NURSES MAKE UP the single largest component of human capital within the health care system, yet little is known about the added value nurses bring to patient care. How can this value be measured? This is a difficult question to answer in the current health care environment. Competing policy, payment, and clinical priorities are calling for higher quality of care, better outcomes, and lower costs (Berwick, Nolan, & Whittington, 2008), but very little is known about the cost and quality of nursing care and, specifically, the effectiveness of each nurse providing care (Pappas & Welton, 2015).

In this article, the efforts and results of a national expert workgroup tasked with defining and measuring nursing care value, including a data model to allow extraction of key information from electronic health records to measure nursing care value, are described. The final results and recommendations of an expert workgroup tasked with developing methods to measure nursing value are described. The workgroup is a component of the ongoing efforts of a group of nurses and other professionals participating in a series of conferences exploring the potential of big data in nursing and health care. Sponsored by the University of Minnesota School of Nursing, this endeavor addresses a key question of how we can use emerging large data from electronic health records (EHR) to identify opportunities to improve nursing and health care and share and compare data about nursing care across many different settings (Westra, Clancy et al., 2015; Westra, Latimer et al., 2015).

Nursing care value can be conceptualized as the relationship between nursing cost and quality or cost vs. outcomes (Pappas, 2013). There are several measures that can be used to identify nurse-sensitive quality measures such as reduction or elimination of patient falls, pressure ulcers and infections, etc. (Kane, Shamliyan, Mueller, Duval, & Wilt, 2007). While quality can be measured as discrete events, the cost of nursing care is difficult or impossible to measure on a per patient basis.

Nursing care is embedded in a health care accounting system that was designed in the 1930s and places nurses within a room and board charge (Thompson & Diers, 1991). There is no direct link in most billing systems between individual nurses and patients, and the lack of patient-level costing of nursing care creates an odd financial metric that treats all nursing care of patients within a hospital or most other health care settings as an average cost across many nurses and many patients, stratified only by level of care (e.g., intensive care unit vs. medical-surgical unit). Hospitals use nursing hours and nursing costs per patient day (NHPPD/NCPD) based on monthly or quarterly summary data. This leads to the question, what is an “average” patient?

As we move toward a value-oriented health care system, there is a growing need to address the largest human capital component of the system, nursing care, and devise methods and actions to better understand how nursing costs and resources are expended for each patient and how these relate to the quality and outcomes of
There is no direct relationship between nursing resources expended and the billing and reimbursement for care. This introduces potential biases, e.g., nursing care is under-billed or under-reimbursed for complex patients (who receive above-average hours/costs of nursing care compared to other patients) and overbilled/reimbursed for less-complex patients. This system is unfair in both cases and lacks transparency within the health care finance system (Dalton, 2007; Dalton, Freeman, & Bragg, 2008).

**Value-Based Nursing Care Framework**

In a prior article identifying the preliminary findings of the expert workgroup, we made a proposal to reorient how to collect data about nursing care by focusing on the individual nurse as a provider of care and identify the interaction or encounter of a nurse and a patient, family, or community (Welton & Harper, 2015). This change in measuring nursing care at the individual nurse-patient encounter affects the data collected about patient care and how those data are analyzed to improve care and decrease nursing costs. For example, instead of using NHPPD, actual patient-level nursing hours can be calculated as they vary over the course of a hospitalization for every patient.

This new approach will require a unique identifier for each nurse that can be linked to each patient in the EHR. There are a number of current examples where this already occurs such as bar code medication administration or the nurse-patient assignment. Having such a link within the EHR will allow new analysis of nursing care and provide multiple frames of reference starting at the individual patient.

The ability to measure and understand how nurses affect the care and outcomes of each patient will change our thinking about nurse staffing from a ratio orientation to one where each patient will be matched with the best nurse given the patient’s needs and available nursing resources. Capturing data at the individual nurse-patient encounter or assignment will allow much more granular analysis of nursing care systems and create opportunities to build new clinical and operational data repositories (Zielstorff, Hudgings, & Grobe, 1993).

**The Data Challenge**

One challenge in measuring and analyzing nursing care value is accessing relevant data within various EHR systems. Nurse leaders and clinicians are often stymied when working with information technology personnel to identify and extract data from the EHR. There can be long waits, inaccurate data, labor-intensive coding, and miscommunication between the information technology staff and nurses regarding the type of data needed to answer clinical and operational questions.

A second problem is how to extract similar data across multiple settings and different EHR systems to compare or benchmark nursing care. One emerging approach is to use a common data model to extract similar data from different systems (Overhage, Ryan, Reich, Hartzema, & Stang, 2012). Such a model can be used to capture a wide variety of nursing-sensitive and associated data (e.g., capturing patient-level nursing hours and costs by diagnosis across multiple hospitals).

Information derived and analyzed from a common data model could provide new insights such as identifying efficiency, effective-
### Table 1.
**Value-Based Metrics**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Traditional Model</th>
<th>Proposed Value-Based Model</th>
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</thead>
</table>
| **Costing (Direct and Indirect Care)** | - Nursing Costs Per Patient Day (NCPPD); nursing costs per visit (home health); nursing costs per patients seen (emergency room, clinic) | - Direct Nursing Care Costs Per Patient Day (DNCCPPD) as the actual cost of care from an individual nurse allocated to an individual patient.  
- Indirect Nursing Care Costs Per Patient Day (INCPPD) as the amount of indirect costs such as vacation, education, management, etc., allocated proportionally to each patient. |
| **Costing (All Costs)**    | - Sum of all nursing labor costs within a cost center by budget period\(^2\) | - Cost center: Sum of DNCPPD and INCPPD by budget period within a cost center.  
- Patient: Actual DNCPPD plus proportional INCPPD by case (e.g., sum for entire hospitalization, sum for series of home visits, etc.). |
| **Intensity**              | - Nursing Hours Per Patient Day (NCPPD)\(^2\)                                      | - Direct Nursing Hours Per Patient Day (DNHPPD) as the actual hours of care provided by an individual nurse allocated to an individual patient.  
- Indirect Nursing Hours Per Patient Day (INHPPD) as the nursing hours not directly allocatable to patients such as vacation, education, management, etc., allocated proportionally to each patient. |
| **Billing for Nursing Care** | - Daily room rate, clinic charge, home visit charge, etc.                          | - Separate billing for nursing care based on sum of DNCPPD and INCPPD (mark up), note billing will reflect the actual nursing resources and services provided to an individual patient. |
| **Reimbursement and DRG**   | - No direct reimbursement for nursing care  
- Average room costs across all patients as static DRG cost weight | - Separate nursing cost/revenue center, nursing service line  
- Nursing intensity weight for DRG |
| **Analytics**              | - Average nurse staffing levels (ratios)  
- NCPPD/NCPPD  
- Case mix index (CMI) | - Average direct and indirect nursing intensity (time) and costs per patient per case  
- Nursing CMI  
- Nursing acuity adjusted hours/costs |
| **Unit of Analysis**       | - Unit, hospital (many nurses, many patients)  
- Month or year | - Patient, nurse (individual nurses linked to each patient)  
- Real-time aggregated by time slice as appropriate |
| **Statistics**             | - Mean NCPPD/NCPPD (or nurse-patient ratios) (e.g., NDNQI\(^{TM}\) quarterly cross unit comparisons) | - Multi-level regression by patient, nurse, DRG |
| **Quality**                | - Retrospective aggregate level rates (e.g., falls rate by month/quarter) | - Patient-level quality metrics tied to actual care hours (intensity) and costs (e.g., additional nursing and hospital costs of a fall or infection [retrospective]).  
- Prospective predictive analytics of probability of adverse event occurring for an individual patient-based nursing acuity, patient demographics, or other patient, nurse, and unit factors. |
| **Productivity**           | - Mean unit-level productivity measures (e.g., productive/nonproductive hours percent by unit or cost center) | - Individual nurse/staff productivity (direct care hours/total hours)  
- Unit-level aggregate productivity |
| **Performance**            | - No known measures | - Individual/unit productivity metrics (e.g., patient-level pain assessment and PRN use of narcotics; medication administration delays and omissions, etc.) |
| **Nurse-Patient Encounter** | - Based on average nurse to patient ratios  
- Metrics include average nurse:patient ratios or NHPPD, nursing hours per home visit, nursing hours per member per month (primary care), etc. | - Based on individual patient acuity and nurse experience and acuity-adjusted workload  
- Metrics include average patient demand for nursing care, actual direct care hours allocated for each patient  
- Patient-level aggregate analysis including by day of stay; summary by DRG/diagnosis; summary patient-level data by unit or cost center |

**NOTES:**

NDNQI = National Database of Nursing Quality Indicators\(^{TM}\)

\(^1\) Direct care nursing costs are identifiable as those costs (and time) directly associated with a particular patient. Indirect care costs are those not associated with direct care, such as vacation or sick time, nurse managers, inservice education, etc. Costs per patient day can be allocated as per visit, cost per member per month, or other appropriate patient-level metric that is setting specific.

\(^2\) NCPPD/NCPPD subsumes both direct care and indirect care costs and time and typically are not unbundled.

\(^3\) The nurse-patient encounter can be any relationship between a nurse and patient (e.g., an assignment in a hospital setting, a home health care visit, an interaction with a student in a school based clinic, etc.).
ness, and performance of nursing care systems and individual nurses across many different health care settings (Welton, 2013). New metrics for deriving patient-level nursing costs and intensity will allow development of metrics for nursing finance and calculation of changes in patient clinical and outcomes data over the course of a hospitalization (Pappas & Welton, 2015). Potential new metrics include (a) nursing direct/indirect care time and costs by diagnosis (DRG) or Current Procedural Terminology code; (b) nursing direct/indirect care time and costs by hospital/clinic; and (c) calculation of wage and cost variability related to nursing experience, staffing levels, and nursing acuity mix (see Table 1).

### Measuring Nursing Value

In this article, we summarize the efforts of a group of nurses to provide a starting point for measuring nursing value in many different settings. The overarching question is how can data change nursing and health care to best meet the needs of patients, families, and the communities we serve? How will new nursing and health care data drive innovation, improve performance, increase efficiency and effectiveness, and ultimately create better outcomes and value? What are nursing system characteristics that define best performance and how can we compare nursing across different settings to identify best practices, then emulate these successes across the broad spectrum of nursing care delivery? How can we use data to provide the best nursing care at the best price?

### Methods

**Nursing value expert workgroup.** In June 2013, an initial meeting of experts in nursing, medical informatics, research, academics, and practice met to address the emerging and evolving work of big data science (Delaney & Westra, 2013). This conference was sponsored by the University of Minnesota School of Nursing. During a followup conference in June 2014, an action plan was crafted to devise methods to “share and compare” nursing data across many settings (Delaney & Westra, 2014).

As part of an annual action plan, 10 workgroups were formed at the 2014 Big Data and Nursing Knowledge Development Conference (Delaney & Westra, 2014). The Nursing Value Expert Workgroup was tasked with developing strategies to measure the value of nursing. Primary goals for the expert workgroup included developing a consensus model for measuring patient-level nursing intensity and costs; benchmarking nursing care finance across clinical settings; developing new business intelligence and analytic tools that will utilize the rich clinical, operational, financial, and outcomes data currently available in the EHR; developing nursing business intelligence and analytics consensus variables, metrics, and analytic methods; and developing and testing new nursing finance models that can be used in Accountable Care Organizations, value-based purchasing, and pay-for-performance programs.

**Expert workgroup process.** After setting objectives for the group, meetings were scheduled from August 2014 through March 2015. A total of 14 sessions of 1.5 hours were held during the 8 months (see Table 2).

### Results

The initial report of the Expert Workgroup has been reported previously (Welton & Harper, 2015). The members recommended conceptualizing nursing care value by identifying nurses as individual providers of care and measuring nursing as an encounter between a nurse and patient, family, or community. This consensus recommendation provides a foundation for developing a Nursing Value Data Model that could be used in many different health care settings and across multiple EHR vendors to directly measure nursing care value.

**Nursing Value Data Model.** The primary purpose of the Nursing Value Data Model is to provide a framework for extracting similar patient and nursing-centric data across multiple health care settings and EHR providers to populate a data warehouse that can be shared and compared across multiple settings in which nursing care occurs (see Figure 1). The expert workgroup spent several sessions identifying key data needed and how those data were organized. Of particular interest was to allow use of these data across multiple settings such as acute care, clinics, home care, hospice, and skilled nursing facilities.

The model is organized broadly by facility costing, budget, wage, etc.; patient, assessment, problem, outcome, etc.; nurse/provider, certification, job class, hire date, etc.; and facility/business entity, place of service, unit id, etc. The Nursing Value Expert Workgroup is building the data dictionary which will support the data model with field name, data type, and definition which will allow mapping to Systematized Nomenclature of Medicine - Clinical Terms (SNOMED CT) and Logical Observation Identifier Names and Codes System (LOINC) codes (Kim, Coenen, & Hardiker, 2012; LOINC, 2014; Subramanian et al., 2008). In the future, this will allow integration

### Table 2. Expert Workgroup Participation

<table>
<thead>
<tr>
<th>Category</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group members</td>
<td>14</td>
</tr>
<tr>
<td>Conference calls</td>
<td>14</td>
</tr>
<tr>
<td>Total conference hours</td>
<td>21</td>
</tr>
<tr>
<td>Hours of participation</td>
<td>162</td>
</tr>
<tr>
<td>Median members on call</td>
<td>7</td>
</tr>
<tr>
<td>Percent participation per call</td>
<td>55.1</td>
</tr>
<tr>
<td>Guest participants</td>
<td>7</td>
</tr>
</tbody>
</table>


Figure 1. Nursing Value Data Model Framework
of the Nursing Value Data Model into existing EHRs. This work will continue to be developed as the data model evolves.

**Metrics.** The final deliverables of the workgroup were designed to produce a range of metrics that would allow patient-level costing of nursing care as well as new analytic approaches to develop real-time measures of nursing care (see Table 1). For example, one common problem nurses deal with across many different care settings is pain management. Pain is the primary problem, interventions can include focused pain assessment, administration of opioids, positioning for comfort, as well as reassessment of outcomes of interventions. Each data point is date/time stamped and linked to an individual nurse and patient (see Table 3).

The use of unique nurse identifiers, location identifiers, and time/date stamps could answer questions such as whether high workload leads to fewer nursing encounters with a patient to assess pain or fewer interventions leading to ineffective pain management. The ability to link encounters within a specific setting (e.g., an inpatient medical or surgical unit) would allow trending and comparison of outcomes by patient, nurse, or location (e.g., are recent nursing school graduates or float nurses as effective in pain management compared to experienced nurses?).

### Discussion

The main deliverables from the expert workgroup include (a) a conceptualization of nursing value that identifies individual nurses and the nurse-patient encounter as a primary focus; (b) creation of a Nursing Value Data Model to allow universal data extraction of nursing-sensitive data that is EHR agnostic and setting neutral; and (c) development of new analytic techniques that allow measurement of nursing value in a much granular approach to benchmarking nursing care across different settings and across time.

The primary purpose of the Nursing Value Data Model is to provide a framework for extract-

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### Table 3. Value-Based Analytics

<table>
<thead>
<tr>
<th>Metric</th>
<th>Traditional Model</th>
<th>Proposed Value-Based Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Staffing Levels</strong></td>
<td>Unit-level analysis of hours and costs by skill mix (e.g., percent registered nurse vs. unlicensed assistive personnel)</td>
<td>Patient-level analysis of direct care hours by nursing skill mix, effects of individual nurse and nurse characteristics (e.g., experience level or associate’s vs. bachelor of science degree) on patient outcomes of care</td>
</tr>
<tr>
<td><strong>Outcomes</strong></td>
<td>Hospital and unit-level outcomes (e.g., average length of stay)</td>
<td>Patient-level outcomes analysis (e.g., unit and hospital length of stay adjusted by nursing acuity or tied to DRG/DX, change in shift-level nursing outcomes)</td>
</tr>
<tr>
<td><strong>Trending</strong></td>
<td>Trend of unit average cost per patient day by month or quarter</td>
<td>Trend of patient-level direct nursing costs and hours per patient day (direct) by month, day of stay, DRG, etc.</td>
</tr>
<tr>
<td><strong>Nurse Characteristics</strong></td>
<td>Unit or department-level average nurse experience and academic preparation by budget period (e.g., month, quarter)</td>
<td>Patient-level measures of average experience level and academic preparation of nurses assigned to each patient aggregated by day of stay, summary for hospitalization, trend by shift, etc. These can be rolled into an episode of care (e.g., hospitalization, series of home visits, etc.)</td>
</tr>
<tr>
<td><strong>Nursing Acuity</strong></td>
<td>Unit-level average metrics by month or quarter</td>
<td>Patient-level acuity by day of stay, aggregate metrics by shift, month, day/evening, quarter, etc.; as well as patient-level acuity trends (patient) or aggregate unit-level trending analysis. Patient-level acuity by discharge or DRG</td>
</tr>
<tr>
<td><strong>Workload</strong></td>
<td>Nurse to patient ratios or average NHPPD</td>
<td>Acuity-adjusted assignments and efficiency measures (e.g., relationship between actual patient-level hours needed vs. delivered)</td>
</tr>
<tr>
<td><strong>Outliers</strong></td>
<td>Unit-level average length of stay, NHPPD or NCPPD</td>
<td>Patient-level length of stay, direct nursing care hours and costs</td>
</tr>
<tr>
<td><strong>Nursing Costs</strong></td>
<td>Average total nursing costs per patient day (many patients and many nurses)</td>
<td>Patient-level nursing costs per day per patient; nursing wage variability by patient</td>
</tr>
</tbody>
</table>

**NOTES:** DRG = diagnosis-related group; NCPPD = nursing costs per patient day; NHPPD = nursing hours per patient day
Measuring Nursing Care Value

ing similar data across many different care settings. The advantage of having such a model is that it allows programming and cleaning of the data within a complex EHR. This local data warehouse would be accessible to nurse informaticists working in conjunction with clinical nurses and nurse leaders as well as other disciplines. The Nursing Value Data Model is groundbreaking in combining complex and nursing-sensitive outcomes with financial and standard business process to answer questions that have been posed by nurses for a number of years. The Nursing Value Data Model is placed in the public domain (not copyrighted) and can be used by anyone without permission of the authors. It is the intent and hope of the expert workgroup that this will allow rapid dissemination and adoption of the model.

There are a number of key points regarding the analytic approaches taken by the expert workgroup. First, the identification and linkage of individual nurses to patients allows examination of nursing care as it occurs in near real-time. This can be useful in measuring changes in patient acuity, nursing resource use, and examining the association between care delivery and short-term clinical outcomes (e.g., pain management, glycemic control, and medication administration delays and omissions to identify three potential new metrics). Ultimately better and timelier information will lead to better clinical and operational decision making.

The data will also allow much more granular financial metrics (see Tables 1 and 3). Future development of the value-based framework will provide patient-level nurse costing metrics and ability to benchmark direct care hours and costs for each patient. For example, summary nursing care hours and costs can be allocated to each patient rather than use of NHPPD to examine changes by day of stay, within and across diagnosis-related groups, or used to unbundle nursing care from daily room charges to provide a more transparent and fair billing model for nursing care. Future predictive models could provide better information about nurse staffing and patient assignment patterns to allow optimization of nursing care delivery systems.

**Implications for Nurse Leaders and Educators**

The primary implication of measuring nursing value using common data such as proposed in this article is to create a data environment, data extraction tools, and new analytic methods that measure nursing care at the individual nurse-patient encounter. Why is this important? Current tools and measures are mostly broad averages or aggregates of many nurses across many patients. NHPPD gives very little information about the nursing resources expended for individual patients or the nurses caring for that patient. The model proposed by the Nursing Value Expert Workgroup provides a way to extract patient-level data that can provide a more robust set of data than previously possible.

The model also allows measurement of nursing care across many different settings so it will be possible to follow a patient (e.g., an elder with degenerative hip disease and prosthetic replacement from clinic to acute care, rehabilitation, and home care measuring nursing care along the entire trajectory of care).

From a nurse educator and student standpoint, the analysis of nursing care value provides a way to understand nursing care within the context of the business of caring. There is a critical need to educate nurses on health care finance and economics. Future data will be able to answer the question: What do nurses do differently than other health care members and how does that add value? The data model captures nursing-focused problems, interventions, and outcomes of care. From a learning standpoint, nurses will see how theory and measuring nursing care with standardized terminologies, such as nursing diagnosis, is linked to the trajectory of patient care.

Lastly, the ability to collect and access patient-level nursing data will open new research opportunities and potentially allow new discoveries about nursing care in the future.

**Conclusion**

The findings and recommendations of the Nursing Value Expert Workgroup provide a starting point for action and further discussion on how to measure nursing value in many different settings. The primary conceptualization of nursing value as the relationship between a nurse and patient, family, or community provides a new perspective on acknowledging nurses as individual providers of care.

The implementation of the Nursing Value Data Model will allow measurement of nursing care, as well as care of individual nurses, in ways that have not been possible to date. New analysis techniques will provide real-time information about nursing care quality, performance, effectiveness, and outcomes of care. The specific goals of the Nursing Value Expert Workgroup in 2016 are to test the data model across various patient care settings and further develop new analytic techniques to measure nursing care value. $
Welton, J.M. (2013). Nursing and the value proposition: How information can help transform the healthcare system.