Issues in Coding Hospital Intensive Care for Data Analysis

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Proceedings of the 2013 Federal Committee on Statistical Methodology (FCSM) Research Conference

Abstract

Part of the American Recovery and Reinvestment Act (ARRA) of 2009, the Health Information Technology for Economic and Clinical Health Act (HITECH), offers incentive funding for Meaningful Use (MU) of electronic health records (EHRs). Reporting of Clinical Quality Measures (CQMs) to the federal government is a MU of EHRs. For the measure called ICU Venous Thromboembolism (VTE) Prophylaxis, Intensive Care Unit (ICU) admissions must be identified. The Veterans Health Administration (VHA) Corporate Data Warehouse (CDW) holds several columns describing Intensive Care. These data are loaded from its legacy EHR called the Veterans Health Information Systems and Technology Architecture (VistA). Analysis of these unstructured free text data is all but impossible.

Several ontologies with codes for Intensive Care are discussed, the Systematized Nomenclature of Medicine - Clinical Terms (SNOMED CT) among them. Characteristics of hospitals, wards, rooms, beds, and physician specialty have been used to classify Intensive Care. In contrast, the National Health Service Data Model and Dictionary for England gives definitions describing the care provided to the patient. None of the ontologies lay out a ready means for coding ICU data from the VHA CDW.

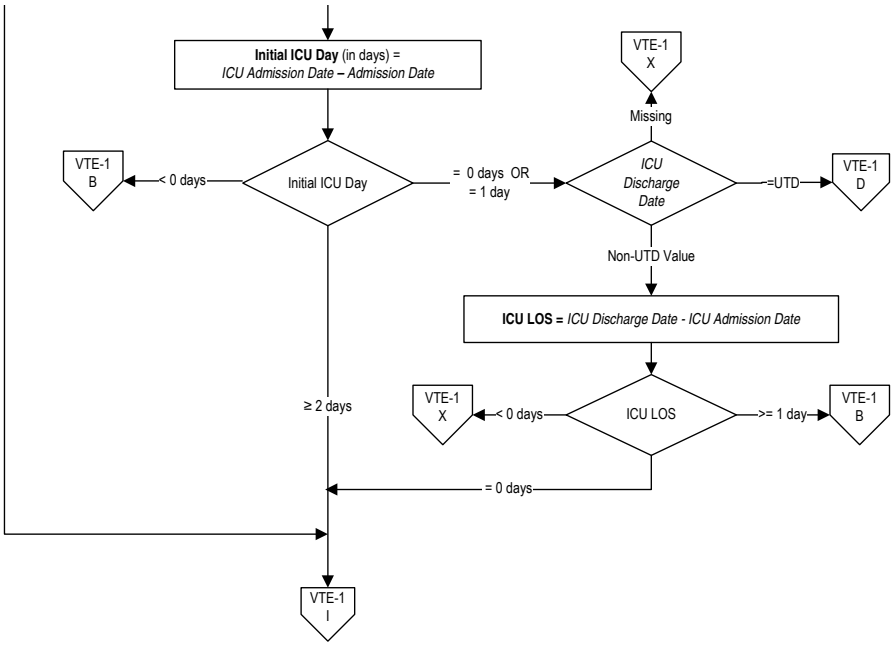

Figure 1: Part of TJC's Specification for VTE-1: Venous Thromboembolism Prophylaxis

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1 Hospital Performance Measurement

With the aim of quality improvement, the Joint Commission (TJC) began the first national program of hospital performance measurement in 1998 [11]. Not only TJC but the Centers for Medicare and Medicaid Services (CMS) [41] and the Veterans Health Administration [54] use quality measures.

For performance measurement, TJC provides detailed algorithms for the 6 measures in the Venous Thromboembolism measure set[13]. Along with healthcare data documentation, SAS®programmers can use these algorithms to program computation of performance measures.

Figure 1, showing part of 1 of these algorithms, comes from the *NQF-Endorsed Voluntary Consensus Standards for Hospital Care* [13]. Among the populations excluded by TJC specifications is the population of

> Patients who are direct admits to intensive care unit (ICU), or transferred to ICU the day of or the day after hospital admission with ICU LOS greater than or equal to one day

In identification of cases eligible for the denominator of the performance measure, the algorithm tests the Intensive Care Unit Length of Stay, abbreviated ICU LOS in Figure 1. You can see this test in the diamond labeled ICU LOS. For the purposes of this quality measure, TJC defines ICU as a Location, not a Level of Care [14].

2 Hospital Wards, Rooms and Beds

Because VTE1 is an inpatient clinical quality measure, my analysis began with data in the Inpat schema. The diagram shown in Figure 2 makes clear that our CDW does not follow the star schema described by Lupetin [38] .

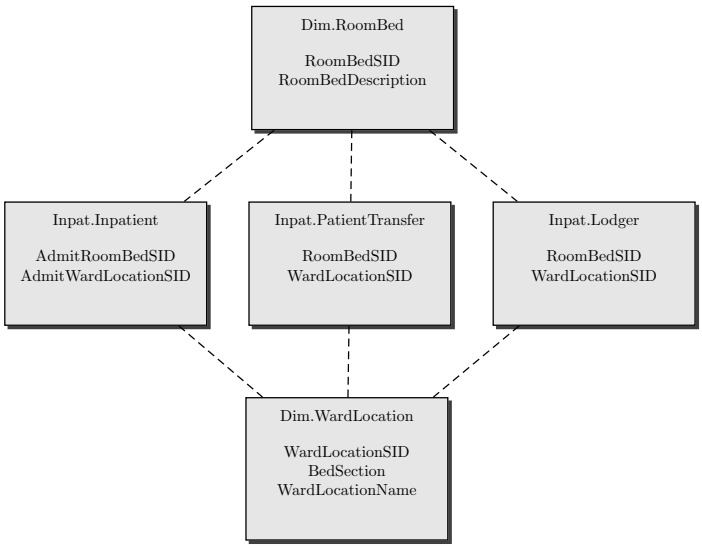


Figure 2: CDW Tables Where I Started Looking for ICU Records

In Figure 2, each rectangle represents a database table with the table name near the top and selected column names listed below the table name. Following advice given in the document titled *Best Practices to Query the VA Data Warehouse*, [37] I know that data users are expected to join selected rows from dimension tables to the rows in fact tables containing patient data. As the Metadata report on the CDW Sharepoint site did not list Data Definitions for any of the columns, I looked at the Entity Relationship Diagram (ERD) for the Inpatient schema and looked for tables with names that indicated they might identify ICU stays. After choosing the tables named Dim.RoomBed and Dim.WardLocation, I looked at the names of the columns within these tables and chose some that appeared as if they might identify ICUs. At this point I ran into a problem encountered by other VA data users. As Kathleen Schutte posted [61]

> We also struggled with the decision of which piece of available DSS pharmacy data to rely on.

When I joined columns from Dim.RoomBed and Dim.WardLocation to 1 of their common Fact tables, Inpat.PatientTransfer, values of the columns named RoomBed, BedSection, WardLocation and RoomBedDescription did not clearly identify ICUs. In Table 1, I have listed selected rows from 2 of these columns. On some of the joined rows, only a single value in 1 of the 4 columns identified the Location as an ICU. Some values of RoomBed and WardLocation identified ICUs but not always consistently. A WardLocationName value of IMICU joined with a RoomBedDescription value of STEPDOWN. Providing a level of care intermediate between Intensive Care and that given on a general ward, step-down units differ from ICUs [3]. On other records joined through the table named Inpat.PatientTransfer, 1 column value was blank while the value of another column joined was nonmissing.

I abandoned this line of analysis.

In the VistA Metadata Repository, the statement

> Select from those ACTIVE beds in the ROOM-BED file which are assigned to the WARD LOCATION chosen for this movement.

tells me that whatever relationship existed between ROOM-BED values and WARD LOCATION values was destroyed when the dimension tables named Dim.RoomBed and Dim.WardLocation were created in the CDW. These 2 tables cannot be joined directly on any keys; they can only be joined through the fact table named Inpat.PatientTransfer.

For room identification, only values of the column named RoomBedDescription can be found in the CDW; room numbers are not available. Within the VistA package named ENGINEERING, a free text field named SYNONYM in the file named ENG SPACE gives colloquial names often used instead of room numbers. However, data from the Engineering package have not been extracted, transformed and loaded into the CDW.

The field named SYNONYM is described as:

> Alternative (informal) designations of physical locations. For example, room 214A-137 may be better known as room 1 of the MICU. In this case, you could use MICU-1 as a synonym for room 214A-137 [22].

WardLocationName	RoomBedDescription
1N HOSPICE	ICU
ICUM	OVERFLOW
ZZ2BSICU	PRIVATE ROOM
SICU	
WCICU	PRIVATE
3 ICU (OBS)	NO DESCRIPTION
IMICU	STEPDOWN
4MICU	PSEUDO BED
OBS-MICU	PRIVATE
1N MED	ICU
2D-SICU	NONE

Table 1: WardLocationName Joined to RoomBedDescription through Fact Table

We need a data model. C. J. Date gives 2 definitions of the term *data model*, [17] his second is

> A *data model* is a model of the persistent data of some particular enterprise.

He tells us a data model is a *database design* and

> ...we might speak of the data model for some bank, or some hospital, or some government department.

Now, we can see that the CDW is not a ”faithful model of reality” [17]. Looking at the Inpatient schema of the CDW, it appears the CDW architecture does not benefit from any data model, having been built without one.

Although hospital beds typically have a one-to-one or many-to-one relationship to hospital rooms and hospital rooms are nested within wards, other arrangements exist. Wards may be synonomous with rooms. Like the wards shown in Civil War images, a ward may comprise many beds in a single large room. Some hospital architecture features a ”decentralized nursing station design” where a desk for a single nurse is situated near 1 or more rooms.

Within the metadata for the VistA File named WARD(S) WHICH CAN ASSIGN are 2 statements implying that the relationship of wards to beds is not simply one-to-one.

> Enter the ward (a pointer to the WARD LOCATION file) which can utilize this bed. Choose, from the available listing, the ward(s) which are permitted to place a patient in this bed. [48]

As a VHA Directive states [57], temporary bed Locations in the Emergency Department or elsewhere in the hospital may be used. Finally, the number of ICU beds in a hospital may be dynamic, continuously adjusted to meet demand within available resources [43].

3 NHS Data Definitions and Data Standards Defining Intensive Care

The National Health Service (NHS) Data Model and Dictionary for England [40] explicitly nests Hospital Beds within Wards, describing a Ward as

- ”A group of **Hospital Beds** with associated treatment facilities managed as a single unit for the purposes of staffing and treatment responsibilities.”

- ”A critical care unit will comprise one **WARD** if the **Hospital Beds** and associated treatment facilities are managed as a single unit.”

Definitions reproduced below tell us that NHS uses the concepts of both Location and Level of Care, listed in Table 2, to define Intensive Care [40], also known as Critical Care.

- A new **CRITICAL CARE PERIOD** starts when the PATIENT is admitted to a critical care **location** regardless of **CRITICAL CARE LEVEL** .

- A **CRITICAL CARE PERIOD** ends when the PATIENT is discharged from the critical care **location**, or dies, or the care that is being delivered in a non-standard **location** is **CRITICAL CARE LEVEL** National Code 00 Level 0 or National Code 01 Level 1.

- A **CRITICAL CARE PERIOD** does not include the following:

  a. Surgical and anaesthetic intra-operative care

  b. Post-operative care within an operating department except where level 2 or level 3 care are provided for more than 4 hours

  c. Care delivered in a cardiac or coronary care unit

  d. Imaging procedures

  e. Endoscopy procedures

  f. Care delivered in an Accident and Emergency Department

Helpful to data analysts, the NHS Data Model and Dictionary gives very precise definitions. High dependency units, also called step-down units, provide a level of care intermediate between an ICU and a general ward [3]. Stepdown care can be more precisely classified with the NHS National Codes.

A recent VHA Directive makes clear that Location alone does not determine Level of Care [57].

> When a patient requires admission to a critical care unit and no Intensive Care Unit (ICU) bed is available, it is an absolute requirement that the patient receive ICU-level care in an alternative location including monitoring, staffing, and treatment consistent with ICU standards.

and

> b. Temporary Bed Location. A temporary bed location is a designated place where a patient awaiting inpatient care can be cared for until a bed in the destination unit is available. Temporary bed locations may include but are not limited to the Post Anesthesia Care Unit for ICU overflow patients; the Observation Unit; and the ED or UCC for newly admitted patients. It may also include short-term use of a higher level of care (for example an ICU bed for a telemetry inpatient admission) while awaiting the appropriate location.

This Directive clearly states that patients may receive a higher level of care than they need. Patients who do not need Intensive Care may be admitted to an ICU, waiting there until another bed becomes available. The NHS Data Model and Data Dictionary names concepts of Location and Level of Care exactly as this Directive.

Vance et al. [69] briefly describe a VHA patient acuity classification system by which Intensive Care patients can be distinguished from others. I did not find these data in the CDW.

National Code	Description
00	Level 0 (Patients whose needs can be met through normal ward care in an acute hospital)
01	Level 1 (PATIENTS at risk of their condition deteriorating, or those recently relocated from higher levels of care, whose needs can be met on an acute ward with additional advice and support from the critical care team.)
02	Level 2 (PATIENTS requiring more detailed observation or intervention including support for a single failing organ system or post-operative care and those 'stepping down' from higher levels of care.)
03	Level 3 (PATIENTS requiring advanced respiratory support alone or monitoring and support for two or more organ systems. This level includes all complex PATIENTS requiring support for multi-organ failure.)

Table 2: NHS National Codes for Critical Care Levels [40]

4 Variety and Change in Healthcare Operations

Classification of ICUs present a challenge.

> Intensive care units (ICUs) vary significantly from hospital to hospital with respect to structure, services provided, personnel and their level of expertise, and organizational characteristics [29].

Hospitals have been described as unique in the way each is run [36]. Trotter and Uhlman open their second chapter of their book with the epigraph [68]

> When you've seen one medical practice, you've seen one medical practice.

Touting VistA's adaptability, Tom Munnecke [33], a VistA developer, gives us the old saying

> If you've seen one VA hospital, you've seen one VA hospital.

The Veterans Administration (VA) developed VistA decades ago. Unconcerned with the utility of data coming from multiple and diverse VistAs, Munnecke dismissed criticism raised when the VA accepted VistA for use in all VA hospitals [33]. Hammond warned that, given the "highly individualized nature" of healthcare, no single EHR would meet universal acceptance. [30] More than 30 years later, the quest for "interoperability" continues [1]. Even among VistAs, no complete semantic interoperability exists. In my second analysis, described in Section 5, I found that data from different hospitals don't describe the same concept.

VA cautions researchers that this means VistA data are not standardized across all VistA sites [50]. From the time VistA development began, VA staff considered each VA healthcare facility unique and in need of EHR customization [31]. Apparently, extensive VistA customization at many VistA sites prevented the authors of the Bed Control Menu User Manual from clearly describing data entry steps for recording patient transfer. VistA customization is the antithesis of standards. For example, the Patient Information Management System (PIMS), Admission, Discharge, Transfer (ADT) instructions under the heading *Transfer a Patient* [42] state

> Action in this function varies depending upon what transfer types have been defined as active at your facility.

and

> The actions in this option will vary depending upon your site's definition of each bed control movement type.

Recently, Elizabeth Alpern reported finding EHRs not only highly customized to each site's work flow but mutable at each site as well [2].

Again, researchers are advised that "VistA files are maintained in 128 centers and data may not be compatible among sites because of local modifications." [50]. The query listed below gave a result set of 130 VistA sites.

```
select distinct Sta3n, active
from [cdwwork].[dim].[vistasite]
where Sta3n > 0 and active='Y'
```

When VA's standardization initiative closes about 2 years hence, there will "133 production VistA instances" [72].

Further challenging CDW data users, "Of the 57,000 data fields in VistA, 34% contain data stored as unstructured, free text." [50]. Trotter and Uhlman remind us that normalized data cannot be produced from free text [68]. Many columns in the CDW come from VistA fields that allow users to enter any text they choose. Cervo and Allen tell us data entry personnel are imaginative and "capable of entering the very same information in may different ways, especially when utilizing free-form entry fields" [10]. That perfectly explains the variability of values entered into many VistA fields.

5 Analysis of Free Text

To study the variety of names used for ICUs, I analyzed free text values. I limited my analysis to searching for only the 2 strings 'ICU' and 'Intensive Care', as shown in the Structured Query Language (SQL) listed here.

```
select distinct TreatingSpecialtyName}
  from [CDWWork].[Dim].[TreatingSpecialty]}
    where TreatingSpecialtyName like '\%[iI][cC][uU]\%'}
       or TreatingSpecialtyName like }
'\%[iI][nN][tT][eE][nN][sS][iI][vV][eE]␣[cC][aA][rR][eE]\%'}
```

Consequently, where CCU means Critical Care Unit, not Coronary Care Unit, and 'INT CARE' means Intensive Care, not Intermediate Care, I excluded those values from my analysis. I used the 10 columns from 4 tables listed in Table 3. After unduplicating all 10 columns I found 1,956 unique values.

Next, I looked for the VA Hospital, identified by Division, with the greatest variety of text strings identifying ICUs. For the column named WardLocationName, I found the Portland, OR VA Hospital used 12 different strings in Fiscal Year (FY) 2013. These strings are listed in the second column of Table 16. In terms of variety of values, in this division WardLocationName was redundant to WardLocation. The 12 values of WardLocationName reappeared among the 118 unique values of column named LocationName recorded by the Portland, OR VA Hospital during FY13.

Table	Column	Distinct Values in Division 648
Dim.WardLocation	WardLocationName	12
Dim.WardLocation	BedSection	0
Dim.RoomBed	RoomBed	28
Dim.RoomBed	RoomBedDescription	1
Dim.Location	WardLocation	12
Dim.Location	LocationName	118
Dim.Location	LocationAbbreviation	5
Dim.Location	PhysicalLocation	2
Dim.Location	TreatingSpecialtyName	2
Dim.Specialty	Specialty	2

Table 3: Columns Joined to Inpatient Records From FY13

This query gave a result set of only 1 row, having a BedSection value equal to "HEMO ICU".

```
select BedSection
from [cdwwork].[dim].[WardLocation]
where Sta3n=648 and BedSection like '%ICU%'
```

Because I did not find this value among FY13 inpatient records, it could be an outdated record.

For the Portland, OR VA Hospital, Values of the column named RoomBed ranged from 3DICU-1 to 3DICU-28.

Table 4 shows the unique values of 5 more columns found in FY13 inpatient records from the Portland, OR VA Hospital.

TreatingSpecialtyName	Specialty	PhysicalLocation	RoomBedDescription	LocationAbbreviation
MEDICAL ICU	MEDICAL ICU	MICU	ICU	ICU
SURGICAL ICU	SURGICAL ICU	SICU		MICU
				SICU
				W MICU
				W SICU

Table 4: Unique Values from 5 Columns. Data from the Portland, OR VAMC Hospital

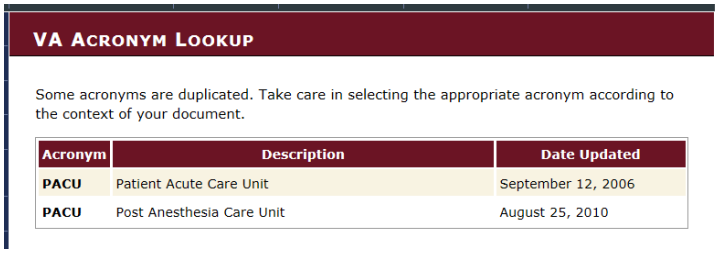
Values from the column named TreatingSpecialty listed in Table 5 do not clearly describe Intensive Care. Because construction of the CDW is not complete, the column named TreatingSpecialty could not be joined to patient records.

Table 6 lists some of the problematical values found by querying 10 CDW columns for Intensive Care Units. All contain the string ICU but none unambiguously represent ICUs.

With 3 different meanings, the acronym PICU illustrates the lack of healthcare data standards. First, On VA's Acronym Lookup site, PICU is given as Patient Intensive Care Unit. Second, a VHA document spells out PICU as Psychiatric Intensive Care Unit [19]. Third, according to SNOMED CT, PICU means Pediatric ICU.

ICU UROLOGY
NEUROLOGY ICU
OPHTHALMOLOGY SICU
PLASTIC SURGERY ICU
POST ICU
PSYCHIATRY(PICU)
CARDIOLOGY TELEMETRY ICU
HEAD AND NECK ICU
MEDICAL ICU/OBSERVATION
ORTHO (INCL HAND) SICU
L-MED MICU HOSPICE
MICU/PALLIATIVE CARE
JC-ICU/CCU

Table 5: Some Ambiguous TreatingSpecialty Name Values



VA ACRONYM LOOKUP

Some acronyms are duplicated. Take care in selecting the appropriate acronym according to the context of your document.

Acronym	Description	Date Updated
PACU	Patient Acute Care Unit	September 12, 2006
PACU	Post Anesthesia Care Unit	August 25, 2010

Figure 3: VA Acronym Lookup

PACU is an acronym with duplicate meanings. Figure 3 gives 2 definitions for this acronym and advises attending to the document's context. Unlike EHR users, data users cannot get any context from the columns in the CDW.

BU-8A/MICU,CCU,CVU	NUR 2B2 PAICU
NUR NICU/6B BO	NUR 4 EAST MICU/CCU
ELP-NSG-TESTICULAR SELF EXAM	NUR PICU
AL-ICU READING ROOM	NUR PSY-WEST (PICU)
NOL ORTHOTIC LAB HUNNICUTT	NUR WCICU
PHL INSOMNIA CVT CONNECTICUT	SMICU virtual bed
HRB-SMOKE CESS PRACTICUUM	NUR MICU STEP
L/NURSING PEDICURE	CCU/MICU/TELE/ISO
O/PICU RECREATION THERAPY GP	pickup ICU
ZZMU-AURICULAR/ACCUPUNCTURE	TLOVICU
TO-REC TX-HORTICULTURE	ICUBOARDER
BU-MEDICAL/SURGICAL ICU	NUR RICU

Table 6: Problematical Values from 10 CDW columns

Render et al. [60] tabled 3 problems they encountered using the physician-centered concept of Treating Specialty to identify ICU patients. The reported wide variation in ICU use among VA hospitals [12], may be due, at least in part, to problems with the classification of ICU beds.

BedSection, a concept unique to VA hospitals, is perhaps best defined in VHA Handbook 1907.04, *Patient Treatment File (PTF) Coding Instructions* [20].

Involving concepts of both a medical or surgical specialty and Location, VHA defines Bedsection as

> A bedsection is the general treatment type (specialty) being provided to a patient on an officially designated (or "VA-approved") ward or bed location.

As we saw earlier, relying on the column named BedSection to identify ICUs would have missed those in the Portland, OR VA Hospital.

6 Catalog of Healthcare Ontologies

6.1 Medicare UB-04 Revenue Codes

Table 7 lists selected Medicare Revenue Codes [18]. Evidently, Medicare deems Pulmonary care less intensive than Psychiatric Intensive Care [18]. Coding problems could be a reason for unexplained variability in use of Intensive Care [64]. Unlike the SNOMED CT classification, Medicare does not include a Respiratory Intensive Care Unit in their classification.

6.2 United States Health Information Knowledgebase (USHIK)

The Consolidated Health Informatics (CHI) website offers a collection of standards [25], including SNOMED CT. None of their Data Elements describe Intensive Care as either a Level of Care or a Location.

020X	Intensive Care	
0	General Classification	INTENSIVE CARE or (ICU)
1	Surgical	ICU/SURGICAL
2	Medical	ICU/MEDICAL
3	Pediatric	ICU/PEDS
4	Psychiatric	ICU/PSTAY
6	Intermediate–ICU	ICU/INTERMEDIATE
7	Burn Care	ICU/BURN CARE
8	Trauma	ICU/TRAUMA
9	Other Sub-acute Care	ICU/OTHER

021X	Coronary Care	
0	General Classification	CORONARY CARE or (CCU)
1	Myocardial infarction	CCU/MYO INFARC
2	Pulmonary care	CCU/PULMONARY
3	Heart Transplant	CCU/TRANSPLANT
4	Intermediate–CCU	CCU/OTHER
9	Other	

023X	Incremental Nursing Charge Rate	
0	General Classification	NURSING INCREM
1	Nursery	NUR INCR/NURSERY
2	OB	NUR INCR/OB
3	ICU (includes transitional	NUR INCR/ICU care)
4	CCU (includes transitional	NUR INCR/CCU care)
5	Hospice	NUR INCR/HOSPICE
9	Other	NUR INCR/OTHER

Table 7: Medicare UB-04 Revenue Codes

6.3 3M Healthcare Data Dictionary

The proprietary 3M Healthcare Data Dictionary (HDD) promises semantic interoperability [66]. The Healthcare Data Dictionary (HDD) is a controlled clinical vocabulary server that 3M has continuously expanded and maintained for over 15 years. The 3M HDD makes it possible to map and manage medical terminologies, integrate content and standardize healthcare data.

Holding over 2.6 million concepts, 3M claims the HDD can be used to map terms used in an EHR to concepts in HDD, thereby standardizing the data fromm the source EHR. As the HDD is proprietary, how it might be used to process data extracted from VistA is unclear. How will the HDD handle undefined acronmyns like those listed in Table 10? How will the HDD handle acronyms such as PICU that have multiple meanings?

Hammond foresaw that even the largest data dictionaries will omit terms used by some [30].

Value	Search Date
TICU	11Oct2013
NICU	15Oct2013
STICU	17Oct2013
DICU	24Oct2013
HICU	24Oct2013
RICU	24Oct2013
CICU	24Oct2013
PAICU	25Oct2013
QICU	30Oct2013
VICU	30Oct2013
ORICU	30Oct2013
PHICU	30Oct2013

Table 10:
Not Found in the VA Acronym Lookup

Concept Name 1	Relationship Type	Concept Name 2
Critical care unit	Parent/Child	Trauma critical care unit
Critical care unit	Parent/Child	Surgical critical care unit
Critical care unit	Parent/Child	Neurosurgical critical care unit
Critical care unit	Parent/Child	Surgical cardiothoracic critical care unit
Critical care unit	Parent/Child	Respiratory critical care unit
Critical care unit	Parent/Child	Prenatal critical care unit
Critical care unit	Parent/Child	Neurology critical care and stroke unit
Critical care unit	Parent/Child	Pediatric critical care unit
Trauma critical care unit	Parent/Child	Pediatric trauma critical care unit
Burn critical care unit	Parent/Child	Pediatric burn critical care unit
Medical critical care unit	Parent/Child	Medical cardiac critical care unit
Medical critical care unit	Parent/Child	Medical/Surgical critical care unit
Medical critical care unit	Parent/Child	Pediatric medical critical care unit
Surgical critical care uni	Parent/Child	Pediatric surgical critical care unit
Neurosurgical critical care unit	Parent/Child	Pediatric neurosurgical critical care unit
Surgical cardiothoracic critical care unit	Parent/Child	Pediatric surgical cardiothoracic critical care unit
Respiratory critical care unit	Parent/Child	Pediatric respiratory critical care unit
Pediatric critical care unit	Parent/Child	Neonatal critical care unit [Level II/III]
Pediatric critical care unit	Parent/Child	Neonatal critical care unit [Level III]
Pediatric critical care unit	Parent/Child	Pediatric burn critical care unit
Pediatric critical care unit	Parent/Child	Pediatric surgical cardiothoracic critical care unit
Pediatric critical care unit	Parent/Child	Pediatric medical critical care unit
Pediatric critical care unit	Parent/Child	Pediatric medical/surgical critical care unit
Pediatric critical care unit	Parent/Child	Pediatric neurosurgical critical care unit
Pediatric critical care unit	Parent/Child	Pediatric respiratory critical care unit
Pediatric critical care unit	Parent/Child	Pediatric surgical critical care unit
Pediatric critical care unit	Parent/Child	Pediatric trauma critical care unit
Medical/Surgical critical care unit	Parent/Child	Pediatric medical/surgical critical care unit

Table 8: PHIN VADS

6.4 Public Health Information Network Vocabulary Access and Distribution System

Public Health Information Network (PHIN) Vocabulary Access and Distribution System (VADS) comes from the Centers for Disease Control (CDC). All concepts listed in Table 8 have their Code System named Healthcare Service Location (HL7) and a publication date of 2010-08-12 [24]. The artificial hierarchical relationships listed in Table 8 are useless for classifying VHA ICUs.

6.5 The Federal Health Information Model

For an Encounter, the Federal Health Information Model gives an attribute named **admissionLevelOfCare**, described as

> ”Indicates the acuity level assigned to the patient at the time of admission.” - HL7 Version 2.8, PV2-40. Possible values include (from HL7 Table 432): Acute; Chronic; Comatose; Critical; Improved; Moribund

[23]

Metathesaurus Browser

Concept	Semantic Types
Level of Care – Critical Care	Idea or Concept
care by level of intensity	Qualitative Concept
transfer to intensive care unit	Health Care Activity
Intensive care	Health Care Activity
intensive care unit	Health Care Related Organization
	Manufactured Object

Table 9: Unified Medical Language System ® Terminology Services

309904001	Intensive care unit (environment)
397821002	Patient transfer to intensive care unit (procedure)
297945004	Unexpected admission to intensive care unit (procedure)
305351004	Admisssion to intensive care unit (procedure)

Table 11: Result of search for ICU in SNOMED CT Browser on 30 October 2013

6.6 Value Set Authority Center

SNOMED CT codes for ICU Admission or Transfer can be found at the Value Set Authority Center [44]. Keith Boone reports a lack of satisfaction with currently available value sets [6].

6.7 International Health Terminology Standards Development Organisation

Along with geographic entities such as countries and states, the International Health Terminology Standards Development Organisation views the ”Intensive care unit” as an example of an environment concept [55]. In Table 11, I listed the result set from my search of the Unified Medical Language System ® Terminology Services [62] for ICU. The records listed in Table 11 can also be found in PHIN VADS [63]. SNOMED CT gives us multiple concepts for Intensive Care. See Table 11 and Figure 13. How can all these different concepts describe Intensive Care? Compared with the NHS Data Model, SNOMED CT shows a lack of agreement in the US on the concept of Intensive Care. Results from searching the Metathesaurus Browser, shown in Table 9, will not help us classify ICUs. We need a better controlled clinical vocabulary for Intensive Care than SNOMED CT gives us.

6.8 Other Healthcare Classification Efforts

At this writing, ONC’s S&J Framework has not produced yet another ontology [27]. Neither has the Clinical Information Modeling Initiative [32].

7 NHS Data Model and Data Dictionary Compared to SNOMED CT

On the next page, Table 12 gives a comparison I made in October 2012, showing how little overlap in ICU varieties exists between the NHS Data Model and Data Dictionary and SNOMED CT.

Table 12: CRITICAL CARE UNIT FUNCTION Description from the NHS Data Model and Dictionary for England

Compared with SNOMED CT Intensive Care unit (environment) Concept

	NHS Data Model and Dictionary for England	SNOMED CT
Adult Facilities (Patients more than 19 years old on admission predominate)		
01	Non-specific, general adult critical care patients predominate	Adult ICU
02	Surgical adult patients (unspecified specialty)	Surgical ICU
03	Medical adult patients (unspecified specialty)	Medical ICU
05	Neurosciences adult patients predominate	Neurological ICU
06	Cardiac surgical adult patients predominate	Cardiac ICU
07	Thoracic surgical adult patients predominate	
08	Burns and plastic surgery adult patients predominate	Burns ICU
09	Spinal adult patients predominate	
10	Renal adult patients predominate	
11	Liver adult patients predominate	
12	Obstetric and gynaecology critical care patients predominate	
		Metabolic ICU
		Psychiatric ICU
		Respiratory ICU
		Telemetry Unit
90	non standard location using a ward area	
Children and Young People Facilities (Patients aged greater than or equal to 29 days to less than 19 years predominate)		
04	Paediatric Intensive Care Unit (Paediatric critical care patients predominate)	Pediatric ICU
16	Ward for children and young people	
17	High Dependency Unit for children and young people	
18	Renal Unit for children and young people	
19	Burns Unit for children and young people	
92	Non standard location using the operating department for children and young people	
Neonatal Facilities (Patients aged less than 29 days on admission predominate)		
13	Neonatal Intensive Care Unit (Neonatal critical care patients predominate)	
14	Facility for Babies on a Neonatal Transitional Care Ward	
15	Facility for Babies on a Maternity Ward	
Other settings		
91	non standard location using the operating department	

309908003	Metabolic intensive care unit (environment)
309909006	Neurological intensive care unit (environment)
309911002	Respiratory intensive care unit (environment)
404821007	Psychiatric intensive care unit (environment)
418433008	Surgical intensive care unit (environment)
426439001	Burns intensive care unit (environment)
441994008	Medical intensive care unit (environment)
133903000	Care of intensive care unit patient (regime/therapy)
305353001	Admission to pediatric intensive care unit (procedure)
397945004	Unexpected admission to intensive care unit (procedure)
183446009	Admission to cardiac intensive care unit (procedure)
183447000	Admission to respiratory intensive care unit (procedure)
183448005	Admission to neurological intensive care unit (procedure)
183449002	Admission to metabolic intensive care unit (procedure)

Table 13: Partial result of search on Intensive Care Unit in SNOMED CT Browser

8 A Better Data Model for VA Intensive Care

The concepts of Location and Level of Care used in the NHS Data Dictionary and Data Model to model Intensive Care can, if data are collected, be used in data analysis. It seems that developing a healthcare ontology without data analysis in mind can produce an ontology of uncertain utility. We have learned

> The location of patients does not determine their care. [21]

Supporting the statement made by The Intensive Care Society, Veterans Health Administration standards require provision of Intensive Care in alternate Locations when no ICU bed is available [57]. That VHA patients can receive Intensive Care in Locations such as the Post Anesthesia Care Unit, the Emergency Department or an Urgent Care Clinic proves that the Location of VHA ”patients does not determine their care”.

I propose modeling Intensive Care with a state-transition model [39]. A patient in hospital is a state-dependent object. A hospital stay can be described as a sequence of chronological events that may bring about change(s) in the patient’s state. States would be Levels of Care whether in an ICU or another hospital Location, such as Post Anesthesia Care (PAC), Surgery or Hospice. Birth, Death, Admitted and Discharged would be Terminators. In the following hypothetical scenario I illustrate a conceptual data model of Intensive Care using a state-transition model.

Admitted to the Emergency Department, a patient receives a level of care described by Level 2 to support his life. He is admitted to hospital and goes to surgery. Following surgery his gurney is rolled into a Post Anesthesia Care Unit where he continues to receive Level 2 care. Some hours later, hospital staff push his gurney into an ICU where Level 2 care continues. His condition improves and he is sent to a stepdown unit providing care corresponding to Level 1. His condition deteriorates, he is returned to the ICU for Level 3 care. Within hours, his provider writes a Do Not Resuscitate order. During this patient’s last hours in this ICU, he receives Level 0 care. His care plan is changed to discharge him to a Hospice facility.

My recommendation to add Level of Care to an open source EHR received no response [74]. That change would likely mean extensive modification of much Massachusetts General Hospital Utility Multi-Programming System (MUMPS) code. Of course, data on the patient’s Location would still need to be collected.

9 Corporate Data Warehouse (CDW)

The CDW holds unaggregated transaction level data from the entire nation. It is built with Microsoft SQL Server and SQL Server Integration Services [47], also known as SSIS packages. In the production CDW, all tables are designated as either dimension or fact tables.

9.1 Extract, Transform, Load

After extraction and transformation, VistA data are loaded into the Veterans Administration Corporate Data Warehouse (CDW) [49]. No documentation of data transformation during extract, transform, load (ETL) processes turned up. Figure 4 gives a representation of data extraction from VistA. As it is my understanding that data are not

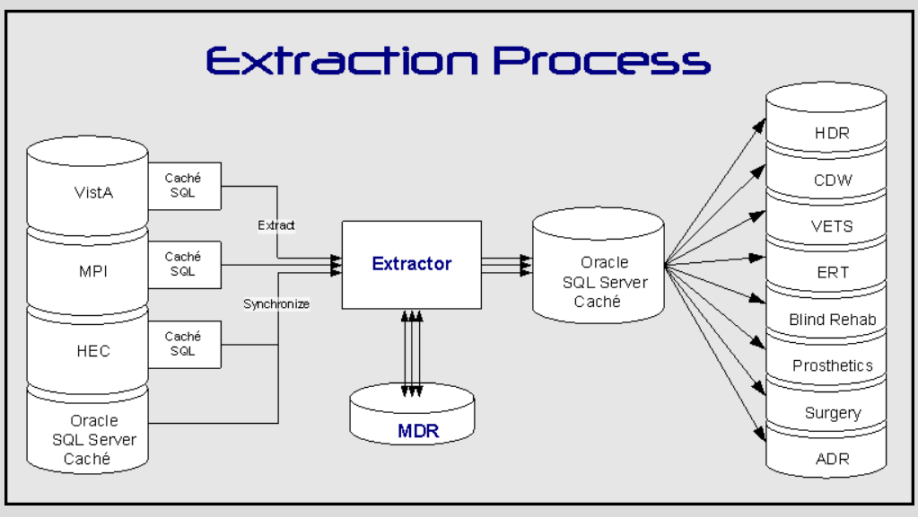


Figure 4: Data Extraction from VistA

stored in Oracle between extraction from VistA and load into the CDW, I believe the diagram shows processes at an early point in building the CDW [45]. ”Field descriptions that are available within the VistA system are extracted to the CDW Metadata... Unfortunately, VistA field descriptions tend to be cryptic and/or technical.” [9].

10 VistA Metadata Repository

Developed in secret [59], VistA has no manual [8]. Some documentation prepared after VistA implementation may be found in the VA Software Document Library [51]. Within the Department of Veterans Affairs Data Architecture Repository, under the tab labeled VHA, data users can find the VistA Metadata Repository. The VistA Metadata Repository gives metadata for the ”VistA Platinum image”.

> VistA Platinum is the master version of the complete VistA system maintained by the Standards and Compliance Office within the Office of Information and Technology. [52]

It is not clear if VistA Platinum is one of the ”production VistA instances” in actual use. Descriptions given for VistA Field Names can read as if they are outdated or incorrect. For example, the description for the VistA Field named SERVICE CATEGORY in the File Named VISIT and Numbered 9000010 tells us

> This service category field represents what kind of service was provided. The IHS definition is represented by a set of codes. This field can be used by IHS to screen on service categories. The VA continues to populate this field to be backward compatible with IHS utilities depending on this field. The VA uses the Service Provided file (#150.1) to define a more detailed file of services provided. When a VA user identifies the Service Provided (field 15001), a trigger will automatically populate this service category based on relationships between entries in File 150.1 and the set of codes for this field. The population of this field is dependent upon entries provided by applicaions as well as default values and caculated codes. [*sic*] [52]

However, searching the VistA Metadata Repository for a file named Service Provided uncovers only a file named File Num 150.1, named ANCILLARY DSS ID. Moreover, the file named Service Provided is numbered 162.03. As the Indian Health Service uses a VistA variant, [68] I interpret the undefined abbreviation IHS to mean Indian Health Service. The final sentence in the VistA Field description above suggests that not only are inputs to this field numerous but their traceability within the various VistAs and VistA packages has been lost to mankind. No wonder data users choose to rely on word of mouth instead of the available data documentation.

Unintentionally, the Heath Services Research Data Discussion listserv promotes this word of mouth. For example, when a data user found an empty cell instead of the metadata he sought, he posted an inquiry to the listserv [56]. Data documentation is so lacking that posting an ”anecdotal” story based on a conversation with an individual outside of VHA data processing is accepted as a valid contribution to knowledge of VistA and the CDW [65]. The lack of documentation and metadata coupled with reliance on word of mouth means different data users choose different columns from the CDW for analysis.

Bentley [5] cites work by Barry Devlin in which Devlin likened using a data warehouse without metadata to exploring the Wild West without maps. Without the metadata they need, data users will be as lost as pioneers without maps.

IPEC	Clinical Inventory	National Bed Control System
MICU	Medical ICU	MICU
MICU/CCU	Specialty ICU	
CCU	CCU (Cardiac Care)	
SICU	Surgical ICU	SICU
Mixed	Mixed ICU	

Table 14: Classifications Used by IPEC and the Clinical Inventory

11 Admission Discharge Transfer

VistA's Admission/Discharge/Transfer (ADT) package built upon the Medical Administration System package [59]. Vista includes not only the VA's electronic health record [50], but administrative functions such as ADT [42]. HL7 standard messages represent the hospital healthcare events known as Admission, Discharge and Transfer [30]. VA documented ADT HL7 messages in 1995 [67]. A re-engineering of the ADT package, called ADT Encapsulation began in early 2005 but was terminated by the end of that year [71]. An undated intranet site headed BMS Project Center gives the Bed Management Solution's status as "BMS is currently in Class II Limited Deployment" [46]. Apparently, automated reporting on beds cannot be achieved without changing VistA or building software on top of VistA.

Nowhere in the document titled *Bed Management Solution (BMS) User Guide* does the term Bed Section appear [15]. Instead, the BMS User Guide uses the term "Bed Groupings", an apparently identical concept. Further confusing the reader, the BMS User Guide also uses the terms "ward group" and "type group". In a screenshot purporting to illustrate use of the application, redundancy among the fields named "VISTA WARD NAMES", "VISTA WARD SPECIALTY", "BMS TYPE GROUP", and "BMS WARD GROUP TEXT" is evident, as are consequent inefficiencies. Beginning without a clear understanding of concepts and an information model, BMS design lacked vision. This situation supports the assertion that an enterprise architecture framework requires domain ontologies [4].

The *Bed Management Solution (BMS) User Guide* describes its column named "Type of Bed/Ward Required" as "The type of bed/ward required for the particular ailment of that patient. Because it has a unique and more flexible means of providing beds to meet patients' needs, the Portland VAMC has found it cannot use the BMS [16].

Although data from all VistA sites are poured together into the CDW, listing data by Division value can reveal a pattern unique to a single hospital. See Table 16. At the Portland, OR VA hospital, values of WardLocationName contain not only text identifying the Location by hospital floor, e.g. 3D, but text suffixed to these Location identifiers. The suffixed text appear to be abbreviations for Treating Specialties. It appears that the Portland, OR VA Hospital has repurposed this VistA field in an undocumented manner. I requested descriptions spelling out the text of these apparent abbreviations from the Portland, OR, VA Hospital, but did not get them. Without a code set, the meanings of the values listed in the second column of Table 16 remain unknown.

12 Administration

Kolodner makes clear VistA was not designed to be a management information system. Originally named the Decentralized Hospital Computer System (DHCP), VistA was designed to meet the needs of individual healthcare facilities [26]. Indeed, data for management was seen only as a byproduct of VistA. Never intended as a management information system for central administration of more than 100 hospitals, free text values combined from VHA's many VistAs are not ready for identification of ICUs. So stovepiped are VHA reporting systems, no 2 of the 6 discovered use the same classification of ICUs. Apparently, willing programmers individually papered over the ICU classification problem but collectively failed to conceal it.

12.1 Inpatient Evaluation Center (IPEC)

IPEC classifies ICUs based on "VistA Ward Treating Specialty" [34] as shown in Table 14. In an e-mail message addressed to me, Richard Pham wrote

> IPEC also has the same difficulties in Ward Identification as we do [58].

12.2 Clinical Inventory

The Clinical Inventory v2.0 application can be found on the Reports and Measures Portal (RAMP). It can be run to produce reports of ICUs by ICU Type at each VA hospital [70]. These ICU Types are tabled in Table 14.

DSS Production Unit Code	Name
E1	Surg ICU
E2	Telemetry ICU
E3	Medical ICU 1
E4	Medical ICU 2
E5	Neuro ICU
E8	Med/Surg ICU Combined

Table 15: Production Unit Names Containing String ”ICU”

MAS Wards Listed in the Nursing Unit Mapping Application	Values of WardLocationName That Joined to Inpatient Records From FY13
3DANS-ICU	
3DCARD-ICU	√
3DCIT-ICU	
3DEN-ICU	√
3DGS1-ICU	√
3DGU-ICU	√
3DINTS-ICU	√
3DKID-ICU	√
3DNS-ICU	√
3DOP-ICU	
3DOR-ICU	√
3DPLS-ICU	√
3DTRA-ICU	√
3DTS-ICU	√
3DVAS-ICU	√

Table 16: Critical Care Wards Listed for 648 Portland, OR

12.3 VHA National Bed Control System

The VHA Support Service Center (VSSC) supports the National Bed Control System. On 10 June 2013, I ran this point and click application. From the pulldown menu labeled ”Bed Service”, I selected MICU and SICU. The resulting report listed counts for both MICUs and SICUs. Clicking on the Data Definition button did not reveal any data definitions.

12.4 Decision Support Systems Product Units

The Decision Support Office, now named the Managerial Cost Accounting Office, published the Decision Support Systems (DSS) classification of hospital wards [53] including those listed in Table 15. They did not share a mapping of VA hospital wards to Production Unit codes with me when I requested one [73].

12.5 Nursing Unit Mapping Application

On 12 December 2013, I ran the Nursing Unit Mapping Application (NUMA) for Facility 648, Portland, OR, requesting a report listing all Unit Types. For Unit Type ”Acute - Critical Care” and DSS Production Units ”241E81 - UE81 - Med/Surg ICU combined” the ”MAS Wards” were listed as shown in the first column of Table 16.

12.6 Seasonal Weekly Flu Report

During flu season, VHA publishes an internal weekly Influenza Activity report based on stay level data on ICU utilization [35]. How data are collapsed into the 3 categories of ”Medical ICU and Step Down”, ”Surgical ICU and Step Down”, and ”Cardiac ICU and Step Down” is not explained.

13 Summary

Of ICUs, Atul Gawande [28] gave his qualitative assessment: ”Nowhere in health care do we expend more resources.” Spending on Intensive Care has been estimated at one percent of the U.S. Gross Domestic Product [64]. To better answer questions about the amount of resources expended on Intensive Care, we need a more comprehensive classification of ICUs.

VHA Directive 1009 uses the concepts of Location and Level of Care to describe Intensive Care [57]. So does the NHS Data Model and Dictionary for England. These concepts, already in use, are superior to the concepts given by SNOMED CT. Only in the United Kingdom, with development of the NHS Data Model and Dictionary and its national codes has there been progress on useful classification of ICUs. No progress toward meaningful analysis of its diverse VistAs and many free text fields within them has been made in the VHA since Hammond, writing nearly 20 years ago, [30] advocated controlled clinical vocabularies.

The NHS Data Model for Intensive Care, using concepts of both Level of Care and Location can be used in an incremental approach to modeling healthcare data [7]. Modeling the hospitalized patient as a state-dependent object could bring order to data capture, storage, and analysis of inpatient care records. The next ontology of Intensive Care should be designed to meet requirements for data analysis and administration.

Credit Notices

Acknowledgements

I am grateful to Dan Gillman, Research Mathematical Statistician, Mathematical Statistics Research Center, Bureau of Labor Statistics for helpful suggestions. David Reed, BlueCross BlueShield of Tennessee, Inc. told me about Medicare Revenue Codes.

Disclaimer of Endorsement

The views and opinions of the author expressed herein do not necessarily reflect those of the Office of Informatics and Analytics, the Veterans Health Administration or the Department of Veterans Affairs. Reference herein to any specific commercial products, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the Department of Veterans Affairs.

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