The Accuracy of Administrative Data for Identifying the Presence and Timing of Admission to Intensive Care Units in a Canadian Province

Allan Garland, MD, MA,†‡ Marina Yogendran, MSc,‡ Kendiss Olafson, MD, MPH,* Damon C. Scales, MD, PhD,§ Kari-Lynne McGowan, MSc,‡ and Randy Fransoo, PhD†‡*

Background: A prerequisite for using administrative data to study the care of critically ill patients in intensive care units (ICUs) is that it accurately identifies such care. Only limited data exist on this subject.

Objective: To assess the accuracy of administrative data in the Canadian province of Manitoba for identifying the existence, number, and timing of admissions to adult ICUs.

Research Design: For the period 1999 to 2008, we compared information about ICU care from Manitoba hospital abstracts, with the criterion standard of a clinical ICU database that includes all admissions to adult ICUs in its largest city of Winnipeg. Comparisons were made before and after a national change in administrative data requirements that mandated specific data elements identifying the existence and timing of ICU care.

Results: In both time intervals, hospital abstracts were extremely accurate in identifying the presence of ICU care, with positive predictive values exceeding 98% and negative predictive values exceeding 99%. Administrative data correctly identified the number of separate ICU admissions for 93% of ICU-containing hospitalizations; inaccuracy increased with more ICU stays per hospitalization. Hospital abstracts were highly accurate for identifying the timing of ICU care, but only for hospitalizations containing a single ICU admission.

Conclusions: Under current national-reporting requirements, hospital administrative data in Canada can be used to accurately identify and quantify ICU care. The high accuracy of Manitoba administrative data under the previous reporting standards, which lacked standardized coding elements specific to ICU care, may not be generalizable to other Canadian jurisdictions.

Key Words: intensive care, administrative data, health services research

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The care of critically ill patients in intensive care units (ICUs) is an important component of health care[1,2]; such care is expensive,[3–7] common,[8,9] and increasing.[5,7,9,10] Also, many people die in ICUs.[11–13]

Much critical care research has prospectively gathered data on a limited topic over a relatively brief interval from a small population in 1 or a few ICUs. Some observational studies have used existing ICU databases containing detailed data from 1 to many ICUs, but such data sets exist in few locations. These limitations can be overcome by using hospital administrative data, often maintained by health care funders such as governments and insurance companies.[14,15] Although administrative databases usually contain limited clinical details, they can be used to answer important questions about critical illness,[14,15] by virtue of being repositories of systematically collected, population-based health data over extended follow-up periods.

The most basic requirement for using administrative hospital data to study critical illness is accurate identification of ICU care in hospital abstracts. Although Canadian provinces have long been required to identify and report to the Canadian Institute for Health Information (CIHI) whether hospitalizations included ICU care, the nature of such data reporting has changed over time. Specifically, in 2002 CIHI sought to improve the coding of ICU admissions in administrative hospital data by standardizing definitions and coding practices.

In this study, we used Manitoba hospital abstracts to advance 2 goals: (i) assess the accuracy of hospital abstracts to identify the existence and timing of ICU care and (ii) compare the accuracy of these determinations in the periods before and after the change in CIHI reporting requirements.

From the Departments of *Medicine; †Community Health Sciences; ‡Manitoba Centre for Health Policy, University of Manitoba, Winnipeg, MB; and §Department of Medicine, University of Toronto, Toronto, ON, Canada.

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Reprints: Allan Garland, MD, MA, Department of Medicine, Health Sciences Centre, University of Manitoba, 820 Sherbrook Street—GF222, Winnipeg, MB, Canada R3A 1R9. E-mail: agarland@hsc.mb.ca.

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We hypothesized that predictive accuracy would improve after the change in reporting requirements. This work was performed as part of a larger project funded by Manitoba Health (the provincial health care agency) and was approved by the Health Research Ethics Board of the University of Manitoba and the Manitoba Health Information Privacy Committee.

METHODS

We evaluated the accuracy of administrative data for identifying admission to adult ICUs, using the Winnipeg ICU database (WICUDB) as the criterion standard. The WICUDB contains detailed clinical information about all adults admitted to ICUs in the Winnipeg Health Region since 1999. The Winnipeg Health Region includes over 671,000 Manitobans, being the largest of the 11 health regions in a province with a population of 1.19 million in 2007.[16] There are 11 adult ICUs within 6 hospitals in the Winnipeg Health Region. Two of these hospitals are tertiary referral centers, whereas the other 4 are community hospitals. The types of ICUs are: 5 medical-surgical, 1 medical, 1 general surgical, 1 cardiothoracic surgical, 2 coronary care, and 1 respiratory. The information for the WICUDB is obtained in real time by specially trained and dedicated data collectors, all of whom are former ICU nurses. This extensive data set includes information on all admitted ICU patients including dates/times of ICU admission and discharge, obtained from ICU flow sheets and nursing notes. These data undergo extensive reliability and validity testing to ensure validity of the many data fields; in particular, much effort is spent validating patient identification with the assistance of the provincial health authority.

In Manitoba, extensive data on every hospitalization is collected, validated, maintained, and reported to CIHI by the provincial health authority, Manitoba Health. These hospital abstracts, which include information mandated by CIHI and other data elements, are collected by centrally trained data abstractors using uniform definitions, data collection methods, and data entry software (Med2020 Health Care Software, Ottawa, ON).

As mentioned, in April 2002 CIHI changed its coding specifications for tracking ICU care. Under the earlier specification, which we will refer to as the "old coding specification," provinces reported whether hospitalizations included any time in a special care unit (SCU), defined as "inpatient units specifically designed, staffed, and equipped for the continuous observation and treatment of critically ill patients."[17] This definition included all types of ICUs, and intermediate care or step-down units. The old coding specifications did not define or request information on specific types of SCUs or the timing of SCU admission or discharge, and it did not specify the data elements used to obtain the desired information. Subsequently, under the "new coding specification," hospital abstracts have been required to report separate entries for each period of time in an SCU, separately identify stepdown units from ICUs, specify the type of ICU, and provide the dates and times of admission and discharge for each such admission.

Manitoba adopted the new coding specifications on April 1, 2004. Before this date, under the old coding specification, information about ICU admission was made by reference to the service codes contained in hospital abstracts. Service codes represent the sequence of physician groups who had primary care responsibilities during the course of the hospitalization, for example, orthopedic surgery, cardiology, etc. Each code is associated with the date that the given physician group took over care. Coupled to each service code was a modifier indicating that while under the care of that physician group the patient was in an ICU. Thus, the Manitoba version of hospital abstracts separately identified ICU from stepdown care, and we compared that version of the hospital abstracts against the WICUDB in the current study. A maximum of 6 service codes were included in each hospital abstract. Thus, although not part of CIHI reporting, the starting and ending ICU dates could be assessed by perusing the temporal sequence of service code data in hospital abstracts. To comply with the new coding specifications, specific new data elements were added to hospital abstracts. Implementation of the new coding specifications in Manitoba include: (a) hospital abstracts with no SCU admissions require entry of a specific code indicating this fact; (b) each SCU entry requires entry of admission and discharge dates and times; and (c) allowing up to 6 SCU episodes per hospital abstract. Because in the new coding specification era CIHI did standardize data elements, the ICU-related data contained in Manitoba's hospital abstracts are identical to what was reported to CIHI.

The data collection period for this study spans 106 months from June 1, 1999 to March 31, 2008. Thus, June 1, 1999 to March 31, 2004 was within the old coding specification period, and April 1, 2004 to March 31, 2008 used the new coding specification. During this study, no hospitals in Manitoba had electronic medical records, so that data for both study databases were abstracted from paper records and then entered into computerized data collection tools. The work for this study was done at the Manitoba Centre for Health Policy.

Creating Linkage Between the 2 Databases

A link was sought for each ICU record in the WICUDB with a unique hospital abstract. We included all hospital abstracts representing admissions to the 6 hospitals included in the WICUDB for patients 17 years of age or older at the time of hospital admission, with hospital admission on or after June 1, 1999 and hospital discharge on or before March 31, 2008. Analysis was not limited to Manitobans, as approximately 5% of ICU care in Winnipeg is for non-Manitobans.

Eight variables contained in both data sources were used for linking records: the unique provincial personal health identifier, hospital identifier, hospital chart number, sex, birth year, birth month, dates of ICU admission, and discharge (specifically that the ICU admit and discharge dates from the WICUDB are contained within the hospital admit and discharge dates from hospital abstracts). For Manitobans the linkage was accepted if any 6 of 8 variables matched, and one of these was the personal health identification number.

Because non-Manitobans lack the provincial personal health identifier, for them the linkage was accepted if 6 of the other 7 identifiers matched.

Data Analysis

We separately analyzed the periods covered by the old and new coding specifications. We first assessed the accuracy of the administrative database for identifying whether a hospitalization included any time in an ICU, using hospital abstracts as the unit of measure. In the old coding specification period, a hospital abstract was taken as indicating ICU admission if it included any ICU service code modifiers, excluding those coupled to care under pediatric services. In the new coding specification period, we used a variable representing the existence of any ICU episodes, excluding those for pediatric ICUs, neonatal ICUs, or stepdown units.

Using the WICUDB as the criterion standard, we expressed performance of these administrative data variables as indicators of ICU admission during hospitalization by their sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). We calculated 95% confidence intervals for these parameters by exact binomial calculation. For this analysis, we compared the performance of these codes for hospitalizations in the 4 community hospitals versus the 2 tertiary care hospitals.

Next, using ICU admissions as the unit of measure, we compared the timing of ICU admission and ICU discharge between the 2 data sources, considering the WICUDB as the criterion standard. In administrative data during the old coding specification period, this information was obtained from the temporal sequence of service code start dates contained in hospital abstracts, that is, an ICU admission commenced on the first calendar date containing the ICU code and ended on the calendar date attached to the next service code in the temporal sequence, or the date of hospital discharge or death. In the new coding specification period, the timing of ICU admission and discharge in the hospital abstracts was taken directly as the dates/times associated with ICU entry and separation. We expressed the data as the differences in ICU admission or ICU discharge timing between the administrative data and the WICUDB in integer days for the old coding specification period, and as hours for the new coding specification period.

Statistical analysis was done using SAS 9.2 (SAS Institute Inc., Cary, NC).

RESULTS

Linkage of the 2 Databases

During the study period, there were 557,448 acute hospital admissions in the Winnipeg Health Region, of which 308,395 (55.3%) occurred during 58 months under the old coding specification and 249,053 (44.7%) during 48 months under the new coding specification. Community hospitals accounted for 126,536 (41.0%) of hospitalizations in the old coding specification period and 92,983 (37.3%) in the new coding specification period.

Of 48,326 eligible WICUDB records, we were able to link 47,932 (99.18%) to a single hospital abstract. These ICU admissions were contained within 42,880 hospitalizations; thus, 7.69% of the 557,448 hospital abstracts included time in an ICU for patients 17 years of age or older during the study period.

Accuracy of Administrative Data for Identifying the Presence of ICU Care

Table 1 shows the performance of administrative hospital abstracts in the 2 time periods for correctly identifying ICU admission during a hospitalization. The following patterns are evident: (i) performance in the 4 community hospitals was very similar to that in the 2 tertiary care hospitals; (ii) although all sensitivities and specificities exceeded 96%, the specificities were even higher, being close to 100% and; (iii) although all PPVs and NPVs exceeded 97%, the NPVs were even higher, being close to 100%. In addition, the ability of the service codes in the old coding specification to identify ICU care was very similar to that of the specific information on SCU admissions mandated under the new coding specification.

The accuracy of the administrative data for identifying the number of separate ICU admissions during a hospitalization is shown in Tables 2 and 3. For both time periods, over 98% of hospitalizations included just 1 or 2 ICU stays. Hospital abstracts correctly identified the number of ICU admissions for 306,134 of 308,395 (99.2%) under the old coding specification and 247,604 of 249,053 (99.2%) under

TABLE 1. Performance Parameters, With 95% CI, for the Variables Used for Identifying the Presence of ICU Care in Administrative Hospital Abstracts, With the Winnipeg ICU Database as the Criterion Standard

	# Hospital Abstracts					
Hospital Type	**Showing ICU Care**	**Not showing ICU care**	**Sensitivity (95% CI)**	**Specificity (95% CI)**	**PPV (95% CI)**	**NPV (95% CI)**
Old Coding Specification Period: June 1, 1999 to March 31, 2004						
Both	24,137	284,258	96.4 (96.1, 96.6)	99.8 (99.8, 99.9)	98.0 (97.9, 98.2)	99.7 (99.7, 99.7)
Community	8833	117,703	96.7 (96.3, 97.0)	99.9 (99.9, 99.9)	98.5 (98.3, 98.8)	99.8 (99.7, 99.8)
Tertiary	15,304	166,555	96.2 (95.9, 96.5)	99.8 (99.8, 99.8)	97.8 (97.5, 98.0)	99.7 (99.6, 99.7)
New Coding Specification Period: April 1, 2004 to March 31, 2008						
Both	18,743	230,310	97.2 (97.0, 97.5)	99.9 (99.9, 99.9)	98.7 (98.5, 98.8)	99.8 (99.8, 99.8)
Community	6399	86,584	96.2 (95.7, 96.7)	100.0 (99.9, 100.0)	99.3 (99.1, 99.5)	99.7 (99.7, 99.8)
Tertiary	12,344	143,726	97.7 (97.5, 98.0)	99.9 (99.8, 99.9)	98.3 (98.1, 98.6)	99.8 (99.8, 99.8)

CI indicates confidence interval; ICU, intensive care unit; NPV, negative predictive value; PPV, positive predictive value.

TABLE 2. Comparison During the Old Coding Specification Period (June 1, 1999 to March 31, 2004) of the Number of ICU Admissions During Hospitalization as Indicated by Hospital Abstracts, Versus the Criterion Standard of the Winnipeg ICU Database.

	# ICU Admissions Indicated by the Hospital Abstracts				
True # of ICU Admissions	0	1	2	3 or More	Row Totals
0	283,792	428	35	3	284,258
	99.84%	0.15%	0.01%	0.001%	100%
1	864	20,665	193	9	21,731
	3.98%	95.09%	0.89%	0.04%	100%
2	12	425	1549	17	2003
	0.60%	21.22%	77.33%	0.85%	100%
3 or more	0	57	179	167	403
	0.00%	14.14%	44.42%	41.44%	100%
Column totals	284,668	21,575	1956	196	308,395
	92.31%	7.00%	0.63%	0.06%	100%

Row percentages are shown.
ICU indicates intensive care unit.

the new coding specification. Among hospitalizations that actually had any ICU admissions, these numbers were 22,342 of 24,137 (92.6%) under the old coding specification and 17,542 of 18,743 (93.6%) under the new coding specification. For hospitalizations with multiple ICU admissions, the hospital abstracts tended to underestimate the number of ICU episodes; the number of ICU stays indicated by the administrative data was incorrect for a substantial number of hospitalizations containing 3 or more ICU stays, especially in the old coding specification period.

Accuracy of Administrative Data for Identifying the Timing of ICU Admission and Discharge

The accuracy of the hospital abstracts for identifying ICU admission and discharge timing is shown in Tables 4 and 5 for hospitalizations where they correctly identified that there was a single ICU stay. As indicated (Tables 2 and 3), that situation represented most ICU-containing hospitalizations, 20,665 of 24,137 (85.62%) in the old coding specification period, and 16,212 of 18,743 (86.5%) in the new coding specification period. There was agreement within ±1 day between the 2 databases for 99.5% of ICU admit dates and 97.1% of ICU discharge dates during the old coding specification period and for 99.2% of ICU admit dates and 98.0% of ICU discharge dates during the new coding specification period. During the new coding specification period, there was agreement within ±8 hours for 97.7% of ICU admissions and 95.8% of ICU discharges.

We next evaluated the accuracy of the hospital abstracts when they correctly identified 2 separate ICU stays occurred during the same hospitalization. The accuracy of administrative data for correctly identifying ICU admission and discharge timing was poor during both the old (N=3098) and new (N=2308) coding specification periods. Administrative data in the old coding specification period correctly identified ICU admission and discharge timing within ±1 day in 39.2% and 35.0%, respectively. The corresponding values for the new coding specification period

TABLE 3. Comparison During the New Coding Specification Period (April 1, 2004 to March 31, 2008) of the Number of ICU Admissions During Hospitalization as Indicated by Hospital Abstracts, Versus the Criterion Standard of the Winnipeg ICU Database.

	# ICU Admissions Indicated by the Hospital Abstracts				
True # of ICU Admissions	0	1	2	3 or More	Row Totals
0	230,062	245	3	0	230,310
	99.89%	0.11%	0.001%	0%	100%
1	516	16,212	247	48	17,023
	3.03%	95.24%	1.45%	0.28%	100%
2	6	207	1154	65	1432
	0.42%	14.46%	80.58%	4.54%	100%
3 or more	0	10	57	221	288
	0%	3.47%	19.79%	76.74%	100%
Column totals	230,584	16,674	14,61	334	249,053
	92.58%	6.70%	0.59%	0.13%	100%

Row percentages are shown.
ICU indicates intensive care unit.

TABLE 4. Comparison During the Old Coding Specification Period (June 1, 1999 to March 31, 2004) of the Timing of ICU Admission and Discharge as Indicated by Hospital Abstracts, Versus the Criterion Standard of the Winnipeg ICU database (WICUDB), Limited to the Situation Where Both Sources Concur That There Was Only a Single ICU Stay During Hospitalization*

Difference in Days (WICUDB—Hospital Abstracts)	No. (%) ICU Admissions (Total = 20,665)	
	ICU Admission Date Difference	ICU Discharge Date Difference
≤ −3	41 (0.20%)	193 (0.93%)
−2	19 (0.09%)	177 (0.86%)
−1	730 (3.53%)	645 (3.12%)
0	19,528 (94.50%)	18,905 (91.48%)
1	311 (1.50%)	510 (2.47%)
2	15 (0.07%)	76 (0.37%)
≥ 3	21 (0.10%)	159 (0.77%)

Column percentages are shown.

*Accuracy of ICU admission and discharge timing in other situations was poor (see text).

ICU indicates intensive care unit.

were 53.3% and 49.7%. In the earlier period, the 2 sources differed by *greater* than ±2 days for 55.5% of ICU admissions and 58.9% of ICU discharges; in the later period they differed by greater than ±2 days for 40.8% of ICU admissions and 44.4% of ICU discharges.

These 2 situations, in which the 2 data sources agreed that there were 1 or 2 ICU admissions within a hospitalization, accounted, respectively, for 76.9% and 11.3% of the 47,932 ICU stays in these 6 hospitals during the study period.

TABLE 5. Comparison During the New Coding Specification Period (April 1, 2004 to March 31, 2008) of the Timing of ICU Admission and Discharge as Indicated by Hospital Abstracts, Versus the Criterion Standard of the Winnipeg ICU Database (WICUDB), Limited to the Situation Where Both Sources Concur That There was Only a Single ICU Stay During Hospitalization*

Difference in Hours (WICUDB—Hospital Abstracts)	No. (%) ICU Admissions (Total = 16,212)	
	ICU Admission Date Difference	ICU Discharge Date Difference
−24 to −72	19 (0.12%)	93 (0.57%)
−8 to −24	18 (0.11%)	122 (0.75%)
0 to −8	248 (1.53%)	323 (1.99%)
0	2786 (17.18%)	2374 (14.64%)
0–8	12,800 (78.95%)	12,839 (79.19%)
8–24	223 (1.38%)	227 (1.40%)
24–48	85 (0.52%)	115 (0.71%)
48–72	9 (0.06%)	37 (0.23%)
≥ 72	24 (0.15%)	82 (0.51%)

Column percentages are shown.

*Accuracy of ICU admission and discharge timing in other situations was poor (see text).

ICU indicates intensive care unit.

The remaining 11.8% of ICU stays were more complex situations, being part of hospitalizations with at least 3 ICU stays or when the 2 data sources indicated differing numbers of ICU stays. Preliminary analysis indicated that such ICU stays showed even greater discordance in timing between the 2 data sources, and for this reason we did not evaluate them further.

DISCUSSION

Using a comprehensive clinical ICU database as the criterion standard, we examined the accuracy of administrative data in Manitoba for identifying the presence, number, and timing of ICU admissions during hospitalization. Hospital abstracts both before and after the change in national coding requirements were extremely accurate in identifying the presence and absence of ICU care, over 98% of adults indicated to have been in an ICU actually were, and the accuracy for excluding ICU admission was close to 100%. Administrative data correctly identified the number of distinct ICU admissions for 93% of ICU-containing hospitalizations, although it was increasingly inaccurate as the number of ICU stays within a given hospitalization rose. Lastly, hospital abstracts were accurate for identifying when an ICU stay began and ended, but only for hospitalizations containing a single ICU admission, which constituted 38,754 of the 42,880 (90.3%) ICU-containing hospital abstracts in our dataset.

One prior study evaluated the ability of administrative data to identify the presence of ICU care; no published studies have evaluated accuracy for identifying the number or timing of ICU admissions. As in our study, Scales et al[18] found that the NPV for ICU care as ascertained from Ontario hospital abstracts was nearly perfect. However, they found much lower values of PPV, being 35% under the old coding specification and 84% under the new coding specification. That study was limited by including only 9 months of data under the new coding specification and having a criterion standard for ICU care that did not include all types of ICUs. This latter point is especially important, as it would be expected to lower the measured PPV; this plausibly explains the difference under the new coding specification between their PPV of 84% and our value of 99%. The much larger disparity between the 2 studies in observed PPV (35% vs. 98%) under the old coding specification requires further consideration. Before implementation of the updated CIHI reporting requirements for ICU care, there was no standardized, Canada-wide method for determining whether patients were admitted to ICUs. The service code methodology described above was used uniformly throughout Manitoba, but each Ontario hospital was free to determine its own method for identifying ICU care. The disparate PPVs therefore strongly suggest that Manitoba's methodology was a highly accurate way to identify ICU care in that earlier era, whereas the approaches used in Ontario hospitals were less accurate. More generally, the accuracy of Manitoba administrative data under the old coding specification does not provide assurance that similar accuracy would be reproduced in other provinces in that era. Indeed, use of the CIHI version of hospital abstracts in the old coding specification era would have to contend with the fact that patients who had been in

stepdown units were not distinguished from ICU patients. This would result in false positive identifications of ICU care from those hospital abstracts, reducing the measured specificity and PPV of that administrative data. However, because the updated CIHI requirements mandating collection of specific ICU data elements have been implemented since 2004 in all provinces and territories of Canada except Quebec,[19] they should ensure similarly high accuracy throughout Canada after they were implemented; again, the lower PPV in the article by Scales and colleagues likely reflects their problematic criterion standard. Furthermore, CIHI conducts regular audits across Canada to ensure the quality of chart abstractions for such mandatory coding systems. The high accuracy of the new coding specification for identifying ICU admissions seen in our study should therefore make it possible to conduct population-based critical care studies involving almost all parts of Canada.

The main limitation of our study is that only the 6 hospitals in Winnipeg were used in this validation work. However, the consistent accuracy in community versus tertiary hospitals (Table 1) and the provincially centralized training and supervision of administrative data collectors in Manitoba make it likely that our results are not specific to those 6 hospitals. Although missed or incorrect entries in our criterion standard ICU database would lead to misestimation of predictive performance measures, the very high agreement for ICU admission between the administrative and ICU database suggests that such miscodings and misclassifications occurred infrequently.

Conducting ICU research using administrative data depends on the ability to correctly identify such care within hospital abstracts. The implication of our findings, in the context of those of Scales et al,[18] is that Canadian administrative data can be used to reliably study ICU care. Thus, investigators throughout Canada, even in jurisdictions that do not possess clinical ICU databases, can use provincial or national hospital abstracts to conduct population-based research on ICU care. Although we showed similarly high accuracy in Manitoba before the change to the current national coding specifications, the lack of ICU-specific coding requirements in that earlier era means one should not assume that similar accuracy holds in other jurisdictions. The most generalizable inference of our study is that administrative data achieves a high accuracy for determination of ICU care when standard definitions and coding practices are aligned to collect the specific data of interest.

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