Special Article

Audit of critical care: aims, uses, costs and limitations of a Canadian system

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We describe an audit system used in our Medical/Surgical Intensive Care Unit (ICU) during 1989–90. The system emphasizes the integration of data acquisition (database function) with the analysis and use of data (decision function). Resource *input (human and technological) included patient demographics, diagnoses, complications, procedures, severity of illness (Apache II), therapeutic interventions (TISS), and nursing workload (GRASP and TISS).* The output *was assessed by survival, length of stay and ability to return home. The annual operating cost for 277 admissions (249 patients) to this ICU was $7,333. The implementation costs were $58,261 including program development and computer purchases. Non-survivors of ICU and hospital had higher Apache II scores on admission ($P < 0.0001$) and longer ICU length of stay ($P < 0.05$) than survivors. The nursing workload (both TISS and GRASP®) on the day of admission and the last day in ICU were greater in non-survivors ($P < 0.0001$) than survivors. Limitations of this audit system included the delay (6–9 mos) from ICU admission until data entry, the large number of diagnostic groups in the ICD.9.CM classification, and lack of a documented cause/effect relationship between interventions and complications. This audit system was more useful for utilization management than for quality assurance purposes.*

Nous décrivons un système de vérification utilisé en 1989–90 dans nos soins intensifs chirurgicaux et médicaux. Le système met l'accent sur l'intégration de l'acquisition des données (fonction database) avec l'analyse et l'utilisation de ces données (fonction décision). Les entrées (humaines et technologiques) englobaient les données démographiques des patients, les diagnostiques, les complications, les procédures, la sévérité de la maladie (Apache II), les interventions thérapeutiques (TISS), et la charge de travail infirmier (GRASP et TISS). Le rendement (output) *était évalué à l'aide de la survie, de la durée du séjour et de l'habilité du patient à retourner à la maison. Le coût d'opération annuel de cet unité de soins intensifs était de $7 333 pour 277 admissions (249 patients). Les coûts d'implantation étaient de $58 261, incluant le développement du programme et l'achat des ordinateurs. Les patients qui décédaient aux soins intensifs ou à l'hôpital avaient un pointage Apache II plus élevé à l'admission ($P < 0{,}0001$) et un séjour aux soins intensifs plus long ($P < 0{,}05$) que les patients qui survivaient. La charge de travail infirmier (TISS et GRASP) le jour de l'admission et la dernière journée aux soins intensifs était plus élevée chez les patients qui décédaient que chez les patients qui survivaient ($P < 0{,}0001$). Les limites de ce système de vérification comprenaient le délai entre l'admission aux soins intensifs et l'entrée des données (six à neuf mois), le nombre élevé de groupes diagnostiques dans la classification ICD.9.CM, et le manque d'une relation cause à effet documentée entre les interventions et les complications. Ce système de vérification a été plus utile pour gérer l'utilisation des soins intensifs que pour assurer une qualité de soins.*

Key words
ANAESTHESIA: audit;
INTENSIVE CARE.

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A medical audit can be defined[1] as a "systematic and public examination of factors which affect the delivery of good medical care." Audit is intended to provide reassurance to physicians, nursing staff, administrators and other health care workers, that quality service is achieved within the limits imposed by the resources available.[2] Linton and Peachey[3] have suggested that "the medical profession has an absolute responsibility to maximize the effectiveness of health care so that scarce resources are not wasted." They also speculated that Canadians have not supervised the expenditure of health care funds as effectively as have our American and British colleagues.[3] Essential to the audit of an Intensive Care Unit (ICU) is a detailed description of patient case-mix, which can be termed the *input*, as well as the outcome of care *(output)*. Equally important, the audit must describe resources used within the ICU.

The process of utilization assessment and analysis is particularly important in critical care not only because of the high cost of resources but also because of unanswered questions concerning the efficacy of technology used and benefits of its use.

If improved utilization is to result from audit, more than a structural framework for data collection is required. Many reports[4–6] have focused on isolated aspects of data acquisition. However, the analysis of data by medical and nursing staff is a component of audit that is frequently overlooked. After data analysis it is the responsibility of the critical care providers to modify or correct problems identified by the audit. This process of utilization improvement[3] may improve assessment of technology in critical care and provide guidelines for acceptable practice.

Linton and Peachey have suggested that "the choice facing physicians is no longer one of whether or not we should participate in utilization management but rather who will design and control the management system."[3] This study reports the design, costs and limitations of a system organized by critical care physicians and nursing staff in a Canadian hospital to serve as a utilization management and quality assurance tool.

Methods

Structural design of the SMH AUDIT SYSTEM

An audit system was developed in St. Michael's Hospital (SMH), Toronto, in 1981 and based on this experience, the SMH AUDIT SYSTEM has evolved. This Audit System (Figure 1) has three functional components: a Patient Care Function in which policies and procedures are established in each unit, a Database Function involving data collection, management and analysis, and a Decision Function involving evaluation of reports as well as policy and procedure revisions. The Co-ordinator of Critical Care and the Director for Critical Care Nursing are responsible for assessment of ICU utilization. The role of the CCC (multidisciplinary representatives from all units and administration) is to assist unit managers (nursing and physician staff) in the development of policies and to evaluate the utilization of each ICU.

A 24-hr ICU flowsheet is used to record 12 physiological variables required for the calculation of Apache II score.[7] On admission and discharge the bedside nurses complete a form on each patient, recording two nursing workload measurements (TISS[8] and GRASP®[9]) used to determine nurse staffing. The medical staff include a daily note on the chart of each patient with special reference to complications, procedures performed, and organ system failure(s) which develop during ICU stay. The Health Records Department allocate a trained Health Records Technician (HRT) to abstract and enter data from each Critical Care chart after patient discharge from hospital. Quarterly reports were presented to the CCC after unit staff had analyzed the report and initiated a response (Figure 1). Additional reports were generated which focused on specific issues identified by nursing and medical staff. Examples of specific questions posed by unit managers include a review of nosocomial pneumonia as a complication in ICU and evaluation of outcome as well as diagnosis and complications in patients re-admitted to ICU.

Dataset collected

DEMOGRAPHIC DATA

Information describing the patient population admitted to each intensive care unit (ICU) included: age, sex, source of transfer to the unit and type of admission to ICU (elective/urgent/emergency).

DIAGNOSES, COMPLICATIONS AND SEVERITY OF ILLNESS

All diagnoses and complications for each patient are listed using the International Classification of Diseases (ICD.9.CM).[10] Specific complications noted in each report are renal failure, myocardial infarction and sepsis. Severity of illness during the first 24 hours in ICU is assessed using a measure (Apache II) specifically designed and validated[7,11] for critically ill patients permitting a quantitative assessment of acuity of critical illness on admission. This tool weights each of 12 physiological variables commonly measured in critically ill patients on a scale of 0–4 based on its deviation from the normal value. The Apache II score includes the weighted value of these physiological variables plus points for age and chronic health status. Specific consideration was given to standardization of values for the Glasgow Coma Score (GCS) in the Apache II scale since many surgical patients are anaesthetized and partially paralyzed for a period of time after operation in the ICU. The GCS was recorded as normal if the patient was awake and following commands the morning after surgery to avoid any systematic increase in this variable. Each component of the Apache II score was independently entered into the database permitting assessment of independent variables such as serum creatinine, temperature, haemoglobin, etc., for all patients. The total score was calculated by the program.

The development of multiple organ failure is common among critically ill patients.[12] The presence of organ system failure (OSF) during each unit admission was noted using the definitions developed by Knaus *et al.*[12]

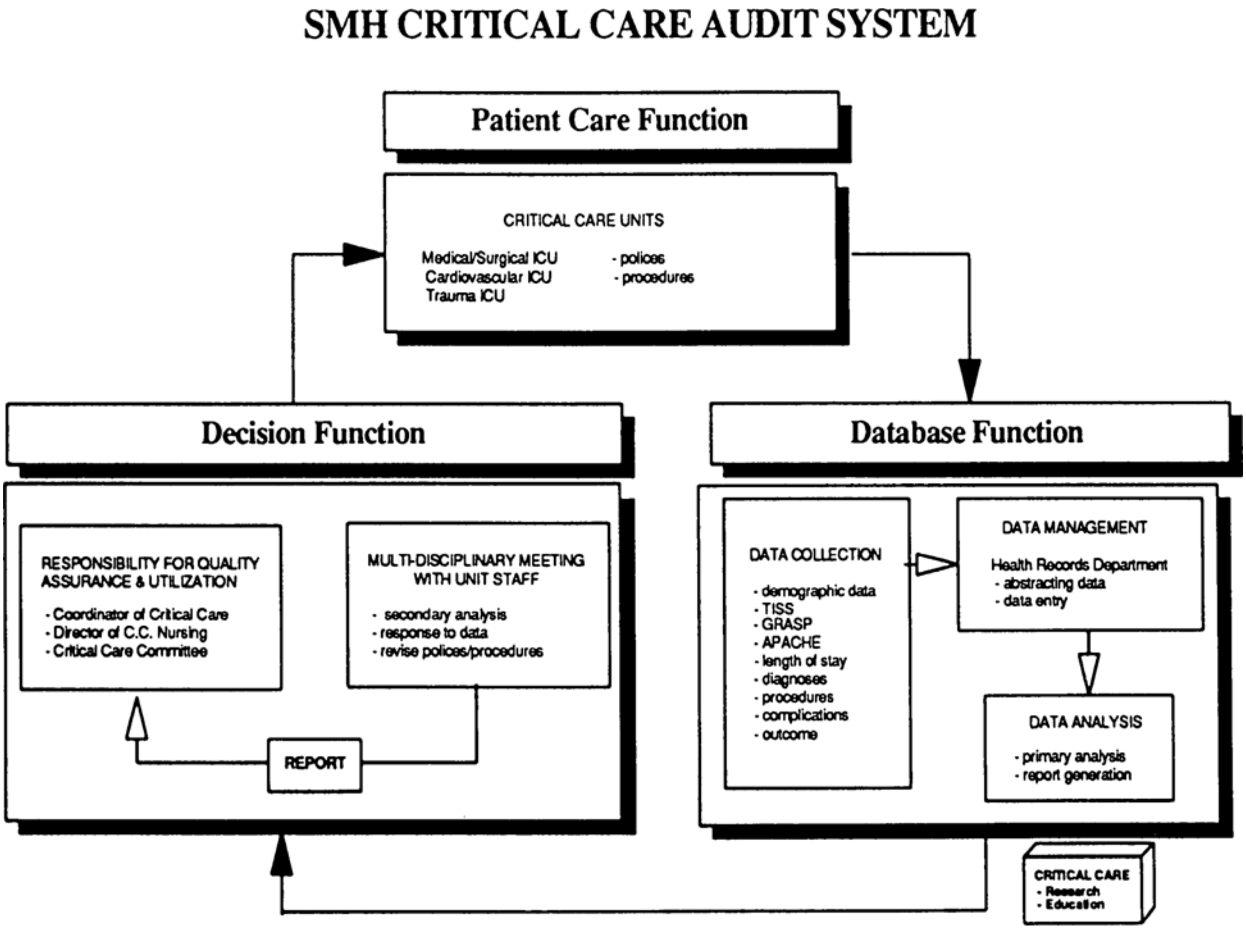

FIGURE 1 A schematic representing the functions of the "audit cycle" which involves administrative responsibility, data collection, management, and the analysis procedure (primary analysis with report generation and secondary analysis with revisions to policy and procedure).

NURSING WORKLOAD

Human resource utilization was assessed by quantifying nursing workload. We used both the TISS (Therapeutic Intervention Scoring system)[8,13] and the GRASP®[9] (copyright FCG/GRASP® 1984; FCG Enterprises Inc. and CHCL Comprehensive Healthcare Consultants Ltd., Suite 501, 200 Elgin St., Ottawa, Ont.) nursing workload tools to assess the nursing requirements during the first 24 hr after admission and before discharge. The discharge TISS is not calculated in the same manner as the admission TISS. The TISS scored at the time of discharge is a one-time measurement (not a cumulative 24 hr score). The discharge TISS is used to estimate the amount of nursing interventions required for each patient in step-down facilities or on the ward. These workload management systems (TISS and GRASP®) have been designed to determine the type and amount of care required by each patient and, in our unit, GRASP® is used to determine nurse staffing and reflect individual patient needs, rather than acuity of illness or bed occupancy. The GRASP® score reflects the sum of estimated time units required to perform a set of nursing tasks actually ordered for a given patient (including emotional support of patient and family). The GRASP® tool was weighted in our hospital before use by each Critical Care Unit.

TECHNOLOGY USED IN ICU

In order to assess the input of technology, each individual component of the TISS score[8] was recorded as well as the total score. These interventions were quantified on a scale of 1–4 depending on an estimate of the expertise required for each task. The weighting was determined by Cullen and colleagues.[8,13] Trends in the use of specific interventions listed in TISS (e.g., pulmonary artery catheters) could be assessed.

OUTCOME MEASURES

The outcome of a critical illness was assessed by mortality both in ICU and hospital. Outcome assessment also considered length of stay and identifiable complications

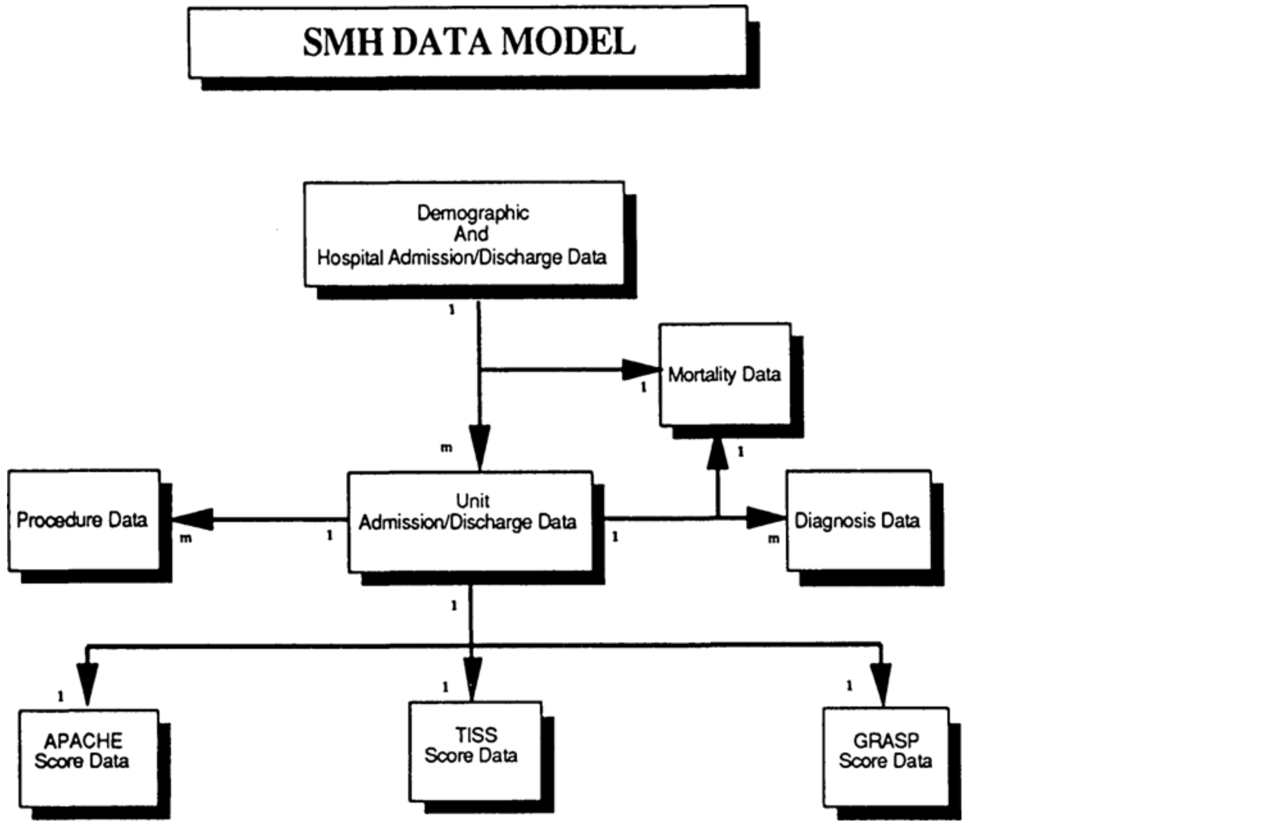

FIGURE 2 A schematic representing the data model used to construct the relational database.[13] Some of the important relationships between databases (represented by the boxes) are indicated by the labelled arrows. For example, a relationship where a single record in one database can be linked to more than one record in a second database (one-to-many) is shown with a 1 on the "one" side of the relationship and an m on the "many" side of the relationship.

such as renal failure, sepsis and myocardial infarction, that may have contributed to an adverse outcome.

The location to which survivors were discharged from hospital was identified. Whether patients were discharged to other acute care hospitals, to nursing homes or home with home care could be used to assess the requirements for community resources by these patients after hospital discharge.

Software and hardware used for SMH critical care audit

A programmable relational database[14] management program (DBASE IV, Ashton-Tate, Torrance, CA) was used to develop the application program (CareBase) and database system used in the SMH audit. The program is menu driven and consists of a main program and several major modules which control the operations of adding, editing, and updating of records as well as report generation and routine database maintenance. Although several report generation modules have been developed, work in this area is still in progress. There are 25 custom-designed data input screens accessing eight databases with a total of 388 non-redundant fields. The data input screens have data validation and error-checking features to minimize data entry errors and enhance the process of data entry. Refinements and improvements to the program are made periodically based on feedback from the HRT and problems encountered during report generation and data retrieval.

A simplified schematic of the critical care data model is shown in Figure 2. The structure of the data model was arrived at by identifying entities, such as "Diagnosis Data," which name a class of information to be included in the database system. The data were then examined to determine the attributes, such as "diagnosis code" and "diagnosis type," that describe or apply to a specific entity. The labelled arrows indicate some of the important relationships between entities. For example, the arrow from "Unit Admission/Discharge Data" to "Diagnosis" indicates that for each unit admission the patient can have more than one (one-to-many) diagnosis. Similarly, a one-to-one relationship exists between "Unit Admission/Discharge Data" and "Apache Score Data."

The selection of hardware was based on the requirement for fast and efficient data entry, with minimum processing delays, and the need to accommodate potential future growth of the system. Data entry is labour-intensive and it is important that screen changes and updates as well as data validation and processing proceed as smoothly as possible. The computer systems chosen for data management and program development are high-speed 386-based IBM compatible personal computers. For data entry, editing, updating and database maintenance, the HRT uses a 20 MHz computer with 4 Mb of RAM, and 80 Mb hard drive, and an 80 Mb tape backup system. For program development, data analysis, and report generation, the programmer uses a 25 MHz computer with 4 Mb of RAM, a 135 Mb hard drive, and a 150 Mb tape back up system. The additional memory makes it possible to take advantage of performance enhancement features, in dBase IV 1.1, such as hard disk caching and a RAM drive for temporary file management.

Cost of implementing audit system

The SMH Audit System is integrated into the daily activities of nursing staff and the Health Records Department. Costs attributable to the system, in addition to routine management, were estimated based on "time-in-motion" studies. These costs resulted from the incremental time required for nursing staff to complete TISS/GRASP® forms and data entry by the HRT. Time in motion studies demonstrated that 50 trained ICU nurses, familiar with the TISS/GRASP® workload tools, required 4.3 min to complete a form. The hourly rate of reimbursement for ICU nurses was \$18.23 at the time; thus, we estimated a nursing cost per patient of \$2.60.

Although an HRT must review each chart and enter data for hospital use, the SMH Audit System requires additional information that is not routinely collected for hospital purposes (e.g., Apache II). The incremental time per chart for the HRT to abstract data not included in routine hospital reports (procedures in ICU, complications in ICU, Apache II scores etc.) varied, depending on the complexity of the case. The HRT time in motion study demonstrated that 60% of charts required 30 min, 35% required 60 min, and 5% needed 120 min to complete data abstraction and entry. Using these data we estimated the average cost to complete this task was \$18.82 per patient chart.

An additional cost to the hospital was the time for development of a customized program for database management. Although the program development costs are a one-time investment, these are included as an implementation cost for the first year of operation. The cost of computer hardware (described above) was \$21,261. We estimated that the programmer required 85% of his time during 1989–90 for program development and report generation at an annual cost of \$39,000.

Using these data, we estimated the cost to the hospital for 249 admissions during the first year of operation (Table I). The time for review of data by medical and nursing staff is not an incremental cost since this is considered routine management.

TABLE I Estimated costs (Canadian dollars) of the first year of operation of the SMH Audit System. Only the increase above routine hospital (nursing time and health record technician time) are considered to be incremental operating expenses for 277 admissions

Implementation costs	
Computer hardware	21,261
Program development	37,000
Total	58,261
Operating costs	
Report generation	2,000
Nursing time	647
Data abstraction/entry (HRT)	4,686
Total	7,333

TABLE II Summary report of admission and discharge data from all patients in the Medical/Surgical ICU from 1/7/89 to 30/6/90.

	n	*% of Total*
Hospital admissions		
Total	249	100
From other institutions	85	34.1
Emergency	163	65.5
Urgent	34	13.7
Elective	52	20.9
Total hospital deaths	84	33.7
Discharged to		
– other hospital	43	17.3
– nursing home	1	0.4
– home	93	37.3
– home with home care	28	11.2
I.C.U. admissions		
Total	277	100
Postoperative admission	128	46.2
Non-operative admission	149	53.8
Deaths in ICU	61	24.5
Discharged to step-down unit in SMH	54	21.7

Statistical analysis

Data are reported as the mean ± one standard deviation. Data were analyzed using the SAS® (Statistical Analysis System) statistical package. Comparisons between units and groups of patients within units (survivors and non-survivors) were made using the Wilcoxen Rank Test for non-parametric data and linear regression analysis.

TABLE III Report summarizing utilization of medical/surgical ICU for all patients during the first 24 hrs (admission) and the last 24 hrs (discharge) in the unit

	Mean ± SD	*Median*	*n*
Average length of stay			
- in ICU	8.9 ± 15.3	3.0	277
- in hospital	32.0 ± 35.5	20.0	249
Duration of ventilation	8.6 ± 15.0	3.0	272
APACHE II (admission)	22.4 ± 7.6		277
Admission TISS (all patients)	37.7 ± 16.1		173
Admission GRASP® (all patients)	218.3 ± 54.5		182
Nursing workload for ICU survivors			
TISS (admission)	31.9 ± 16.8		139*
TISS (discharge)	17.3 ± 13.7		139**
GRASP® (admission)	190.4 ± 80.3		151***
GRASP® (discharge)	155.0 ± 67.1		151****
Nursing workload for non-survivors of ICU			
TISS (admission)	44.5 ± 19.3		47*
TISS (death)	39.3 ± 19.8		47**
GRASP® (admission)	223.9 ± 80.5		49***
GRASP® (death)	218.1 ± 68.3		49****

Asterisk(s) denote significant difference between survivors and non-survivors ($P < 0.0001$).

TABLE IV Utilization of medical/surgical ICU resources for survivors and non-survivors of hospital and re-admissions to the ICU after discharge

	Survivors			*Non-survivors*			*P value*
	n	*Median*	*Mean ± SD*	*n*	*Median*	*Mean ± SD*	*P <*
Average length of stay							
- in ICU	185	3.0	8.02 ± 14.7	92	5.0	10.9 ± 16.3	0.05
- in hospital	165	21.0	34.4 ± 36.9	84	15.5	27.2 ± 32.0	0.01
APACHE II	185		19.2 ± 5.0	92		28.8 ± 7.9	0.0001
TISS (admission)	108		33.3 ± 15.1	65		45.1 ± 15.0	0.0001
GRASP® (admission)	117		208.0 ± 55.5	65		236.7 ± 47.4	0.0001
Duration of ventilation	180	3.0	7.5 ± 14.2	92	5.0	10.7 ± 16.2	0.01
Patients with 1 readmission	12		—	6		—	NS
Patients with 2 readmissions	4		—	1		—	

Results

The SMH Audit System (Figure 1) was implemented in July 1989 and all admissions from July 1, 1989 until June 30, 1990 to a six-bed Medical-Surgical ICU (249 patients) were included. Missing data were limited to the nursing workload measurements (TISS and GRASP®). The most common missing data were discharge TISS (107/277 admissions). Sample reports, shown in Tables II–IV and Figures 3 and 4 from this 12-month period, illustrate report format. Reports were generated after patient discharge from hospital at the time of routine HRT chart review, 6–9 months after ICU admission.

Table II outlines hospital and ICU admission and outcome data for the 277 admissions for 249 patients. The hospital mortality rate was 33.7%. Of the 249 patients 48.1% were discharged to their home (11.2% required home care). During the 12-mo period 181 different diagnoses (MRD's) were attributed to 249 patients using the ICD.9.CM coding system, making analysis difficult and reports lengthy.

Table III summarizes ICU utilization data including: average length of stay, severity of illness (Apache II) and nursing workload measures (TISS and Grasp®). The nursing workload, assessed by both TISS and GRASP® was significantly greater for non-survivors of ICU than for survivors of ICU.

Table IV reports data for survivors and non-survivors of hospital. The non-survivors of hospital had a higher Apache II score recorded during the first 24 hr of ICU ($P < 0.0001$). Non-survivors of hospital stayed in ICU

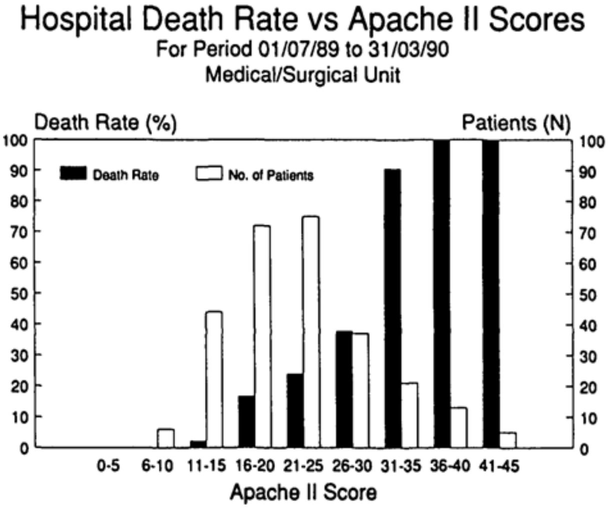

FIGURE 3 The mortality rate (%) for 249 patients in Medical/Surgical ICU for varying severity of illness (APACHE II) over a 12-month period of time (1/7/89 to 30/6/90).

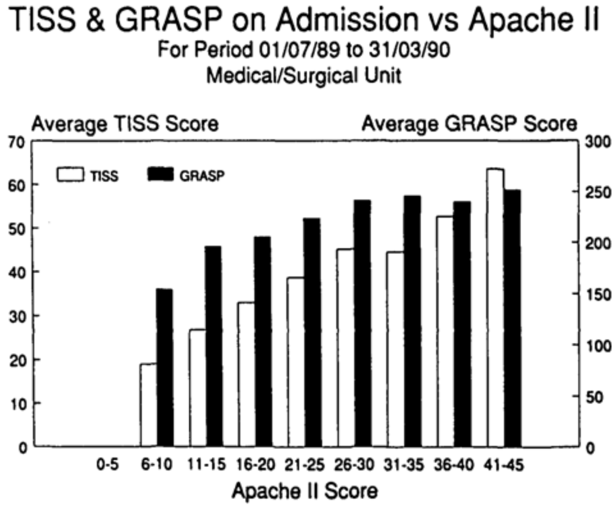

FIGURE 4 Admission nursing workload measurements (TISS and GRASP®) for varying severity of illness (APACHE II) in 249 patients over the 12-month time period.

longer than survivors ($P < 0.05$) and accounted for a greater nursing workload (TISS and GRASP®) on the day of admission ($P < 0.0001$) than survivors. Since the distribution of length of stay is asymmetrical, the mean value does not represent a typical length of stay. We have, therefore, also reported the median, which is not as affected by extreme values as the mean and is closer to a typical value (Table IV).

Table IV also shows that 23 of 249 patients were re-admitted to ICU after discharge and five of these were re-admitted twice during the same hospital stay. Of these 23 re-admissions, 16 survived hospital. No increase in mortality was noted for patients re-admitted to ICU than for similar patients who were not re-admitted. A detailed review of these 23 re-admissions was undertaken and a summary of this report is shown in Table V. These 23 patients had 51 admissions to ICU with 34 unique diagnostic categories (MRD's).

The relationship between hospital mortality (%) and the severity of illness on admission to ICU is shown in Figure 3. Two hundred thirty-one of 277 admissions had an Apache II score between 11 and 30. Only 18 of 249 patient admissions had an Apache II score of 35 or higher, which was associated with a 100% mortality. When patients were grouped according to Apache II score intervals (Figure 3), the mortality rate increased as Apache II score increased.

The mean TISS and GRASP® scores for patients grouped by Apache II score intervals are presented in Figure 4. There was no significant relationship between TISS and GRASP® scores in individual patients measured at either admission or discharge. When individual admission TISS and GRASP® scores were analyzed versus the Apache II score on admission, the correlation was not good ($r = 0.5$; $r = 0.3$ respectively).

Discussion

The SMH Audit System includes elements of case-mix, resource input, nurse staffing and outcome assessment that individuals with specialized knowledge in Critical Care believed were important. Since the purpose of audit includes the assessment of care within available resources,[2] it recognizes the reality of resource limitation. It is important for an audit system to relate the utilization of both human and technological resources to patient characteristics and outcome. The limiting resource in Canadian hospitals recently has been critical care nurse and bed availability. By using an audit that stratifies patients according to severity of illness, nursing workload could be assessed (Table III and Figure 4). Although both GRASP®[9] and TISS[8,13] have been used to evaluate nursing workload, these indices were not related to each other in these critically ill patients. TISS[13] specifically examines interventions (technology) used in Critical Care. GRASP®[9] evaluates all nursing tasks and is used to allocate nurse staffing hospital-wide. GRASP® was specifically weighted for each ICU. The lack of a significant relationship between GRASP® and TISS for individual patients suggested that these workload measurement tools assessed different aspects of patient care or possibly that the GRASP® tool was insensitive to increasing use of interventions in the critically ill beyond a threshold limit (Figure 4). O'Brien-Pallas[15] suggested that estimates of nursing "hours of care provided" differ significantly when

TABLE V An example of a special report profiling patients re-admitted to the medical/surgical ICU during the same hospital stay, outlining survival rates, length of stay (LOS), nursing workload (TISS), and severity of illness on each re-admission

	First admission		*Second admission*		*Third admission*	
	Mean ± *SD*	*n*	*Mean* ± *SD*	*n*	*Mean* ± *SD*	*n*
APACHE II	20.3 ± 4.9	24	21.8 ± 6.4	22	22.4 ± 7.6	5
ALOS ICU (days)	13.0 ± 31.1 (median = 5)	24	16.6 ± 25.9 (median = 4)	22	4.4 ± 4.0 (median = 3)	5
TISS (admission)	34.0 ± 20.0	8	38.2 ± 14.4	11	43.3 ± 10.2	4
TISS (discharge)	15.6 ± 5.9	11	27.0 ± 18.6	13	28.7 ± 7.2	3
GRASP® (admission)	237.7 ± 55.5	10	243.3 ± 48.6	10	203.0 ± 33.5	4
GRASP® (discharge)	192.5 ± 56.2	13	192.2 ± 59.4	13	204.7 ± 76.7	3

various workload measurement tools are used. More research needs to be done on the relationship between these workload tools and patient severity of illness. We use this issue as an example of how an audit can assist physician and nursing managers to understand utilization issues. The GRASP® tool is being re-evaluated for use in our Critical Care Units as a result of this audit. One of the more powerful uses of the Apache II system may prove to be the assessment of ICU workload management and assessment of measurement tools for nursing workload.

Advantages of using Critical Care to develop an Audit system include a well-defined patient population, a data-rich environment making a comprehensive dataset possible and a high-cost area that makes the marginal operating cost of this audit (Table I) potentially cost-effective. Systems have been developed that provide automated, continuous data collection in ICU using computerized flowsheets.[4,6] These automated systems require integrated analysis and management functions for effective utilization improvement. Such automated systems have the potential for improved and less labour-intensive data acquisition. We have employed labour-intensive data entry which accounts for considerable cost (Table I). In Canada, HRT's complete a formal course at the college level and are responsible for abstracting information from charts. We have integrated data entry into the daily HRT workload in the Health Records Depatment and this data entry mechanism minimized costs which would be greater if dedicated data entry clerks were hired specifically for each ICU.

A recent review of HRT coding reliability in Ontario hospitals revealed important discrepancies between HRT-derived data and re-abstractors coding.[16] Re-abstracting charts resulted in only 81% agreement of the MRD and other diagnosis codes matched only 40% of the time. Similar results were found for procedure-related information (only 53% of original codes matched with re-abstraction). The match rates for non-medical fields (e.g., age, sex, survival, length of stay etc.) in the same study[16] was 95%. Again, this emphasizes the need for establishing standardized definitions, coding practices and communication between the HRT and clinicians using this system.

We have used this audit system to provide information on quality assurance issues (e.g., re-admissions – Table V) and utilization problems. The difficulty with multiple codes in the ICD.9.CM system for diagnostic and procedural data and the lack of a documented cause/effect relationship between specific interventions and complications limited the use of this system for Quality Assurance purposes. In contrast, data from the audit have been most useful for management utilization. The major limitation of this system for management utilization has been the lack of detailed information on the use of interventions and nursing workload for days between admission and discharge.

Flexibility of the customized program enabled us to create specialized (Table V) and routine (Tables II–IV) reports. Nursing and medical directors evaluated reports and assessed the adequacy of resources, admission and discharge policies, set new strategies to cope with changing needs (including case-mix variations), evaluated new technology and its impact on resources and used data to develop a basis for discussions with administration regarding the adequacy of facilities. If patient case-mix changes or unit structure is altered for any reason, the impact of these changes on utilization can be analyzed.

Major limitations of the SMH Audit System during this 12-month period include:

1 the 6–9 mo time lapse before HRT chart review and data entry,
2 large number of diagnostic groups (MRD's) using the ICD.9.CM system,
3 reliability of HRT coding of diagnostic and procedural data,[16]
4 lack of a documented cause/effect relationship between interventions and complications,
5 recording of intervention data and nursing workload measures only on the days of admission and discharge.

In view of the limitations, this audit is continuously being evaluated and revised to deal with these specific problem areas. We accepted that the HRT can abstract accurate chart data from admission and discharge information to permit an assessment of utilization. Reliable documentation of specific ICD.9.CM diagnostic and procedural codes and GCS and chronic health status has been a persistent problem and having only one HRT designated to input data and a single group of ICU clinicians to control record-keeping has been a major factor in maintaining the quality of data collection. Specific records are reviewed by the authors with the HRT.

The importance of having established ICU policies and procedures (e.g., discharge criteria) to serve as standards of care in each unit should be emphasized. Policies and procedures should be evaluated in a collaborative manner by nursing and medical practitioners. One of the greatest assets of audit is fostering interaction between medical, nursing and paramedical staff, particularly in response to reports. These responses may be in the form of preventative measures, altered policies and procedures and/or educational programs.

Knaus *et al.*[17] emphasized that the process by which Critical Care is delivered is one factor which impacts significantly on patient outcome. The "process of care" is difficult to define and quantify. This dataset examines "process" only by detailing resource input, diagnoses, procedures and specific interventions. We do not examine some fundamental, non-quantifiable, aspects of "process" such as communication, availability of transportation facilities, co-ordination of ICU staff and protocols. We do focus on nursing workload and relate workload and interventions to severity of illness.

In conclusion, continuing development of flexible audit systems including automated data acquisition systems,[4–6] analysis and decision functions, will allow clinicians to focus on specific problems and assist in the development and implementation of strategies to optimize use of Critical Care.[18–20] Any audit being implemented should stress not only the database function but also the decision function (Figure 1). Information obtained from routine audit has resulted in improved communication between physicians, nursing staff and administration regarding ICU management. From experience it is our belief that an audit system of some form is valuable in the organization and utilization of ICU resources.

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