Brief Communication

Representation of occupational information across resources and validation of the occupational data for health model

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ABSTRACT

Reports by the National Academy of Medicine and leading public health organizations advocate including occupational information as part of an individual's social context. Given recent National Academy of Medicine recommendations on occupation-related data in the electronic health record, there is a critical need for improved representation. The National Institute for Occupational Safety and Health has developed an Occupational Data for Health (ODH) model, currently in draft format. This study aimed to validate the ODH model by mapping occupation-related elements from resources representing recommendations, standards, public health reports and surveys, and research measures, along with preliminary evaluation of associated value sets. All 247 occupation-related items across 20 resources mapped to the ODH model. Recommended value sets had high variability across the evaluated resources. This study demonstrates the ODH model's value, the multifaceted nature of occupation information, and the critical need for occupation value sets to support clinical care, population health, and research.

Key words: occupation, employment, standards, NIOSH, occupational data for health model

BACKGROUND

The accelerated adoption of electronic health records (EHRs), driven by health care reform with existing¹ and emerging² payment incentives, presents an opportunity to improve electronic capture of patient data at the point of care. Reports from advisory bodies advocate including social and behavioral factors in EHRs due to their impact on health status and outcomes. These require guidance on essential patient-level elements in an EHR to represent social-behavioral context. The National Academy of Medicine (NAM) report "Incorporating Occupational Information in Electronic Health Records" in 2011³ highlighted the need to represent occupational information in EHRs. This report was initiated by the National

Institute for Occupational Safety and Health (NIOSH),⁴ a leader in efforts around occupation data. Subsequent reports in 2012 by the American College of Occupational and Environmental Medicine,⁵ the Council of State and Territorial Epidemiologists,⁶ and the American Public Health Association⁷ underscored this need. Recommendations by NAM in 2014^{8,9} focusing on social and behavioral domains and measures in EHRs have subsequently brought the issue to the forefront. Altogether, these reports emphasize the need to include occupational information in EHRs as an integral part of patients' social context and to consistently collect data regarding occupation for uses ranging from public health to clinical care delivery.

Figure 1. Methodology for occupational elements identification and mapping.

NIOSH has supported several studies related to representation of occupation-related information. NIOSH has also developed the Occupational Data for Health (ODH) model,¹⁰ which is currently in draft version, with expected release of a final version in the near future. Currently, occupation-related information is required for certain public health scenarios, such as death and cancer reporting. Surveys conducted by public health organizations, specifications developed by biomedical and clinical standards organizations, and measures developed for research contain a range of occupation-related representation models, data elements, and value sets.

Prior studies have examined occupation-related data from a variety of perspectives. In a formative study examining social history information in clinical notes, occupation was included as part of the representation model.¹¹ This work was then extended to social and behavioral information in public health surveys to augment those models, including a model focused on occupation.¹² This approach of utilizing clinical notes, standards, and research measures has also been used to augment representation of social and behavioral factors such as drug use,¹³ alcohol use,¹⁴ tobacco use,¹⁵ residence, living situation, and living conditions,^{16,17} as well as familial factors in the form of family history.¹⁸ More recently, the content and quality of free-text occupation documentation in the social history section of an enterprise EHR was characterized.¹⁹ Overall, this study demonstrated significant variability in representation and quality issues around occupational information in the EHR.

The objective of the present study was to collect occupation-related elements from resources representing recommendations,

standards, public health reports, public health surveys, and research measures to validate the draft ODH model developed by NIOSH, as well as to conduct an initial evaluation of associated value sets and an in-depth analysis of 1 element, employment status. This detailed assessment is expected to present a comprehensive picture of the current state of occupation-related data representation in order to facilitate standardization.

METHODS

Study resources

Five key source types (reports and recommendations, standards and specifications, public health reports, public health surveys, and research measures) were identified by review of relevant reports and Internet searches using various search terms and their combinations (eg, “occupation,” “industry,” “employment,” “representation,” “standards,” “recommendations,” “public health reporting,” and “research”). All 3 NAM reports from 2011 and 2014 related to occupation and social history domains were included in this study. Four resources were identified by examining major biomedical and clinical standards organizations: (1) the Health Level Seven (HL7) Clinical Document Architecture content module of the Integrating the Healthcare Enterprise Patient Care Coordination Technical Framework,²⁰ (2) the Occupational Disease Injury and Fatality domain of Public Health Functional Profile release 2 of the HL7 EHR System Functional Model and Standard,²¹ (3) openEHR archetypes

CONCEPT	DEFINITION
<i>Occupation</i> ³	Individual's job title, although a general description of a person's work may be included
<i>Usual Occupation</i> ²¹	Occupation worked in for most of the working life up to the time of encounter
<i>Usual Occupation Duration</i> ²⁰	Statement about the quantity of time a person spent in the occupation they held the longest over the course of their career.
<i>Industry</i> ³	Type of employer or business establishment—for example, auto repair, retail sales, education, health care, or airplane manufacturing.
<i>Usual Industry</i> ²¹	Industry worked in for most of the working life up to the time of the encounter
<i>Usual Industry Duration</i> ²⁰	Statement about a quantity of time in which a person was employed in an industry.
<i>History of Occupation and Industry</i> ²⁰	Information about a person's various specific occupations over time. It may hold current as well as prior observations about occupations which may include details about the employer and places where work was performed. A person's occupation also includes industry information which is used to more precisely specify the occupation
<i>Employment Status</i> ⁸	Individuals who are employed have a job or occupation, usually in the formal paid labor market (including self-employment).
<i>Employer</i> ³	To adequately capture employer information, current employer name and worksite address are necessary
<i>Work Schedule</i> ²⁰	The "shift" or typical time within a work-day in which a person is scheduled to perform their duties
<i>Weekly Work Hours</i> ²⁰	The typical hours per week that a person spends working
<i>Work-relatedness</i> ³	Denotes the assessment of a link between work and health status. This term is different from other occupational information in that it is not a separate data element within EHR
<i>Exposures</i> ³	Accurate information about the chemical, physical, or radiation exposures an employee has experienced would be the most specific, and therefore the most useful, occupational information, although it is the most difficult to obtain.
<i>Work-related Injuries and Illnesses</i> ³⁰ (Occupational Injury)	Information about work-related death and work-related injury or illness that involves loss of consciousness, restricted work activity or job transfer, days away from work, or medical treatment beyond first aid; Includes significant work-related injuries and illnesses that are diagnosed by a physician or licenses health care professional; Includes work-related injuries and illnesses that meet any of the specific criteria listed in 29 CFR Part 1904.8 through 1904.12.

Figure 2. Definitions of occupation-related concepts.

identified using the Clinical Knowledge Manager,²² and (4) HL7 Fast Healthcare Interoperability Resources (FHIR) resource types.²³

The subsequent step in the process was to explore elements for public health reporting, including death certificates²⁴ and cancer incidence.²⁵ Next, occupational elements from 5 public health surveys were included: (1) the National Health and Nutrition Examination Survey,²⁶ (2) the Behavioral Risk Factor Surveillance System,²⁷ (3) the National Health Interview Survey (NHIS),²⁸ (4) the American Community Survey,²⁹ and (5) the Survey of Occupational Injuries and Illnesses.³⁰ Additionally, consensus research measures with occupation-related elements and values from the Phenotypes and eXposures (PhenX) Toolkit³¹ and Common Data Element (CDE)³² were included.

ODH model validation methodology

Twenty resources encompassing 5 major source types (listed in Figure 1) formed the foundation for evaluation. Resources were reviewed manually by study authors (SR, RA) to extract occupation-related elements, which were used to create a master list of items

(elements or questions/responses) on representation of occupational information. This list was used as a guideline to evaluate the draft ODH model, which comprised 6 categories and 18 elements: (1) *Occupational History*: industry description, occupation description, job duties, current occupation date, start date, end date, hours worked per week, days worked per week, employer name, employer location; (2) *Usual Occupation and Industry*: industry description, occupation description, duration in years, start year; (3) *Employment Status*: name, start date, end date; (4) *Work Schedule* (description); (5) *Occupational Injury*; and (6) *Occupational Exposure*. The methodology consisted of 5 main steps (Figure 1): (1) creating a comprehensive list of items from representative resources, (2) developing guidelines to map items to the NIOSH ODH model, (3) mapping items to ODH categories and elements, (4) ascertaining coverage and identifying areas for enhancement, and (5) evaluating value sets for representation of concepts.

A key step in the methodology was to create a "definition matrix," which outlined the occupation-related concepts and their definitions (Figure 2). Definitions were drawn from 20 identified

Table 1. Mapping of resource items to NIOSH Occupational Data for Health model

Categories and Elements from the ODH Model	Reports and Recommendations			Standards and Specifications				Public Health Reports		Public Health Surveys					Research Measures					
	2011 NAM	2014 NAM: #1	2014 NAM: #2	IHE PCC TF	PHFP ODIF	openEHR	HL7 FHIR	Death Certificate	Cancer Reporting	NHANES	BRFSS	NHIS	ACS	SOII	PhenX Occ. History	PhenX Employment	PhenX Exposure	CDE Occupation	CDE Employment	CDE Industry
Occupational History	✓	✓		✓	✓	✓				✓	✓	✓	✓		✓			✓	✓	✓
Industry Description	✓			✓	✓					✓	✓	✓	✓		✓			✓	✓	✓
Occupation Description	✓	✓		✓	✓	✓				✓	✓	✓	✓		✓			✓	✓	✓
Job Duties										✓		✓	✓		✓			✓		
Current Occupation Date					✓															
Start Date				✓	✓										✓			✓		
End Date				✓											✓			✓		
Hours Worked per Week				✓						✓	✓	✓	✓		✓			✓	✓	
Days Worked per Week				✓														✓		
Employer Name	✓				✓					✓		✓	✓		✓					
Employer Location					✓										✓					
Usual Occupation and Industry				✓	✓			✓	✓	✓		✓			✓			✓		✓
Industry Description				✓	✓			✓	✓	✓		✓			✓					✓
Occupation Description				✓	✓			✓	✓	✓		✓			✓			✓		
Duration in Years				✓								✓			✓					
Start Year																				
Employment Status		✓	✓	✓			✓			✓	✓	✓	✓			✓		✓	✓	
Name		✓	✓	✓			✓			✓	✓	✓				✓		✓	✓	
Start Date				✓																
End Date				✓																
Work Schedule		✓		✓								✓			✓			✓		
Description				✓								✓			✓			✓		
Occupational Injury														✓						
Occupational Exposure	✓	✓			✓	✓											✓			✓

NAM - National Academy of Medicine (formerly Institute of Medicine); IHE PCC TF - Integrating the Healthcare Enterprise Patient Care Coordination Technical Framework; CDA - Clinical Document Architecture; PHFP - Public Health Functional Profile; ODIF - Occupational Data, Injuries and Fatalities; NHANES - National Health and Nutrition Examination Survey; BRFSS - Behavioral Risk Factor Surveillance System; NHIS - National Health Interview Survey; ACS - American Community Survey; SOII - Survey of Occupational Injuries and Illnesses; PhenX - Consensus Measures for Phenotypes and eXposures; CDE - Common Data Elements

resources that provide authoritative information on this topic and served as a knowledge base for development of mapping guidelines. A concept that was unique to the public health context was *usual*, which referred to the longest serving occupation and industry and was collected for purposes of examining long-term outcomes or impact of exposures with long latent periods. Concepts such as *work-relatedness* (2011 NAM report) are clinical interpretations and are not captured as separate data elements within the EHR.

Guidelines for mapping were developed by study authors with expertise in biomedical standards, informatics, and clinical and public health practice (refer to Supplementary Appendix A for the mapping guidelines). Two of the experts (SR, RA) mapped 10% of items, resulting in excellent interrater reliability (Cohen's $\kappa = 0.94$, proportion agreement = 0.99). The rest of the items were mapped by the 2 experts independently, followed by group review to confirm mappings and achieve consensus on any issues identified.

Data Elements	Sources	Recommendations for Value Sets	
		Value Sets	# Values/ Value concepts
Occupational History Industry Description	2014 NIOSH Data Model (DRAFT)	CDC_CensusIndustry2010	272
	2011 NAM Letter Report	NAICS codes 2007	19,720
Occupational History Occupation Description	2014 NIOSH Data Model (DRAFT)	CDC_CensusOccupation 2010	544
	2011 NAM Letter Report	SOC codes	1,421
	IHE PCC TF Supplement - CDA Content Modules	PHVS_Occupation_Census	540
	PhenX	List of Job Titles	45
Usual Industry	2014 NIOSH Data Model (DRAFT)	CDC_CensusIndustry2010	272
Usual Occupation	2014 NIOSH Data Model (DRAFT)	CDC_CensusOccupation 2010	544
	IHE PCC TF Supplement - CDA Content Modules	PHVS_Occupation_Census	540
Usual Occupation Duration	IHE PCC TF Supplement - CDA Content Modules	UCUM	7
Usual Industry Duration	IHE PCC TF Supplement - CDA Content Modules	UCUM	7
Employment Status	2014 NIOSH Data Model (DRAFT)	Structured List	6
	2011 NAM Letter Report	Not Listed	-
	2014 NAM Report on SBH #1	Not Listed	-
	2014 NAM Report on SBH #2	Structured List: MESA Measure	10
	IHE PCC TF Supplement - CDA Content Modules	PHVS_EmploymentStatus_ODH	8
	HL7 FHIR	Structured List	11
	NHANES	Structured List	9
	BRFSS	Structured List	8
	NHIS	Structured List	12
	ACS	Structured List	3
	PhenX	Structured List	8
	CDE (NCIP Steward)	Structured List	8
	CDE (CTEP/NCI Steward)	Structured List	13
	CDE (NINDS Steward)	Structured List	10
External Cause of Occupational Injury	2014 NIOSH Data Model (DRAFT)	ICD-10-CM codes	141,747

Figure 3. Value sets recommended and in use for occupation-related data elements.

For example, the question “Which of the following best describes the hours you usually work?” in NHIS was mapped to *Work Schedule* in the ODH model, a question about “patient’s longest occupation” from cancer reporting was mapped to *Usual Occupation and Industry*, and an “industry” item from the 2011 NAM report was mapped to *Occupational History*. *Occupational Injury* was the ODH category to which the Survey of Occupational Injuries and Illnesses question “What object or substance directly harmed the employee?” was mapped. “What kinds of chemicals or materials did (you/he/she) handle in that job?” from the PhenX occupational history was mapped to *Occupational Exposure* in the ODH model.

Approach for assessment of value sets

The vocabulary repository titled PHIN Vocabulary Access and Distribution System³³ maintained by the Centers for Disease Control and Prevention (CDC) was used as the main resource to access value sets. This was supplemented with direct access to various codes/value sets through Internet searches. Given the recommendation of *Employment Status* as a key metric related to occupation, this value set was examined across 12 resources: the NIOSH ODH model,¹⁰

the NAM-recommended Multi-Ethnic Study of Atherosclerosis questionnaire,⁹ the PHIN Vocabulary Access and Distribution System,³³ HL7 FHIR,²³ the National Health and Nutrition Examination Survey,²⁶ the Behavioral Risk Factor Surveillance System,²⁷ NHIS,²⁸ the American Community Survey,²⁹ the PhenX toolkit,³¹ 1 CDE resource from the National Institute of Neurological Disorders and Stroke,³⁴ and 2 CDE resources from the National Cancer Institute (NCI),³² with the NCI Cancer Biomedical Informatics Grid and the NCI Cancer Therapy Evaluation Program as stewards.

RESULTS

Twenty resources (Table 1) including 247 items were identified for inclusion in the master list for representation of occupational information and 100% mapped to the ODH model (refer to Supplementary Appendix B for entire mapping). *Occupational History* was the most common category across the resources (65%), followed by *Employment Status* (55%) and *Usual Occupation and Industry* (45%). Certain elements contained clinical interpretations (eg, *work-relatedness*) and some were derived data elements (eg, duration of occupation and industry). The need for more granularity in

Table 2. Representation and value sets of employment status from select sources

CONCEPT	VALUE SETS	RESOURCES											
		NIOSH Data Model	NAM - MESA Question	PHIN VADS	HL7 FHIR	NHANES	BRFSS	NHIS	ACS	PhenX Toolkit	CDE - NINDS Steward	CDE - NCI/CTEP Steward	CDE NCI/NCIP Steward
Not employed – caring household	Homemaker, not working outside the home												
	Homemaker												
	Home manager (housewife)												
	Keeping house												
	Taking care of house or family												
Employed – full-time or part-time and getting paid	In paid employment												
	Work for pay at a job												
	Working now												
	Employed (or self-employed) full time												
	Full-time employed												
	Employed 32 hours or more per week												
	Employed (or self-employed) part time												
	Part-time employed												
	Employed less than 32 hours per week												
	Employed for Wages												
	Contract, per diem												
	Self-employed												
	Employed Full-time												
	Employed Part-time												
Employed – but temporary not working for various reasons	Employed, but on leave for health reasons												
	Employed, but temporarily away from my job (other than health reasons)												
	Leave of absence (e.g. family leave, sabbatical, etc.)												
	Only temporarily laid off, sick leave or maternity leave												
	On medical leave												
	Between Jobs												
	Temporarily Unemployed												
	On a planned vacation from work												
	On family or maternity leave												
	Have job/contract and off season												
	Temporarily absent from job or business (vacation, temporary illness, maternity leave, other family/personal reasons)												

(continued)

Table 2. Continued

the *Occupational Injury* and *Occupational Exposure* categories was identified. Some of the survey questions captured temporality for the recent past (eg, last week) and compensation for work (eg, wages). The ODH model includes *Employer Location* that may be different from actual worksite for exposure data.

The evaluation of occupation-related information that had recommendations for value sets pointed to 8 categories: (1) *Employment Status*, (2) *Current Occupation*, (3) *Current Industry*, (4) *Usual Occupation*, (5) *Usual Industry*, (6) *Usual Occupation Duration*, (7) *Usual Industry Duration*, and (8) *External Cause of Occupational Injury*. Details of the elements, corresponding value sets, numbers of values, and corresponding sources are shown in Figure 3. The Unified Code for Units of Measure, comprising 7 codes, is recommended for representing *Usual Industry* and *Usual Occupation*. Some of the value sets are expansive, such as the Standard Occupational Classification System³⁵ from the US Bureau of Labor Statistics, with 1421 codes. Likewise, the North American Industry Classification System 2007 version for representing industries contains an elaborate list of 19 720 codes, and the International Classification of Diseases, Tenth Revision, Clinical Modification contains 141 747 codes for external cause of occupational injury. Organizations such as NIOSH¹⁰ have worked to create subsets of codes that may be easier to adopt and use, and also include value-added codes. The 2010 NIOSH enhanced subsets for occupation and industry maintained by the CDC have 544 codes and 272 codes, respectively.

Value sets for *Employment Status* were varied across the 12 resources examined, with no 2 resources holding similar sets of values (Table 2). Sixty-three values were grouped into varying value sets to represent 11 concepts: Not employed – caring household; Employed – full-time or part-time and getting paid; Employed – but temporary not working for various reasons; Not employed; Retired and employed post-retirement; Not employed – disability; In military service; Volunteer; Student; None/other and Unknown.

DISCUSSION

This study offers a unique contribution to the evaluation of the current state of occupation representation models and validates the current draft ODH model developed by NIOSH. This research demonstrates the multitude of concepts related to occupational information and the complexity of their representation. Standard definitions for occupational categories and elements are essential to realize the full utility of occupation data for clinical care decisions and for purposes of research, public health, and population health. In this evaluation, developing a definition matrix greatly assisted the guideline development and mapping processes. In creating the master list of values for evaluation, relevant resources were included from respected advisory bodies and reputable national organizations. This research illustrates the robustness of the ODH model for representation of occupational information, with 100% mapping of items identified from a comprehensive list of resources.

Occupational injury and occupational exposure were identified as categories in the model that need additional granularity. The ODH model is in draft stages, with a final version to be released and likely to have expanded elements. Though granularity helps to capture additional details, it needs to be balanced with efforts to collect data and its utility. This study also highlights the inconsistency in use of concepts and variability in value sets. Value sets for certain categories (eg, *Employment Status*) are highly variable, with comparisons across resources on data for employment status not currently feasible. A possible next step in this research is to analyze value sets for representation of

Occupation and *Industry*. NIOSH has developed value sets for these categories, which include a subset of nationally recommended codes and additional CDC value-added codes. Hence, additional evaluation needs to be done in collaboration with NIOSH and other stakeholders to ensure that further research adds to existing knowledge.

This study presents a conceptual framework for representation of occupational information. The research points to a need for education around concepts related to occupational information and their representation and promotion of standardization. Assessments that present the current state of representation (eg, occupational information, in this study) are critical to providing a knowledge base to promote adoption of existing representation models and standards, stimulate additional research, and facilitate updates to EHR products. With the growing adoption of EHRs and the possibility of future EHR certification criteria for occupational information, it is essential to support entities like NIOSH in leading these efforts.

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COMPETING INTERESTS

The authors have no competing interests to declare.

CONTRIBUTORS

GMM, ESC, and SR conceptualized the study. GMM and ESC provided guidance for various aspects of the study, including guideline development for evaluation and value sets assessment. SR and EL collaborated on examining the various resources used for evaluation and assessment of associated value sets. SR and RA collaborated on development of the master list from resources for evaluation and completed the mapping. YW calculated the needed statistics, and SR wrote the first draft of the manuscript. All authors were involved with the consensus-based processes used for evaluation as well as reviewing and editing the manuscript.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *Journal of the American Medical Informatics Association* online.

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