Systematic Refinement of a Health Information Technology Time and Motion Workflow Instrument for Inpatient Nursing Care using a Standardized Interface Terminology

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ABSTRACT
Time and motion (T&M) studies provide an objective method to measure the expenditure of time by clinicians. While some instruments for T&M studies have been designed to evaluate health information technology (HIT), these instruments have not been designed for nursing workflow. We took an existing open source HIT T&M study application designed to evaluate physicians in the ambulatory setting and rationally adapted it through empirical observations to record nursing activities in the inpatient setting and linked this instrument to an existing interface terminology, the Omaha System. Nursing activities involved several dimensions and could include multiple activities occurring simultaneously, requiring significant instrument redesign. 94% of the activities from the study instrument mapped adequately to the Omaha System. T&M study instruments require customization in design optimize them for different environments, such as inpatient nursing, to enable optimal data collection. Interface terminologies show promise as a framework for recording and analyzing T&M study data.

INTRODUCTION
With the complexity of our current healthcare environment, nurses increasingly function as knowledge professionals, applying skills such as analysis, synthesis, and cross-disciplinary coordination.13 To improve efficiency and quality within healthcare, it is critical to understand nursing care activities and workflow.4,7 A major factor influencing nursing workflow is the interaction that nurses have with health information technology (HIT), primarily in the form of electronic health record (EHR) systems, where nurses frequently supply documentation, retrieve information, and coordinate care. EHR system implementation, which often involves major workflow adjustments for clinicians, can negatively impact patient care in some cases.8,9 Workflow studies to understand care processes and their relationship to documentation-related workflow both before and after EHR system implementation are critical to anticipating potential problems and supporting successful solutions for effective HIT implementation.

Time and motion (T&M) instruments and studies enable measurement of clinical workflow. These measurements provide the foundation for management and optimization of clinical workflow. If designed optimally, they can help to investigate the impact EHR implementation in the clinical setting. Most quantitative T&M studies record the duration of time providers spend on various clinical activities. Several of these studies have demonstrated negligible time impact of EHR implementation systems.10-14 Conversely qualitative investigations of the perceptions of providers suggest that unintended adverse workflow consequences may be associated with the implementation of EHRs.15-19 We speculate that these previous T&M studies may have been designed to gather data of insufficient granularity to assess certain aspects of the impact of EHR implementation on clinical work flow.17 The contradictory results between T&M studies and qualitative studies may be due to oversimplified workflow quantifiers, including averaging aggregated clinical time (time expenditures) used in previous T&M studies. Some researchers have concluded that while the average aggregated clinical time can be useful for time utilization studies, it does not reveal other important temporal dynamics embedded within clinical workflow.17

Nursing workflow is dynamic and detail-oriented, with multiple simultaneous activities and frequent interruptions. The complexity and rapidity of nursing activity increases the difficulty of an observation-based T&M study in the clinical care setting. Finishing one nursing care activity often involves going to multiple locations; obtaining many types of supplies and information; and communicating with patients, patients' family members, and other clinicians. In addition, several nursing activities may co-occur. For example, a nurse may administer intravenous medications while assessing the patient, or a nurse may walk to obtain supplies for patient procedures while simultaneously communicating with other clinicians. Previous T&M studies have been limited by the use of a data collection instrument capable of only recording one activity at a time. It is likely that these instruments and their resultant data
were insufficient for demonstrating the complexity and cognitive challenges inherent in nursing workflow. Classic T&M instrument design limits the number of activities and attributes of data that can be recorded, ultimately resulting in an oversimplification of workflow, which masks patterns in clinical care. In addition, purely recording a nurse activity (i.e., talking or walking) without documenting the purpose for the activity (i.e., the nurse was talking to a patient to assess pain) may also mask critical workflow patterns related to the focus of care. Consequently, there is a critical gap in current T&M study instruments for evaluating inpatient nursing care workflow. To address this gap, our goal was to develop an observational instrument that can accurately measure and classify complex, co-occurring nursing actions. The purpose of this project was to 1) rationally adapt an existing T&M HIT assessment instrument for recording nursing activities in the inpatient setting and 2) to evaluate the utility and feasibility of informing and linking this instrument with an existing interface terminology.

**BACKGROUND**

T&M studies provide an objective method to measure the expenditure of time by clinicians. For example, Pizziferri et al demonstrated that 71% of respondent physicians perceive an increasing time burden with electronic patient documentation whereas T&M study data on the same physicians showed no significance increase in documentation time. However, this study, along with others, did not assess the impact of workflow sequence changes associated with task execution.

**Nursing Workflow Studies**

Nursing workflow has been examined using several approaches, such as work sampling, self-reporting of activities, and continuous T&M observation. In work sampling, an independent observer intermittently records nursing activities, resulting in a record of activities without associated time factors. Nurse self-reporting of time and activity is a low-cost method for measuring work activities but has limitations including disruptions in workflow, time burden, and data reliability issues due to observer bias and interpretation of activity measures. In these studies, nurses typically record their activities retrospectively at infrequent intervals, greatly biasing the resulting data. In contrast, continuous T&M observation is a more objective but costly method of measuring nursing workflow. It captures very detailed and time-specific information related to health activities. T&M studies can be applied to improve care using lean design. Lean design is an innovative movement in healthcare, where the concept of “value-added care” and process improvement are essential to systematically re-designing and improving healthcare processes.

The Transforming Nursing Workflow study and the Quantifying Nursing Workflow in Medication Administration study exemplify some of the challenges in using an observational instrument to measure T&M in nursing. The Transforming Nursing Workflow study had four objectives: 1) determine nurses’ time expenditure on the computer and other work; 2) document baseline activity prior to introduction of new software; 3) discover nurse activity pattern, flow, and sequence; and 4) quantify nursing work for purposes of evaluating and re-designing nursing care roles. The investigators developed and utilized an observational tool for the study. They found that the most frequently observed nursing activities were assessment (18.1%), charting (9.9%), and communicating (11.8%). Many nursing activities were of extremely short duration, with less than 10 seconds of time recorded for 40% of all activities. The researchers interpreted that the nursing activity timeline data indicated no pattern or flow in nursing care. Instead, they report complex, chaotic circumstances that appeared to limit opportunities for nurses to use critical thinking to plan and engage in thoughtful nursing care. They concluded that constant task-shifting during nursing care negatively affects performance, especially related to complex decision-making and reasoning. This study highlighted the tension between measuring a small set of broad categories, versus a highly granular menu of nursing activities that would provide more detailed data. The authors emphasized the importance of ease in identifying the nursing activity items and recording the items in a standardized fashion.

In the Quantifying Nursing Workflow in Medication Administration, investigators employed a different customized observational tool. They found that nurses spent 25% of their time on medication administration and another 25% on communication. Medication administration activities appeared to occur via similar processes on different units. They observed that multi-tasking was common (e.g., the nurse observing the patient take an oral drug while talking with the family) but could not be documented accurately. Also, despite observer training and piloting of the instrument, there was variation in interpretation and recording of nursing activities.

These two studies emphasized the importance of standardized data collection in T&M observations. However, it is
impossible to compare results across studies due to the non-standardized nature of instruments that were developed. It was our hypothesis that the use of a standardized interface terminology to describe nursing activities could help to address this limitation.

**Interface Standards**

Interface terminologies, as opposed to reference terminologies that are designed for the secondary representation of data, are designed for use at the point of care. Because they are used to document care, we were interested in exploring the application of an interface terminology from an alternative perspective: using it to record data for T&M observer assessments of nursing care and processes. Nursing scholars have been leaders in the development of interface standards to describe health care assessments and activities since the 1970’s. There are 12 standardized terminologies recognized by the American Nurses Association. Of these, four are interface terminologies that can be used to describe nursing activities, including Nursing Intervention Classification (NIC), International Classification of Nursing Practice (ICNP), Clinical Care Classification (CCC), and the Omaha System. The Omaha System is particularly well-suited to describe nursing actions in a T&M study because of its hierarchical multi-axial, relational structure. It is amenable to automation, suitable for multidisciplinary use, and is highly granular in its depiction of activity in combination with the focus of care. Care descriptions are customizable, enabling precise notation for specialized purposes.

The Omaha System exists in the public domain. It is listed in the US Department of Health and Human Services interoperability standards for EHR systems after successfully passing the Healthcare Information Technology Standards Panel (HITSP) Tier 2 selection criteria for Use Cases in 2007. Also, it is integrated into the National Library of Medicine’s Metathesaurus; CINAHL; ABC Codes; NIDSEC; Logical Observation Identifiers, Names, and Codes (LOINC®); and SNOMED CT®. It is registered (recognized) by Health Level Seven (HL7®) and is congruent with the reference terminology model for the International Organization for Standardization (ISO). The Omaha System has three valid, reliable components: the Problem Classification Scheme, the Intervention Scheme, and the Problem Rating Scale for Outcomes. Omaha System codes are words instead of numbers, providing ease of use and clarity in mapping with other tools and systems. The Intervention Scheme is designed to describe health care activities, and therefore was the component of the Omaha System that we used. The Omaha System Intervention Scheme consists of four levels: a) the problem, or focus of care; b) the category, or action term; c) the target, a defined term that provides more detail about the intervention; and d) the care description, unstructured text that may be customized for a particular purpose, population, or service. One intervention consists of combined `term` term. Details about the Omaha System are available on-line.

The goals of the study were several-fold. First, we wanted to build a T&M instrument to measure baseline inpatient nursing activities prior to implementation of a new EHR system. Second, our objective was to facilitate time expenditure analysis (including activity ordering and different dimensions of activity) of nurses with different tasks categories, particularly usage of HIT, from several perspectives. Finally, we wished to explore structuring data collection using an interface terminology and to evaluate the utility of the Omaha System for these purposes.

**METHODS**

**Setting**

This study was conducted within a medical-surgical inpatient unit with 24 beds at a tertiary University-affiliated medical center. The hospital has over six hundred beds with multiple intensive care units and adult, pediatric, and maternal services. The hospital conducts more than 300 solid organ transplants annually. This particular nursing unit primarily provides care to adult patients both medical and surgical, most often caring for surgical patients with a 4 night average length of stay. There were a total of 44 registered nurses in the unit, with 4 to 8 nurses working at any one time, dependent upon unit census, along with 3 nursing station technicians (1 nursing station technician at the night shift) which is a combined certified nursing assistant and health unit coordinator role. Each shift lasts 8.5 hours, and each nurse usually cares for 3 to 4 patients on any given day shift and 4 to 5 patients during an evening shift.

**Overall Study design**

We defined workflow as “systems that help organizations to specify execute, monitor and coordinate flow of the work cases within a distributed office environment” and considered workflow process as “a predefined set of work steps, and partial ordering of these steps.” An existing open-source T&M study instrument developed from Agency for Healthcare Research and Quality (AHRQ) funding designed for evaluating the impact of HIT for physicians in...
an ambulatory setting was modified for this environment.\textsuperscript{12,16} The AHRQ HIT workflow instrument has an interface to an electronic form in Microsoft Access with an automatic time-date stamp function. This instrument provides the ability to capture provider activities rapidly and accurately. The instrument was initially developed by Overhage et al. and was modified by Pizziferri et al.\textsuperscript{12,16} for outpatient physicians HIT workflow assessment. This instrument is available for download from the AHRQ website. There are 60 total clinical activities for physicians classified under 12 categories such as 'computer-read' or 'computer-Looking for' (Figure 1).

**Figure 1.** Screen shot of Original T&M Instrument

<table>
<thead>
<tr>
<th>Computer - Read</th>
<th>Computer - Looking for</th>
<th>Computer - Writing</th>
<th>Procedures</th>
<th>Talking</th>
<th>Writing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chart</td>
<td>chart</td>
<td>note</td>
<td>exam patient</td>
<td>advance directives</td>
<td>computer</td>
</tr>
<tr>
<td>Data ( Labs, Others)</td>
<td>data</td>
<td>orders</td>
<td>EKG</td>
<td>colleague/Staff for Pt.</td>
<td>paper</td>
</tr>
<tr>
<td>Drug Reference</td>
<td>radiograph</td>
<td>forms</td>
<td>IV</td>
<td>colleague/Staff for non-pl</td>
<td>patient</td>
</tr>
<tr>
<td>Article</td>
<td>patient</td>
<td>forms</td>
<td>joint inf/asp</td>
<td>educating patient</td>
<td>phone</td>
</tr>
<tr>
<td>Reviewing Dictation</td>
<td>patient</td>
<td>forms</td>
<td>lab test</td>
<td>patient family</td>
<td>consultant</td>
</tr>
<tr>
<td>Literature Search</td>
<td>colleague</td>
<td>forms</td>
<td>pelvic exam</td>
<td>patient</td>
<td>consultant</td>
</tr>
<tr>
<td>Schedule</td>
<td>consultant</td>
<td>forms</td>
<td>phlebotomy</td>
<td>patient</td>
<td>consultant</td>
</tr>
<tr>
<td>Pvt. Email</td>
<td>consultant</td>
<td>forms</td>
<td>other</td>
<td>study consent</td>
<td>other</td>
</tr>
<tr>
<td>Forms</td>
<td>other</td>
<td>forms</td>
<td>other</td>
<td>other</td>
<td>other</td>
</tr>
</tbody>
</table>

**Paper - Read**

- Chart
- Data ( Labs, Others)
- Drug Reference
- Article
- Reviewing Dictation
- Literature Search
- Schedule
- Pvt. Email
- Forms
- Other

**Paper - Looking for**

- Chart
- Data ( Labs, Others)
- Drug Reference
- Article
- Reviewing Dictation
- Literature Search
- Schedule
- Pvt. Email
- Forms
- Other

**Paper - Writing**

- Note
- Orders
- Forms
- Other

**Personal**

- Eating
- id
- Restroom
- Email
- Patient Diary
- Other

**Walking**

- Inside
- Outside
- Other

**Phone**

- Patient
- Getting Results
- Scheduling Tests
- Paging
- Dictating Notes
- Personal
- Other

The objectives of this study were to rationally adapt the original T&M instrument to record nursing activities in the inpatient setting and evaluate the utility and feasibility of informing and linking this instrument with an existing interface terminology. The original T&M instrument was adapted with empiric observational studies (1) and then refined with content experts (2) (Figure 2). The T&M instrument actions were mapped to the Omaha System with the assistance of content experts (3), and the refined instrument was evaluated by conducting follow-up observational sessions with the refined T&M instrument at the point of care (4). This study was approved by the University of Minnesota Institutional Review Board Committee.

**Figure 2.** Overview of study design.

**Inpatient nursing T&M instrument refinement**

As a baseline, nurses were shadowed in three sessions over three days for a total of 14 hours. The data from these sessions provided primary observations of nursing activities and different aspects nursing workflow. The shadowing researcher took an anthropologic approach, observing nurse activities at the point of care on a tablet personal computer. These notes were then summarized and categorized into different tasks by three of the investigators (YZ, GM, MD). Demographic and other basic information about the nurses were collected with each study session, including years of experience in nursing, age, and length of time using the EHR system application.

Over a separate set of follow-up sessions (n=10), these tasks and their characteristics were grouped using the
framework from the original T&M instrument and discussed with content experts to generate further nursing actions. These content experts included two physicians (GM, TA), a nursing terminology expert (KM), and five practicing nurses (including the nurse manager and an experienced charge nurse) (MD). Several of these modifications were based off additional considerations discovered during interface terminology mapping. These adaptations were made using paper mock-ups of potential data elements for the workflow instrument. After the final data elements and mock-up interface were defined, the mock-up changes were added to the user interface and database for the original T&M instrument to create a module for observing nursing care in the inpatient setting.

Mapping nursing care workflow observations to the Omaha system
Each of the defined nursing actions in the refined T&M instrument was mapped to Omaha system problem, category, and target terms by a nursing terminology expert with extensive experience with the Omaha system (KM). Inter-rater reliability was assessed on a subset of these mappings (n=20, a 30% subset) by another investigator with experience with the Omaha system (GM). Both Kappa and percent agreement are reported for overall mappings and each of the axes of target mapping. These mappings were then added to the refined T&M instrument as a linked table in the database, allowing for this data to be collected in the process of workflow assessment.

Refined T&M instrument evaluation
The refined T&M instrument was then utilized and validated in four follow-up observational sessions with nurses on the same inpatient unit. Issues with the instrument were recorded by the researcher, along with direct observations, which were compiled in the final analysis.

RESULTS
Inpatient nursing T&M instrument refinement
Over a total of 3 empiric observational sessions and 10 iterative content expert vetting sessions, there were 69 additional unique observations in the inpatient nursing setting perceived as valuable that were not covered in the original T&M instrument (Table 1). Of these, 22 (32%) of observations were in common or similar with the original T&M instrument, 40 (58%) were new and did not overlap at all, and 7 (10%) were of greater granularity than the original T&M instrument. 55 (65%) of items were removed from the instrument due to the differences in activities between nurses, physicians, and environment (e.g., inpatient versus outpatient settings).

Through empiric observations and content expert input, nursing activity observations appeared to have multiple-dimensions. While most T&M instruments collect data in 2 dimensions (activity and time-date stamp), we observed multiple additional attributes with potential utility to understanding clinician activity, including 1) location of activity; 2) whom the activity served (generic identification of receiver of action); 3) whether the nurse was walking, sitting, or standing when performing an activity (position), 4) the stage of the care, such as admission, ongoing care, or discharge; and 5) the clinical purpose of the activities, such as pain management or bowel care. Nurses often engaged in multiple actions simultaneously. We modified the instrument to enable the collection of more than one action at a time, particularly when a nurse talks and performs a task simultaneously.

After mapping activities to the Omaha system (next section), the T&M instrument was further refined. Modifications included: 1) under intervention activities: checking monitor, physical assessment, interactive activities, correcting environment, personal hygiene, exercise, collecting specimen, and urinary care and 2) recording the clinical purpose of activities including pain management, bowel care, wound care, activity or exercise. A screenshot of the refined T&M instrument is depicted in Figure 3.

Mapping nursing care workflow observations to the Omaha system
Items in the refined T&M instrument were mapped to the Omaha System. In the refined T&M instrument, 64 unique nursing activities were mapped to 6 Omaha System problems, 4 categories, and 14 targets (Tables 2 and 3). Also, Omaha System problems Pain, Bowel care, Skin, Physical activity, and Urinary Care were incorporated into the instrument as the Clinical Purpose for detailed interventions. The most common target was communication, followed by education, signs/symptoms physical, and medication administration (Table 3). Inter-rater reliability on 30 mappings demonstrated percent agreement (100%, 95%, and 95%) and Kappa (1.00, 0.87, and 0.91) for problem, category, and target terms, respectively. Unmapped elements from the instrument were not interventions or a care focus; they included data dimensions from interface such as location (patient room, med room, station, supply room); position (walking, sitting, standing); and personal activities (eating/drinking, personal break, idle, other) resulting in successful mappings for 60 (94%) activities.
Table 1. Comparison of activities in the original T&M instrument and refined T&M instrument.

<table>
<thead>
<tr>
<th>Unchanged</th>
<th>Modified-Different Granularity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Computer-Read:</strong> Lab Data, Drug Reference</td>
<td><strong>Computer-Read:</strong> Chart (change to Assessment, Vital Signs I/O)</td>
</tr>
<tr>
<td><strong>Computer-Looking for:</strong> Forms, Patient</td>
<td><strong>Procedures (Intervention):</strong> Exam Patient, (change to Checking Monitor, Physical assessment)</td>
</tr>
<tr>
<td><strong>Computer-Writing:</strong> Note, Orders, E-mails</td>
<td><strong>Talking:</strong> Patient Family, Patient (change to Pt/Family Non-clinical)</td>
</tr>
<tr>
<td><strong>Intervention(Procedures):</strong> IV, Lab Test (as collecting specimen)</td>
<td><strong>Paper-Read, Paper-Looking for, Paper-Writing:</strong> Forms (change to Administrative Tasks: Prepare</td>
</tr>
<tr>
<td><strong>Talking:</strong> Colleague/Staff for Pt, Colleague/Staff for non-pt, Educating Patient</td>
<td></td>
</tr>
<tr>
<td><strong>Writing-paper:</strong> Orders, Note</td>
<td><strong>Phone:</strong> Getting Results, Scheduling Tests as (Other Department/Clinicians)</td>
</tr>
<tr>
<td><strong>Personal:</strong> Eating, Idle, Restroom, Other</td>
<td></td>
</tr>
<tr>
<td><strong>Phone:</strong> Patient, Paging, Personal</td>
<td></td>
</tr>
<tr>
<td><strong>Waiting:</strong> Computer, Patient</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Removed</th>
<th>New</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Computer-Read:</strong> Article, Reviewing Dictation, Literature Search, Schedule, Pt, Email, Form, Other</td>
<td><strong>Computer-Read:</strong> Order, Medication Detail, Documentation on Patient, Diagnosis/Treatment Reference, Guidelines, Policies, Procedures</td>
</tr>
<tr>
<td><strong>Computer-Looking for:</strong> Chart, Data, Lab Result, Radiograph, Patient, Colleague, Consultant, Other</td>
<td><strong>Computer-Looking for:</strong> Task list, Contact Information</td>
</tr>
<tr>
<td><strong>Computer-Writing:</strong> Forms, Other</td>
<td><strong>Computer-Writing:</strong> Nursing Intervention, Shift Summary, Education, Assessment, Vital Signs I/O, Implementing Orders, Add New Parameter, Progress note on PT.</td>
</tr>
<tr>
<td><strong>Procedures (Intervention):</strong> EKG, Joint Inj/Asp, Pelvic Exam, Phlebotomy, Other</td>
<td><strong>Intervention:</strong> Patient service (non-clinical), Check Medication, Wound/Skin Care, Prepare Medication or Supplies, Administer Intravenous Fluid or Medication, Administer Non-Intravenous Medication, Interactive Activities, Correcting Environment, Collecting Specimen, Ostomy Care, Personal Hygiene, Exercise, Urinary Care</td>
</tr>
<tr>
<td><strong>Talking:</strong> Advance Directives, Consultant, Study Consent, Other</td>
<td><strong>Talking:</strong> Pt/Family Assessment</td>
</tr>
<tr>
<td><strong>Paper-Read:</strong> Chart, Data (Labs, Others), Drug Reference, Article, Review Dictations, Books, Schedule, Mail, Other</td>
<td><strong>Writing-paper:</strong> Self-Workflow Sheet, Nursing Assistant Sheet</td>
</tr>
<tr>
<td><strong>Paper-Looking for:</strong> Chart, Data, Lab Result, Radiograph, Patient, Colleague, Consultant, Other</td>
<td><strong>Waiting:</strong> Orders/Supply, Other Co-workers</td>
</tr>
<tr>
<td><strong>Paper-Writing:</strong> Mail, Other</td>
<td><strong>Administrative Tasks:</strong> Move Supply/Equipment, Send Labs, Miscellaneous questions, Helping Co-workers, Printing/Fax/Scanning</td>
</tr>
<tr>
<td><strong>Personal:</strong> Email, Palm/Diary</td>
<td><strong>Location:</strong> Patient room, Hallway, Station, Med room, Supply room</td>
</tr>
<tr>
<td><strong>Walking:</strong> Inside, Outside</td>
<td><strong>Status:</strong> Standing, Sitting, Walking</td>
</tr>
<tr>
<td><strong>Phone:</strong> Dictating Notes, Other</td>
<td><strong>Stage of Care:</strong> Admit Patient, Ongoing Care, Discharge Patient</td>
</tr>
<tr>
<td><strong>Paper-Looking for:</strong> Chart, Data, Lab Result, Radiograph, Patient, Colleague, Consultant, Forms, Other</td>
<td><strong>Clinical Purpose:</strong> Pain Management, Bowel Care, Wound, Activity, Exercise, Urinary Care</td>
</tr>
<tr>
<td><strong>Waiting:</strong> Paper, Phone, Other</td>
<td><strong>Patient Index:</strong> Pt1, Pt2, Pt3, Pt4 Pt5, Pt6</td>
</tr>
</tbody>
</table>

**Refined T&M instrument evaluation**

Over 21.5 hours of observations with the refined T&M instrument, we observed 1461 events; with 66 kinds of activities in 10 categories. 7 (10%) activities were not observed or recorded, including [computer-read: diagnosis/treatment reference]; [computer-looking for: task list, contact information]; [personal: phone]; [computer writing: education]; [waiting: orders/supply], [administrative tasks: send labs]. We were able to reconstruct the nursing workflow vividly based on the collected data such as where the activity happened and how long the activity lasted; how the nurse performed the task (moving or still); which patient triggered this activity; or whether the nurse communicated with the patient while perform the activity.

**Figure 3.** Screenshot of Refined T&M Instrument.

*Note: The modified portions or new added elements of the interface are highlighted in red font.*

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Table 2. Summarized mapping of T&M instrument items to the Omaha System.
CM = Case management, S = Surveillance, TGC = Teaching, guidance, and counseling, TP = Treatments and procedures

<table>
<thead>
<tr>
<th>Problem</th>
<th>Category</th>
<th>Number of different targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bowel care</td>
<td></td>
<td>CM = 1, S = 1, TGC = 1, TP = 1</td>
</tr>
<tr>
<td>Health care supervision</td>
<td></td>
<td>CM = 48, S = 2, TGC = 4, TP = 2, 14</td>
</tr>
<tr>
<td>Medication regimen</td>
<td></td>
<td>CM = 1, S = 3, TGC = 2, TP = 2</td>
</tr>
<tr>
<td>Personal care</td>
<td></td>
<td>CM = 1, S = 1, TGC = 1, TP = 1</td>
</tr>
<tr>
<td>Physical activity</td>
<td></td>
<td>CM = 1, S = 1, TGC = 1, TP = 1</td>
</tr>
<tr>
<td>Skin</td>
<td></td>
<td>CM = 1, S = 1, TGC = 1, TP = 1</td>
</tr>
</tbody>
</table>

Table 3. Distribution of mapped Omaha System targets from nursing activities.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>communication</td>
</tr>
<tr>
<td>5</td>
<td>education</td>
</tr>
<tr>
<td>4</td>
<td>signs/symptoms - physical</td>
</tr>
<tr>
<td>3</td>
<td>medication administration</td>
</tr>
<tr>
<td>2</td>
<td>laboratory findings, medical/dental care, nursing care, supplies</td>
</tr>
<tr>
<td>1</td>
<td>ostomy care, continuity of care, dressing change/wound care, durable medical equipment, environment, exercises, interaction, medication coordination/ordering, medication set up, personal hygiene, specimen collection, transportation</td>
</tr>
</tbody>
</table>

DISCUSSION
This study addresses the need for an improved T&M instrument for observing nursing workflow relative to EHR use, in preparation for use within the inpatient medical surgical environment before and after implementation of an EHR system at our institution. This instrument goes beyond previous T&M instruments for health care settings because it enables simultaneous recording of two activities, identification of a single focus of care for multiple activities, and recording of multiple dimensions for providing nursing care. During the development and testing of the instrument, observations were made before and after multi-activity functionality was added, and the total number of interventions observed increased considerably. This functionality will greatly improve data granularity and quality, as observers will not have to prioritize which of two activities to record during a given observation. More granular
data may enable previously hidden data patterns to be discovered. Limitations of the instrument are that only two activities can be recorded simultaneously, and that the total time expended by the nurse for the two co-occurring activities requires careful analysis of tasks (as time can “double-count” when 2 tasks are performed simultaneously).

Mapping of Omaha System terms to nursing activities was successful. Observation data from this T&M instrument can be analyzed and compared with future studies because it is standardized data. This will increase the ability to interpret and report findings between studies. Because of the Omaha System mappings, activity data will be related to focus and details of care, and can be aggregated across multiple axes (problems, categories, targets). Use of the Omaha System may also increase reliability of data, because observers can be trained in the definitions of Omaha System terms. Thus, use of the Omaha System addresses several limitations observed in previous studies. 7,27

The purpose of the original AHRQ T&M instrument was to assess changes in workflow related to HIT implementation in outpatient primary care settings. The adapted instrument will also be used to assess change in workflow related to HIT implementation for nurses in inpatient hospital settings. This emphasis is reflected in the granularity of the instrument with respect to clinical documentation, in which many discrete activities map to the Health care supervision problem, the case management category, and the communication target. For example, documentation of patient care in the computer consists of seven interventions, all of which have these three [problem+category+target] terms, but differ in the care description according to the aspect of patient care or assessment that is being recorded.

The refined T&M instrument can easily be modified by changing the standardized terms to reflect the particular focus of the T&M question. For example, a T&M study examining nursing workflow related to cardiac rehabilitation care would require increased granularity of observations related to nurse-patient interaction and equipment, vs. the granularity in computerized documentation activities in this version of the T&M instrument. The instrument will be used to assess differences in nursing workflow before and after implementation of a new HIT system on a medical surgical unit having mostly abdominal surgery patients. For this reason, bowel care was selected as a care focus in the present study, using specific terms related to bowel care, ostomy care, wound care, and pain. The comprehensive problem selection available in the Omaha System enables future T&M instrument refinements to be customized for any health care focus. For example, a hospice unit T&M may include terms for end of life care, pain, and grief; while an inpatient psychiatric unit may include terms for mental health, coping skills, signs/symptoms mental-emotional, and social contact. Resultant data could be then be compared and benchmarked as a universal metric for multidisciplinary T&M studies. Because the Omaha System has been translated into many languages, there is potential to expand use of the instrument internationally. A Chinese language version of the instrument is currently available.

This study is limited in that it is a one-time evaluation of an EHR system implementation. The ultimate desired analysis of nursing workflow and impact of HIT are ongoing. Thus, we approached the problem from the perspective that T&M instruments should be both adaptable and standardized for reliable observation of diverse workflow contexts. This revised instrument will provide future researchers with a framework to record multiple dimensions of nursing actions in a standardized manner. The study turns the traditional use of an interface terminology on its head and applies the Omaha System to the task of documenting nursing actions in practice by an observer. We plan follow-up studies to utilize our refined T&M instrument to observe and improve the current EHR system implementation at our institution, as well as to extend this instrument to the outpatient nursing setting where there will be a phased EHR system implementation.

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