A classification of hospital-acquired diagnoses for use with routine hospital data

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Patient safety advocates have recently posed the question: "Is health care getting safer?"[1] They conclude it is impossible to know, but in order to make progress toward the answer, health systems need to change focus "away from unsystematic voluntary reporting towards systematic measurement". Their prescription is "a broad but manageable spectrum of indicators that are genuinely useful to the clinical teams that monitor quality and safety day to day", using "local data that are relevant to clinical concerns . . . how a team is doing compared with last month and last year".[1]

Most current approaches to systematic measurement of patient outcomes in hospital do not satisfy these criteria, instead relying on voluntary reporting, a relatively narrow range of diagnoses, or detailed, condition-specific profiles of comorbidities for risk adjustment (Box 1). To our knowledge, there has been only one attempt to use routinely recorded data on diagnosis codes to monitor the full range of hospital-acquired illness and injury — the Utah/Missouri Patient Safety Project[16,17] (Box 1). This was limited by the need for expert clinical review to distinguish hospital-acquired diagnoses from comorbidities, eliminating many conditions that could also be community acquired.

Here, we describe the development of a tool to allow routinely coded inpatient data to be used to monitor a full range of hospital-acquired diagnoses ("complications") to support quality improvement efforts by hospital-based clinical teams. This tool — the Classification of Hospital Acquired Diagnoses (CHADx) — was developed under the sponsorship of the Australian Commission on Safety and Quality in Health Care and builds on the Utah/Missouri project. To identify hospital-acquired diagnoses, it uses a "condition onset" flag that is now common in a number of jurisdictions[18] and recorded in all Australian states. We termed these diagnoses "complications" in an attempt to find neutral terminology reflecting the lack of either risk adjustment or information on causation.

The classification is designed to provide a comprehensive overview of all complications as the basis for estimating total and relative per case expenditure by complication type.[19] It is also intended to provide hospitals with a computerised tool to group the 4000 + valid diagnosis codes typically used with a hospital-acquired diagnosis-onset flag into a smaller set of clinically meaningful classes for routine monitoring of patient safety and safety improvement efforts.

ABSTRACT

Objective: To develop a tool to allow Australian hospitals to monitor the range of hospital-acquired diagnoses coded in routine data in support of quality improvement efforts.

Design and setting: Secondary analysis of abstracted inpatient records for all episodes in acute care hospitals in Victoria for the financial year 2005–06 (n = 2.032 million) to develop a classification system for hospital-acquired diagnoses; each record contains up to 40 diagnosis fields coded with the ICD-10-AM (International Classification of Diseases, 10th revision, Australian modification).

Main outcome measure: The Classification of Hospital Acquired Diagnoses (CHADx) was developed by: analysing codes with a "complications" flag to identify high-volume code groups; assessing their salience through an iterative review by health information managers, patient safety researchers and clinicians; and developing principles to reduce double counting arising from coding standards.

Results: The dataset included 126 940 inpatient episodes with any hospital-acquired diagnosis (complication rate, 6.25%). Records had a mean of three flagged diagnoses; including unflagged obstetric and neonatal codes, 514 371 diagnoses were available for analysis. Of these, 2.9% (14 898) were removed as comorbidities rather than complications, and another 118 640 were removed as redundant codes, leaving 380 833 diagnoses for grouping into CHADx classes. We used 4345 unique codes to characterise hospital-acquired conditions; in the final CHADx these were grouped into 144 detailed subclasses and 17 "roll-up" groups.

Conclusions: Monitoring quality improvement requires timely hospital-onset data, regardless of causation or "preventability" of each complication. The CHADx uses routinely abstracted hospital diagnosis and condition-onset information about in-hospital complications. Use of this classification will allow hospitals to track monthly performance for any of the CHADx indicators, or to evaluate specific quality improvement projects.

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METHODS

ICD-10-AM and condition-onset coding

The CHADx (pronounced "chaddix") uses data coded according to the International Classification of Diseases, 10th revision, Australian modification (ICD-10-AM). As the ICD was not designed specifically to identify hospital-acquired conditions, the CHADx had to accommodate the idiosyncrasies of the source data and coding rules, while seeking to extract as much information as possible from the record abstracts.

Like most previous classifications, we began with the "external causes" chapters of the ICD, which contain codes for causes of injury specific to hospital care (*Complications of medical and surgical care*, Y40–Y84), and the codes for manifestations or injuries common in hospital care (T and End of Chapter [EOC] codes). The latter include *Complications of surgical and medical care not elsewhere classified* (T80–T88), *Poisoning by drugs, medicaments and biological substances* (T36–T50), and the EOC or postprocedural complication codes specific to particular chapters (eg, cardiac, respiratory).

The complications flag (C prefix[20]) used in Victoria was the model for the recently adopted national system of "condition onset" flagging.[21] To be flagged, a diagnosis must have occasioned treatment or active

investigation in hospital, or have extended length of hospital stay. Coders review the patient's clinical notes to establish whether each diagnosis was recorded as present on admission. If the diagnosis was not present on admission and is plausibly hospital acquired (ie, not a congenital or chronic condition), the C prefix is assigned. In the past, coding standards have not encouraged assigning of the C prefix to diagnoses in obstetric or perinatal patients because of ambiguities in the timing of onset of particular diagnoses. Thus, because of the small proportion of C prefixes in obstetric and neonatal records, we analysed all codes listed in the obstetric and neonatal chapters of ICD-10-AM that were plausibly hospital acquired.

Sample

We selected records with any hospital-acquired diagnosis code from the Victorian Admitted Episodes Data Set (VAED) for the financial year 2005–06. Of the 2 031 666 inpatient episodes, 126 940 (6.25%) included at least one hospital-acquired diagnosis, with a mean of three flagged diagnoses per record, giving a total of 386 048 flagged diagnoses. With the addition of 128 323 obstetric and neonatal diagnoses, 514 371 diagnoses were available for analysis.

We applied a recently developed computerised algorithm[22] to remove codes judged ineligible for the hospital-acquired flag (ie, congenital or chronic conditions). On this basis, 14 898 diagnoses (2.9%) were removed. Consolidation of redundant codes removed a further 118 640 diagnoses, resulting in 380 833 instances for grouping into CHADx classes.

Analysis and design principles

To determine the optimal number of end classes in the CHADx, we examined how variations between hospitals in depth of coding and total number of separations per year interacted with classifications of various sizes. This suggested that for hospitals with over 6000 admissions per year, 120–130 end classes with an incidence of over 0.1% of cases would provide sufficient granularity (specificity of classes and avoidance of "catch all" classes), without creating too many "empty" classes because of infrequently occurring diagnoses. For hospitals with fewer admissions, major "roll-up" groups could be used to monitor a smaller number of broad complication types.

Australian coding standards mandate that codes be recorded in specific sequences: for

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1 Approaches to systematic measurement of hospital outcomes

Current approaches are of four general types.

Analysis of causal factors. This approach focuses on the causes of adverse events in patient care.[1,3] These systems aim to be "multiaxial", allowing patient "safety events" to be analysed by cataloguing a range of relevant contributory factors, such as characteristics of the patient and care team, and the circumstances leading up to, or causing, any breach of patient safety. This is an important focus for workers at the "sharp end" of patient safety, but will continue to rely on voluntary reporting for the near future. Because of the historical focus on accountability of individual health care workers (largely ignoring contributory organisational factors), voluntary reporting is vulnerable to underestimation of rates of such events.[4-6] These collections may be more useful to characterise events than to count them.

Case-finding for sentinel events. This type of system typically reports serious, "sentinel" or "never" events.[7-9] These systems are better understood as case-finding systems that enable in-depth investigation of particular events. They also use voluntary reporting. The assumption (rarely tested) is that such relatively uncommon events function as sentinels for more systemic problems in patient care.

Performance reporting with risk adjustment. This approach uses routine hospital morbidity data and focuses on performance reporting. It places a premium on preventability and risk adjustment to avoid inappropriate blame of hospitals or providers for adverse outcomes beyond their control. The foremost example of this approach is the US Pay for Performance rules,[10] where a set of specific events coded in the record abstract leads to denial of Medicare funding. Other examples are the US Agency for Healthcare Research and Quality Patient Safety Indicators,[11] which build on similar earlier work;[12,13] the 3M proprietary system Potentially Preventable Complications;[14] and Queensland Health's VLAD (variable life-adjusted display) indicators.[15] By necessity, these systems focus on a narrower range of diagnoses or procedures and rely on detailed, condition-specific profiles of comorbidities that predict a higher rate of unfavourable patient outcomes. This approach is primarily embraced by regulatory and funding authorities seeking to reward better patient outcomes and to penalise poor performance.
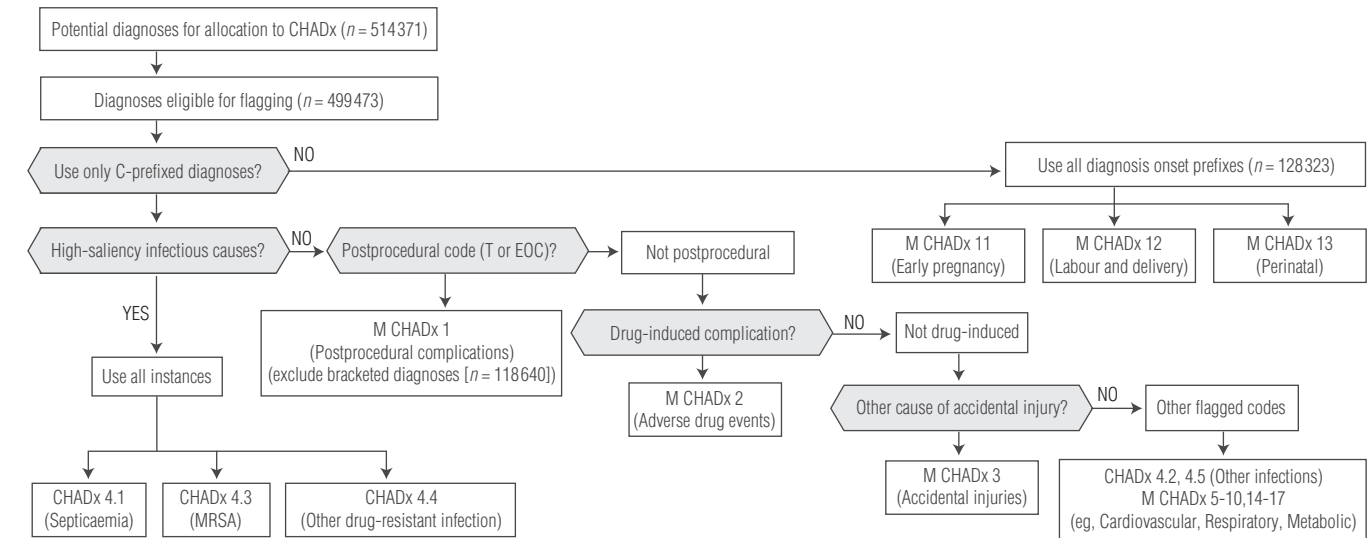
Monitoring of the range of hospital-acquired diagnoses. The final approach also uses routine data but seeks to use the full range of routinely recorded diagnosis codes that characterise hospital-acquired illness and injury. We have identified only one example: the Utah/Missouri Patient Safety Project,[16,17] funded by the US Agency for Healthcare Research and Quality, which developed a set of 64 classes. It used expert clinical review to try to distinguish at the code level between comorbidities (conditions present on admission) and complications (hospital-acquired diagnoses). Thus, it could not include conditions such as pneumonia or urinary tract infections, which may be either community- or hospital-acquired. Because US jurisdictions have yet to switch to the 10th revision of the International Classification of Diseases for coding, the project was developed using the previous version of the World Health Organization's hospital mortality and morbidity coding system (9th revision, clinical modification [ICD-9-CM]). ◆

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example, an injury or manifestation should be coded before the cause.[21] Some combinations of code types represent redundant coding, or only marginally refine the information available from a single code. We developed working principles for prioritising code selection and reducing double counting arising from these sequenced codes. T and EOC codes are given priority as the most specific codes for hospital-acquired conditions. To avoid double counting of manifestations related to the same cause, a "bracket rule" was used: any codes bracketed between a T or EOC code and a following Y (external cause) code were assigned to a postprocedural CHADx, with no further assignment to other CHADx classes. Exceptions were made for three "high saliency" infection-related complications: septicaemia, methicillin-resistant *Sta-*

phylococcus aureus, and "other drug resistant" infections.

Some manifestations are not described with T or EOC codes, and thus the bracket rule defining a code sequence cannot be applied. For example, both a rash and headache could be coded as manifestations of a particular drug. This sequence of three codes is meaningful when it is coded, but ambiguous when analysed. Only the paired external cause code and the immediately preceding diagnosis can be linked; no unequivocal links to other manifestations can be made without referring back to the medical record. Given this limitation on inferring relationships between codes, we took a conservative approach to avoid over-interpreting the data. This had the unavoidable consequence that some causes might have been omitted. In the example above,

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2 Logic for code assignment in the Classification of Hospital Acquired Diagnoses (CHADx)

Potential diagnoses for allocation to CHADx ($n = 514371$)

Diagnoses eligible for flagging ($n = 499473$)

Use only C-prefixed diagnoses? — NO → Use all diagnosis onset prefixes ($n = 128323$)

High-saliency infectious causes? — NO → Postprocedural code (T or EOC)? → Not postprocedural

M CHADx 11 (Early pregnancy) | M CHADx 12 (Labour and delivery) | M CHADx 13 (Perinatal)

YES

Use all instances

M CHADx 1 (Postprocedural complications) (exclude bracketed diagnoses [$n = 118640$])

Drug-induced complication? — NO → Not drug-induced

M CHADx 2 (Adverse drug events)

Other cause of accidental injury? — NO → Other flagged codes

CHADx 4.1 (Septicaemia) | CHADx 4.3 (MRSA) | CHADx 4.4 (Other drug-resistant infection)

M CHADx 3 (Accidental injuries)

CHADx 4.2, 4.5 (Other infections) M CHADx 5–10,14–17 (eg, Cardiovascular, Respiratory, Metabolic)

C prefix = complications flag. M CHADx = major CHADx group. MRSA = methicillin-resistant *Staphylococcus aureus*. ◆

both the rash and the headache were classified in CHADx, although only one was attributed to their shared drug cause.

High-volume sets of codes were then grouped together into the first draft of the CHADx, using an iterative process principally involving the first two authors (T J J and J L M). Major groupings were compared with similar published grouping systems[11,14,16,17,23] to ensure that salient event types were not overlooked in the grouping process. While grouping was based in part on the size of groups, single codes or low-volume code groups with high saliency for patient safety were created as their own groups. Other small-volume and less specific codes were grouped together. The logic used in the construction of the CHADx is shown in Box 2.

The draft classification was reviewed by the remaining three authors (C M J, J G W and R F R) and then by three independent clinical reviewers, two of whom returned full reviews of the classification. Their suggestions and amendments were analysed, and the groups were further refined.

RESULTS

We used 4345 unique codes to characterise hospital-acquired conditions; in the final CHADx these were grouped into 144 detailed subclasses and 17 major "roll-up" groups. These major groups can be routinely monitored by low-volume hospitals, and the sub-

classes by larger hospitals; the subclasses also support economic analysis.

The 17 major groups are shown by volume of diagnoses in 2005–06 in Box 3. CHADx 12 (labour and delivery) was the largest major group by volume (75 320 diagnoses), and CHADx 1 (postprocedural com-

3 Major CHADx groups, by volume of hospital-acquired diagnoses in Victoria in 2005–06*

Group	Descriptor	No. of diagnoses
12	Labour and delivery complications	75 320
13	Perinatal complications	43 339
5	Cardiovascular complications	38 186
17	Other complications	30 743
7	Gastrointestinal complications	29 351
15	Metabolic complications	28 899
1	Postprocedural complications	26 840
9	Genitourinary complications	22 769
6	Respiratory complications	19 885
2	Adverse drug events	12 131
8	Skin conditions	12 085
14	Haematological complications	11 153
10	Hospital-acquired psychiatric states	10 923
4	Specific infections	8 701
3	Accidental injuries	5 067
11	Early pregnancy complications	2 826
16	Nervous system complications	2 615
All CHADx classes		380 833

CHADx = Classification of Hospital Acquired Diagnoses.
* From the Victorian Admitted Episodes Data Set. ◆

plications) was the largest by number of subclasses (23). Box 4 shows the top 20 CHADx subclasses by volume of diagnoses in 2005–06.

Five subclasses with particular relevance for efforts to improve patient safety were kept as separate CHADx categories despite their expected small numbers (< 100 cases in the sample of more than 2 million inpatient episodes). These were: 1.2 *Gas embolism* (3 cases); 3.4 *Injury d/t assault* (19); 1.6 *Foreign body or substance left following procedure* (46); 3.2 *Falls with intracranial injury* (67); and 2.17 *Anaphylactic shock due to correct drug properly administered* (88).

A complete list of the CHADx major groups and subclasses, along with the code sequences assigned to each category and the number of admissions from the 2005–06 VAED in each end class, is available on the website of the Australian Commission on Safety and Quality in Health Care (http://www.safetyandquality.gov.au/internet/safety/publishing.nsf/Content/Priority-Program-08_CostHAD).

DISCUSSION

The CHADx is intended as a tool to help hospitals monitor rates of complications and the effect of patient safety interventions. In most Australian states, hospitals submit diagnosis abstracts on a monthly basis. Monthly use of the CHADx would allow hospitals to identify any changes associated

with local patient safety strategies in near "real time". Longitudinal measurement would provide information not available from methods that rely on periodic and costly intensive investigations, such as chart review. We also foresee its potential to help include cost in prioritising patient safety programs.

In contrast to performance indicators, the CHADx is not intended for external monitoring or holding hospitals to account. However, at a broad systems level, it might be useful for monitoring changes in rates of particular complication types. It does not employ risk adjustment, a technique that seeks to standardise the risk of adverse events in a patient population using information on severity or comorbidity. It avoids risk adjustment for two closely related reasons:

• the classification is not primarily intended to be comparative (a hospital's casemix constitutes the context of its patient safety efforts, regardless of its risk profile); and

• risk adjustment may cultivate a therapeutic nihilism for a proportion of complications or particular patient groups ("old patients just get more complications").

In reality, severity of illness and comorbidities do affect rates of complications. However, it is important as a tool for priority setting and for local efforts to improve patient safety to have the full picture across the patient population, regardless of the spectrum of risk and severity.

The number of end categories in the CHADx is designed according to the level of specificity required. The optimal granularity of the classification (and thus usefulness of the categories) will vary, depending on both hospital size and local depth of coding: fewer classes provide more robust cell sizes for monitoring, but may group unlike complications together. Detail has been highlighted as a critical feature of patient-event classifications.[24] The tiered structure of the 17 major roll-up groups and 144 detailed and comprehensive subclasses is designed to suit a range of potential uses.

The development of any classification system using routine hospital data faces a number of challenges. The quality of both medical record entries and their abstraction varies both between institutions and between jurisdictions. This limits comparisons of data, at least until robust data audits are in place.

Current coding conventions may need to be reconsidered to better support use of routine morbidity data for patient safety. However, monitoring these routine data within institutions remains potentially useful for tracking change, even in the absence of the data audits that would support comparability between institutions. With appropriate quality control and external audits, hospitals may be able to identify peers (with a similar casemix) for comparison of rates of particular CHADx classes for particular procedures or patient groups. The specificity of most CHADx classes might also allow more standardised reporting of complications of care in clinical research.

Assignment of the condition-onset flag has not been audited, although the annual Victorian Department of Human Services inpatient data audit covered assignment of these flags for the first time in 2008.[25] The usefulness of the source codes could be compromised if financial incentives were applied to hospitals reporting hospital-acquired illnesses and injuries in their data. For this reason, we argue against the use of the CHADx for public reporting or the application of financial incentives.

Research groups around the world are trialling ways to collect information on patient outcomes to inform efforts to reduce rates of hospital-acquired illness and injury. Routine data is underutilised in these efforts but has the advantage of being comprehensive, timely and available at no additional cost. Validity and reliability of these data will vary within and between health care systems, and only conditions specifically identified in the record can be coded. In Australia and elsewhere, diagnosis coding is subject to increasing scrutiny and formal evaluation.

Despite increased reporting of mortality rates and other measures of quality of care, individual hospitals have had few ways of systematically investigating rates and patterns of quality problems, focusing instead on incident investigations. The CHADx is designed to provide clinicians and hospitals with a computerised tool to group hospital-acquired diagnoses into smaller sets of clinically meaningful classes for routine monitoring of patient safety. It is premised on a "just culture" approach to improving patient

4 Top 20 CHADx subclasses, by volume of hospital-acquired diagnoses in Victoria in 2005–06*

Subclass	Descriptor	No. of diagnoses
15.2	Electrolyte disorders without dehydration	18 010
5.3	Cardiac arrhythmias, conduction disturbances and abnormal heart beat	14 254
12.14	Breast disorders associated with childbirth	14 188
5.6	Hypotension (not drug induced)	12 172
12.7	Second-degree perineal laceration	11 132
12.9	Maternal haemorrhage	10 235
7.5	Nausea and vomiting	10 234
13.11	Other neonatal complications	10 169
13.10	Gastrointestinal and feeding disorders of newborn	9712
12.3	Complications of umbilical cord	9589
9.2	Urinary tract infections	8467
7.4	Constipation	7232
12.6	First-degree and unspecified perineal laceration	6579
8.3	Dermatitis, rash and other skin effects	6517
10.4	Alterations to mental state	6374
1.4	Other haemorrhage and haematoma complicating a procedure	6332
12.11	Other complications intrapartum and postpartum	5886
12.1	Fetal heart rate anomalies	5728
9.4	Other complications and symptoms of the urinary system	5678
6.3	Acute lower respiratory infections (including influenza and pneumonia)	5668
All other CHADx		196 677
Total CHADx		380 833

CHADx = Classification of Hospital Acquired Diagnoses. * From the Victorian Admitted Episodes Data Set. ◆

safety (which recognises that competent professionals make mistakes, but has zero tolerance for reckless behaviour[26]), and also due attention to the organisational contexts in which clinicians work. It requires well documented medical charts and investment in training and supervision of coding staff, but does not rely on special-purpose collection of data. It supports local monitoring of complication rates over time, to focus efforts to improve patient outcomes by minimising their incidence. These complications may not be preventable in every patient but are amenable to systematic efforts to reduce their rates. The CHADx can also be used as the basis for setting priorities through supporting the estimation of relative per-case and total expenditure attributable to each CHADx class.

COMPETING INTERESTS

None identified.

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