
ICNP Catalogues

• Nursing data subsets for specified health concerns
• Examples:
  – Pediatric Pain Management
  – Palliative Care
  – Partnering with Individuals and Families to Promote Adherence to Treatment
Unique Codes

• All of the ICNP concepts including pre-coordinated concepts have unique codes (identifiers).
  – Acute Pain - 10000454
  – Teaching about Managing Pain - 10019489

• Facilitates electronic use, mapping, storage, and retrieval for reuse.
### Examples of Composing Nursing Diagnoses, Interventions and Outcomes

<table>
<thead>
<tr>
<th>Action</th>
<th>Client</th>
<th>Focus</th>
<th>Judgment</th>
<th>Location</th>
<th>Means</th>
<th>Time</th>
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<tbody>
<tr>
<td>Nursing Diagnoses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Individual</td>
<td>Constipation</td>
<td>Actual</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Nursing Interventions</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Identifying</td>
<td>Individual</td>
<td>Elimination Pattern</td>
<td></td>
<td></td>
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<td>Assessing</td>
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<td>Pain</td>
<td>Abdominal</td>
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<tr>
<td>Teaching</td>
<td></td>
<td>Dietary Need</td>
<td></td>
<td></td>
<td>Dietary Regime</td>
<td></td>
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<tr>
<td>Educating</td>
<td></td>
<td>Side Effect of Medication</td>
<td></td>
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<td>Administering</td>
<td></td>
<td>Constipation</td>
<td></td>
<td></td>
<td>Enema</td>
<td></td>
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<tr>
<td>Nursing Outcomes</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
From ICNP to Patient Records

ICNP

ICNP® 7 Axis Model

Patient Records

Catalogues

Nursing Narratives

Statement A

Statement B

Statement C

Statement D

Statement E

Statement F

Statement G

A catalogue

A catalogue item

A catalogue item

A catalogue item

A catalogue item

A catalogue item

A catalogue item
Number of beds: 1350
Number of outpatients per year: over 1.2 million
Number of nurses: 1000
Components of SNUBH Information System

**BESTCare**: Integrated HIS of SNUBH

- **PACS**: Filmless
- **EMR**: Chartless
- **CPOE**: Slipless
- **MIS, Groupware**: Paperless

Digitalized Image
DICOM

Digitalized medical record
Structured Data Input
Clinical Decision Support
Standard Medical Terminology

Digitalized order communication
Drug Interaction
Drug side effect
Drug Information

Account Management
ADT
Ancillary services
Standardized Terminology-based System

- Chief complaint
- Medical Diagnosis
- Operation procedure
- Drug
- Nursing

- SNOMED CT
- ICD-10
- ATC from WHO
- ICNP
Total digitalization: Patient Bed
Total digitalization: ICU
Total digitalization: OR
Background

• Adoption rate of EMR in Korea as of 2011:
  – 50.2% in tertiary teaching hospitals,
  – 35.0% in general hospitals.

• Korean Government's initiative on Interoperable EHR strongly recommended the use of standardized clinical terminology.

• First ICNP-based electronic nursing records (ENR) system was introduced at Bundnag Seoul National University Hospital in 2003 in Korea.

• Currently there are more than 10 hospitals with ICNP-based electronic nursing records system.
ICNP and Nursing Narratives

- ICNP (up to version 2.0) was translated into Korean
- Structured narratives were mapped to the concepts in the ICNP 7-axis model
- Structured narratives were used in electronic nursing records to document nursing assessments, diagnoses, activities, interventions, and outcomes
Nursing Narratives and Catalogues

• Number of nursing narratives mapped to ICNP
  – About 10,000

• Number of catalogues
  – 21 common catalogues: ADT, vital sign, elimination, nutrition and diet, activity and rest, medication, pain, transfusion, bleeding, emergency care, symptom management, respiratory care, skin care, I/O, and etc.
  – 38 nursing unit specific catalogues: Each nursing unit has about 15 different catalogues
Components of Electronic Nursing Records System

- Terminology Server
  - Standard nursing narratives
  - Population of narratives
  - Identification of new concept
- Extended version of ICNP

- EMR System
  - Clinical Data Repository
  - Store
  - Retrieve
  - Ul's for Data Entry
Clinical Data Repository (CDR)

- CDR, which allows the end-users to access and retrieve the patients’ data directly, was created.
- There are several predefined query functions for specific nursing problems such as pressure ulcers, medication errors, and breast feeding.
- The system also provides query functions with Boolean conditions such as smoking or non-smoking.
- In addition, the system allows the users to create their own queries using any ICNP concepts since structured nursing narratives are mapped to the ICNP concepts.
Purpose

• To explore the usefulness of nursing narratives documented in an ICNP-based electronic nursing records system for different nursing research topics
• 1st study: Study of discrepancies between actual and required nursing care time for nursing management
• 2nd study: Study of practice variations in pressure ulcer care
• 3rd study: Monitoring the adverse drug events (ADEs) in cancer patients
Research Question in the 1st Study

• Are there any gaps between required nursing care time estimated based on patient classification and actual nursing care time based on current staffing level?
Methods

• Retrieved the patient classification data documented in the nursing records of 124,416 patients discharged from 2005 to 2007

• **Required nursing care time** was average nursing care time for a patient estimated by multiplying the nursing care time each class by the number of patients of that class and summed for all class
  
  – Required nursing care time = \( \sum_1^4 (\text{Number of patients}) \times (\text{Number of care time}) \).
Methods

• **Actual nursing care time** based on staffing level is the average nursing care time used for a patient care
  – Staff-mix information comes from the management information system and admission, and discharge and transfer information of patients comes from the billing system.

• Compared required nursing care time with actual nursing care time
Patterns of patient classification-based nursing care time by unit
Comparison of Discrepancies between Required Nursing Care Time Estimated based on Patient Classification and Actual Nursing Care Time

F = 16.42**
F = 23.54**
F = 9.26**
F = 5.22*
F = 4.54*
F = 7.88*
F = 2.37
Results

• The pediatric and geriatric units showed relatively high staffing needs and the trends of understaffing over time.

Research Questions in the 2\textsuperscript{nd} Study

• Can we estimate pressure ulcer incidence using nursing records?

• Are there any practice variations in the nursing interventions documented to prevent and treat pressure ulcer between the pressure-ulcer group and pressure-ulcer risk group?

• Is there any difference in nursing interventions in relation to the patients' medical problems and the characteristics of the nurses who cared for them?
Methods

• The narrative nursing notes of 41891 ICU patients who were discharged in 2007 were analyzed.
• We selected possible subjects by limiting patients with five nursing problems related to the risk of pressure ulcers and actual pressure ulcers: risk of impaired tissue integrity, impaired physical mobility, imbalanced nutrition, high risk for infection related to exposures of the ulcer base, and high risk for ineffective therapeutic regimen management.
Methods

• Then seven areas of nursing intervention related to the previously mentioned five nursing problems were searched: sensory/mobility condition, nutritional condition, ulcer wound care, exercise, position change, skin condition, and use of devices.

• We retrieved nursing interventions using the query builder module in the CDR. For example, the skin condition category has 40 standardized activity statements, such as "dry up the skin," "observe redness on skin," "keep the bed as flat as possible," "observe skin dryness," and "assess skin color."
Methods

• The frequencies of different nursing interventions for pressure-ulcer prevention and treatment were compared between the pressure-ulcer group and pressure-ulcer risk group, as were the characteristics of the nurses who were cared for the patients in these two groups.

• Nursing interventions for pressure-ulcer were also assessed relative to the patients' medical problems.
Table 1 Incidence Rates of Pressure Ulcers and Frequencies of Nursing Interventions by Nursing Unit

<table>
<thead>
<tr>
<th>Nursing Unit</th>
<th>Total No. of Patients</th>
<th>No. of Patients With Pressure Ulcer, %</th>
<th>No. of Relevant Interventions</th>
<th>No. of Interventions per Patient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pediatric</td>
<td>3454</td>
<td>3 (0.09)</td>
<td>192</td>
<td>0.06</td>
</tr>
<tr>
<td>Women’s health</td>
<td>2352</td>
<td>8 (0.34)</td>
<td>260</td>
<td>0.11</td>
</tr>
<tr>
<td>Surgical</td>
<td>11,152</td>
<td>114 (1.02)</td>
<td>9194</td>
<td>0.82</td>
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<tr>
<td>Orthopedic and rehabilitation</td>
<td>5478</td>
<td>110 (2.01)</td>
<td>8028</td>
<td>1.47</td>
</tr>
<tr>
<td>Medical</td>
<td>15,718</td>
<td>282 (1.80)</td>
<td>25,552</td>
<td>1.63</td>
</tr>
<tr>
<td>Geriatric</td>
<td>1821</td>
<td>92 (5.06)</td>
<td>7427</td>
<td>4.08</td>
</tr>
<tr>
<td>ICUs</td>
<td>1916</td>
<td>165 (8.64)</td>
<td>43,864</td>
<td>22.89</td>
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<tr>
<td>Total</td>
<td>41,891</td>
<td>774 (1.85)</td>
<td>94,517</td>
<td>2.26</td>
</tr>
</tbody>
</table>
Table 2 Comparison of Frequency of Performed Nursing Interventions by Intervention Category

<table>
<thead>
<tr>
<th>Intervention Category</th>
<th>Sensory/Mobility Condition</th>
<th>Nutritional Condition</th>
<th>Ulcer Wound Care</th>
<th>Exercise</th>
<th>Position Change</th>
<th>Skin Condition</th>
<th>Use of Devices</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pediatric</td>
<td>2</td>
<td>19</td>
<td>45</td>
<td>0</td>
<td>84</td>
<td>2</td>
<td>40</td>
<td>192</td>
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<tr>
<td>Women's health</td>
<td>0</td>
<td>83</td>
<td>93</td>
<td>1</td>
<td>14</td>
<td>1</td>
<td>68</td>
<td>260</td>
</tr>
<tr>
<td>Surgical</td>
<td>24</td>
<td>(31.92)</td>
<td>(35.77)</td>
<td>(0.38)</td>
<td>(5.38)</td>
<td>(0.38)</td>
<td>(26.15)</td>
<td>(100)</td>
</tr>
<tr>
<td>Orthopedic &amp; rehabilitation</td>
<td>3</td>
<td>(0.64)</td>
<td>(6.95)</td>
<td>(0.39)</td>
<td>(81.86)</td>
<td>(1.08)</td>
<td>(9.04)</td>
<td>(100)</td>
</tr>
<tr>
<td>Medical</td>
<td>97</td>
<td>(1.55)</td>
<td>(21.00)</td>
<td>(0.27)</td>
<td>(65.86)</td>
<td>(0.97)</td>
<td>(9.96)</td>
<td>(100)</td>
</tr>
<tr>
<td>Geriatric</td>
<td>0</td>
<td>(0.81)</td>
<td>(13.34)</td>
<td>(0.40)</td>
<td>(79.76)</td>
<td>(0.40)</td>
<td>(5.68)</td>
<td>(100)</td>
</tr>
<tr>
<td>ICUs</td>
<td>3</td>
<td>(0.07)</td>
<td>(5.93)</td>
<td>(0.03)</td>
<td>(91.75)</td>
<td>(1.54)</td>
<td>(0.37)</td>
<td>(100)</td>
</tr>
<tr>
<td>Total</td>
<td>129</td>
<td>866</td>
<td>11 635</td>
<td>125</td>
<td>75 357</td>
<td>1244</td>
<td>5161</td>
<td>94 517</td>
</tr>
</tbody>
</table>
Variations in Nursing Activities related to Pressure Ulcers
Conclusion

- With the practice variation study, we were able to track nursing interventions for pressure ulcer care. We found that there are nursing practice variations by nursing unit.
Research Question in the 3\textsuperscript{rd} Study

• Can we estimate the incidence of adverse drug events (ADEs)?
• Can we estimate the frequency and the duration of nausea by analyzing nursing narratives documented in a standardized terminology-based electronic nursing records system?
Method

• Reviewed 156,339 nursing narratives documented over 3320 days for 487 admissions of cancer patients who were treated with cisplatin between July 1 and December 31, 2009.

• Analyzed nursing narratives with the terms “adverse drug reaction,” “allergy,” “hypersensitivity,” and other ADEs associated with cisplatin described in the prescription information approved by the Korea Food and Drug Administration.

• Examined the frequency and duration of nausea in more detail.
Result

- Nursing narratives documenting the presence or absence of an “adverse drug reaction,” “allergy,” and “hypersensitivity” were found in 162 (33.3%) of the nursing records of the 487 patients.
- Nursing narratives documenting the presence or absence of ADEs due to cisplatin were found in 476 (97.7%) of the nursing records.
- At least 1 ADE was noted in 258 of the 487 patients (53.0%).
- The presence of nausea was documented in 214 (43.9%) of the 487 patients’ nursing records; the mean duration of this nausea was 5.17 days.
Conclusion

• Conclusion: ADEs can be monitored by using narrative nursing statements documented in standardized terminology-based electronic nursing records.

• CIN 2013 Jan;31(1):45-51.
Next Generation ENR: Generating nursing narratives using detailed clinical models and integrating evidence into nursing catalogues development
Development Phases of ENR based on DCM and CPG

• Generating nursing narratives using DCMs
• Identifying the relevant evidence
• Linking nursing narratives with evidence
• Developing a DCMs and CPGs-based ENR system
• Evaluating the system
Development Phase of ENR based DCM and CPG

ICNP
10011088 Labor pain
10019721 Time point or time interval
10006379 Duration
...

Terminology binding

 Detailed clinical models
Entity: labor pain
Attribute: interval/duration/regularity
Value: irregular
...

Generating nursing statements

Clinical practice guidelines
Intrapartum care,
Suspected labor:
labor pain

Nursing statements
Labor pain presents at 5-minute intervals
Labor pain contraction persist for 30 seconds
Irregular labor pain exists
...

Grouping nursing statements

Recommendations
Assess labor pain

Set of nursing statements
Assess labor pain
Labor pain presents at 5-minute intervals
Labor pain contraction persist for 30 seconds
Irregular labor pain exists
...

Nursing records
Assess labor pain
Irregular labor pain exists
...

Documentation
Detailed Clinical Model

- Data model consisted of entity-attribute-value triplet
- Entity: Focus or core concept of data element
- Attribute: Qualifier or modifier needed to describe characteristics of entity in more detail
- Value: Possible instances of attribute to realize characteristics of element
- Optionality: Indicate if attribute is optional or mandatory to describe an element
- Data type: type of value an attribute can take
Example of DCM: Labour pain

Labour pain

- Duration: 2 (Datatype: REAL, Optionality: mandatory, Unit: sec)
- Interval: 5 (Datatype: REAL, Optionality: mandatory, Unit: sec)
- Occurrence: 20110807_1315 (Datatype: TS, Optionality: optional)
- Rhythm: regular (Datatype: SC, Optionality: optional)
- Severity: severe (Datatype: SC, Optionality: optional)
An overview of a natural language generation system for nursing narratives

**INPUT**

- Semantic knowledge
  - DCM (entity-attribute-value triplet)
  - Vocabulary for entity, attributes, and values
  - Possible combination of attributes

- Syntactic knowledge
  - Entity-attribute order by type of statement
    - Entity-modifier
    - Attribute-modifier
    - Value-modifier

- Contextual knowledge
  - Subject of information
  - Entity-type of statement
    - Tense

**PROCESS**

Generator

**OUTPUT**

Generated nursing narratives
Generating nursing narratives using ‘labor pain’ DCM.

**Detailed clinical model**

**Entity**
- Labor pain

**Attribute**  
- Duration  
  - Unit: minute
- Interval  
  - Unit: minute
- Severity  
  - Absent, mild, moderate, severe
- Regularity  
  - Regular, irregular
- Occurrence  
  - Unit: yyyymmddhhmm

**Nursing statements**

**Nursing statements with 1 attribute**
- No labor pain
- Labor pain presents (duration, 2 minutes)
- Labor pain presents (interval, 3 minutes)
- Labor pain presents (severity, severe)
- Labor pain presents (regularity, regular)
- Labor pain presents (occurrence, 20120420 06:10)

.....

**Nursing statements with 2 attributes**
- Labor pain presents (duration, 2 minutes; interval, 3 minutes)
- Labor pain presents (occurrence, 20120420 06:10; severity, severe)

.....

**Nursing statements with 3 attributes**
- Labor pain presents (duration, 2 minutes; interval, 3 minutes; severity, severe)
- Labor pain presents (occurrence, 20120420 06:10; severity, mild; regularity, irregular)

.....

**Nursing statements with 4 attributes**
- Labor pain presents (duration, 2 minutes; interval, 3 minutes; occurrence, 20120420 06:10; severity, severe)

.....

**Nursing statements with 5 attributes**
- Labor pain presents (duration, 2 minutes; interval, 3 minutes; severity, severe; regularity, regular; occurrence, 20120420 06:10)

.....
Nursing Narratives Sets of Intrapartum Care for Vaginal Delivery

Guideline
Intrapartum care for vaginal delivery

Stage of labor
Suspected labor

Patient problem
Labor pain

Recommendation
Assess labor pain

Nursing statement
Assess labor pain
Labor pain presents at 5-minute intervals
Labor pain contraction persist for 30 seconds
Irregular labor pain exists...

Teach breathing technique

Teach breathing, relaxation and visualization techniques

Encourage ambulation
Encourage patient to ambulate as tolerated

Explain labor progress
Keep patient and caregiver informed of labor progress, including cervical dilatation, effacement, position, and fetal decent
Guideline

분만 중 갑호

Item
Observations on Presentation in Suspected Labour/ Labour pain

Detailed Recommendation

Assessing
분만 동종을 시정한다

Teaching
라마즈 호흡법을 교육한다

Performing
허리통증부위 마사지함

Managing
분만과정에 대한 정보 제공함

Generating

Standardized Data Dictionary: Nursing Statements

Nursing Statement Set

분만 동종 (간격: , 지속시간: , 정도: , 발생시점: , 규칙성: )

경한 분만 동종 있을
분만 동종 5분 간격으로 30초간 지속됨
분만 동종 15분 간격으로 규칙적적으로 있음
분만 동종 10분 간격으로 규칙적으로 있음
라마즈 출산법(호흡법/이완법/연상법) 교육함
라마즈 출산법(호흡법/이완법/연상법)을 하고 있음
편안한 자세 취해움
활성정후 측정함
따뜻한 방포대주움
베개로 지지해움
가족간호: 분만과정 및 보호자 지지 방법 교육하고 점서적 지지 제공함

...
Elements of the ENR system based on DCM and Clinical Practice Guidelines
Next Generation Electronic Nursing Records System

- Generating nursing statements based on EAV (entity-attributes-values) models
- Developing nursing catalogues based on Clinical Practice Guidelines
- Feasibility study was done for the maternity nursing units
- Currently an enterprise-wide system is under development
Thank you

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