Studies on input, output and clinical results of intensive care

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I would especially commend the physician who, in acute diseases, by which the bulk of mankind are cutoff, conducts the treatment better than others.

- Hippocrates

CONTENTS


INTENSIVE CARE

Chapter 1

General introduction and outline of this thesis

Critical care evolved from an historical recognition that the needs of patients with acute, life-threatening illness or injury could be better treated if they were grouped into specific areas of the hospital (inter alia coronary care units, postoperative recovery units, emergency departments and intensive care units). The roots of the intensive care unit (ICU) can be traced back to the Monitoring Unit of critical patients of nurse Florence Nightingale in the 1850s [1,2]. True Intensive Care began in 1926 in the United States when Dr W.E. Dandy opened a three-bed unit for postoperative neurosurgical patients at the Johns Hopkins Hospital in Baltimore [2]. In the 1950s Dr B.A. Ibsen (Head of the Department of Anesthesiology of Kommune Hospital in Copenhagen) set up what became the world's first medical and surgical ICU. Also in those years, Dr P. Safar (the first intensivist doctor in the United States) started and praised the 'Urgency and Emergency Room' setup (now known as an ICU) [2,3]. It took approximately 10 or more years before the first surgical ICU was established in Baltimore. The Society of Critical Care Medicine was formed in 1970 [3].

Patients requiring intensive care may need support for hemodynamic instability, airway or respiratory compromise, acute renal failure, potentially lethal cardiac arrhythmias or for the cumulative effects of multiple organ system failure. They may also be admitted for intensive/invasive monitoring, such as in the crucial hours after major surgery, when it is deemed that they are too unstable to be transfered to a less intensively monitoring unit. Intensive care is usually only offered to those whose condition is potentially reversible and who have a good chance of surviving with intensive care, since a majority of critically ill patients are at high risk of dying in the intensive care unit.

The modern ICU is a bastion of technology, different from when it was introduced in the 50s and 60s, even different from 10-15 years ago [4,5]. Large medical centers frequently have multiple ICUs or critical care centers separated and defined by specialty practices. Over the last 40 years, advances in ventilation support, monitoring and antibiotics have decreased the mortality rate in many ICUs. Patient turnover is high and survival rates continue to improve. Currently admitted patients often receive triage, diagnostic and therapeutic interventions simultaneously. Also, many caregivers are involved, some of whom are focused narrowly, but all provide some input into the care process. Demand for sophisticated technology, increased consumer expectations and an increasingly ageing population, contribute to an increased demand for intensive care services. No form of medical care is more expensive than that provided in the ICU. Since the costs of intensive care are a significant component of the hospital budget, the cost-effectiveness of providing such care, aiming at improving the outcomes of ICU patients is of major concern [6-10].

Outcome of ICU patients: Mortality

The definition of *good outcome of ICU patients* is still subject to debate [11]. In the last decennia critical care physicians have tried to decrease overall mortality. However, at what point does a further decrease in mortality affect health status negatively, i.e. reduction in the overall quality of life of those who indeed survive. Although survival rates have been the most important quality indicator for many years, being alive at the end of a hospital stay nowadays is no longer good enough. Good outcome now often means that the patient has a preserved life expectancy and experiences a good functional health status. Assessing standards for outcomes are important in medical practice and allow comparison of different units, even between hospitals.

Undoubtedly, the first aim of intensive care treatment is survival of ICU or hospital stay (short-term survival). While the short-term outcome for patients treated in ICUs are well described, relatively little is known about long-term survival. Although we know that patients continue to die at an accelerated rate during the first years after hospital discharge, long-term prognosis of ICU patients is relatively unexplored [12,13]. Ideally, survivors of critical illness are followed until the gradient of their survival curve parallels that of the normal population. Unfortunately, this optimal time span is unknown.

Outcome of ICU patients: Quality of life

Modern intensive care medicine offers a wide spectrum of possibly life-saving and -prolonging treatment modalities. Mortality (at the ICU or in-hospital) is a good estimate of prognosis. However, care of critically ill patients should also be targeted to restore optimal health status. If ICU treatment leads to reduced mortality risk, patients may be concerned that small gains in life expectancy come at too high a cost (i.e. reduction in quality of life). Interventions can maintain life in the critical care setting, but the resultant health state may be valued as worse than death for them.

Assessment of the quality of life (QoL) has become an increasingly relevant measure of outcome in ICU patients. Ideally, patients discharged alive from the ICU will attain their previous or an even better quality of life [14].
The attention in measuring QoL in relation to health care has increased in recent years [14–20]. The ICU seems very suitable for the quality of life outcome(s) measures given its diverse, high-volume population of patients at high-risk for a poor outcome and who are treated with so many resources. Increasingly, a good outcome in surgical patients is defined by the quality of life enjoyed by the patient post-discharge. Of increasing relevance to the ICU are medical audits that supplement conventional outcomes (e.g., morbidity, mortality, length of stay) with QoL outcomes.

Health-related quality of life (HrQoL) is the extent of the impact of the disease process on physical, psychological and social aspects of a person's life and well-being. Several validated instruments are available to quantify quality of life and have a number of potential applications [21,22]. They may be used to screen and monitor for psychosocial problems in individuals. They may be population-based and valuable to health care policy makers. Instruments to measure QoL can be divided into three types [21]:

1. Generic instruments, such as SF-36 [24] and the EuroQol-5D [25]. These are applicable across a wide variety of diseases and breadth of illness severity, making them especially valuable for long-term follow-up of ICU care.
2. Disease-specific instruments, such as the Artritis Impact Measurement Scales [26] and the Back Pain Disability Questionnaire [27]. They are especially sensitive for the measurement of changes of clinical importance over time for a discrete entity.
3. Symptom-severity instruments, such as the Pain Visual Analogue Scale [28,29] and the Gastrointestinal Symptom Rating Scale [30]. These focus solely on symptoms without measuring the impact of the symptoms on other aspects of the quality of life.

Not one instrument can fit all purposes, but general guidance is available [22]. Generic instruments have been widely validated and are intended to be applicable to a wide range of health problems [31,32]. Generic instruments measure health-related quality of life in broad terms, generally covering the concepts of duration of life, impairments, functional status, perceptions, and social opportunities. Therefore, it has been said that the generic instruments are more useful to measure HrQoL in an ICU population in comparison to the disease-specific and symptom-severity instruments [21,22].

Outcome of ICU patients: Readmission to the ICU

Higher numbers of admissions, more severely ill patients and the introduction of advanced new technologies, further increase current critical care costs. One way to reduce costs is to discharge patients as early as possible, hence reducing the number of patient days on the ICU. However, such a strategy might not always be beneficial. It may increase the number of premature discharges and thus exert a negative impact on the outcome [33]. Several studies have focused on identifying patients who do not need ICU care and thus are candidates for early ICU discharge [34–36]. In the debate on early ICU discharge, concern has been expressed over the possibility of an increased risk of subsequent clinical deterioration in patients who actually require longer ICU stay [37,38]. Readmissions to the ICU have been associated with worsening of the patients' original disease process, and thus incurring higher (rather than lower) hospital costs, and also leading to poorer patient outcome [39–43]. The Society of Critical Care Medicine's Quality Indicators Committee [43] ranked ICU readmission within 48 hours as the top indicator for judging ICU quality, and is considered to reflect premature discharge behaviour. Unfortunately, there has hardly been any theoretical or experiential evaluation of the factors that might help separating the appropriate ICU readmissions from those resulting from poor quality of care.

Critical care readmissions can be separated into three primary groups:

1. Readmission necessitated by new problems.
2. Readmission caused by recurrence of the primary medical problem.
3. Readmission required by further planned operative intervention.

Readmission is an undesirable event. Although, would a readmission rate of zero reflect a too conservative discharge protocol and, therefore, leading to exorbitant costs? In the literature, an acceptable optimal readmission rate is not yet established. Factors such as the variable course of many diseases and the need to provide critical care services within a global healthcare budget, necessitate ICU discharge when a patient's need for further ICU care is hypothetically low. Patients could be discharged from the ICU in the course of appropriate care and with a small chance of returning.

Different patient groups have different likelihoods of being readmitted. The question arises: do we have to adjust for differences in case-mix before we can comment on the appropriateness of an ICU readmission rate [44]? Patients at risk for readmission should allow for the development of better management strategies. Since specialized ICUs treat different types of diseases and have considerably different mortality rates and length of stay (LOS), these specialized units should be considered separately. The heterogeneity between and within the reviewed studies in the literature makes it difficult to generalize the specific types of ICUs, let alone specific patients. Studies focusing on causes of ICU readmission to well-defined ICU types, given specific diagnoses, could provide data that is more helpful in improving discharge decisions than studies focusing on the general unit with a mixed population.

ICU Predicted Mortality Models

Since the early 1980s the development of mortality prediction models has started [45]. When significant therapeutic advances become standard practice, expected mortality rates based on historical data no longer apply [46], unless these models have been revised. During the last decennia, recent revisions of the major ICU prediction or scoring systems have broadened markedly and increased their statistical accuracy for predicting hospital death. Scoring systems designed to rate the severity of an illness are also being used for comparison of hospital units to identify different standards of care and to allocate resources. Significant questions remain about the reliability of these systems for comparing different ICUs and different patient populations, especially surgical and trauma patients. A standardized mortality ratio (SMR) < 1 reflects that actual mortality rates are less than predicted, thus demonstrating superior health care. Conversely, a SMR > 1 demonstrated a need for improvement. Although the use of SMR as a measure of ICU performance is debatable [47–49], the significant excess in mortality beyond the severity stratified predictions warrants close examination and exploration. Regardless of other performance, lower-than-expected ICU and hospital mortality rates are prerequisites for an institution to be considered a good performer [50]. Yet, it is also still not known how these current scoring systems could be used reliably in either the management of the individual patients or in the making of quality comparisons between ICUs [47].

Since the development of these models, the outcome has been focused on predicting hospital mortality. There has been no validation of these models in predicting long-term mortality yet.

ICU Organization: Nurse staffing

Patients in ICUs require substantial nursing care. Nevertheless, nurse staffing varies widely among critical care units and the optimal nurse-to-patient ratio remains unclear [51,52]. Efforts to reduce costs of hospital care have resulted in decreased nurse-to-patient ratios. Some authors have researched the effect of these reductions [53-56]. Unfortunately, the effect on quality of care is still scarce in the literature. Previous studies that measured nurse staffing at the hospital level found an association between nurse-bed ratio and specific complications [57-62]. Because critically ill patients in an ICU require close nursing surveillance to ensure early detection of potential adverse events and prompt intervention to prevent morbidity, obviously a reduction in ICU nurse staffing may negatively affect quality and outcomes of care. Considering organizational or patient variability across hospital departments, it could be of interest to evaluate the association between nurse staffing and mortality at the unit, before drawing general conclusions. For addressing this association, critical care units seem to be the most suitable setting, because mortality rate, intensity of nursing care required from patients and sensitivity of patients to lapses in care, is high [63,64].

ICU Organization:
Changing specialized surgical critical care units to overall general units

In the course of the last decennia, highly specialized intensive care units (i.a. surgical/neurosurgical and cardiac ICUs) have been transformed to general critical care units with a mixed population. Whereas the specialized units were firmly embedded in their own department and the corresponding physician had primary responsibility for the patients' treatment, critical care physicians (certified in critical care by one of several specialty boards: Internal Medicine, Anesthesiology or Surgery) assumed responsibility for delivery of intensive care in the newly transformed general unit. The intensivist had no other clinical care responsibilities outside the ICU and was primarily available to the critically ill patient. In the literature, this ICU-organization setting has been described as a 'closed format' [66-73]. Until today, debate continues whether quality of care has improved after this transition to a 'closed format' setting [61,74-78].

Often the impetus to do this comes from statistical comparisons between ICUs using administrative databases. Performance measurement is a fundamental component of health care reform. There is a broad consensus concerning the need for risk adjustment when comparing outcomes across different intensive care units. However, there is a threat to risk adjustment because different prognostic models will not always agree on the identity of high- and low-performance. Comparison of performance among different ICUs is done through the use of severity of illness models and the associated SMR. Nevertheless, the use of the SMR as a measure of ICU performance is debatable [47–49]. Especially because diversity in patient mix is a concern when comparing risk-adjusted ICU-specific death rates to assess the quality of ICU's performance [79]. Therefore, it is advisable to produce quality performance to be as robust as possible in the methodology used. Critical to accomplishing this task could be the need to develop better measures to adjust for case-mix and severity of disease.

Taken together, the studies described in this thesis address the usefulness of different prognostic indicators for in-hospital mortality used in the surgical ICU (Chapter 2). Subsequently, we address both short- (Chapter 3-5) and long-term (Chapter 6-7) outcomes and their prediction, in patients admitted to surgical intensive care units. Concerning short-term outcome, we offer more insight in the effect on mortality of critical care organization differences.

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Chapter 2

Validation of six mortality prediction systems for surgical population admitted to the ICU

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Timmers TK, Verhofstad MHJ, Moons KGM, Leenen LPH

ABSTRACT

Introduction: This study investigates the prognostic quality of six prediction models (APACHE II Score, SAPS II, SAPS II(Expanded), SAPS 3, MPM II_0 and MPM III) for the assessment in an adult surgical intensive care unit in the Netherlands. Secondly, we tested the capability of the APACHE II model to identify patients at risk of dying the first five years after ICU discharge.

Patients / Methods: Of all single admissions to the surgical ICU of the St. Elisabeth Hospital between 1995 and 2000, data to calculate the results of six prediction models were prospectively documented. To evaluate discrimination and calibration, receiver operating characteristic (ROC) curves, area under the characteristic (AUC) curve and the Hosmer-Lemeshow goodness-of-fit test were performed.

Results: The data of 1821 patients were applied to all six models. Accurate overall mortality prediction was found for the APACHE II, SAPS II, SAPS 3 and MPM models. Discrimination was best for the SAPS 3 and MPM III models and worst for the APACHE II model with AUC of 0.81, 0.77 and 0.77, respectively. Calibration was poor for the six prediction systems, varying between 23 (SAPS 3) to 233 (SAPS II(Expanded)). There was a significant improvement in calibration for the APACHE II, SAPS II, SAPS II(Exp) and MPM II models after adjusting the baseline risks (intercepts) for each model. The SAPS 3 and MPM III system did not so much show improved calibration, as the former was already good in the lower probability groups

Conclusion: The newer SAPS 3 prediction mortality model is the best validated model for a surgical ICU population of six models tested. The other general prognostic models underestimate the risk of dying. The APACHE II model could also be helpful to identify patients at risk of dying during the five years after ICU discharge.

INTRODUCTION

Prognostic prediction models have been implemented in the intensive care unit (ICU) setting since the 1980s. They provide health care providers with important information to guide decisions related to treatment and prognosis (for individual patients and for cohorts of patients), as well as to compare outcomes across institutions. The predictors in the Acute Physiology and Chronic Health Evaluation (APACHE) II [1] and the Simplified Acute Physiology Score (SAPS) II [2], II (Expanded) [3] and SAPS 3 [4,5] measure severity of illness based on continuous physiologic parameters and non-physiologic parameters, such as age and co-morbidities (Appendix I, page 126). The predictor values documented in an ICU patient are converted to a probability of dying during hospital admission. The Mortality Probability Models (MPM) II_0 [6] and III [7] differ slightly in that they use besides age, only categorical variables as predictors (Appendix I, page 126).

All these prediction models were developed from cohorts including general ICU patients. Although these models indeed have shown to perform well in predicting the in-hospital mortality in a general ICU patient population, they may well under- or overestimate mortality in specific ICU subpopulations that were not substantially represented in the original cohorts. The investigators who developed these models have tried to neutralize for this heterogeneity in subpopulations by including an extra predictor (representing the admission diagnosis/specialisation) in the model, except for the MPM score.

Knowing which prediction model performs best in which specific ICU subpopulation, will improve communication with relatives and could eventually enhance healthcare for these patients. Our objective is to quantify the prognostic accuracy of all above six ICU mortality prediction models (four out-of-date, APACHE II / SAPS II / SAPS II(Exp) and MPM II, and two up-to-date models, SAPS 3 and MPM III) in a large cohort of surgical intensive care patients, using up-to-date methods for prognostic model validation [8,9]. Secondly, we tested the capability of the original APACHE II model to identify patients at risk of dying the first five years after ICU discharge.

PATIENTS/ METHODS

Patients

This (external) validation study involved a cohort study, including all consecutive surgical patients who were admitted to the intensive care unit (ICU) of the St. Elisabeth Hospital, in Tilburg (the Netherlands), between January 1995 and February 2000. Exclusion criteria were an age below 18 years, re-admission to the ICU during the same hospital admission, multiple admissions to the ICU over the study period, and gynaecological and non-trauma neurosurgery. Gynecologic and non-trauma neurosurgery patients were excluded because we aimed to quantify mortality outcome in a specific surgery patient population. The number of excluded medical patients was unknown. The hospital is a 673-bed teaching hospital that also serves as a level one trauma centre and as a regional referral centre for a population of about 2.1 million people. The 32-bed ICU admits medical and surgical critically ill patients, and is staffed by intensive care specialists with an internal, anaesthesiological or surgical background. All data has been prospectively collected and patients were followed-up, on average 60 months. The study was part of a continue quality improvement program towards long-term mortality and quality of life.

Outcome

Survival (all-cause mortality) was determined by reviewing the hospital's electronic patient data management system. If the patient's death – either in- or outside the hospital – could not be confirmed by the patient data management system (n=754 patients), the general practitioner was consulted (n=94). Finally, if a date of death could not be found, the patient or relatives were directly consulted by telephone (n=88). In addition, the cause of death may not have been related to the surgical ICU admission. Follow-up of each (surviving) patient was continued until all patients were followed for at least 5 years.

Prediction models

In our cohort we quantified the accuracy of the six previously developed models to predict in-hospital mortality for ICU settings: APACHE II, SAPS II, SAPS II (Expanded), SAPS 3, MPM II_0 score, and MPM III. The predictors and formula's of each model, are given in Appendix I (page 126). To enable this external validation study, all data on required predictors and outcome were documented in each patient. The APACHE II, SAPS II and SAPS 3 scores were calculated in accordance with the original definitions (specific coefficients for diseases), using the worst physiologic values as measured during the first ICU day [1-5]. All data were checked and completed if necessary by a data manager. At the time this study was conducted and evaluated, our data was not sufficient to calculate the predicted mortality rate using the newer third and fourth version of the APACHE prognostic model.

Data analysis

In comparing the predictive performance of the six models we focused on their discrimination and calibration. The discrimination indicates to which extent each model distinguished between patients who survived or died during hospital admission, and was expressed by the area under the Receiver Operating Characteristic (ROC) curve with 95% confidence interval. The calibration of a model describes to which extent the predicted mortality risks reflect the observed mortality. It was determined using calibration plots and the Hosmer-Lemeshow goodness-of-fit test [10]. The overall outcome incidence between the original cohorts from which the prognostic models were developed was to varying extents different from our cohort, potentially affecting the models' calibration (not discrimination). Customization is an accepted method used to improve the performance of prognostic models. Hence, we subsequently adjusted the intercept of each model before validation, such that the overall mean predicted probability was equal to the observed overall outcome frequency [8,11].

Independent-samples t test and Chi-square analysis were used to compare values between deceased and surviving patients. P-values less than 0.05 were regarded as statistically significant. Only 13 patients had a missing predictor value, for which we used normal values (some models use normal values for missing data) or the mean value was imputed based on an age, gender and type of surgery matched group. Statistical analysis was performed using SPSS 15.0, Chicago, IL (for The Netherlands: SPSS Benelux, Gorinchem).

RESULTS

Of the total study population 34% was female and the median age was 63 years (Table 1). The type of admission was more likely to be emergency surgical admission in non-survivors. A total of 286 patients (16%) died during the hospital admission. The subspecialties of Gastro-Intestinal (G-I) and general surgery had a twice as high in-hospital mortality (25 and 22%, respectively) compared to the other three subspecialties (trauma 14%, vascular 11% and general surgery 14%). Vascular surgery patients had the lowest mortality: 11%. Compared to in-hospital survivors, non-survivors were older (Table 1) and had higher average scores for each of the six models (Table 2).

Table 1
Distribution of the patient characteristics, outcome and length of stay (ICU and hospital) in the total study population, and across hospital-survivors and non-survivors.

	Total (*n*=1822)	**Hospital survivors** (*n*=1536)	**Non-survivors** (*n*=286)
Females	613 (34)	508 (33)	105 (37)
Age (years) [1]	63 (48-73)	62 (45-72)	70 (58-76)
Surgical classification			
Trauma	476 (26)	408 (27)	69 (24)
Vascular	538 (30)	478 (31)	60 (21)
G-I	278 (15)	209 (14)	69 (24)
Oncology	334 (18)	288 (19)	46 (16)
General	195 (11)	152 (10)	42 (15)
Elective surgical admission	962 (53)	854 (56)	108 (38)
IC LOS [1,2]	2 (1-5)	2 (1-4)	3 (1-9)
Hospital LOS [1,2]	12 (8-23)	13 (8-23)	9 (3-21)
ICU mortality	209 (11)	0	209 (73)
In Hospital mortality	286 (16)	0	286 (100)

Figures in parentheses are percentages. [1]: Score value in median with 25th and 75th percentile. [2]: LOS (Length of Stay) given in days.

Table 2
Distribution of the prediction model scores in the total cohort, and among hospital survivors and non-survivors separately.

	Total n= 1822	**Hospital survivors** n= 1536	**Non-survivors** n= 286	***p*-value**[1]
APACHE II score	11.9 ± 7.0	11 ± 6.1	18 ± 8.5	< 0.001
SAPS II score	24.7 ± 14.7	22.2 ± 12.7	37.9 ± 16.6	< 0.001
SAPS II (Exp) score	24.7 ± 14.7	22.2 ± 12.7	37.9 ± 16.6	< 0.001
SAPS 3 score	44.6 ± 14.1	42 ± 12.5	58.5 ± 14.6	< 0.001
MPM II_0 value beta	1.0 ± 1.2	0.9 ± 1.1	2.0 ± 1.3	< 0.001
MPM III value beta	0.6 ± 1.1	0.5 ± 1.0	1.3 ± 1.5	< 0.001

[1]: *P*-value based on independent-sample t-test between hospital survivors and non-survivors. Score value in mean ± SD.

2

Older prediction models

Discrimination

The calculated in-hospital mortality risk by the four models were: APACHE II 13%, SAPS II 12%, SAPS II (Exp) 8% and MPM II_0 11%. Figure 1A shows the receiver operating characteristic (ROC) curves for each of the four models. The corresponding areas under the curves were: APACHE II, 0.77 (95% CI 0.74 – 0.80); SAPS II, 0.79 (0.76 – 0.81); SAPS II(Exp), 0.78 (0.76 – 0.81) and MPM II_0, 0.79 (0.77 – 0.82).

Calibration

Figure 2 shows the calibration plots of the six models. For the APACHE II model the calibration plot closely followed the ideal calibration line. The MPM II_0 and SAPS II showed a similar pattern, but with a larger underestimation below predicted probability of about 0.3 and 0.4 and an increasing overestimation above these values, although the latter was based on small patient numbers. The SAPS II (Exp) yielded a systematic underestimation of the in-hospital mortality across the entire range, but particularly below 0.6. Standardized mortality ratios (SMR) were APACHE II 1.19 (95% CI: ±0.14), SAPS II 1.33 (±0.15), SAPS II (Exp) 2.0 (±0.23) and MPM II_0 1.38 (±0.17). The Hosmer-Lemeshow test was statistically significant for all four prediction models, indicating poor calibration. Chi square statistics were: APACHE II 59.8 [P<0.001]; SAPS II 152.7 [P<0.001]; SAPS II (Exp) 259 [P<0.001] and MPM II_0 80.0 [P<0.001].

Figure 1
Receiver Operating Characteristic curves for four prediction models (A: APACHE II score, SAPS II, SAPS II (Exp), MPM II_0), and for the two newest models (B: SAPS 3 and MPM III).

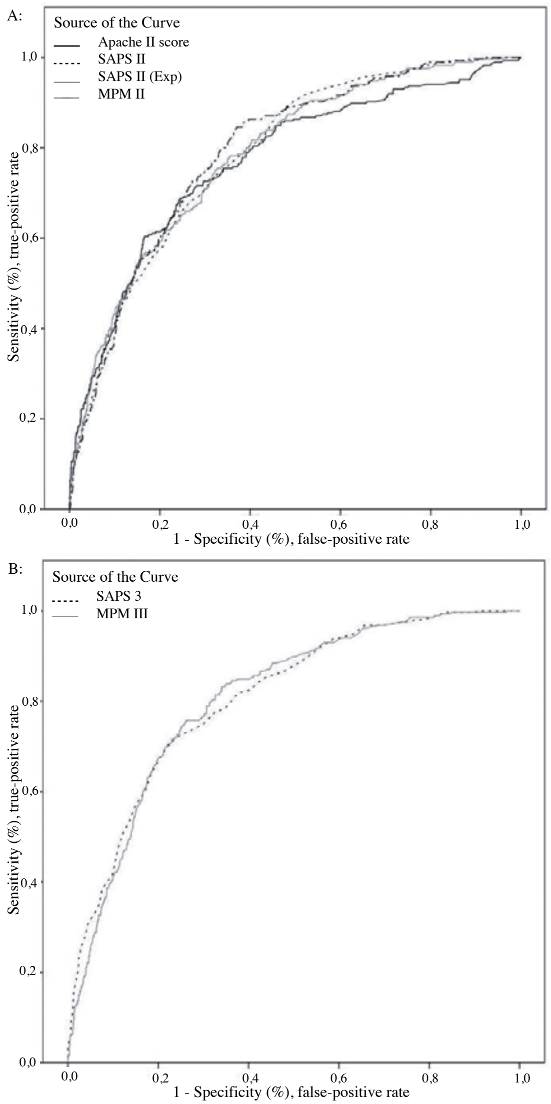
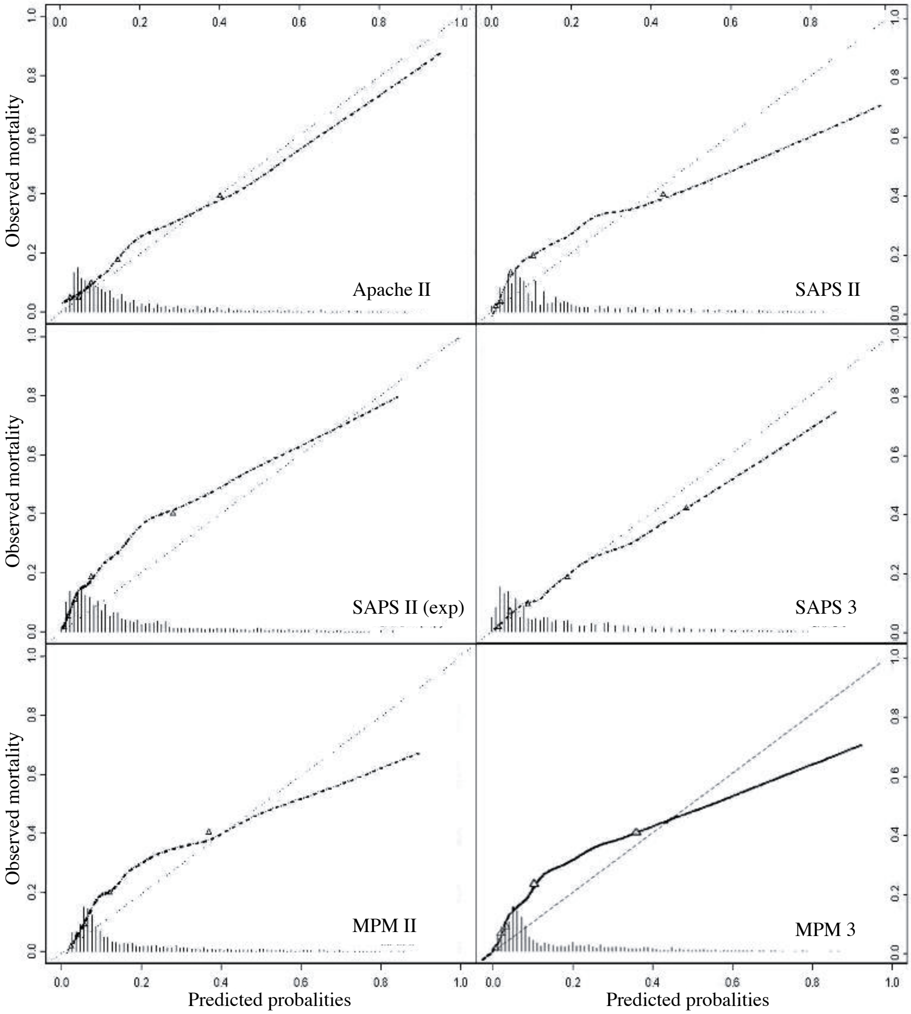


Figure 2
Calibration plots (in-hospital mortality) for the six prediction models. The dotted line represents the ideal calibration (with intercept 0 and regression coefficient 1).



Bars contain amount of patients per prediction probability group.

Intercept adjustment

Notably in the probability categories containing the largest patient numbers (below predicted probability of 0.3), there was a significant improvement in calibration for the APACHE II, SAPS II, SAPS II(Exp) and MPM II models after adjusting the baseline risks (intercepts) for each model (Figure 3). As expected, for all four models the calibration in the higher probability groups largely remained unchanged due to small group sizes.

Newest prediction models (up-to-date)

Discrimination

The calculated in-hospital mortality risk by the two models were: SAPS 3 16% and MPM III 10%. Figure 1B shows the ROC curves for both models. The corresponding areas under the curves were: SAPS 3, 0.81 (0.78 – 0.83) and MPM III, 0.80 (0.78 – 0.83).

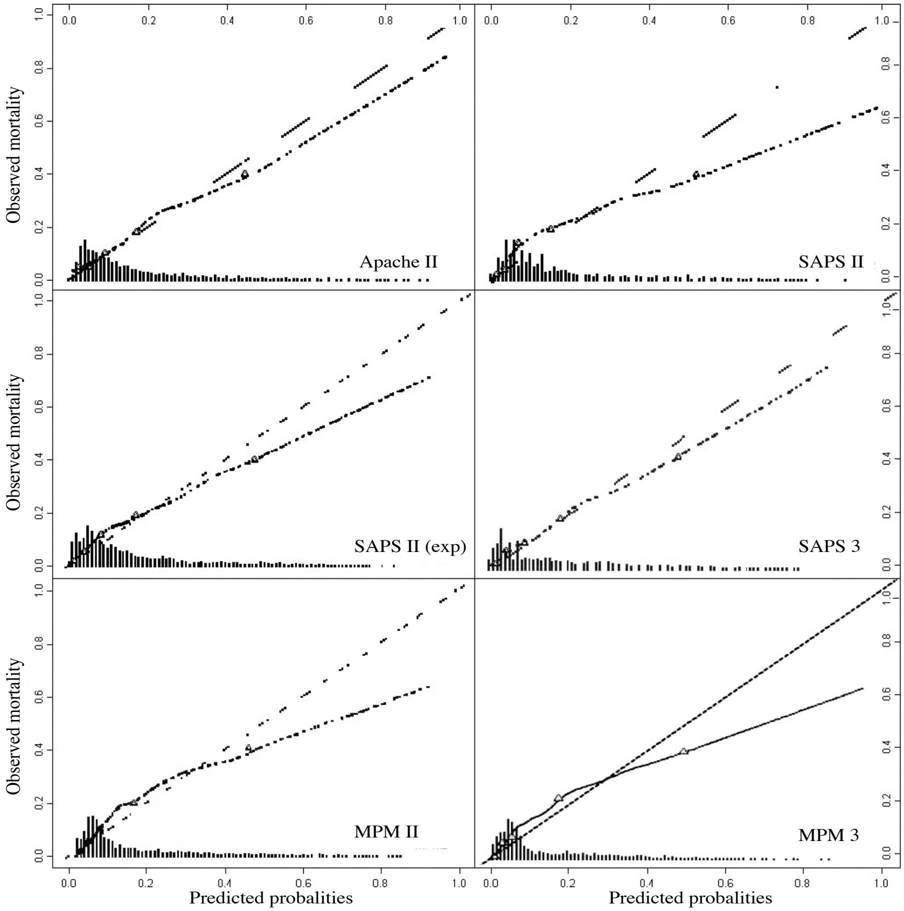
Calibration

In the calibration plot, the SAPS 3 model closely followed the ideal calibration line with a small overestimation for the SAPS 3 score in the higher range of predicted probabilities**.** The MPM III curve shows a larger underestimation below predicted probability of about 0.4 and an increasing overestimation above this value. Standardized mortality ratios (SMR) were SAPS 3 1.0 (±0.11) and MPM III 1.6 (±0.18). The Hosmer-Lemeshow test was statistically significant for both prediction models, indicating poor calibration, though the chi-square statistic was smallest (indicating best fit of the two updated models) for the SAPS 3 model**.** Chi square statistics were: SAPS 3 22.3 [P<0.01] and MPM III 157 [P<0.001].

Intercept adjustment

The SAPS 3 system did not so much show improved calibration, and the MPM III system only improved in the lower prediction mortality risks (<0.4), as both were already good in the lower probability groups.

Figure 3
Calibration plots (in-hospital mortality) after adjustment of the baseline risk (intercept) in each model. The dotted line represents the ideal calibration (with intercept 0 and regression coefficient 1).



Bars contain amount of patients per prediction probability group.
New adjusted baseline risks (intercepts) were: APACHE II: -3.292; SAPS II: -7.3042; SAPS II(Exp): -13.4973; SAPS 3: -32.71652; MPM II: 5.92496 and MPM III: -4.715

Long-term mortality prediction of the APACHE II system

Cumulative mortality increased to 25% at one year and to 42% five years after ICU discharge. Shown in Table 3A, prediction mortality and the APACHE II score were significantly higher in the population who died 1 year after ICU discharge.

These patients were older, had more comorbidities (as scored in the chronic health points in the APACHE II score) and had a higher Acute Physiology Score (APS). Five years after discharge, the prediction mortality and the APACHE II score were still significantly higher in the deceased patients compared to the surviving patients. Again, these patients were older (68±14 *versus* 53±18), had more comorbidities (14% *versus* 6%) and had higher mean APS (9±7 *versus* 6±6), Table 3B.

Discrimination decreased from (areas under the curves) 0.72 (fair discrimination) to 0.68 (poor discrimination), and the calibration (Hosmer-Lemeshow goodness-of-fit test) was poor at respectively one and five years after ICU discharge (results not shown).

Table 3
Prediction mortality (APACHE II score) characteristics for the entire cohort at one year (A) and at 5 years of follow-up after discharge (B).

A:	**Survivals** *n*=1370	**Non-survivals** *n*=451	***p*-value** [4]
PMR APACHE II (%) [1]	10	23	< 0.001
APACHE II score	10 ± 6	16 ± 8	< 0.001
APS	6 ± 6	11 ± 8	< 0.001
Age (years) [2]	57 ± 18	67 ± 16	< 0.001
Comorbidities (%) [3]	7	17	< 0.001

B:	**Survivals** *n*=1051	**Non-survivals** *n*=770	***p*-value** [4]
PMR APACHE II (%) [1]	10	19	< 0.001
APACHE II score	10 ± 6	14 ± 7	< 0.001
APS	6 ± 6	9 ± 7	< 0.001
Age (years) [2]	53 ± 18	68 ± 14	< 0.001
Comorbidities (%) [3]	6	14	< 0.001

[1]: PMR (%): Predicted Mortality Rate was calculated by the formula based on the APACHE II score by Knaus *et al*. [2]: Score value in mean ± SD. [3]: Comorbidities as scored in the chronic health points in the APACHE II score), [4]: *P*-value based on independent-sample t-test between hospital survivors and non-survivors. Score value in mean ± SD.

DISCUSSION

We investigated the prognostic accuracy of four older and two newer ICU mortality prediction models in an adult surgical intensive care unit. When validated or applied as such (i.e. without adjusting for differences in outcome incidence between the original and our cohort), only the older APACHE II and notably and the newer SAPS 3 models showed reasonable calibration. The other models showed a clear over- or underprediction. Discrimination was fair for all systems (0.77 – 0.81), but again highest for the SAPS 3 and MPM III models. However, all curves had confidence intervals that overlapped. Hence non of the comparisons were statistically significant. After adjusting the baseline risks (intercepts), the calibration of all models, notably in the largest (lower) probability groups, improved substantially. The APACHE II model could even be helpful identifying patient at risk for dying during the first five years after ICU discharge. However, the more up-to-date models have not been analysed in their long-term mortality predictive power.

Since the first scoring systems for the evaluation of disease severity in ICU patients have been developed, many studies have highlighted their limitations when applied to other patients in a wide variety of ICUs and countries [12-15]. Models that predict mortality accurately and perform well in various ICU (sub)populations are essential for ICU benchmarking. Glance *et al*. [16] recently discussed that the APACHE II, SAPS II and MPM II_0 are no longer suitable for benchmarking. Our study results showed similar results.

Good accuracy of a prognostic model in the patients that were used to develop the model is no guarantee for good prediction in new patients. Most prediction rules show a reduced accuracy when validated in new patients [8,9]. The most likely reason for insufficient calibration of the majority of the original six (older and newer models) validated models was the differences in case mix. It is well known that there is great international variability in patient mix and thus in severity of illness in ICU populations [13,17]. Some of the differences are inherent to the type of ICU patients, but they are also determined by local or regional admission capacity and type of hospital, for example tertiary, transplant or trauma centre. Our study population did not contain medical patients, in contrast to the original populations from which the models were developed; percentage of medical patients were: APACHE II 58%; SAPS II 49%, SAPS II (Expanded) 73%; SAPS 3 43%; MPM II_0 45%; MPM III

65% [1,4,6,7]. On the other hand, 19% of our patients underwent 'peripheral vascular surgery', which is associated with a low mortality risk (APACHE II diagnostic weight is -1.315), compared to 10% in the original APACHE II study [1], and we did not have patients who underwent 'heart valve surgery' or 'coronary artery disease'. Regarding the SAPS II model, it was updated to the SAPS II (Expanded) by Le Gall *et* al. for a French ICU setting, showing a major improvement in mortality prediction in their setting [3]. However, in our population we could not reproduce this improvement for either of the two SAPS models. In the development of these six prognostic models, the original studies did not contain the kinds of numbers of oncological patients which are being admitted to the ICU today (14% in the development database of the APACHE II system, unknown for the original database of the other prediction models). Differences in outcome incidence between ICUs are to some extent associated with case mix diversity. After adjustment for these differences in outcome incidence, we indeed found improved calibration of almost all models.

Another reason for finding poor accuracy of a model in other patients are changes in practice over time. Improvements in administered treatments may change the prognosis of patients, and thus as well the accuracy of the older prognostic models [9]. Some of the validated models were developed years ago: 20 years for APACHE II [1] and 10 years for SAPS II [2] and APACHE III [18]. Indeed, the newer models constantly performed better than the older ones; APACHE III versus APACHE II in the study of Harrison *et al*. [19]; SAPS II (Expanded) versus SAPS II by Le Gall *et al*. [3] and in our study SAPS 3 *versus* SAPS II and SAPS II (Expanded), and MPM III *versus* MPM II. Improvements in diagnostic tests or treatment will eventually lower hospital mortality. This is visible when comparing our hospital mortality (16%) with the development databases hospital mortality of the prediction systems (APACHE II 20%, SAPS II 22%, SAPS II(Exp) 21%, SAPS 3 15%, MPM II_0 21% and MPM III 14%). Performance of the different prediction models tested in our study was found to be similar to that of previous studies [4,12,19]: acceptable discrimination but lack of calibration. However, we showed that a simple intercept adjustment to the patients at hand, can clearly improve the model's calibration in the largest and thus most important risk categories.

A previous study showed that the APACHE II, SAPS II and MPM II underestimate the risk of dying for cancer patients admitted to ICUs [10]. However, when validating them in the cancer diagnosis subgroup of our study population only, the APACHE II

and SAPS 3 models had an excellent mortality prediction (results not shown). This validation study has certain limitations. First, the data represent a cohort study from a single centre, which makes it biased towards a certain case mix. However, our ICU and hospital (short-term) mortalities are almost identical to the Dutch National Intensive Care Evaluation (NICE) Foundation Study, in which 18 ICU's were evaluated [20]. Patient's characteristics (age, gender, severity of illness and ICU length of stay) were identical compared to the NICE study. However, our data is 10 to 15 years old. Critical care management and organisation has changed during this period. The research done by Dowdy *et al*. demonstrated that the prospective cohort study is a powerful research design to assess relationships between exposures and ICU outcomes [21]. Second, we included only surgical patients. Hence, it may well be that the associations of the predictors in the models are different in the surgical ICU patients or perhaps even other predictors may play a role. To enhance their use in surgical ICU patients may thus require more rigorous updating of the models than only adjusting the baseline risks (intercepts), as we did [9].
At the time this study was conducted and evaluated, our data was not sufficient to calculate the predicted mortality rate using the newer third and fourth version of the APACHE prognostic model. We are aware that the performance of outcome prediction models deteriorates over time. Nevertheless, the APACHE II score is still one of the prediction models (together with its severity of illness score) most widely used today in the world, despite the fact that APACHE III and APACHE IV are much more current.

In conclusion, many prognostic models for ICU patients are developed but few have their predictive performance seen validated (or tested whether they accurately measure outcome) in only surgical ICU patients. The older APACHE II and the newer SAPS 3 models seem the best suitable (with regard to discrimination and calibration) for a surgical ICU population, certainly after adjustment of the baseline risk to the patients at hand. The APACHE II model could also be helpful to identify patients at risk of dying during the five years after ICU discharge.

2

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Chapter 3

Patients' characteristics associated with intensive care unit readmission in a surgical ICU

Submitted for publication

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ABSTRACT

Introduction: Readmission to the ICU within 48 hours is a leading indicator for the quality of ICU care. The aims of this study are to investigate different variables which could be associated with readmission to the surgical ICU (SICU). In this study we quantified and measured the long-term survival and QoL over a period of more than 10 years of patients readmitted to a SICU.

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Patients / Methods: Of all surgical patients admitted to the ICU of the St. Elisabeth hospital between 1995 and 2000, patients' characteristics, disease category, severity of illness score (APACHE II and SAPS 3) and survival were prospectively registered. We quantified readmission occurrence during hospital length of stay within 30 days after ICU discharge. We used the EuroQol-6D questionnaire to measure quality of life. A mean follow up of 8 years after discharge was achieved. Multivariate logistic regression analysis was used to calculate the independent association of expected covariates.

Results: One-hundred-forty-one of 1682 patients alive at ICU-discharge (8%) were readmitted to the SICU. The main cause of readmission was respiratory decompensation (48%) followed by cardiac conditions (16%). Patients readmitted to the SICU were older, mostly suffered from a vascular (39%) or gastro-intestinal surgical disease (26%), had a significantly higher initial admission APACHE II and SAPS 3 score ($p<0.01$) and significantly more comorbidities (14% versus 8%, $p=0.005$). We found an independent association with readmission in all different surgical classifications except in the general surgical patient, for the type of admission and for the need for mechanical ventilation. Twenty-eight patients were readmitted within 48 hours (1.7%). Long-term mortality was higher compared to the total study population (70 versus 42%; $p<0.001$). Readmitted patients had the same QoL score compared to non readmitted patients, mean EQ-us 0.63 ± 0.30 versus 0.71 ± 0.26.

Conclusion: The negative effect of readmission to the SICU on survival appears to be long lasting. Predictors for ICU readmission are scarce. Readmitted patients had worse severity of illness scores, higher prevalence of preadmission disease (comorbidities) and their initial admission type was more active treatment (true ICU) dependable.

INTRODUCTION

The Quality Indicators Committee of the Society of Critical Care Medicine recommended that readmission within 48 hours is a leading performance indicator of the quality of intensive care unit (ICU) care [1]. However, there has been no evaluation of factors separating appropriate ICU readmission rate from those resulting from poor quality of care. It is therefore important to timely identify which patients after first ICU admission, are at a high risk of ICU readmission [2-5]. Readmitted patients are most often the sickest in the ICU. The association between ICU readmission and patient characteristics such as age, gender and underlying disease during first admission has been studied earlier on [6-15]. However, the association between different surgical background and ICU readmission has yet to be addressed. Moreover, the outcomes of patients readmitted to a surgical ICU, have not been well described until now.
The first aim of this study is to investigate which factors, measured during the first surgical ICU admission, are independently associated with readmission to the SICU. Secondly, we compared the long-term (over more than 10 years) survival and quality of life of surgical patients with and without readmission to the ICU.

PATIENTS AND METHODS

Patients

In this prospective observational cohort study, all 1979 consecutive surgical patients who were admitted to the ICU of the St. Elisabeth Hospital, a 673-bed teaching hospital in Tilburg (the Netherlands) were included in the cohort. Study inclusion period was from January 1995 until February 2000, 61 months. The 32-bed ICU admits medical and surgical critically ill patients, and is staffed by intensive care specialists with an internal, anesthesiological or surgical background. As the surgical population is a distinct ICU population, both from admission profile and outcome, it was chosen to focus on the general surgical ICU population with specific surgical subspecialties (trauma, vascular, gastro-intestinal (G-I), oncological and general surgery). Exclusion criteria were age below 18 years, readmission beyond 30 days after first ICU discharge and gynaecological and non-trauma neurosurgery. Our idea was that when we included these patients, the outcome-data would be unrealistic for a genuine surgical population. The study was approved by the local medical ethics committee.

Patient characteristics

To address the first aim, we documented from each patient gender, age, type of surgical classification, severity of illness (measured by APACHE II Score [16] and SAPS 3 [17,18]), the presence of any preadmission disease (as scored in the chronic health points of the APACHE II score and comorbidities), type (indication) of first ICU admission, and length of first ICU and hospital stay. The APACHE II score was calculated in accordance with the original definitions (specific coefficients for diseases), using the worst physiologic values as measured during the first ICU day [16]. Types of surgical ICU (SICU) admissions were divided into five different surgical classifications: trauma, vascular (excluding cardiac surgery), gastro-intestinal (G-I), oncological and general surgery.

The indication for SICU admission was categorized as 'low risk monitoring' (admission for monitoring and observation), 'high risk monitoring' (stable patient but extended care with high risk of complications) or 'active treatment' (unstable patient with continuous medical intervention). Initial ICU length of stay (LOS) was defined as the period from the day of the first admission until the day of ICU discharge. Length of (initial) hospital stay was defined as the period from the day of hospital admission until definitive discharge from the hospital, including the initial ICU and eventual readmission periods. Only 16 patients had a missing value on either the APACHE II or SAPS 3 score. For these we imputed the mean value using linear regression analysis based on age, gender and type of surgery. This is different in comparison with the approach Knaus *et al*. uses, whereas they use normal values for missing data [16].

Outcome

To address the first aim, readmission to the ICU was defined as a return within 30 days (early or late readmission, ≤48 or >48hours) internationally defined as ICU readmission after discharge of the original ICU admission. Our mean hospital length of stay was 25 days.

For the second aim, survival was determined by reviewing the hospital's electronic patient medical record. If the patient's death – either in- or outside the hospital - could not be confirmed by the database, the patient's general practitioner was consulted. If a date of death could not be found, the patient or relatives were consulted. Follow-up of each (surviving) patient was continued until February 2006. All patients were followed for at least 6 years, with a follow-up of 8.4 ± 1.4 (mean ± SD) years. Fiftytwo patients were eventually lost during the study (the follow-up rate was 97%). Quality of life (QoL) was measured in all patients (readmitted and patients with a single admission) alive at the end of follow-up, February 2006. We used the EuroQol-6D [19-24] questionnaire (EQ-6D) to measure QoL. The first EQ-6D outcome (EQ-us) was obtained with the help of the UK EQ-5D index tariff for all possible health states defined by the EQ self-classifier [25-27]. The cognitive dimension was ignored (not yet available for analysis). This index tariff links a single index value for all hypothetical health states [25]. The second outcome was the percentage of problems for each dimension. We dichotomised the outcome categories (i.e. no problems, mild problems, and severe problems) of these dimensions to: no problems versus (mild or severe) problems.

Data analysis

To address the first aim, we quantified the incidence of ICU readmission within 30 days after first ICU discharge. We excluded patients who died during first ICU stay or ≤30 days after original ICU discharge because it could be possible that these patients died before readmission was possible. Subsequently, multivariable logistic regression analysis was used to determine the independent association of the above defined patient characteristics with ICU readmission. Age, APACHE II score and SAPS 3 score were included as linear parameters, after cubic spline analysis confirmed their linearity [28]. Then we evaluated a priori defined effect modification (interaction) between gender, age, surgical classification, comorbidity and SAPS 3 score.

For aim 2, we compared the survival (short-term, ICU, and long-term survival) between the readmitted and non-readmitted patients using Pearson Chi-Square test. The QoL outcome was compared using the nonparametric Mann-Whitney U test (EQ-us variable) and the Pearson Chi-Square test (percentage of reported problems (dichotomised value). We also made different survival curves with the use of Cox-regression modeling.

P-values less than 0.05 were regarded as statistically significant. Statistical analysis was performed using SPSS 15.0, Chicago, IL (for The Netherlands: SPSS Benelux, Gorinchem) for Microsoft Windows XP Professional Version 2002, Service Pack 2.0.

RESULTS

In the first column of Table 1 the baseline characteristics are shown of the total group of 1979 patients. Of these patients, 297 died during their initial ICU admission or within 30 days after discharge from the ICU before being readmitted to the ICU (Table 1, second column). One-hundred-forty-one (8%; 95% CI: 5-14) of the 1682 surviving patients were readmitted to the SICU within 30 days after discharge. Readmission rate was 15% (11-19) for G-I, 10% (10-13) for vascular, 9% (8-11) for oncological, 4% (3-5) for trauma, and 4% (4-7) for general surgery patients. The majority of these patients (83%) was readmitted within the first 2 weeks, Figure 1. Twenty-eight patients were readmitted within 48 hours (1.7% of the total cohort of 1682 patients; 20% of the readmitted population). The main causes of readmission were respiratory failure (68 patients, 48%) followed by cardiac (16%), sepsis (14%), reoperation (11%) and other reasons (10%). Figure 2 shows the reasons for readmission during the various admission years. Despite low readmission numbers for each admission year, there seems to be a trend that fewer patients are being readmitted due to sepsis and more patients are readmitted because of a reoperation.

Predictors of readmission

In comparison to non-readmitted patients, the readmitted ones were older, were mostly patients with a vascular (39%) or gastro-intestinal surgical disease (26%), had a significant higher initial severity of illness score (APACHE II: p=0.007, SAPS 3: p=0.003), had more comorbidities (14% *versus* 8%, p=0.005) and their initial type of admission was more Intensive Care dependable (low risk monitor 49 *versus* 63, p=0.001; high risk monitor 34 *versus* 27%, not significant; active treatment 17 *versus* 10%, p=0.004) (Table 1, right side). Patients readmitted within 48 hours were significantly older, had more comorbidities, had higher initial severity of illness score (SAPS 3) and were more in need for mechanical ventilation compared to the patients readmitted after 48 hours in their initial SICU admission. Between patients with and without readmission in the various surgical subspecialties only a significantly higher presence of preadmission comorbidities was found in the vascular and oncological surgery patients, respectively 20 *versus* 10% (p=0.05) and 24 *versus* 6% (p<0.001). Surgical subspecialties, higher level of care needed during initial admission and age were independently associated with readmission (Table 2). None of the tested interactions were independently associated with readmission (results not shown).

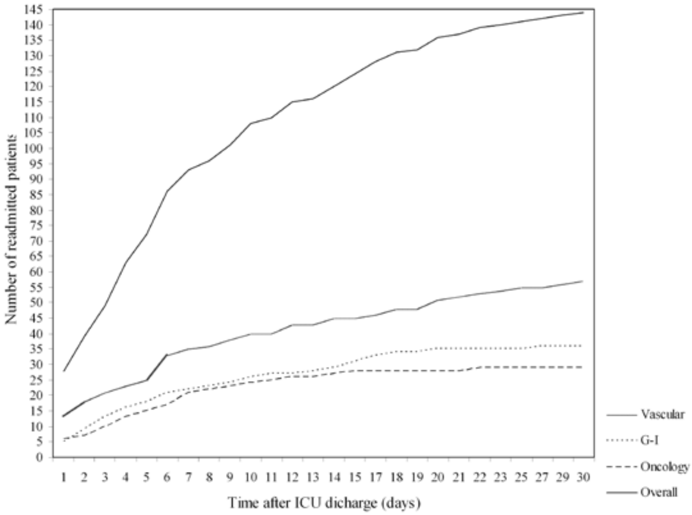
Table 1
Baseline characteristics of the overall cohort and subdivided by readmission groups.

	Total	Deceased < 30 days	Non readmission	Readmission	*p*-value
Number of patients (%)	1979	297	1539	141 (8)	
Age (years) [1]	60 ± 18	65 ± 17	58 ± 18	65 ± 15	<0.001
Male gender (%)	66	65	67	64	0.65
Comorbidities [2] (%)	10	19	8	14	0.005
Surgical classification (patients):					0.17
Gastro-intestinal (%)	318 (16)	74 (25)	209 (14)	35 (25)	
Vascular (%)	599 (30)	61 (21)	483 (31)	55 (39)	
Oncology (%)	365 (18)	49 (17)	287 (19)	29 (21)	
Trauma (%)	493 (25)	71 (24)	407 (26)	15 (10)	
General (%)	204 (10)	42 (13)	155 (10)	7 (5)	
Initial Admission Severity Scores [1]					
APACHE II [3]	12 ± 7	18 ± 8	11 ± 6	12 ± 6	0.007
SAPS 3 [3]	45 ± 14	58 ± 14	42 ± 13	46 ± 12	0.003
Readmission Severity Scores [1]					
APACHE II	--	--	--	14 ± 8	
SAPS 3	--	--	--	52 ± 15	
Emergency admission initial (%)	47	63	56	58	0.47
Type of admission:					<0.001
Low risk monitor (%)	56	26	63	49	0.001
High risk monitor (%)	29	37	27	34	0.09
Active treatment (%)	15	38	10	17	0.004
Mechanical Ventilation (%)	36	73	30	32	0.55
Dialysis (%)	3	13	1	2	0.29
ICU LOS [4]	2 (1-5)	3 (1-9)	2 (1-4)	2 (1-4)	0.43
Hospital LOS [4]	13 (8-25)	9 (3-19)	13 (8-24)	36 (22-65)	<0.001

[1]: Mean ± SD values. [2]: The presence of a preadmission disease (comorbidities, as scored in the chronic health points in the APACHE II score). [3]: The APACHE II score ranged from 0 to 40 in our population. The SAPS 3 score ranged from 13 to 93. [4]: LOS (Length of Stay) given in days, value in median with 25th and 75th percentile.

3

Figure 1
Readmission occurrences within 30 days after SICU discharge.



Figures of trauma and general surgery patients not shown because of low numbers of SICU readmission, respectively 15 and 7 patients.

Figure 2
Comparison of reasons for readmission during different admission years.

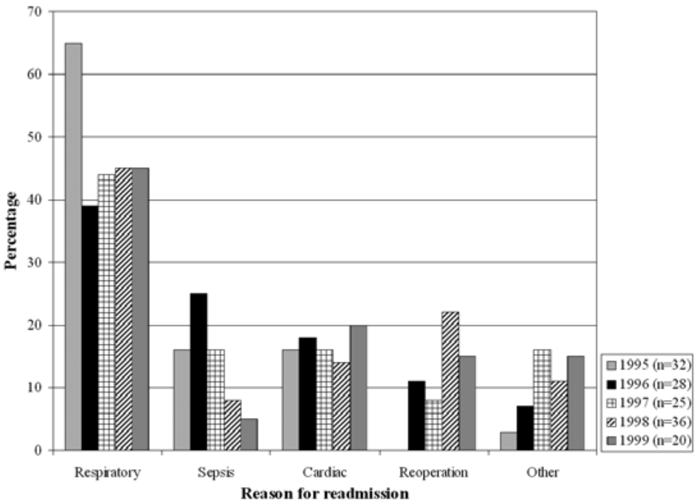


Table 2
Independent association of gender, age, surgical classification, comorbidities, type of admission, APACHE II score, SAPS 3 score, emergency admission and use of mechanical ventilation with readmission, based on multivariable logistic regression.

	Readmission	95% CI		*p*-value
Gender	0.97	0.66	1.42	0.89
Age (per life year)	1.01	1.00	1.03	0.16
Surgical classification:				<0.001
Gastro-intestinal	4.21	2.04	8.70	<0.001
Vascular	2.91	1.39	6.11	0.005
Oncological	2.48	1.16	5.33	0.02
General	1.23	0.46	3.31	0.67
Trauma [1]				
Comorbidities	1.47	0.85	2.54	0.17
Type of admission:				<0.001
Low risk monitoring [1]				
High risk monitoring	2.56	1.60	4.09	<0.001
Active treatment	3.96	2.12	7.39	<0.001
APACHE II (continue)	1.02	0.97	1.07	0.42
SAPS 3 (continue)	1.00	0.97	1.03	0.80
Emergency v/s elective	0.89	0.54	1.47	0.7
Mechanical ventilation	1.79	1.03	3.11	0.04
Dialysis	0.63	0.17	2.49	0.5

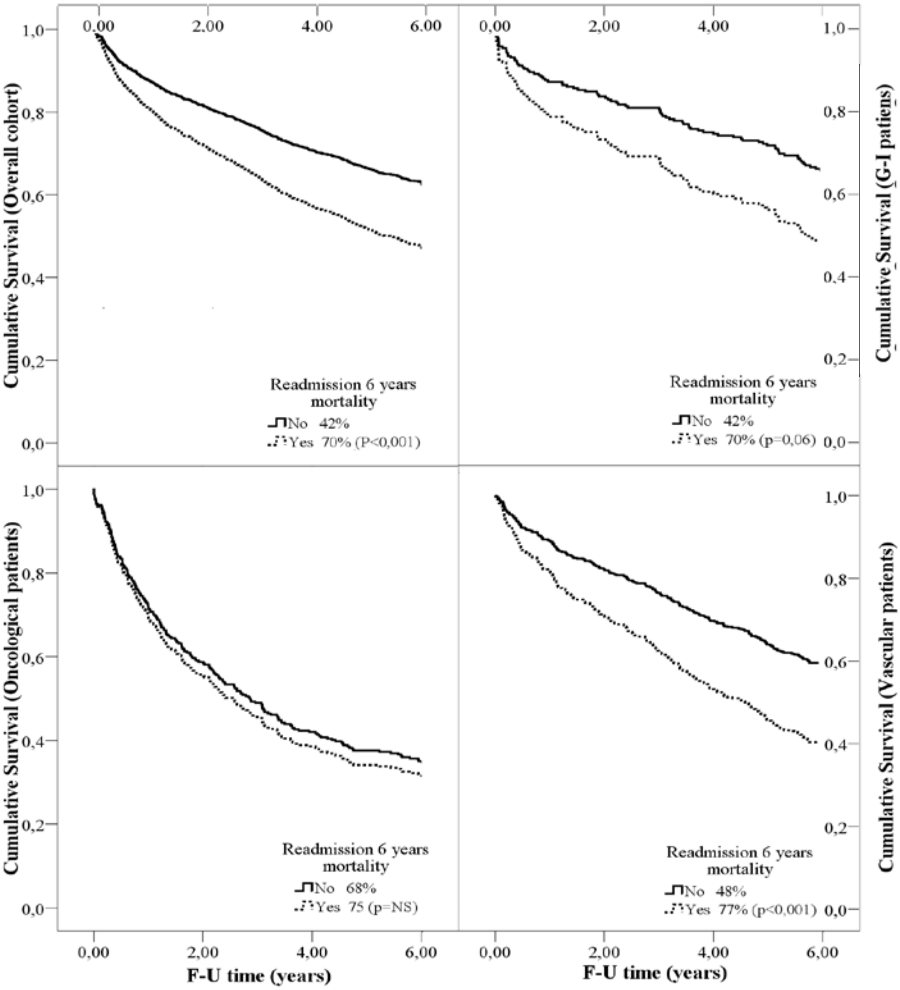
Results are expressed as odds ratios.
[1]: the trauma patient group is the comparison group within the multivariable logistic regression for surgical classification; for type of admission the low risk monitoring group is the comparison group within the regression analysis. NS = not significant.

Outcomes of readmitted versus non-readmitted patients

Short-term (ICU) mortality in the readmitted group was equal compared to the non-readmitted patient group (10% *versus* 11%). Irrespective of its cause, the long-term mortality rate (6 years after ICU discharge) was higher (70 *versus* 42%, $p<0.001$), Figure 3. Long-term mortality per different surgical classification was significantly higher for the G-I and Vascular patients, Figure 3.

Of the 141 readmitted patients only 43 survived until the end of follow-up. Of these 43 patients we were able to measure quality of life (EQ-6D) in 32 patients (response rate of 74%). QoL was also measured in 575 of the non-readmitted patients (65%). As shown in Table 3, the median EQ-us in readmitted and non-readmitted patients was equal.

Figure 3
Survival curves for readmitted and non readmitted patients who survived the first SICU and readmission for the entire cohort, G-I, vascular and oncology patients.



Figures of trauma and general surgery patients not shown because of low numbers of SICU readmission, respectively 15 and 7 patients.

Table 3
Outcome: cumulative long-term quality of life (at the end of the study period) for the non readmission and readmission groups.

	Non Readmission *n*= 575	Readmission *n*= 32	Mean/ Risk difference	*p*-value
EQ-utility score [1]	0.76 (0.62-0.88)	0.67 (0.59-0.88)	0.09	*p*=0.08
Problems in Dimension:				
Mobility (%)	52	69	17	*p*=0.07
Self-care (%)	20	31	11	*p*=0.12
Usual activity (%)	53	66	13	*p*=0.20
Pain/ disorder (%)	57	59	2	*p*=0.86
Anxiety/depression (%)	29	38	9	*p*=0.32
Cognition (%)	43	31	12	*p*=0.27

QoL was measured in 575/ 886 non readmitted patients and in 32/ 43 readmitted patients (74% reply) alive at the end of the study period. We dichotomised the outcome scales of the EQ-5D+ dimensions from no problems, mild problems and severe problems to no problems versus problems. [1]: EQ-utility score value in median with 25th and 75th percentile. Mean ± SD: readmitted group 0.63±0.30, non-readmitted group 0.71±0.26.

3

DISCUSSION

This report describes a large group of patients who required readmission to a surgical ICU in a large teaching hospital. During a five years study period, 141 (8%) patients were readmitted to the SICU within 30 days after ICU discharge.
Patients who require readmission were older, had a higher prevalence of preadmission disease (comorbidities), had worse initial SAPS 3 scores, and therefore their initial type of admission required more often intensive treatment than monitoring only, compared to the non-readmitted patients. Our study showed hardly any predictive variable for readmission at the beginning of the initial SICU admission. Independent association with readmission was found for all surgical classifications (except general surgery), admission type and the need for mechanical ventilation. Modification analysis showed no significant interaction between all the different variables tested for

readmission (gender, age, surgical classification, comorbidities, SAPS 3 score and the use of mechanical ventilation). The majority of readmissions was due to respiratory distress and occurred within the first 2 weeks after ICU discharge. Twenty-eight patients (1.7%) were readmitted within 48 hours. They were significantly older, had more comorbidities, had higher initial severity of illness score and were more in need for mechanical ventilation compared to the patients readmitted >48 hours in their initial SICU admission. More than 80% of readmitted patients had been discharged from the SICU for a period longer than 48 hours. Readmitted patients had significantly higher severity of illness scores in comparison with their initial admission, except for trauma and general surgical patients.

Patients, who require readmission, had a significant worse long-term outcome. Morbidity of the surviving readmitted patients was below an age- and gender-matched general population norm [19,20]. The EQ-utility score (EQ-us) was equal compared to the QoL of the non-readmitted patients [19].

Our SICU readmission rate is comparable to the 3-13% (SICU population) and 5-10% (mixed ICU) rates reported by others [2-4,6-16]. With regard to causes for SICU readmission, our results are in accordance with many earlier reports [2-5,6-11,16,29]. In general, respiratory distress is the main cause for readmission to the intensive care. We did not see a decline in readmissions for respiratory failure during the study period as shown by Nishi *et al*. [9] (Figure 2). Although readmission caused by sepsis or reoperation changed during the different admission years, numbers are low for all groups. Readmission to the SICU is an unexpected unfavourable event for the patient, his relatives and the health care workers, and is associated with a worse outcome. Patients were sicker at readmission than at their initial admission, as measured by the SAPS 3 score. Our hospital mortality rate (16%) is lower than the 20 to 46% rates reported in the literature [4-6,9-11,28,29]. Nevertheless, readmitted patients do have a longer hospital admission and a significant worse long-term survival. Others have demonstrated that early ICU readmission is associated with higher morbidity and mortality [4,7-9,11-15,29,30]. The question rises, whether readmission could be an important quality indicator. It may indicate that these patients are discharged prematurely. Then the incidence of early readmission must be high. Our 20%, of the total readmission group, early readmission (≤48 hours after ICU discharge) is slightly below published rates of 22 to 30% [3,5,7,29]. Moreover, a performance quality indicator requires a certain number of patients [2,6]. Our early readmission rate of nearly 2% (of the total study population) is probably not sufficient for a performance quality indicator. The relation between quality of care and late readmission – the vast majority in our study population – is questionable. Late readmission could be a sign of patho-physiological disturbance in a patient with an underlying disease/comorbidity. While early readmission may indeed be related to the initial presenting disease, late readmissions are likely related to factors beyond initial ICU control. Hypothetically, these ‘readmissions’ are more likely to be a second ICU admission for a separate or additional problem rather than a true ‘readmission’. Nevertheless, Chen *et al*. evaluated the reasons for ICU readmission in patients readmitted within and after 24 hours [3]. They found no significant difference in the cause of readmission or the quality of care between these two groups; although, the number of patients in our early readmission group was small (28 patients).

Throughout the various surgical classifications, G-I and vascular patients had a worse outcome (readmission incidence and long-term mortality) compared to other classifications. Hypothetical trauma patients are pre-ICU admission in a better health than G-I and vascular patients. The ICU-admission disease (G-I and vascular patients) is not the same as comorbidity. Moreover, trauma patients are significantly younger than patients in the other classifications.

Several limitations have to be considered. First of all, the data represent a cohort study from a single centre. However, the ICU and hospital (short-term) mortality ratios are almost identical to the Dutch National Intensive Care Evaluation [31] and comparable to international ICU-studies from Finland [32], Canada [33] and the United States [34,35], indicating a certain generalisability of our data. Although the hospital is not a tertiary referral hospital, it is a level one trauma center and acts as a regional referral center for a population of 2.1 million people. The research done by Dowdy *et al*. demonstrated that the prospective cohort study is a powerful research design to assess relationships between exposures and ICU outcomes [36]. A second limitation could be that the gathering of some parameters has been done retrospectively. However, the collection of in-hospital data and the survival status of individual patients have been prospectively registered, and only 52 patients (3% of our entire cohort) were lost to follow-up. In comparison to other studies, this number is very low [37-39]. Furthermore, the presence of preadmission disease (comorbidities) was captured only via the Chronic Health Evaluation component of the APACHE II score. Using this process no comorbidities were identified in 1787 patients of the total study population (90%), this could be an underestimation. This does not accurately take into account many disease states which may predispose to poor outcomes. The use of a different, more detailed scoring system may have yielded more specific information regarding the degree of comorbidities for the study cohort. We only captured the severity of illness score at the beginning of a (re)admission. Several authors showed that patients (readmitted to the ICU) had a higher severity of illness score at time of initial ICU discharge compared to the single ICU-admission patients [4,5,11,12]. Therefore, it would have been more valuable if we collected the APACHE II and the SAPS 3 score daily during the initial ICU admission. Currently there are hardly any [6] systematic studies of how daily severity of illness score changes from admission to initial discharge predict ICU readmission, except for the study accomplished by Lee *et al*. They concluded that the APACHE II score at the time of ICU discharge is a significant predictor of ICU readmission [12]. Moreover, the APACHE II score has not been validated after the first 24 hours. This information may improve the ability to predict the readiness for discharge for individual SICU patients and improve the efficiency of intensive care units. Readmitted patients had a worse long-term outcome; however, QoL was equal compared to the non-readmitted patients. There were only 141 patients readmitted and long-term QoL information was only available in 32 patients. The non-significant difference may be a reflection of type I error due to small sample size of readmitted patients, and comprises the results leading to false negative results.

In conclusion, our results demonstrate that the negative effect of a readmission to the ICU on survival appears to be long lasting. They have a worse long-term survival in comparison with patients who were not readmitted to the SICU. Readmitted patients had a worse initial severity of illness scores, higher prevalence of preadmission disease (comorbidities) and their initial admission type was more active treatment (true ICU) dependable. The possibility exists that the higher long-term mortality could be associated with the higher prevalence of comorbidities and not the ICU readmission. While no single (ICU-admission) factor was able to independently predict ICU readmission, hypothetically, it seems most probable that the conditions predisposing to initial admission to the ICU, and not the fact that these patients required readmission, are responsible for the long-term outcome. The design of our study will not allow us to determine whether readmission is an independent prognostic factor of quality of care. The relationship between readmission to the SICU, inadequate care, premature or inappropriate discharge, and clinician decision-making practices requires more study.

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Chapter 4

Organizational problems are reflected in the results (throughput) of general surgical intensive care

Submitted for publication

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ABSTRACT

Introduction: We report the influence of an organizational reorganization on the results of surgical intensive care (SICU). Moreover we report the subsequent interventions and adjustments resulting in very favourable results.

Patients / Methods: We performed a prospective observational cohort study of all consecutive surgical patients entering the SICU of the University Medical Center, over the period 2000-2004. In order to meet the budget cuts of the surgical division, a reduction of number of SICU beds from ten to eight with a corresponding reduction of nursing staff was implemented. In the subsequent period culminating on the year 2002, problems arose in the collaboration between medical and nursing staff. This led to fierce discussions on the floor. Supported through external mediators structures/ work ethics/communication/collaborative behavior and organization of the SICU were reviewed and restructured.

Results: 1477 patients were admitted to the SICU, covering 1601 admissions. The admission characteristics, mean APACHE II score and TISS points were not significantly different throughout the years. The median ICU LOS was in the admission year 2002 significant longer ($p=0.001$) and the crude ICU mortality was higher ($p=0.02$) compared to the two admission years before. The adjusted mortality (ICU standardized mortality ratio) was also worse in 2002, however, statistically not different. After the intervention (2003 and 2004), a better result (crude ICU mortality and length of ICU stay) was achieved, compared to 2002.

Conclusion: Intensive care reorganization, in which higher workload is seen in medical and nursing staff, could have a negative effect on crude ICU outcome and length of ICU stay. Interventions in ICU structures, communication, work ethics and organization have a positive impact in conflict management.

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INTRODUCTION

Several studies have suggested that organizational issues on the intensive care unit (ICU) influence patient outcome [1-3]. As changes occur in the way health care is organized, financed, and delivered, it is important to understand the impact of organization (input, throughput, and output) characteristics, such as ICU physician and nurse staffing on patient outcomes [1]. The practice of nursing is a critical factor influencing the quality of patient care in ICUs [4].
Survival of critically ill patients has been improved by treatment developments and the use of highly specialized nurses and physicians. Due to these changes, ICU-treatment has become more expensive [5]. Jegers *et al*. (1996) showed that the median daily costs within 25 European ICUs was around €692 for each patient [6]. Because of hospital financial constrains, a reorganization (downsizing of ICU beds with a corresponding gradual reduction of the number of nursing staff) of our surgical ICU (SICU) was carried through. Higher workload caused conflicts within the ICU team. While conflicts (that occur) in the ICU are common, they have not been well documented in medical literature with respect to their nature, participants involved or their management skill and resolution [7]. ICUs are probably the most stressful places in hospitals [8-11]. Azoulay *et al*. have described that up to 70% of ICU personnel reported conflicts in a large cross-sectional survey [11]. However, there is hardly any documentation in the literature about the association of ICU conflicts with quality of ICU care (throughput and output).
We report the results of a university surgical intensive care, which are influenced by a reorganization of the department because of a reduction of the number of beds with the corresponding reduction of personnel resulting in a decrease in nurse-bed ratio. We also report the subsequent interventions and adjustments resulting in very favourable results.

PATIENTS AND METHODS

Patients / Organization of the Intensive Care Department

The study involved a prospective observational cohort study. All consecutive surgical patients who entered the SICU of the University Medical Center, a 1042-bed university hospital in Utrecht (the Netherlands), between January 2000 and December 2004 were recorded. The University Medical Center serves as a regional trauma center and regional referral center for major surgical problems/second opinions. Additionally a separate neurosurgical, cardiothoracic surgery and internal medicine ICU were available. These were not considered in this overview. The study was part of a continuous quality improvement program.

Before the year 2000, the unit included three separate rooms for isolation of patients with multi-resistant microbes. All were equipped by a lock chamber. On the ward itself seven beds were located. All modern state of the art equipment was available (except for IABP), including computerized ventilators, jet ventilation equipment, continuous intra-arterial blood gas analysis, PiCCO, tissue pO2 monitoring and nephro-dialysis. Limited surgical interventions, such as open abdominal lavage, were performed on the SICU.

The SICU was staffed by two internists and two surgeons, all with longstanding training and certificated as intensivist. In the beginning, one of the intensivists took responsibility, along with on-call responsibility, around the clock during a whole week. This was done in order to guarantee continuity of care, for the mostly longstanding complex problems. Every morning a daily patient multidisciplinary review took place involving the responsible staff intensivist, head nurse, responsible nurse for the patient at hand, the resident and a pharmacist. In a structured, preformatted way every patient and all its available data were thoroughly discussed. Three times a week this session was attended by a microbiologist for discussion of microbiological and antibiotic matters. The final responsibility and decision however laid by the intensivist. After day-time hours, the responsible intensivist was not in the hospital, but available within 10 minutes. When needed, evening rounds were made at eleven pm.

A total of four residents were working on the unit. One of them was a surgical trainee, one was an intensivist trainee, one was an anesthesiologist trainee and the other was not in training and just out of medical school, working to gain clinical experience. Because of the limitation of working hours, they were allowed only to work for a maximum of 48 hours each week. As a result, they worked in a three shift (eight hour schedule) covering 24 hours each day of the week.

The fulltime-equivalent (FTE) of 37 nurses were employed on the surgical ICU with a nurse-bed ratio 3,7 to 1 (24 hours). Most of them were very experienced and worked in the same unit for the last five to ten years. All of the nurses were certified for their intensive care skills.

Embedding in the surgical department

The service was firmly embedded in the surgical department, as the morning and evening conferences of the surgical department were attended by all staff and residents responsible for the patients on the SICU. Reciprocally, all patients on the SICU were reported and thoroughly discussed, to have optimal treatment policies. This provided information regarding all surgical patients to be operated the next day, and were scheduled for direct postoperative care in the SICU. These strong liaisons with the surgical staff gave a low threshold to the operating and responsible surgeon and direct notification on information shared with the patient and the patients' family, treatment options and goals. Also (uneasy) necessary end-of-life discussions and limitations of the care provided were more easily shared.

Sequence of events

At the end of 1999, the University Medical Hospital was confronted with severe financial problems, leading to major budget cuts throughout the hospital. In order to meet the budget cuts of the surgical division, it was decided by its supervising management, to reduce the number of SICU beds from ten to eight (three isolation boxes and five beds on the ward itself). It was to be effective on January 1st 2000. During the year 2000 the number of nursing staff was not altered resulting in a nurse-bed ratio of 4,1 to 1. Throughout the year 2001 the reduction of nursing staff was implemented. In approximately one year, the number of nursing staff was reduced, trying to maintain the nurse-bed ratio of 3,7 to 1. In the year 2002 the definitive formation of 24 FTE nurses was reached. However, due to inter alia longstanding illness, pregnancy, working floor disagreements, burnout syndrome a nurse-bed ratio of 3,0 to 1 was developed. There was no reduction in intensivists or residents working on the unit.

In the subsequent period (2002) problems arose in the collaboration between medical and nursing staff, based on poor communication within the ICU team (in general or during end-of-life care or around requiring treatment-limitation decisions). The medical interventions, performed by nurses, were also reduced. This led to fierce discussions on the floor. Nurses have reported that it is difficult to speak up, that disagreements are not appropriately resolved, and that nurse input in to decision making was not well received by physicians. Nurses felt that physicians started treatment and diagnostic screening without any form of consultation, and, physicians had the idea that nurses began the conflict without adequate substantiation. While nurses have to face the emotional distress induced by deterioration in these policies, nurses workload (which was already higher comparable to the years before 2002) sink even more because of the present of burnout syndrome.

Changes in 2003

It became obvious that an intervention was needed. Both sides (physicians and nurses) were heard and problems were notified. Although we did not perform a measurement of the problems on the floor, the main cause of disturbance was the problem in communication between doctors and nurses. Supported through external mediators structures/work ethics/collaborative behaviour/communication and organization of the SICU were reviewed and restructured.

The main entry was culture, based on the basic values established for the UMC Utrecht as a whole. Within the physicians, unconsciously, a contra-productive coping strategy may have been used on the working floor in 2002 to overcome the frustrations originated from i.a. ICU capacity cut-back, maintaining a high turn-over rate, communication difficulties within the ICU-team. The differences in culture were clarified in both groups separately, and in joint conversations these problems were appointed and ultimately trust and in particular communication was restored. The organization was also restructured:

1. The intensivists were no longer on-call for a whole week but the intensivist in charge was on for one day (24 hours) only.
2. A conference was instituted at the beginning of the day, with all intensivists of the service attended, along with the residents on-call for the night and the day and the head nurse for the day. After the conference, the head nurse eluded to the nursing staff the treatmentpolicies per patient for the day in order that specific treatment decisions were communicated earlier on the day. The rest of the daily organization remained untouched.

Especially the improvement in communication between doctors and nurses had an important positive result in the collaboration between both groups after the intervention. After the interventions (beginning 2003) the nurse staff formation was corrected and the nurse-bed ratio was back to 3,7 to 1 (24 hours).

Data management

In the SICU an electronic medical record was in place, in continuity with the same electronic record used in the surgical department. Admission reports and procedure notes were done directly in the electronic medical record by staff and/or residents. For each patient gender, age, APACHE II score [12], the presence of a pre-admission disease (comorbidities, as scored in the chronic health points in the APACHE II score), therapeutic intervention scoring system-28 items (TISS-28) points (a score system to measure intensity of work for each patient) [13-15], the need for acute nephro-dialysis/ mechanical ventilation, length of ICU and hospital stay and type of ICU admission were prospectively collected. Type of admission to the ICU was categorized as Low risk monitor (consists of stable patients with use of close observation), High risk monitor (stable patients due to extended care) and Active treatment (unstable patients with continuous intervention needed). All data were checked and completed if necessary by a data manager. The guidelines of Knaus *et al*. were used [12]. The APACHE II score has been validated to be used in Dutch surgical intensive care patients [16]. All patients admitted to the SICU were included in the study. Readmission to the ICU was defined as a return within the same hospital admission. Three patients were deleted from our research due to lack of data in the medical record. There was no continuing record of ICU quality of care before the year 2000.

The primary outcome measure was the incidence of mortality during ICU admission and hospitalization. Mortality between different groups was evaluated through the use of the ICU standardized mortality ratio (ICU-SMR) calculated with the APACHE II score. Secondary outcome measures were length of ICU and hospital stay and incidence of readmission.

Data analysis

Continuous variables were reported as mean ± SD or median (25^{th} and 75^{th} inter quartile ranges) and categorical variables as number and percentages, unless otherwise stated. After January 2003, monthly performance reports, based on ICU outcome and ICU length of stay (LOS) were issued to staff and other personnel in order to monitor the results of treatment in the ICU. Independent-samples *t* test and Chi-square analysis were used to compare values between different admission years. Comparison between different SMRs was done through Poisson distribution (regression) tests, as described by Breslo *et al*. [17]. Besides this technique we also evaluated the relative risk between the different admission years SMRs whether a difference would occur. The TISS of five admissions has not been recorded. These admissions are excluded from the TISS analysis. Statistical analysis was performed using SPSS 15.0, Chicago, IL (for The Netherlands: SPSS Benelux, Gorinchem) for Microsoft Windows.

RESULTS

Overall

From January 2000 until December 2004 a total of 1477 patients were admitted to the surgical intensive care, covering 1601 admissions. The reduced admission-capacity from 10 to 8 in 2000 was responsible for the lesser number of admissions in the following years compared to 2000. Of these 1601 admissions, 87 patients had multiple admissions (185, original and re-admission to the SICU) during the same hospital stay. The distribution of readmitted patients to the SICU was equal during the different admission years, re-admission rate between 5-7% (2000: 22 patients (45 admissions), 2001: 18 (41), 2002: 14 (28), 2003: 13 (27) and 2004: 20 (44)). Patients' characteristics were outlined in Table 1 for the total cohort and subdivided by the admission year. The admission characteristics, however, were not significantly different throughout the years. The mean severity of illness score (APACHE II score) was 12 for the overall study population, and did not differ between the admission years. In the admission year 2002 lesser patients were admitted with an Active treatment type of admission compared to other admission years. Mean intensity of work score (TISS points) did not differ between different admission years. The admission disease characteristics did not differ per admission year, Table 2.

ICU throughput and output

Table 3 shows the SICU outcome (length of ICU stay, mortality and re-admission to the SICU during same hospital admission). The median ICU LOS was for all admission years equal, except for the admission year 2002. Resulting in a significant higher mean ICU LOS of 12 days compared to 6 and 8 days of the two admission years before, p=0.001 (Table 4). Subsequently, the median hospital LOS was also higher in the year 2002. Crude ICU mortality rate in the year 2002 was significantly higher, p=0.02, compared to the two years before, 18 versus 12%. However, the adjusted mortality (ICU-SMR) was not statistically different. Neither was the crude hospital mortality different during all admission years. Re-admission rate to the SICU was equal during the subdivided years.

After the intervention early 2003, a change has been noticed. A better result was achieved measured in the crude ICU mortality and length of stay (ICU and hospital LOS), compared to 2002. This performance improvement continued in the year 2004, Table 4.

Table 1:
Baseline characteristics of the overall cohort and subdivided by admission year.

	Total	2000	2001	2002	2003	2004
Number of admissions [1] (%)	1601	428 (27)	322 (20)	234 (15)	287 (18)	330 (21)
Age (years) [2]	56 ± 18	55 ± 18	55 ± 19	55 ± 18	57 ± 18	57 ± 18
Male gender (%)	65	63	62	66	69	66
Comorbidities (%) [3]	14	15	12	14	15	15
APACHE II [4]	11 ± 6	11 ± 6	11 ± 5	12 ± 6	11 ± 7	12 ± 6
PMR APACHE II (%) [5]	13.5	13.3	12.3	15.5	13.7	13.6
TISS points [4]	29 ± 7	28 ± 6	29 ± 6	30 ± 6	29 ± 7	27 ± 8
Mean maximal TISS points	34 ± 9	33 ± 8	34 ± 9	37 ± 9	35 ± 10	33 ± 10
Emergency admission (%)	53	56	49	54	50	55
Type of admission (%) [6]:						
Low risk monitor	24	27	15	30	30	19
High risk monitor	12	18	8	15	9	11
Active treatment	64	55	77	55	61	70
Mechanical Ventilation (%)	81	79	86	91	78	76
Dialysis (%)	5	4	4	4	7	5

[1]: 1477 patients constituted 1601 admission of which 110 patients had in total 234 admissions (original and re-admission to the SICU during study inclusion period). [2]: Mean ± SD values. [3]: The presence of a pre-admission disease (comorbidities, as scored in the chronic health points in the APACHE II score). [4]: The APACHE II score ranged from 0 to 41 in our population, TISS points ranged from 0 to 60. [5]: Predicted mortality rate calculated by the APACHE II score. [6]: Low risk monitor consists of stable patients with use of close observation; high risk monitor consists of stable patients due to extended care; active treatment consists of unstable patients with continue intervention needed.

DISCUSSION

Among factors affecting the quality of nursing care, staffing levels are believed to be the most basic component with a direct bearing on patient care and to be independently associated with ICU and hospital mortality [1,4]. Recent studies reported a 33% high level of burnout among ICU nurses and 46% among physicians due to work

Table 2
Admission disease characteristics (%) of the overall cohort and subdivided by admission year.

	Total	2000	2001	2002	2003	2004
Aneurysmatic Vasc. Disease	13.5	13.3	15.5	11.5	13.9	12.7
Obstructive Vasc. Disease	3.6	2.1	5.0	3.4	5.6	2.7
Oesoph or gastroduodenal pathol.	3.8	3.3	4.7	5.1	2.4	3.9
Short bowel or colon pathol.	9.4	11.7	8.1	11.1	9.8	6.1
Pancreas path.	2.9	4.7	1.2	1.3	2.1	3.9
Gastro eci	5.1	5.6	5.6	3.4	7.0	3.3
Trauma	19.8	20.3	19.9	20.1	16.7	21.5
Oncology [1]	17.8	11.9	20.2	15.0	22.3	21.2
Neurology or neurosurgery	6.3	8.6	5.0	6.8	5.2	5.2
Gynaecology	3.2	3.3	4.0	3.4	2.8	2.7
General path. [2]	14.6	15.2	10.9	18.8	12.2	16.7

[1]: We included oncological diseases only in this particular admission disease group except neuro-surgical oncology. [2]: General pathology includes: cardiothoracic, pulmonology, orthopedic, urologic, general and oral surgery patients and patients with drug intoxication.

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intensity [18-20]. Burnout amongst healthcare professionals has been found to affect the quality of care provided to patients [21]. Variation in ICU organization also affects patient outcome [1-3].

In our hospital the SICU needed to reorganize due to financial constraints. The number of beds was reduced from ten to eight effective January 1st 2000, resulting in an over-capacity of nursing care in the year 2000 and beginning of 2001. The number of nursing staff followed the bed-reduction (admission capacity) in the year 2001. Due to poor communication, present frustrations within the ICU-team, and a higher workload (lesser nurses), conflicts within the ICU team arose in the year 2002. In this year the crude ICU mortality was significantly higher in comparison to the two years before (<2002), and ICU and hospital LOS was significantly longer. Patients admitted in 2002 were not sicker, did not have a higher severity of illness score (APACHE II score and type of ICU admission), mean intensity of work score (mean TISS points) and had equal patient characteristics compared to the years before. However, the adjusted

Table 3
Outcome: cumulative and adjusted mortality for the entire cohort and across admission years at the end of SICU-stay and during hospital-stay. And length of ICU and hospital stay.

	Total	**2000**	**2001**	**2002**	**2003**	**2004**
Number of admissions (%)	1601	428 (27)	322 (20)	234 (15)	287 (18)	330 (21)
ICU LOS [1]	2 (1-9)	2 (1-6)	3 (1-8)	6 (1-15)	2 (1-10)	3 (1-11)
Hospital LOS 1	17 (9-39)	16 (9-31)	18 (9-42)	23 (10-45)	17 (8-40)	19 (9-37)
ICU Mortality (%)	13	13	10	18	14	13
Hospital mortality (%)	19	21	17	23	20	17
ICU-SMR	0.98	0.97	0.83	1.13	1.04	0.94
Re-admission to SICU [2] (%)	87 Pts	22 (25)	18 (21)	14 (16)	13 (15)	20 (23)

[1]: LOS (Length of Stay) given in days, value in median with 25th and 75th percentile. [2]: Re-admission within same hospital admission.

Table 4
Outcome and length of ICU stay: cumulative and adjusted mortality for the entire cohort and across the three different ICU periods at the end of SICU-stay.

	<2002	**2002**	***p*-value [3]**	**>2002**	***p*-value [4]**
Number of admissions	750	234	--	617	--
ICU LOS [1]	2 (1-7)	6 (1-15)	0.001	3 (1-10)	0.008
ICU Mortality (%)	12	18	0.02	14	0.13
ICU-SMR	0.92	1.13	0.30	0.99	0.55
Re-admission to SICU [2] (%)	5.6	6.4	--	5.7	--

[1]: LOS (Length of Stay) given in days, value in median with 25th and 75th percentile. [2]: Re-admission within same hospital admission. [3]: Independent-samples *t* test between the period before 2002 and the year 2002. [4]: Statistical comparison between the year 2002 and the period after 2002.

mortality did not change statistically. Nevertheless, there seems to be a worse trend in ICU outcome (ICU-SMR of 0.92 in <2002 compared to the 1.13 in 2002). The outcome changed over the years after the necessary intervention supported through external mediators. ICU and hospital mortality, and ICU length of stay returned to comparable results like before the reorganization of 2002.

Comparable to other studies, the most common types of conflicts reported occur in the decisions to withdraw or withhold treatment, and because of a result of disagreement between the goals of treatment [7,11,19,22]. In studies describing conflicts in the care of patients with prolonged ICU stay, nearly a third of patients had conflicts associated with their care. Of these, 31-48% of conflicts occurred between ICU team members [23,24]. In a large cross-sectional survey, Azoulay *et al.* found that up to 70% of ICU personnel reported ICU conflicts and that intrateam disputes accounted for the majority of conflicts with half the conflicts stemming from end-of-life care [11]. This result is in agreement with previous studies in which most conflicts occurred during the care of dying patients [22,24,25]. Azoulay *et al.* also concluded that workload, communication, and end-of-life care emerged as potential targets for improvement. Unit-level meetings, with the head nurse and ICU director rotating as facilitators, provide excellent opportunities for highlighting the valuable role played by nurses in the ICU, enhancing respect and understanding within the ICU team and ensuring that all team members send the same messages to patients and families [26]. However, as yet there is hardly any documentation about the association of such ICU conflicts with quality of ICU care.

In our study we have showed that organizational problems (possibly the capacity within the nursing staff levels) could be associated with ICU throughput (LOS) and output (outcome), comparable with the results of Pronovost *et al.* and the literature review by Numata *et al.* [1,4]. However, it is difficult to eliminate al possible factors which could have an association with the worse results seen in 2002. However, more communication problems arose in this admission year at the time a lower nurse-bed ratio (3,0 to 1) was present. Although the length of the workweek and number of beds per ICU may seem difficult to change, previous studies indicate that decreasing the patient-to-nurse ratio to mitigate the physical and emotional strain placed on nurses improves patient safety and quality of care [19,27,28].

Hutchings *et al.* [29] investigated the consequences of an increased admission capacity within intensive care units on ICU outcome. They did not find a direct correlation between increased capacity and improvement in outcome. However, they did find an association within the rate (decline) of transfers and early discharges. In our study, patient outcomes (crude ICU mortality and ICU LOS) improved in the admission years 2003 and 2004 due to several interventions (better communication within the ICU-team, improvement in trust, organisational/structural changes and a higher nursing care capacity [nurse-bed ratio of 3,7 to 1]). Reorganization with bed reduction, alone, could have had a negative influence on patient quality of care. Nguyen *et al*. concluded that if beds were added (increased ICU capacity), both the number of patient transfer and the number of days with a full unit decreased [30]. Even the reorganization within surgical resident taskforce, addressing duty hour restriction, has a negative influence on ICU outcome. In the study of Frankel *et al*. SICU service readmission rates doubled after work-hour restriction [31]. Our medical staff of two internists and two surgeons, all certified as critical care physicians, did not change during the five admission years (2000-2004). Literature shows that there is an association between ICU mortality and having a critical care physician certified with surgical critical care (surgeon intensivist) [32,33]. Nathens *et al*. demonstrated a beneficial effect of an intensivist-model with a surgeon intensivist in the care for critically injured trauma patients [34]. This association has not yet been investigated in an overall general surgical ICU population, comparable to our study population. Further research around this topic needs to be done to understand the full effect of ICU organization on outcome in a general SICU population.

Several limitations have to be considered. First of all, the data represent a cohort study from a single centre. Our overall crude ICU and hospital mortality were equal to an identical Dutch general surgical ICU population [5,35,36] and to international studies [37-40], reflecting a certain generalisability of our data. The research done by Dowdy *et al*. demonstrated that the prospective cohort study is a powerful research design to assess relationships between exposures and ICU outcomes [40]. A second limitation of our study concerns that there was no continuing record of ICU quality of care before the year 2000. Because the reduction of SICU beds was effective on January 1st of 2000, technically we did not have a baseline reference (1998-1999) to compare our throughput and output results after this bed-reduction. Thirdly, it must be considered that we can not (completely) exclude a difference in case mix in the year 2002. Patients' characteristics, severity of illness, intensity of work and the admission disease characteristics may not be different throughout the year 2002 and the period before 2002, suggesting that these two groups are equal. However, the predicted mortality rate (PMR calculated by the APACHE II score) was statistically higher in 2002 compared to the two years before, 15.5 versus 12.8 (p=0.004). Obscurity exists whether the APACHE II model is still capable of adjusting for case mix differences in our study population. Civetta *et al*. demonstrated that the APACHE II model is not adequate to monitor appropriate resource allocation and quality assurance in a surgical ICU [41,42]. However, in a previous study (Timmers *et al*. [16]) the APACHE II model seemed suitable (with regard to discrimination and calibration) for a Dutch general surgical ICU population. Furthermore, the difference in throughput and output may be a reflection of type I error due to a lower number of admitted patients in the year 2002, and comprises the results leading to false negative/positive results.

In conclusion, intensive care reorganization (downsizing the number of beds with a corresponding reduction in nursing personnel), in which higher workload is seen in medical and nursing staff, could have a negative effect on ICU throughput and output. Continue evaluations are required of both new and existing ICU interventions (reorganizations) to improve the quality of care. If an ICU has been through reorganization, evaluation of its effect on ICU mortality and length of stay could be an acceptable predictor of its functionality. Interventions in ICU structures, communication, work ethics and organization have a positive impact in conflict management.

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Chapter 5

Input, througput and output changes after ICU transformation from a specialized surgical unit to a general mixed intensive care unit

Submitted for publication

Timmers TK, Joore JCA, Leenen LPH

ABSTRACT

Introduction: We report the transition of a specialized surgical intensive care unit (SICU) to a general mixed 'closed' format ICU, and its influence on immediate outcome and performance data.

Patients/ Methods: We performed a prospective before and after the study of all consecutive patients entering the SICU of the University Medical Center, over the period 2004-2007. After the year 2005 all specialized ICUs were combined into three general mixed units. For each patient baseline characteristics and eventual outcome were collected.

Results: In the four-year inclusion period we had a total of 2420 admissions to the surgical intensive care (ICU3). After the reorganization (end of 2005) patients were older, had lesser comorbidities, the ICU-admission had a more elective character and patients were more in need of mechanical ventilation. Our SICU population changed from mostly surgical patients (70%) to a mixed general ICU population, which comprises mostly of cardiac and cardiac-surgery patients (67%). We saw better results in all overall outcome domains (lower ICU mortality: 9 *versus* 12%, lower ICU length of stay and lower percentage of ICU-readmissions). The overall predicted mortality rate (PMR) decreased significantly; however, the ICU standardized mortality ratio (ICU-SMR) remained the same (0.73 *versus* 0.78). In the complete cohort (ICU3) 752 surgical admissions were identified. Between both periods, there was no difference in short-term mortality (ICU mortality for both periods 12% and hospital mortality 17 and 18%), no difference in PMR (both groups 14%), ICU-SMR (0.79 and 0.81), no difference in ICU length of stay (both mean 7-8 days) and no difference in severity of illness score (both mean APACHE II score of 13). Surgical patients outcome did not differ between both periods comparing all surgical patients of the 3 units combined.

Conclusion: Organizational changes from a surgical ICU to a general mixed critical care unit can have profound influences on performance data. All different dimensions of crude ICU outcome (short-term mortality/length of ICU stay and ICU readmission) improved after the reorganization. Nevertheless, ICU-SMR did not change. The ICU output has not improved nor decreased after the organizational change for general surgical patients alone.

INTRODUCTION

The organization of Intensive Care Medicine has changed over the years, from specialized open format units (run by specialty physicians with specific critical care training) to general closed format units, run by intensive care specialists, confined to the intensive care unit (ICU) itself [1,2]. Results of these changes on outcome have been discussed disparately in literature [1,3-6,8].

We report the changes and outcome during the structural reorganization of a specialized surgical intensive care unit to a general mixed, 'closed' format ICU. The aim of this study was to describe this transition, with all its differences in population, immediate outcome and influence on performance data.

PATIENTS AND METHODS

Patients/ Organization of the Intensive Care Department

The study is a prospective before and after study. All consecutive patients who entered the specialized surgical ICU (SICU) of the University Medical Center, a 1042-bed university hospital in Utrecht (the Netherlands), between January 2004 and December 2007 were prospectively recorded. The University Medical Center serves as a regional trauma center and regional referral center for major surgical and medical problems/ second opinions. The study was part of a continuous quality improvement program.

The unit included three separate rooms for isolation of patients infected or colonized with multi-resistant microbes. All were equipped by a lock chamber. The central part of the unit consisted of a ward of five beds. All modern state of the art equipment was available, including computerized ventilators, jet ventilation equipment, continuous intra-arterial blood gas analysis, PiCCO, tissue pO2 monitoring and nephrodialysis. Limited surgical interventions, such as open abdominal lavage, were performed on the SICU.

In the years 2004 and 2005 the SICU was strongly embedded in the surgical department. Morning and evening conferences of the surgical department were attended by all staff and residents responsible for the ICU. All patients in the SICU were reported and thoroughly discussed, to have optimal treatment policies. The operating surgeon had primary responsibility for postoperative care. However, final decision was made by the intensivist on call. The SICU was staffed by two internists and two surgeons, all with longstanding training and certification as intensivist. The intensivist in charge was on for one day (24 hours). A conference was held at the beginning of the day, with all intensivists of the service attending, along with the residents on-call for the past night and the upcoming day and the head nurse for the day. Patients admitted to the SICU were mostly surgical.

At the end of the year 2005, by hospital policy, all specialized intensive care units (neurosurgical, cardiothoracic surgery and internal medicine) were embedded in a new general intensive care department. Specialized ICUs became general units with a mixed population, in which critical care physicians from various backgrounds assumed responsibility for delivery of intensive care. The intensivists had no other clinical care responsibilities outside the ICU and were primarily available for the critically ill patients, consistent with the concept of a 'closed' ICU format. Patients of all different medical departments were admitted to this unit. During this period we were able to monitor the influence of the organizational change on patient outcome of this single unit (in total one of 3 intensive care subunits).

Data management

During the study period an electronic medical record was in place in the SICU (and all other ICUs), in continuity with the same electronic record used in the surgical department. Admission reports and procedure notes were done directly in the electronic medical record by staff and/or residents. For each patient gender, age, APACHE II score [7], the presence of a pre-admission disease (comorbidities, as scored in the chronic health points in the APACHE II score), the need for mechanical ventilation and length of ICU and hospital stay were collected. All data were checked and completed if necessary by a data manager. The guidelines of Knaus *et al*. were used [7]. All patients admitted to the SICU were included in the study.

The primary outcome measure was the incidence of mortality during ICU admission and hospitalization. Mortality between different groups was evaluated through the use of the ICU standardized mortality ratio (ICU-SMR) calculated with the APACHE II score. Secondary outcome measures were length of ICU and hospital stay and incidence of readmission.

Data analysis

Continuous variables were reported as mean ± SD or median (25th and 75th inter quartile ranges) and categorical variables as number and percentages, unless otherwise stated. Results of the years 2004 and 2005 have been described in a different report on performance improvement [14]. Independent-samples *t* test and Chi-square analysis were used to compare values between different admission years. Comparison between different SMRs was done through Poisson distribution (regression) tests, as described by Breslo *et al*. [15]. Besides this technique we also evaluated the relative risk between the different admission years SMRs whether a difference would occur. *P*-values less than 0.05 were regarded as statistically significant. Statistical analysis was performed using SPSS 15.0, Chicago, IL (for The Netherlands: SPSS Benelux, Gorinchem) for Microsoft Windows.

RESULTS

Overall

From January 2004 until December 2007 a total of 2296 patients were admitted to the surgical intensive care unit (ICU3), covering 2420 admissions. Of these 2420 admissions, 124 patients had multiple admissions (237 in total, collected as first and re-admissions to the SICU) during hospital stay or during the inclusion study-period. Patient characteristics were outlined in Table 1 for the total cohort and subdivided by admission year. In comparison after the reorganization (end of 2005) patients were older, had lesser comorbidities, the ICU-admission was more elective and patients were more in need of mechanical ventilation.

Population

Our study-population consisted mostly of surgical (trauma / vascular / gastro-intestinal / oncological / general surgery / orthopaedic / urologic and otolaryngologeal) patients at the time the unit was a specialized surgical unit. After the reorganization the population changed; lesser surgical patients (15%) and more profoundly cardiac and cardiac-surgical patients (67%) were admitted, Table 2.

Table 1
Baseline characteristics of the cohort and subdivided SICU admission years (2004 / 2005) and ICU3, mixed general ICU, admission years (2006 / 2007).

	2004 / 2005	**2006 / 2007**	***p*-value**
Number of admissions [1] (%)	705	1715	
Age [2] (years)	57 ± 18	61 ± 15	<0.001
Male gender (%)	63	65	0.58
Comorbidities [3] (%)	17	7	<0.001
APACHE II [4]	13 ± 6	13 ± 6	0.21
PMR APACHE II (%)	16	12	<0.001
IC SMR	0.73 [±0.16]	0.78 [±0.13]	0.71
Emergency admission (%)	56	38	<0.001
Mechanical Ventilation (%)	78	90	<0.001
ICU LOS [5]	2 (1-8)	1 (1-3)	<0.001
Hospital LOS [5]	18 (9-35)	10 (7-22)	<0.001
ICU Mortality (%)	12	9	0.05
Hospital Mortality (%)	17	13	0.01
Re-admission to ICU [6]	42 pts	71 pts	

[1]: In 2004, 305 patients constituted 330 admissions of which 21 patients had in total 46 admissions; in 2005, 21 patients had 45 admissions; in 2006, 30 patients constituted 62 admissions; and in 2007, 41 patients constituted 84 admissions (original and re-admission to the ICU3 during study inclusion period). [2]: Mean ± SD values. [3]: The presence of a pre-admission disease (comorbidities, as scored in the chronic health points in the APACHE II score). [4]: The APACHE II score ranged from 0-38 (2004), 2-50 (2005, 2006) and from 1-50 (2007) in our population. [5]: LOS (Length of Stay) given in days, value in median with 25^{th} and 75^{th} percentile. [6]: Re-admission within same hospital admission.

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Mortality

Overall ICU and hospital mortality rates were statistically significant lower, *p*=0.05 and *p*=0.01, after the reorganization compared to the two years before, respectively 9 *versus* 12% and 13 *versus* 17% (Table 1). However, for the surgical patients short-term (ICU and hospital) mortality was equal between both study periods. Nevertheless, after the reorganization mortality was higher for neurological and neuro-surgical patients admitted to this unit, ICU: 12 *versus* 25%; hospital: 16 *versus* 34%. Cardiac and cardiosurgical

Table 2
Intensive care unit (SICU and eventually ICU3) outcome (cumulative ICU and hospital mortality/ mean ± SD APACHE II score/ Predicted mortality rate/ IC-standard mortality ratio and ICU length of stay) of the overall cohort for each admission year and subdivided by patients' admission department.

	Overall	Surgery	Cadiology / Cardiac Surgery	Neurology / Neuro-Surgery	Other Specialties
2004 / 2005 (SICU):					
Number of admissions (%)	705	494 (70)	20 (3)	92 (13)	99 (14)
ICU Mortality (%)	12	12	35	12	5
Hospital mortality (%)	17	17	50	16	9
APACHE II Score	13 ± 6	13 ± 6	17 ± 8	15 ± 7	12 ± 7
PMR	15.7	14.8	30.7	18.3	15.6
ICU SMR	0.73	0.79	1.14	0.66	0.32
ICU LOS	7 ± 11	8 ± 12	3 ± 3	6 ± 10	3 ± 5
2006 / 2007 (ICU3):					
Number of admissions (%)	1715	258 (15)	1153 (67)	187 (11)	117 (7)
ICU Mortality (%)	9	12	5	25	16
Hospital mortality (%)	13	18	8	34	21
APACHE II Score	12 ± 5	12 ± 5	12 ± 5	15 ± 7	16 ± 7
PMR	11.3	13.9	8.2	23.7	16.6
ICU SMR	0.78	0.81	0.61	1.05	0.96
ICU LOS	4 ± 11	7 ± 11	3 ± 11	6 ± 9	6 ± 11

patients had the lowest short-term (ICU and hospital) mortality, Table 2. The predicted mortality ratio of the overall study population (all patients) was significant lower after the reorganization 12 versus 16%. Nevertheless, the mean ICU-SMR was equal between both groups, 2004/2005: 0.73 and 2006/2007: 0.78, Table 1. The mean severity of illness score (APACHE II score) was also comparably equal, p=0.05 (Table 1).

Length of stay

The median ICU LOS was lower for the 2006/2007 cohort of patients, Table 2 (page 80). Subsequently, the median hospital LOS was also statistically significant lower.

In the year 2006/2007 cardiac patients had the lowest mean ICU LOS, 3±11. No differences were found in length of stay for the general surgical cohort throughout different admission years.

Readmission

The distribution of readmitted patients (total of 113) to the SICU/ICU3 was lower after the reorganization; 4% re-admission rate in the years 2006/2007 compared to 6% in the years 2004/2005 (2004: 21 patients (46 admissions), 2005: 21 (45), 2006: 30 (62) and 2007: 41 (84)).

Table 3
Outcome characteristics of the surgical population admitted to all the three intensive care units in the year 2006 and 2007 combined.

	ICU 1 2006 / 2007	ICU 2 2006 / 2007	ICU 1 / ICU 2 2006 / 2007	ICU 3 (SICU) 2006 / 2007	*p*-value
Number of admissions	290	178	468	258	
APACHE II Score	12 ± 5	14 ± 5	13 ± 5	12 ± 6	0.08
PMR APACHE II (%)	15	17	16%	14%	0.16
IC SMR	0.8 [±0.27]	1.0 [±0.36]	0.88 [±0.53]	0.86 [±0.30]	0.99
ICU Mortality (%)	12	17	14	12	0.36
Hospital mortality (%)	17	23	19	18	0.69

Table 4
Outcome characteristics of the complete surgical population admitted to all the three intensive care units in the year 2004/2005 and 2006/2007.

	2004 / 2005	2006 / 2007	*p*-value
Number of admissions	494	726	
APACHE II Score	13 ± 6	13 ± 6	0.70
PMR APACHE II (%)	14.8	15.3	0.54
IC SMR	0.79 [±0.20]	0.86 [±0.17]	0.66
ICU Mortality (%)	11.7	13.2	0.25
Hospital mortality (%)	17.4	18.7	0.31

Surgical admission to the other intensive care units

In the year 2006 and 2007 468 surgical patients were admitted to the other two general intensive care units (ICU 1: 290 admissions and ICU 2: 178 admissions). The predicted mortality ratio and the ICU and hospital mortality rates of these surgical patients were not different from the surgical patients admitted to the former SICU unit; resulting in a comparable ICU-SMR of 0.88 and 0.86 (p=0.99). Also the severity of illness score was similar between those surgical admissions, Table 3.

Comparably there is no statistical difference in the ICU-mortality, severity of illness, PMR and ICU-SMR of all surgical patients between both periods (2004/2005: all surgical patients were admitted in the SICU; 2006/2007: surgical patients were spread throughout the 3 different subunits of the general Intensive Care Center) (Table 4).

DISCUSSION

Physicians and ICU managers are increasingly under pressure to monitor and improve clinical performance as well as economic impact. Often these comparisons are based upon statistical comparisons between different units using administrative databases. It is thus important that both the advantages and pitfalls of these strategies of comparison are examined and understood.

One of the primary uses of intensive care unit (ICU) severity of illness models is the comparison of performance among general medical-surgical or similar ICUs or within the same ICU over time. First, the model is used to determine if patients are comparably ill. Then, the observed mortality rate among patients is compared with the 'expected' rate which is calculated using the model. If the mortality rates are the same, then the quality of care can be assumed to be equivalent to the referent group of hospitals that participated in the model development. For practical applications economic performance comparisons should be performed among similar types of ICU. Comparing groups by comparing scores is appropriate only when the groups are homogenous with respect to admitting ICU diagnosis. The performance of a specialized surgical ICU should not be compared to that of a general medical/ surgical ICU.

After a change in hospital policy the surgical ICU became embedded in a general intensive care department at the end of the year 2005. The specialized surgical unit was transformed into a general mixed adult intensive care unit. Our SICU population changed from mostly surgical patients to a mixed general ICU population, which

comprises mostly of cardiac and cardiac-surgery patients (67%). Surgical (excluded were cardiac-surgery patients) admissions after the reorganization were cut in half (in this subunit of the general intensive care center). We recorded better results in all overall outcome domains (lower ICU mortality, lower ICU length of stay and lower percentage of ICU-readmissions). The overall predicted mortality rate (PMR) however decreased significantly; but the ICU standardized mortality ratio (ICU-SMR) remained the same.
At first sight the performance of this unit became better evaluating the different overall outcome dimensions. However, there are different aspects which need to be considered: 1) During the study period the population had changed substantially, from a general surgical to for the most part a cardiac surgical study population. Diversity in patient mix is therefore a major concern when comparing risk-adjusted ICU-specific death rates to assess the quality of an ICU's performance [8,9]. 2) In the course of the two years after the reorganization, 2,5 times more patients were admitted to the unit (2004/2005: 705 *versus* 2006/2007: 1715 admissions). In this time period the admission capacity did not change compared to the years before the intervention. Because of the high turnover-rate the overall severity of illness score, statistically seen, becomes lower by definition. The issue of diversity in patient mix has been addressed in the literature as a factor that may strengthen the validity of severity of illness models of ICU patients and therefore has an immediate association with ICU quality performance [8,10]. When we compare the outcome of surgical patients of both study periods (total of 752 admissions, ICU3) we see no difference in short-term mortality (ICU mortality for both periods 12% and hospital mortality 17 and 18%), no difference in PMR (both groups 14%), ICU-SMR (0.79 and 0.81), no difference in ICU length of stay (both mean 7-8 days) and no difference in severity of illness score (both mean APACHE II score of 13). Surgical patients outcome did not differ between both periods comparing all general surgical patients of the 3 subunits of the intensive care center combined.
In prediction models the APACHE II score is still one of the most widely used tools today in the world, despite the fact that APACHE III and APACHE IV are much more current [16,17]. At the time this study was conducted and evaluated, our data were not sufficient to calculate the predicted mortality rate using the newer third and fourth versions of the APACHE prognostic model. We are aware that the performance of outcome prediction models deteriorates over time, when the tools are not updated in due time. The problem of patient mix also arises when using a model to compare performance among different ICUs. The discrimination and calibration of the model deteriorated progressively as the frequency of subjects with each model variable was increased above the frequency in the original development data set. While publication

of risk-adjusted ICU-specific death rates is one response, debate continues over whether higher than predicted mortality is a warning about quality of care or rather a reflection of an ICU's typical patient population. Statistics purporting to measure effectiveness of care from ICU death rates should be modified to account for diversity in patient mix. In our study the population before the reorganisation consisted mostly of general surgical patients (excluding cardiac-surgery). Civetta *et al*. demonstrated that the APACHE II model is not adequate to monitor appropriate resource allocation and quality assurance in a surgical ICU [11,12]. However, in a previous study (Timmers *et al*. [13]) the APACHE II model seemed suitable (with regard to discrimination and calibration) for a Dutch general surgical ICU population. In the study population of the year 2004/2005 this unit had a SMR of 0.73±0.16. After the reorganisation, the study population consisted mostly of cardiosurgical (heart valve surgery/CABG/etc) patients (67%). Knaus *et al*. reported that although the APACHE II scoring works for CABG admissions, the surgical and anaesthetic management resulted in high scores at ICU admission (average 12.4 in the development data set) but with very low observed ICU and hospital death rates. They concluded that the inclusion of these CABG patients resulted in little change in the equation (in the original development of the APACHE II model) but would have made the resulting predictions slightly less accurate for the majority of ICU admissions [7]. In spite of the difference in study-population between both periods, the overall 2006/2007 ICU-SMR did not change (0.78±0.12). Cardiac surgery patients had the lowest ICU-SMR of 0.61, whereas the general surgical population demonstrated a SMR of 0.79 and 0.81 respectively.

In conclusion, organizational changes from a surgical ICU to a general mixed critical care unit can have profound influences on performance data. Comparing both periods before and after the reorganization, the ICU standardized mortality ratio did not change. However, all the different dimensions of crude ICU outcome (short-term mortality/length of ICU stay and ICU readmission) improved after the reorganization. These outcome differences were caused by a transformation in study population structure. ICU quality performance should not only be measured in SMR, especially when different ICUs are compared. The ICU output has not improved nor decreased after the organizational change for general surgical patients alone.

The calculations and results of the APACHE II scores presented in this article are based on a subpopulation analysis and partly re-calculated "Acute Physiology Scores". Therefore, the data presented are not identical to and do not represent the national benchmarked results registered by the National Intensive Care Evaluation (NICE) foundation.

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Chapter 6

Long-term survival after surgical intensive care admission: 50% dies within 10 years

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ABSTRACT

Introduction: Intensive care unit (ICU) treatment of surgical patients comes along with major disadvantages which have to be justified by an acceptable short- and long-term outcome. Short-term effects of ICU treatment have been well documented. The aims of this study were to quantify the long-term survival of more than 10 years follow up of a large cohort of patients admitted to a surgical intensive care unit and to investigate the effects of age, gender and underlying disease on this long-term survival.

Patients / Methods: Of all surgical patients admitted to the ICU of the St. Elisabeth Hospital between 1995 and 2000, patient characteristics, disease category, APACHE II score and survival were prospectively registered. A follow up with a mean of 8 years after discharge was achieved. The independent association of multiple co-variates was done using cox proportional hazard analysis.

Results: Of the 1822 patients included, 936 (51%) had died within 11 years. 52 patients were lost to follow up. Overall ICU and in-hospital mortality were 11% and 16% respectively. Age, gender, APACHE II score, the need for dialysis and surgical classification were independently associated with long-term survival. Mortality increased with age of admittance to the ICU (hazard ratio 1.058), whereas female patients had a lower chance to die, HR 0.793. However, the pre-admission disease did not influence long-term outcome. Long-term mortality rates in various surgical classification groups varied between 29% for trauma and 80% for gastro-intestinal patients. In gastro-intestinal, oncological, general surgical and/or high-aged patients a negative effect on mortality persisted beyond 5 years. The mortality ratio was increased two-fold in comparison to the general population (51 vs 27%).

Conclusion: Ten years after ICU discharge, survival was only 50%. After ICU treatment survival follows distinct patterns in which age, gender, surgical classification, the need of dialysis and APACHE II score are independent determinants, and long-lasting.

INTRODUCTION

In recent years there has been an increased focus on outcome after intensive care treatment.
Disadvantages, such as complications and prolonged hospital stay for the patients, as well as the staggering costs of more extensive treatment, have to be justified by favorable, preferably long-term outcome. It is well known that patients continue to die at an accelerated rate following hospital discharge. In the last few decades most studies [1-10] of long-term outcome after intensive care unit (ICU) admission did not exceed a follow-up period longer than 2 years. Only nine studies had a follow-up of five years [11-14,26-31. However, these studies were either conducted in the early 1980s [11,12,31], or contained low numbers of patients [13,14,31], or the study population did not distinguish between medical and surgical patients [27-31]. Since intensive care medicine is still improving, but is also becoming more expensive, new data on mortality are required. Moreover, the influence of patients' characteristics (such as age and gender) and surgical classification on long-term outcome have never been addressed. This study focused on the surgical population as it is a distinct ICU population, in both admission profile and outcome.
The aims of this study were to quantify the long-term survival, over a period of more than 10 years, of a large cohort of patients admitted to a surgical intensive care unit and to investigate the effects of age, gender and underlying disease on this long-term survival.

PATIENTS AND METHODS

Patients

The study involved a prospective observational cohort study. All consecutive surgical patients who entered the intensive care unit (ICU) of the St. Elisabeth Hospital, a 673-bed teaching hospital in Tilburg (The Netherlands), between January 1995 and February 2000 were prospectively recorded. The 32-bed ICU admits medical and surgical, critically ill patients, and is staffed by intensive care specialists with an internal medicine, anesthesiological or surgical background. In order to ensure a more homogeneous population, only surgical patients with a single ICU admission during the study period were included. Exclusion criteria were an age below 18 years, re-admission to the ICU during the same hospital admission, multiple admissions to the ICU over the study period, and gynecological and non-trauma neurosurgery. Gynecologic and non-trauma neurosurgery patients were excluded because we aimed to quantify mortality outcome in a specific surgery patient population. The study was approved by the local medical ethics committee.

Outcome

Survival (all-cause mortality) was determined by reviewing the hospital's electronic patient data management system. If the patient's death – either in- or outside the hospital - could not be confirmed by the patient data management system (*n*=754 patients), the general practitioner was consulted (*n*=94). Finally, if a date of death could not be found, the patient or relatives were directly consulted by telephone (*n*=88). In addition, the cause of death may not have been related to the surgical ICU admission. Follow-up of each (surviving) patient was continued until February 2006. Therefore, all patients were followed for at least 6 years up to a maximum of 11 years, with a mean follow-up of 8.4 (± 1.4) years.

Patient characteristics

For each patient gender, age, type of surgical ICU classification, APACHE II score [25] (a prediction mortality scoring system based on the acute physiology score, age-points and chronic health points), the presence of a pre-admission disease (comorbidities, as scored in the chronic health points in the APACHE II score), the need for acute dialysis (because of kidney function failure), length of ICU and hospital stay, and type of ICU admission were prospectively collected. Chronic health points is based on organ insufficiency or an immuno-compromised state before hospital admission (categorized as 0 = no comorbidity (*n*=1430), 2 = elective postoperative (*n*=65) and 5 = emergency postoperative (*n*=54)). Type of admission to the ICU was categorized as 1 = admission for monitoring and observation (Low risk monitoring); 2 = stable patient but extended care with high risk of complications (High risk monitoring); 3 = unstable patient with continuous medical intervention (Active treatment). Surgical ICU admissions were divided into five different surgical classification groups: trauma, vascular (excluding cardiac surgery), gastro-intestinal, oncological and general surgery. Length of ICU stay was defined as the period from the day of admission until the day of ICU discharge. Length of hospital stay was defined as the period from the day of admission until definitive discharge from the hospital, including the ICU period.

Data analysis

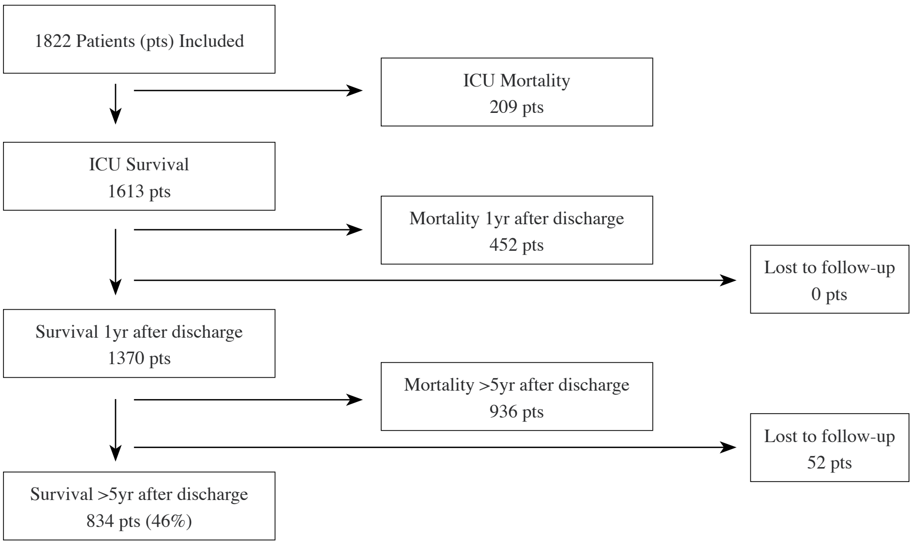
We first quantified the mortality occurrence during ICU and in the subsequent period among those who survived hospital admission. We then analyzed the (overall) survival after ICU discharge for the entire cohort using Kaplan-Meier (KM) analysis. Hence, ICU mortality was not included in the mortality analysis during follow-up after discharge alive. Subsequently, Cox proportional hazard analysis was used to calculate the independent association of the co-variates (e.g. gender, age, surgical classification, APACHE II score, chronic health points, the need of dialysis and type of ICU admission) on long-term overall survival. Age and APACHE II score were included as linear parameters, after cubic spline analysis confirmed their linearity. As the sample size allowed for, we pre-specified the testing of potential effect modification between gender, age, surgical classification and ICU LOS. Finally, subgroup-specific long-term survival across gender, age-groups [18-44; 45-65; 66-93 year cohorts] and surgical classification were also estimated.
To put the results into perspective, the mortality of our cohort was compared with the overall mortality in the general Dutch population, adjusted for age and gender.
P-values 0.05 or less were regarded as statistically significant. Statistical analysis was performed using SPSS 15.0, Chicago, IL (for The Netherlands: SPSS Benelux, Gorichem) for Microsoft Windows XP Professional Version 2002, Service Pack 2.0.

RESULTS

A total number of 2145 surgical patients were admitted to the ICU, of which 1822 patients met the inclusion criteria. Follow-up during the first year after ICU discharge was 100%. Only 52 patients during the subsequent study period were lost to follow-up (Figure 1).
The majority of patients included trauma and vascular surgery classifications. Both groups also contained more males. Trauma patients were on average younger. Overall, APACHE II score ranged from 0 to 40. The mortality incidence in patients in need of dialysis was low (both overall and across mortality of 1 - 5%, Table 1a). The trauma

and vascular classification group appeared to have a lower in-hospital predicted mortality rate (PMR). Most patients were admitted to the ICU with low risk, for monitoring and observation.

Figure 1
Cohort study population evolution chart.



Survival, mortality and lost to follow up numbers are cumulative.

Overall mortality at ICU discharge was 11% (Table 1b). The observed in-hospital mortality was significantly higher than the calculated PMR (Table 1a): 16.0% (CI 14.0-17.4%) versus 13.5% (CI 12.8–14.2%), p=0.001. Cumulative mortality increased to 25% at one year and to 42% five years after ICU discharge. Of the 243 patients who died between ICU discharge and 1 year follow-up, 34% (n=101) did so in the first month after ICU discharge, of whom 24 were already discharged from the hospital. At 133 months, 936 patients (51%) had died. ICU mortality ranged between 8% and 19% across patients in different surgical classification groups (Table 1b). Vascular, gastro-intestinal and oncological in-hospital mortalities were equal to the PMR.

Table 1
1A: Baseline characteristics of the overall cohort and subdivided by surgical classification groups.
1B: Cumulative mortality for the entire cohort and across surgical classification groups at the end of ICU-stay, during in-hospital stay, at one year of follow up after discharge, and at the end of the study period.

	Overall	**Trauma**	**Vascular**	**Gastro – Intestinal**	**Oncology**	**General**
	n= 1822	*n*= 477 (26%)	*n*= 538 (30%)	*n*= 278 (15%)	*n*= 334 (18%)	*n*= 195 (11%)
1A:						
Female (%)	34	24	29	45	35	46
Age (years)	63 (48-73)	40 (27-58)	69 (62-76)	67 (52-77)	64 (57-72)	61 (42-73)
APACHE II [1]	11 (7-15)	10 (5-16)	10 (7-14)	13 (8-17)	12 (8-15)	10 (6-15)
Dialysis (%) [2]	58 (3)	10 (2)	19 (4)	14 (5)	5 (1)	10 (5)
Length of stay (days):						
ICU	2 (1-5)	2 (1-7)	1 (1-2)	3 (1-7)	3 (1-5)	2 (1-4)
Hospital	12 (8-23)	11 (5-25)	10 (7-18)	17 (10-29)	15 (10 -23)	14 (8-23)
PMR [3]	13.5	9.5	9.8	22.0	15.7	17.1
SMR	1.19	1.47	1.12	1.14	0.89	1.29
Type of admission [4] (%):						
Low risk monitor [5]	1043 (57)	183 (38)	402 (75)	132 (47)	197 (59)	120 (62)
High risk monitor [5]	522 (29)	202 (42)	82 (16)	88 (32)	101 (31)	49 (25)
Active treatment [5]	259 (14)	92 (20)	50 (9)	57 (21)	35 (10)	25 (13)
1B:						
Mortality at discharge:						
ICU	209 (11)	59 (12)	45 (8)	53 (19)	28 (8)	24 (12)
In-hospital	286 (16)	69 (14)	60 (11)	69 (25)	46 (14)	42 (22)
1 yr	452 (25)	81 (17)	107 (31)	115 (42)	118 (35)	57 (29)
6-11 yrs	936 (51)	136 (29)	291 (54)	215 (78)	242 (72)	106 (54)

1A: All values are medians with 25th and 75th percentile between parenthesis (except for gender and predicted mortality). [1]: The APACHE II score ranged from 0 to 40 in our population. [2]: Data of six patients were missing. [3]: PMR (%): Predicted in hospital Mortality Rate was calculated by the formula based on the APACHE II score by Knaus *et al*. [24]. [4]: Data of four patients missing. [5]: Low risk monitor consists of stable patients with use of close observation; high risk monitor consists of stable patients due to extended care; active treatment consists of unstable patients with continue intervention needed. SMR = standardized mortality ratio for in-hospital death.
1B: Absolute numbers are given and percentages between parenthesis.

6

Table 2 shows that gender, age, APACHE II score, dialysis and type of surgery were all independently associated with long-term survival. The presence of a pre-admission co-morbidity or the type of admission (group 1 as a reference group), were not associated with long-term survival. Figure 2a shows the corresponding survival curve of this overall model. Figures 2b, 2c and 2d show the survival curve across the various subgroups, adjusted for the other variables, i.e. age, gender, surgical classification and APACHE II score. Female patients had a significantly lower likelihood of dying with a hazard ratio of 0.79. When age was divided into 7 different subgroups (instead of a continuous variable as depicted in Table 2 and with the 18-25 years as reference group, the hazard ratios increased with age: 1.65 (95% CI:1.05-1.07) for age 26-35, 4.43 (1.31-15.04) for age 36-45, 7.62 (2.36–24.66) for age 46-55, 12.23 (3.84-38.94) for age 56-65, 18.76 (5.91-59.57) for age 66-75 and 36.94 (11.63-117.31) for age 76-93 years. Vascular, gastro-intestinal, oncological and general surgery patients had a significantly higher risk of dying after ICU discharge than trauma patients over the entire follow-up period, as shown in Figure 2d.

There was only a significant interaction between age and surgical classification, and notably for oncological surgery (Table 2).

DISCUSSION

Ideally, healthcare professionals' immediate (medical) treatment of critically ill patients is based on sound data concerning life expectancy and quality of life. To this end knowledge of the long-term outcome of surgical patients admitted to the intensive care unit and the influence of age, gender and surgical classification on the prediction of short and long-term survival is severely lacking. Such data may guide patient management, direct the use of expensive resources, and improve the information that can be given to patients and their relatives. In our large cohort, we found that more than 50% of all patients died within 10 years after discharge from our surgical ICU. All-cause mortality increased with age of admittance to the ICU. Above 65 years of age more than 70% died within ten years, whereas the mortality rate after ten years of patients younger than 44 years of age was less than 20%.

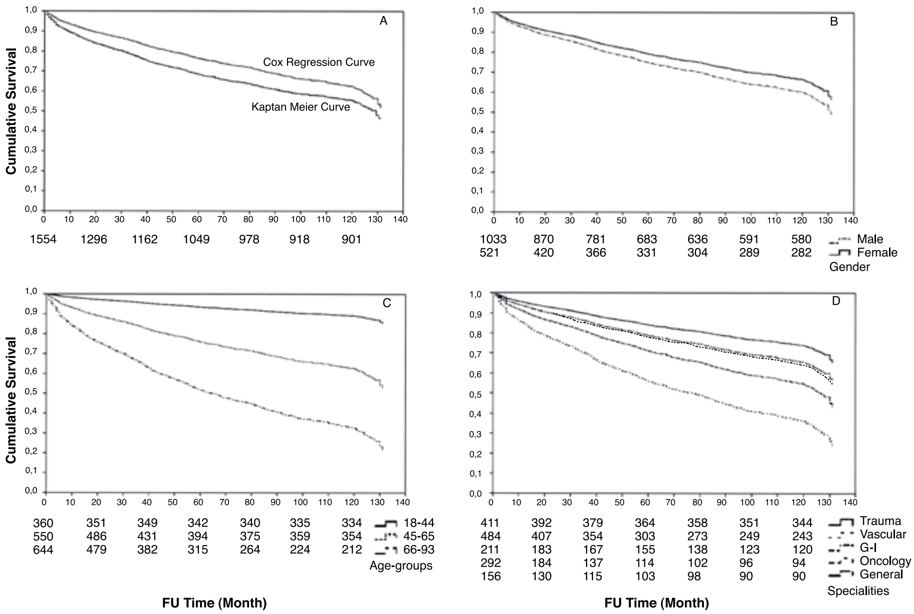
The ICU mortality of our single centre study is 11%, which is comparable to the results of the Dutch multicentre National Intensive Care Evaluation (NICE) [15].

Table 2
Association of age, gender, APACHE II score and surgical classification with survival among patients surviving the ICU stay, as obtained from the multivariable Cox proportional hazard model. Age and APACHE II score were included as continuous, linear variables.

	Hazard ratio	*p*-value	95.0% CI	
			Lower	Upper
Female gender	0.79	0.006	0.67	0.94
Age (per year)	1.06	<0.001	1.05	1.07
APACHE II score (per unit) [1]	1.01	0.05	1.00	1.03
Chronic health points [2]		NS		
2 *vs* 0	1.42	0.03	1.04	1.93
5 *vs* 0	1.11	0.6	0.77	1.60
Dialysis	2.16	0.01	1.15	4.06
Length of stay ICU (per day)	1.00	NS	0.99	1.02
Surgical classification		<0.001		
Trauma	1.00			
Vascular	1.37	0.03	1.04	1.81
Gastro-intestinal	1.41	0.04	1.02	1.94
Oncological	3.38	<0.001	2.56	4.23
General	2.03	<0.001	1.44	2.86
Type of admission:		NS		
2 *vs* 1	1.00	NS	0.82	1.21
3 *vs* 1	0.88	NS	0.65	1.19
Age (year) by surgical classification				
Age*specialty1 (Vascular)	1.01	NS	0.99	1.03
Age*specialty2 (G-I)	0.99	NS	0.97	1.01
Age*specialty3 (Oncology)	0.96	<0.001	0.94	0.98
Age*specialty4 (General)	1.00	NS	0.98	1.02

[1]: The APACHE II score ranged from 0 to 40. NS = not significant. [2]: Chronic health points based on the APACHE II score. 0 = no disease (*n*=1430), 2 = elective postoperative (*n*=65) and 5 = emergency postoperative (*n*=54). Data of five patients are missing

Figure 2
Survival curve of ICU stay survivors during follow up adjusted for gender, age, surgical classification and APACHE II score based on Cox-regression modeling.



A: Kaplan-Meier curve for the entire cohort who survived the ICU plus the survival curve of the entire cohort after adjustment for gender, age, surgical classification and APACHE II score. 1554 patients were alive at > 0 days after ICU discharge. 59 patients died the day they were discharged from the ICU and admitted on the general surgical ward; The X-axis also depicts the number of patients still alive for each follow up time.
B: Survival curve for gender after adjustment for surgical classification, age and APACHE II score;
C: Survival curve per age category after adjustment for gender, surgical classification and APACHE II score;
D: Survival curve per surgical classification after adjustment for gender, age and APACHE II score.

However, the latter study included 46% cardiac surgery and 28% non-surgical patients, whereas our population contained non-cardiac surgery patients only. Such differences in case mix are well known for the variability in ICU and hospital mortality. Outcome of surgical ICU patients is currently better than for medical patients [7,8,10,17,18]. In this study, we concentrated on surgical patients because the results could affect not only decisions made in the ICU, but could also have a bearing on discussion of outcome with patients before their surgical procedure, based on their underlying disease and type of surgical procedure. Further differentiation was made on gender, age and pre-admission comorbidity as measured by the APACHE II score chronic health points, in order to possibly identify the subsets of patients that will have a relatively benign course as opposed to those who will suffer limited life expectancy. The long-term mortality found in this study was comparable to several studies containing both non-surgical and surgical ICU populations with a follow-up of 5 – 15 years [12-14,26-30] (42 – 60% mortality).

Despite the influence of age, the long-term survival rate depended on the underlying patient disease. The highest 10-year survival rate - more than 70% - was found in the group of trauma patients, whereas survival in the group of patients with gastro-intestinal and oncological diseases did not exceed 30%. The 5 year mortality in the oncological group was equal to findings in the literature [12]. After adjustment for age, all surgical classification groups had a significantly higher risk of death than the trauma population. This effect was most profound in gastro-intestinal and oncological patients, probably because their mortality is closely related to the underlying disease. Likewise, the mortality in vascular patients might very well be related to progression of the underlying atherosclerosis. A correlation between a pre-admission comorbidity and long-term outcome was not found. However, the absence of a pre-existing disease might be the reason why the survival of trauma patients is equal to the normal population. Reference data with specified surgical classification are lacking.

In addition to surgical classification, age, APACHE II score and the need of dialysis were also independently associated with long-term mortality. The youngest age groups showed the lowest mortality rates, which is comparable to observations by Nicolas *et al*. [19]. Both their study and this one found that the ICU mortality in patients under 45 years of age is less than half as compared to patients over 65 years (37% versus 15%; our findings 35% versus 11%). Moreover, these observations agree with the results of Dragsted *et al*. and William *et al*. who showed that patients older than 70 years had a 2.5-fold increase in mortality within the first 5 years after ICU discharge compared to an age- and gender-adjusted normal population [12,28].
The APACHE II score was developed to predict short-term, in-hospital mortality. There is ongoing debate as to whether it also predicts long-term survival. Although Sage *et al*. showed no correlation between APACHE II score and long-term survival [25], Ridley *et al*. found a strong correlation between APACHE II score and survival

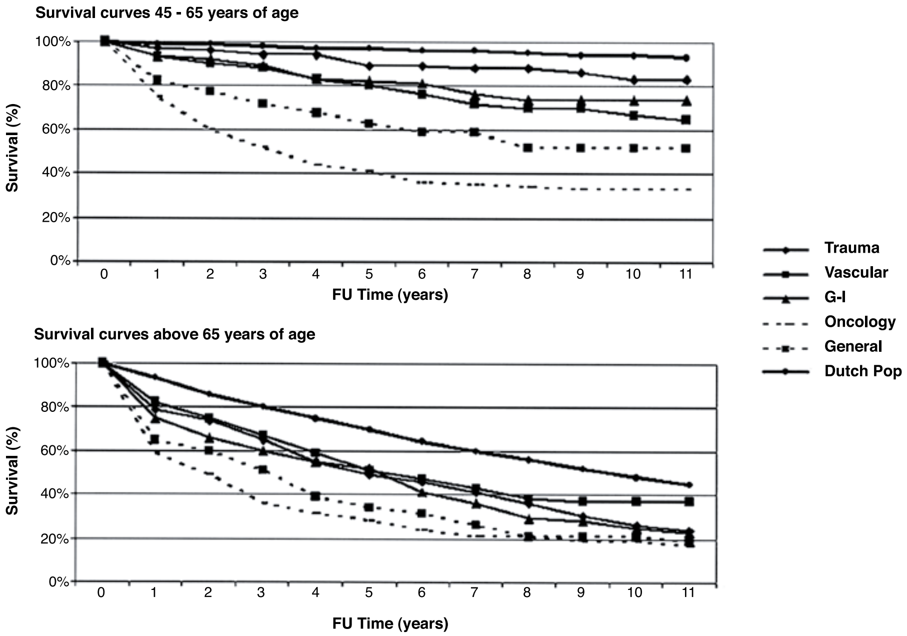
two years after ICU discharge [18]. In their study an initial APACHE II score ≥ 20 resulted in > 60% mortality, whereas a score of < 10 had a mortality of only 20%. Wright *et al*. suggested that this correlation was not simply linear and that a kind of threshold existed [26]. They could not demonstrate a negative effect on survival of an APACHE II score < 10. Our study supports these suggestions: an APACHE II score < 10 did not increase the likelihood of death (results not shown).

The effect of age, APACHE II score and the need of dialysis on survival of discharged ICU patients beyond a period of 5 years has not been studied to date. Therefore, this study is the first to suggest that both age and acute physiologic status, represented by the APACHE II score, have a significant effect on survival outcome beyond 5 years of follow-up.

The overall all-cause mortality rate of our ICU population after a period of 10 years was different from the mortality ratio of the general population as published by the Dutch Government [16] (50% *versus* 27%). These results are comparable to the studies of Ghelani *et al*. and Williams *et al*. [27,28]. However, several studies with a 5 year follow-up showed a three- to five-fold increase in mortality in medical and surgical ICU populations [11,12,26]. We did not find an increase to such an extent in our population after 5 years of follow-up (Figure 3).

A comparison of the specific classification groups with the general population must be done with caution. Most typical is the survival pattern of trauma patients, which equals the general population soon after ICU discharge. This phenomenon has also been described by Wright *et al* [26]. The cohort of vascular patients needs at least several years to equal the normal population survival pattern, whereas the remaining subgroups of surgical patients need approximately 8 years to do so. Also, the survival pattern of our ICU patients below 45 years of age, follows the general Dutch population closely, but our oldest ICU patient group (>65 years of age) continues to show a more rapid decrease (Figure 3). This is in contrast to Niskanen *et al*. who found that mortality in those surviving surgical intensive care paralleled the general population after 2 years, irrespective of the diagnosis [11]. Another interesting phenomenon described by Wright *et al*. was the relative reduction in mortality rate for the entire study population, irrespective of surgical classification, in comparison to the general population data. We only found this phenomenon, though less clearly, in the vascular and oncological subgroups. This phenomenon might be explained by the fact that general population data contain equal numbers of patients per decade for each age group. As in our cohort, in the age-group > 65 years of age, the number of older patients are low in comparison to younger patients. From a population-based perspective an episode of critical illness with ICU admission is a 'pathophysiological challenge', where only the fittest survive. Our data suggest that the effect of this challenge can take 7 to 8 years. However, the literature contains a study, in which the study population did not parallel the general population at the end of the study period, 15 years after discharge [28].

Figure 3
Survival of study population across types of surgical classification as compared to the general Dutch population, for two different age-groups. Age-group < 45 years of age not shown.



One possible limitation of this study is that the data represent a cohort study from a single centre. However, the ICU and hospital (short-term) mortality ratios are almost identical to the Dutch National Intensive Care Evaluation Society [15], and comparable to international ICU-studies from Finland [11], Canada [22] and the United States [23,26], reflecting a certain generalisability of our data. Although the hospital is not a tertiary referral hospital, it is a level one trauma center and acts as a regional referral center for a population of 2.1 million people. The research done by Dowdy *et al*. demonstrated that the prospective cohort study is a powerful research design to assess relationships between exposures and ICU outcomes [32]. A second limitation could be the retrospective study design. However, both in-hospital data and mortality of individual patients are prospectively registered and only 52 patients, 3% of our entire cohort, were lost to follow-up. In comparison to other studies, this number is very low [9,13,14]. A third point to make is that the study population only contained surgical ICU patients which hampers a reliable comparison to other studies. The withdrawal of gynaecological patients (*n*=20) had no influence on the results of our analysis. Another possible limitation is that this study looks at all-cause mortality. Although long-term mortality is an objective estimate of the prognosis of critically ill patients, it is not the optimal tool to measure intensive care outcome. Ideally, it should be accompanied with quality of life measurements. Such tools are increasingly used for this purpose, but not yet available for our cohort. Furthermore, the presence of pre-admission disease (comorbidities) was captured only via the Chronic Health Evaluation component of the APACHE II score. Using this process no comorbidities were identified in 1430 of the study patients, this is clearly an underestimation. The use of a different, more detailed scoring system may have yielded more specific information regarding the degree of comorbidities for the study cohort. Finally, this study did not evaluate sepsis and organ dysfunction, which have been identified as independent risk factors for death [27]. We explicitly chose not to implement sepsis or organ failure in the analysis because data from almost 350 patients were missing. Of the 1479 patients 8% (121 patients) had sepsis. Despite these limitations the current study has several strengths. It is the first study with a follow-up of at least 6 years, up to 11 years, and long-term mortality figures across different surgical classification groups.

In conclusion, survival of surgical patients after intensive care treatment appears to follow distinct patterns in which age, surgical classification and APACHE II score play an important role. The negative effect of an ICU stay on survival appears to be long-lasting. Particularly, in patients with a gastro-intestinal, oncological and/or general surgical classification and in patients with advanced age this effect takes more than 5 years to diminish. Ten years after discharge from a surgical ICU, survival is only 50%.

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2. CLOSE DOOR AND LATCH
3. SQUEEZE DRIP CHAMBER 1/3 TO 1/2 FULL AND PRIME ADMINISTRATION SET
4. MOVE CONTROL TO
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Chapter 7

Long-term (>6 years) quality of life after surgical intensive care admission

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Timmers TK, Verhofstad MHJ, Moons KGM, Van Beeck EF, Leenen LPH

ABSTRACT (prolonged)

Introduction: Treatment of surgical patients in the ICU, affected by severe illnesses or injuries, should be justified by an acceptable survival and long-term health-related quality of life (HrQoL). The primary aim of this study was to quantify the long-term HrQoL (>6 years) of a large cohort of patients admitted to a surgical intensive care unit. In addition, we aimed to explore the influence of different surgical classifications on long-term health status and to make comparisons with general population norms.

Patients / Methods: HrQoL was measured in all surviving surgical ICU patients admitted to a Dutch teaching hospital between 1995 and 2000. Patient-reported data on HrQoL were collected with the EuroQol-6D after a mean follow-up of 8 (range 6-11) years. Patient characteristics, surgical classification, length of ICU stay and survival were prospectively registered. EQ-utility scores (EQ-us, measured with the US EQ-5D index tariff), EQ Visual Analoge Scales (VAS) and prevalences of domain-specific health problems were calculated. The effect of surgical classification on EQ-us/EQ-VAS was assessed by multivariable generalized linear regression analysis. Logistic regression was used to explore the influence of surgical classification on domain specific health problems. Long-term HrQoL of surgical ICU patients was compared to an age- and sex-matched general Dutch population using the *t*-test analysis.

Results: 834 patients survived the ICU and were available for follow-up. In 575 (69%) patients the HrQoL was measured. For all surgical classifications combined, after 6-11 years nearly half of all patients still suffered from problems in the dimensions mobility (52%), usual activity (52%), pain (57%) and cognition (43%). Compared to the age- and sex-matched general population HrQoL was worse with a difference of 0.11 on the EQ-us (range 0-1). Oncological surgery patient had the best (EQ-us 0.83) and vascular patients had the worst (EQ-us 0.72) HrQoL. Trauma (odds ratio between 2.47-3.47) and vascular surgery (2.27-5.37) showed significantly increased prevalences of problems in mobility, self-care, usual activities and cognition.

Conclusion: More than 6 years after a surgical ICU admission, HrQoL of this patients' population has been largely reduced. Many patients still suffer from a variety of health problems, including decreased cognitive functioning. Treatment advances should be made to reduce the current health deficit of surgical ICU survivors compared to the general population.

INTRODUCTION

In recent years there has been an increased focus on outcome after intensive care treatment. Complications and prolonged hospital stay as well as the staggering costs of more extensive treatment have to be justified by favourable, preferably long-term outcome including health-related quality of life (HrQoL). A significant amount of resources in the intensive care unit (ICU) are devoted to patients with a poor prognosis, many of whom ultimately succumb [1,2]. Consequently, improvements of functional status and HrQoL of ICU patients have become important treatment goals. Accordingly, ICU research could shift focus from survival to HrQoL outcomes.

HrQoL assessments occurred infrequently in the ICU literature before 1995, and was of limited methodological quality [3]. In the last decennium, various studies [4-13] of long-term HrQoL after ICU admission appeared. Most of these studies did not exceed a follow-up period longer than 2 years. Only two studies had a somewhat longer follow-up [14,15]. Both found a lower HrQoL at six years in ICU patients as compared to a general population, but included a relatively small cohort and did not distinguish between subgroups, such as, surgical versus non-surgical patients. The study of Livingston *et al*. demonstrates that less than half of the patients, who underwent trauma, returned to work and more than two-third reported a lower level of activity than before the trauma after a follow-up of 3 years [16]. Longer term follow-up will improve our understanding of the nature and duration of ICU-acquired deficits [17], and what length-of-time is sufficient to accurately determine outcome. Furthermore, knowledge on which patient characteristics (such as age and gender) and surgical classification are related to long-term HrQoL have yet to be addressed. Insight in problems with cognitive functioning should be expanded, since this dimension was previously not addressed in the international literature. All these aims require larger and long-term cohort studies [18].

The primary aim of this study was to quantify the HrQoL, specified by health domain (including cognition), of a large cohort of patients more than 6 years after admission to a surgical ICU. In addition, we aimed to explore the influence of different surgical classifications, adjusted for age, gender and severity of the underlying condition on long-term health status, and to make comparisons with general population norms.

PATIENTS AND METHODS

Patients

The study involved a prospective observational cohort study. All consecutive surgical patients who entered the ICU of the St. Elisabeth Hospital, a 673-bed teaching hospital and a level I trauma centre in Tilburg (the Netherlands), between January 1995 and February 2000 were included. Follow-up of each patient was continued until a minimum follow-up of six years was achieved, until February 2006.
The 32-bed ICU admits medical and surgical critically ill patients and is staffed by intensive care specialists with an internal, anaesthesiological or surgical background. To ascertain a more homogeneous study-population, the current research was restricted to surgical patients only with a single ICU admission during the study period and who were alive when contacted for the HrQoL questionnaire. Exclusion criteria were age below 18 years, re-admission to the ICU during the same hospital admission, multiple admissions to the ICU over the study period, and gynaecological and non-trauma neurosurgery.

Patient characteristics

For each patient gender, age, type of surgical ICU diagnosis, ICU length of stay (LOS), were documented. Surgical ICU admissions were divided into five different surgical classifications: trauma, vascular (excluding cardiac surgery, including aneurysmatic and occlusive disease), gastro-intestinal, oncological and general surgery. All patients with a surgical oncological pathology were included in the oncological classification group. LOS was defined as the period from the day of admission until the day of ICU discharge.

Follow-up and HrQoL measurement

Survival was determined by reviewing the hospital's electronic patients' data management and medical record system. If the patient's death - either in - or outside the hospital - could not be confirmed by the database, the general practitioner was consulted. Finally, if a date of death could not be found, the patient or his/her relatives were directly consulted. Patients, alive in February 2006, were sent a HrQoL questionnaire (EuroQol-6D. Patients were reminded and contacted by telephone if the questionnaire was not returned.
A number of questionnaires that aim to measure specific dimensions of HrQoL have been developed, using different criteria depending on the aim of the study and the

patient population. One such instrument is the EuroQol-6D (EQ-6D), a generic HrQoL instrument which was developed at an European level [7,19-21] and based on the EQ-5D by adding a question on cognitive functioning. The questionnaire has been translated into Dutch and tested on its reproducibility in prior studies [7,21]. The original EuroQol-5D questionnaire is a generic instrument designed to measure health outcome on the following dimensions: mobility (MO), self-care or autonomy (SC), usual activities (UA), pain/discomfort (PD) and anxiety/depression (AD). We selected EQ-6D, because of its extension with a cognitive dimension (CO) [18-20].
The EQ-6D consists of two parts: the EQ-6D self-classifier and the EQ-6D VAS, a self-rated health status using a visual analogue scale (VAS) recording the perception of the participant's current overall health state. The later is ranged from 0 (the worst imaginable health state) to 100 (the best imaginable state) [20,22,23]. The EQ-6D self-classifier scores the severity of problems (1= no problem, 2= some/moderate problems, 3= severe/extreme problems). Since there is no international validated tariff for the EQ-6D health states, the EQ-us (EQ-utility score) was obtained with the help of the US EQ-5D index tariff for all possible health states defined by the EQ self-classifier [24-27], and the cognitive dimension was ignored. This index tariff links a single index value for all hypothetical health states. Full health is represented by an index of 1.00. This single index value is also referable and comparable to the patients' health status scored by the patients in the EQ VAS. To compare the European EQ-us with the United States, we have also included the UK EQ-5D tariff utility score [25,26]. This questionnaire has three different outcomes: the EQ-us, the VAS score and the percentage of reported problems in the six EQ-6D dimensions.

Data analysis

Normal distribution of the EQ-6D scores was established first. HrQoL values (continuous) of the EQ-6D index and the VAS measured at follow-up are given as mean values with standard deviation (SD). This was also done for patient subgroups defined by gender, age, surgical diagnosis and ICU LOS. Subsequently, multivariable linear regression modelling was used to assess an association of the different surgical diagnosis-groups with the long-term HrQoL (dependent variable), corrected for age, gender and severity of the health condition at ICU admission (as approximated by ICU LOS, elective or emergency admission and mechanical ventilation). Continuous independent variables were analyzed as linear terms as there were no indications of nonlinearity based on cubic spline analysis [28].

In an additional analysis we dichotomised the outcome scales of the EQ-6D dimensions from no problems, mild problems and severe problems to no problems versus problems. Through multivariable logistic regression we analysed the independent association of gender, age, surgical classification and duration on the ICU with this dichotomised outcome.
Finally, the average HrQoL of our study-population was compared to an age- and gender-adjusted general population using the Student's *t*-test analysis. The reference population [29] was a representative sample (*n*=9685) of the Dutch population, without ICU care: age 18-97 years old, 37.5% males, and 38% with long-standing illness such as diabetes; asthma, hypertension, angina pectoris or low back pain.

RESULTS

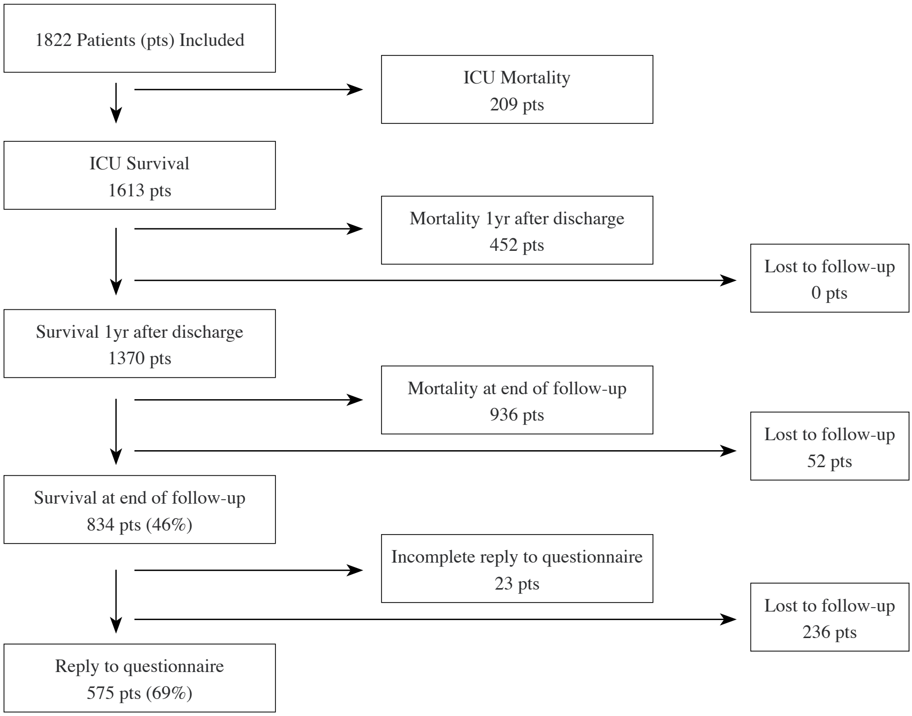
A total number of 2145 patients was admitted to the surgical ICU in the study period. 1822 patients met the inclusion criteria. The mean follow-up was 8.4 (SD=1.4) years, with a minimum of 6 and a maximum of 11 years. Eight-hundred-thirty-four patients (46%) survived the total follow-up of at least six years. HrQoL could be measured in 72% of these 834 patients (*n*=598). Twenty-three patients did not answer one or more questions and/or did not answer the VAS (Figure 1). Accordingly, 575 (69%) patients, aged 18 to 93 years, fully completed the questionnaire. Sixty-four percent was male (Table 1). Most patients were in their 7th and 8th year after ICU discharge, 136 and 129 patients respectively; 103 and 109 patients were in their ninth and tenth FU year, and lower numbers of patients were seen at their sixth (*n*=52) and eleventh (*n*=46) year after ICU discharge.

Long-term HrQoL: all surgical ICU patients combined

As shown in Table 1, the overall percentages of patients reporting problems in the six EQ dimensions were 52% for mobility (MO); 20% for self-care (SC); 53% for usual activities (UA); 57% for pain/discomfort (PD); 29% for anxiety/depression (AD) and 43% for cognitive ability (CA). EQ-us (US-tariff) was higher than the patient's own actual self-rated health status (VAS) for the total study group and for each surgical group separately.

Figure 1

Cohort study population evolution chart.



Long-term HrQoL by surgical diagnosis-group

When dividing the total study-population in the different surgical classifications, patients with an oncological diagnosis appeared to have the best and patients with a vascular diagnosis had the worst EQ-us (0.83±0.20 and 0.72±0.22 respectively). These low EQ-us were particularly related to problems reported in the EQ-6D dimensions mobility, self-care, usual activity and cognition, Table 1.

Using the oncological surgery as a reference group, only in trauma and vascular surgery patients a significant decrease in EQ-us was found after correction for age, gender, emergency admission, the use of mechanical ventilation and ICU LOS (Table 2: EQ-us Part). Age and gender were also independently associated with long-term HrQoL.

This significant decrease in EQ-us for trauma and vascular surgery patient was most profoundly in the dimensions mobility, self-care, usual activity and cognition (Table 3).

Odds ratio's for the dichotomised EQ-6D outcomes of the trauma diagnosis-group were between 2.47 and 3.47 and for the vascular diagnosis-group between 2.27 and 5.37. ICU LOS, emergency admission and mechanical ventilation did not show any association with long-term HrQoL, nor as a continuous or dichotomised variable.

Comparison with age- and sex-matched general population norms:
In comparison to the general Dutch population [29], a lower EQ-us (US-tariff) was found for the total study-population (difference of 0.11) and for each surgical diagnosis (difference between 0.05 and 0.16). Remarkable is the almost equal EQ-us of patients with an oncological diagnosis compared to the general population. Comparing the single EuroQol dimensions of the study-population and of the different surgical classifications with the reference population, 3–5 times higher percentages of reported problems were seen in mobility, self-care, usual activity and cognition (data not shown).
Categorising the study-population in different surgical classifications and age-groups (18-49, 50-69 and 70-97), significantly lower HrQoL was observed in the whole study-population, except for oncological surgery patients (Table 4).

DISCUSSION

Intensive care unit (ICU) care is undoubtedly useful for most critically ill patients. The outcome of ICU treatment is usually reported as mortality and most studies have focused at a specific diagnostic group [4,12,30].While mortality is a clear outcome measure, HrQoL is largely subjective and difficult to describe using objective measures. We demonstrated that the long-term (>6 years) HrQoL (EQ-us, US-tariff) of the total study-population is worse in comparison to an age- and sex-matched general Dutch population [29], and to other published population norms [31-34]. Patients that underwent oncological surgery had the best EQ-us whereas those who had vascular surgery had the worst EQ-us of all surgical classifications. The low EQ-us directly show that the reported problems of (nearly) half of our study-population could be attributed to problems in the EQ dimensions mobility, self-care, usual activity and cognition. Trauma and vascular surgery patients were both independently associated with long-term HrQoL loss.

Table 1
Study group demographics.

	Overall	Trauma	Vascular	Gastro-Intestinal	Oncology	General	Refer. Pop.34
Baseline characteristics	*n*= 575	*n*= 194 (34%)	*n*= 175 (30%)	*n*= 84 (15%)	*n*= 70 (12%)	*n*= 52 (9%)	*n*= 9685
Females (%)	205 (36)	47 (24)	53 (30)	43 (51)	33 (47)	28 (56)	5355 (55)
Age (years) [1]	61 (16)	49 (15)	72 (10)	62 (16)	66 (11)	57 (16)	39
Apache II score [1]	10 (6)	10 (7)	10 (5)	11 (6)	11 (5)	9 (7)	NA
Length of stay (days) [1]:							
ICU	5 (8)	7 (11)	3 (6)	6 (9)	4 (4)	4 (5)	NA
Hospital	19 (21)	21 (28)	13 (12)	27 (22)	15 (11)	19 (18)	NA
Outcome							
EQ-us (UK-tariff) [1]	0.71±0.26	0.74±0.22	0.65±0.28	0.71±0.27	0.77±0.23	0.72±0.31	0.88±0.19
EQ-us (US-tariff) [1]	0.77±0.21	0.79±0.19	0.72±0.22	0.78±0.21	0.83±0.20	0.80±0.24	0.88±0.19
VAS [1]	69±21	73±19	63±22	69±23	74±17	68±26	NA
Problems in Dimension							
Mobility (%)	52	44	72	44	33	47	18
Self-care (%)	19	15	29	15	9	22	4
Usual activity (%)	52	53	57	57	36	47	15
Pain/ disorder (%)	57	60	57	57	50	51	34
Anxiety/depression (%)	29	27	31	31	24	29	12
Cognition (%)	43	45	49	41	29	33	8

[1]: Mean ± SD values; The visual analogue scale (VAS) was not measured in the age and gender matched Dutch population.

Unfortunately, we did not find any similar long-term HrQoL study that used the same validated HrQoL measurement to compare our findings. There is indeed no uniformly accepted standard test for HrQoL in general or for ICU patients in particular. A review of HrQoL assessments in the critical care literature between 1995 and 2009 showed that 108 different instruments had been used in 64 publications. In only 7% of these instruments were the reliability and validity of the test reported [3]. Normative

Table 2
Independent association of gender, age, surgical classification, duration on the ICU, emergency admission and the use of mechanical ventilation with the EQ-us (US-tariff, D1) Part and the VAS Part based on multivariable linear regression analyses.

EQ-us Part	**WHS**	**Regression Coëfficiënt**	**95% CI**		***p*-value**
Male gender	0.79 ± 0.20	0.06	0.03	0.1	0.001
Age (per life year)		-0.002	-0.004	-0.001	<0.001
Surgical classification					
Oncological	0.83 ± 0.20	-	-	-	-
Trauma	0.79 ± 0.19	-0.09	-0.16	-0.03	0.005
Vascular	0.72 ± 0.22	-0.1	-0.17	0.06	<0.001
Gastro-intestinal	0.78 ± 0.21	-0.06	-0.13	0.01	NS
General	0.80 ± 0.24	-0.06	-0.13	0.02	NS
ICU LOS (per day)		-0.002	-0.004	-0.001	NS
Emergency v/s elective	0.79 ± 0.21	0.02	-0.03	0.06	NS
Mech. Ventilation	0.76 ± 0.21	-0.04	-0.08	0.01	NS
VAS Part	**VAS**				
Male gender	71 ± 20	6.49	2.85	10.1	<.001
Age (per life year)		-0.22	-0.35	-0.09	0.001
Surgical classification					
Oncological	74 ± 17	-	-	-	-
Trauma	73 ± 19	-7.85	-14.5	1.2	0.02
Vascular	63 ± 22	-11.29	-17.1	-5.5	<.001
Gastro-intestinal	69 ± 23	-7.58	-14.4	0.7	0.03
General	68 ± 26	-9.03	-16.6	-1.5	0.02
ICU LOS (per day)		-0.06	-0.30	0.18	NS
Emergency v/s elective	72 ± 20	3.27	-1.12	7.66	NS
Mech. Ventilation	68 ± 20	-3.98	-8.38	0.42	NS

NS = not significant.

scales such as the Short-Form Health Survey (SF-36) and Sickness Impact Profile (SIP) assess difficulty and disability against a general population [35]. Watsen *et al*. using the SF-36 found that the baseline for injured patients was not necessarily representative for a general population [36]. Previous data of HrQoL measured by the EQ-6D for a Dutch ICU population are not available. Tian *et al*. [37] used the SIP to conclude that HrQoL 6 months after ICU discharge had decreased in a large cohort of patients in the Netherlands in comparison to the general population. They noted that the physical dimension (ambulation, mobility and body care) was responsible for the highest variance of the total score, which is in line with our results. Kaarlola *et al*. used the RAND-36 six years after ICU discharge and reported that 9% (15 of 169 patients) considered their present health status to be excellent, 37% good, 45% satisfactory and 9% poor [14]. Our study-population more than 6 years after ICU discharge (*n*=52 patients) resulted in a higher proportion of patients with an 'excellent' health state (37%) and a slightly lower proportion in a 'poor' health state (6%). Norwegian investigators used the SF-36 to study the HrQoL 12 years after intensive care [15]. The HrQoL indices physical and social functioning, physical and emotional role limitations appeared statistically worse ($p<0.05$) than the values for the general Norwegian population.
Several studies have focussed on resumed employment as outcome (patients who underwent trauma). Most of these studies showed that even after a long follow-up period (2 to 8 years) high percentages of their study-population did not resume to work. However, the results improved with a longer follow-up period [38-41].

As described in other HrQoL studies, our patients most frequently reported problems in the dimensions mobility, usual activity and pain. The dimension cognition has not yet been addressed. We found a high percentage of cognitive problems in our total study-population (43%). Further research on this important issue is required in order to replicate and explain this largely unexpected finding. Also a recalibration of the EQ-5D tariff formula with the inclusion of the dimension cognition should be done for a more accurate description of HrQoL of patients after severe illness.

Several limitations have to be considered. First of all, in an ideal study HrQoL should be measured in each subject before and after ICU admission, as the real interest is not 'absolute' health but rather the change in perceived health. However, the HrQoL

Table 3
Independent association of gender, age, surgical classification, ICU LOS, emergency admission and use of mechanical ventilation with the dichotomized outcomes of EQ-6D subscales, based on multivariable logistic regression. Results are expressed as odds ratios.

	MO	SC	UA	PD	AD	CO
Age (continue)	1.04***	1.04***	1.021**	1.01	1.01	1.02**
Gender	1.90**	1.28	2.17***	2.33***	1.75**	0.91
Surgical classification:						
Oncology						
Trauma	3.47***	3.21*	3.19***	2.10*	1.47	2.47**
Vascular	5.37***	4.09**	2.64***	1.48	1.52	2.27**
G-I	1.91	1.76	2.51**	1.35	1.42	1.81
General Surg.	2.76*	4.33*	1.91	1.11	1.37	1.52
ICU LOS (per day)	1.03	1.05**	1.05*	1.01	1.00	1.00
Emergency vs Elective	1.13	1.68	1.34	1.18	1.05	1.15
Mech. Ventilation	0.88	0.57	0.72	0.77	0.95	0.87

*: <0.05, **: <0.01, ***: <0.001, n= 575 patients.
MO: mobility; SC: self-care; UA: usual activities; PD: Pain/ discomfort; AD: anxiety/ depression; CO: cognition.

Table 4
Mean EQ-us[1] by age (18 to 97, age at time of answering questionnaire) of the general Dutch population and for our study group, both overall and per diagnosis at admission (n= 575).

	Age		
	18 – 49	50 - 69	70 - 97
Refer. Pop.	0.91	0.87	0.80
Study Group:			
Overall	0.82 (148)	0.78 (239)	0.74 (188)
Trauma	0.81 (102)	0.79 (74)	0.72 (18)
Vascular	NA[2]	0.72 (65)	0.72 (107)
G-I	0.78 (21)	0.79 (33)	0.77 (30)
Oncology	0.88 (5)	0.83 (43)	0.81 (22)
General Surg.	0.89 (17)	0.78 (25)	0.69 (11)

[1]: EQ-6D index values based on the US EQ-5D index tariff (D1) [25, 26]. NA = not applicable, conclusive numbers when $n \geq 5$ patients. [2]: Only three patients in this group. G-I = Gastro-intestinal surgery. Number of patients shown between parentheses.

before treatment could only be scored retrospectively in the acutely admitted patients. This is difficult if not impossible without bias, as patients are still influenced by their critical illness. In a UK study different authors used the SF-36 questionnaire at the time of discharge from the ICU as an instrument to score the premorbid HrQoL. However, their patients (medical and mixed ICU population) appeared to have a much lower pre-ICU score than the general population [13,42,46-48]. Nevertheless, the study of Watson *et al*. showed that the pre-injury scores in trauma patients were better compared to a general population [36]. And there have been reported problems with the recall bias influencing preadmission HrQoL [36,46-48]. The possibility exists that the worse long-term HrQoL seen in our study could be associated with the higher prevalence of comorbidities and not solely the ICU admission. The systematic follow-up of ICU patients by Kvåle *et al*. agrees that ICU patients in general have more comorbidity than the normal population [43]. Nevertheless, only 30 patients (5%) did have a presence of a preadmission disease (comorbidities, as scored in the chronic health points in the APACHE II score) in our study-population. This could be an underestimation. The use of a different, more detailed scoring system may have yielded more specific information regarding the degree of comorbidities for the study cohort. From a methodological point of view the nearest approach is to compare the self-reported health status of patients to that of a healthy reference population of corresponding age without ICU care. A second limitation of our study concerns that the HrQoL assessment was conducted only once. Ideally assessment of HrQoL is conducted in a longitudinal design with multiple measurements over time [44]. However, a design like ours does provide important and relevant findings, since health problems have most often stabilized some years after ICU admission. This hypothesis is also likely from our data, a comparison of the 6 years follow-up group with the group ≥ 10 years after ICU discharge revealed no significant difference in HrQoL (results not shown). Thirdly, it must be considered that HrQoL measurement was done in 2006 at the end of the study follow-up time. Before HrQoL could be measured, already 50% of the total study-population (all surgical ICU patient, n=1822) had died [45]. A group of 92 patients who died, did survive a follow-up period of more than 6 years, but was not alive anymore when HrQoL was measured. We choose to exclude these patients from this study. We assume that HrQoL would decrease even more if these patients could have been included and that our estimates of reported health problems should even be seen as conservative or optimistic.

In conclusion, our results show that after ≥6 years post-ICU discharge, patients still experience considerable difficulties of their HrQoL. Patients with a vascular surgery diagnosis had the worst and patients with an oncological diagnosis the best HrQoL. Many patients still suffer from a variety of health problems, including decreased cognitive functioning. Because this study shows a high percentage of problems in the dimension cognition, a recalibration of the EQ-5D tariff with the inclusion of the cognitive dimension should give a better insight of the HrQoL. To compare the results of future HrQoL studies, the ICU community should agree on a limited list of questionnaires to measure HrQoL, e.g. the SF-36 and the EQ-6D. Treatment advances should be made to reduce the current health deficit (0.11) of surgical ICU survivors compared to the general population.

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Chapter 8

Appendix I

Model 1
The APACHE II severity of disease classification system (part I) [1].

Physiologic variable	**High abnormal range**						**Low abnormal range**		
	+4	+3	+2	+1	0	+1	+2	+3	+4
Temperature	≥ 41	39-40.9		38.5-38.9	36-38.4	34-35.9	32-33.9	30-31.9	≤ 29.9
Mean Arterial Pressure	≥ 160	130-159	110-129		70-109		50-69		≤ 49
Heart rate	≥ 180	140-179	110-139		70-109		55-69	40-54	≤ 39
Respiratory rate	≥ 50	35-49		25-34	12-24	10-11	6-9		≤ 5
Oxygenation									
Fio^2 > 0.5	≥ 500	350-499	200-349		< 200				
Fio^2 < 0.5					PO$_2$ > 70	61-70		55-60	≤ 55
Arterial pH	≥ 7.7	7.6-7.69		7.5-7.59	7.33-7.49		7.25-7.32	7.15-7.24	< 7.15
Serum sodium	≥ 180	160-179	155-159	150-154	130-149		120-129	111-119	≤ 110
Serum potassium	≥ 7	6-6.9		5.5-5.9	3.5-5.4	3-3.4	2.5-2.9		< 2.5
Serum creatinine	≥ 3.5	2-3.4	1.5-1.9		0.6-1.4		< 0.6		
Hematocrit (%)	≥ 60		50-59.9	46-49.9	30-45.9		20-29.9		< 20
White blood count	≥ 40		20-39.9	15-19.9	3-14.9		1-2.9		< 1
Glascow Coma Score									

Total Acute Physiology Score (APS): sum of the 12 individual variable points.

Model 1
The APACHE II severity of disease classification system (part II) [1].

Nonoperative patients

Respiratory failure or insufficiency from:		Trauma:	
Asthma/allergy	-2.108	Multiple trauma	-1.228
COPD	-0.367	Head trauma	-0.517
Pulmonary edema (noncardiogenic)	-0.251	Neurologic:	
Postrespiratory arrest	-0.168	Seizure disorder	-0.584
Aspiration/poisoning/toxic	-0.142	ICH/SDH/SAH	0.723
Pulmonary embolus	-0.128	Other:	
Infection	0	Drug overdose	-3.353
Neoplasm	0.891	Diabetic ketoacidosis	-1.507
Cardiovascular failure or insufficiency from:		GI bleeding	0.334
Hypertension	-1.798		
Rhythm disturbance	-1.368	If not one of the specific groups above, then which major vital organ system was the principal reason for admission?	
Congestive heart failure	-0.424		
Hemorrhagic shock/hypovolemia	0.493		
Coronary artery disease	-0.191	Metabolic/renal	-0.885
Sepsis	0.113	Respiratory	-0.890
Postcardiac arrest	0.393	Neurologic	-0.759
Cardiogenic shock	-0.259	Cardiovascular	0.470
Dissecting thoracic/abdominal aneurysm	0.731	Gastrointestinal	0.501

Postoperative patients

Multiple trauma	-1.684		
Admission due to chronic cardiovascular disease	-1.376	For postoperative patients admitted to the ICU for sepsis or postarrest, use the corresponding weigths for nonoperative patients.	
Peripheral vascular surgery	-1.315		
Heart valve surgery	-1.261		
Craniotomy for neoplasm	-1.245		
Renal surgery for neoplasm	-1.204		
Renal transplantation	-1.042	If not one of the groups above, then which major vital organ system led to the ICU admission postoperative?	
Head trauma	-0.955		
Thoracic surgery for neoplasm	-0.802		
Craniotomy for ICH/SDG/SAH	-0.788	Neurologic	-1.150
Laminectomy and other spinal cord surgery	-0.699	Cardiovascular	-0.797
Hemorrhagic shock	-0.682	Respiratory	-0.610
GI bleeding	-0.617	Gastrointestinal	-0.613
GI Surgery for neoplasm	-0.248	Metabolic/renal	-0.196
Respiratory insufficiency after surgery	-0.140		
GI perforation/obstruction	0.060		

Age points: age (yrs) ≤44 = 0 (points), 45-54 = 2, 55-65 = 3, 65-74 = 5 and ≥75 = 6.
Chronic Health Points (If the patient has a history of severe organ system insufficiency or is immunocompromised assign points as follows): a. for nonoperative or emergency postoperative patients – 5 points; b. for elective postoperative patients – 2 points.
APACHE II score: sum of APS, Age points and chronic health points.
Baseline risks (intercepts): -3.517

Ln (R/1-R) = -3.517 + (APACHE II score (Part I)* 0.146) + (0.603* post emergency surgery score) + (diagnostic category weight (Part II))
R = Predicted probability of death (in-hospital).

Model 2
New Simplified Acute Physiology Score (SAPS II) [2].

SAPS II variable	Score	SAPS II variable	Score	SAPS II variable	Score
Type of admission:		Temperature:		Heart rate:	
Unscheduled surgery	8	< 39	0	< 40	11
Medical	6	≥ 39	3	40 – 69	2
Scheduled surgery	0	Urine output (24hr):		70 – 119	0
Chronic diseases:		< 0.5L	11	120 - 159	4
None	0	0.5 – 0.99L	4	≥ 160	7
Metastatic carcinoma	9	≥ 1L	0	Bilirubin (micmol/l):	
Hematologic malignancy	10	PaO2/FiO2 (mmHg):		< 68.4	0
AIDS	17	< 100	11	68.4 – 102.5	4
Glasgow Coma Scale:		100 – 199	9	≥ 102.6	9
< 6	26	≥ 200	6	Serum Urea/BUN:	
6 – 8	13	WBC (mm3):		< 10 mmol/l	0
9 – 10	7	< 1000	12	10 – 29.9 mmol/l	6
11 – 13	5	1000- 19000	0	≥ 30 mmol/l	10
14 – 15	0	≥ 20000	3	(BUN) < 28 mg/dl	0
Age:		Potassium (mEq/l):		(BUN) 28- 83mg/dl	6
< 40	0	< 3	3	(BUN) ≥ 84 mg/dl	10
40 – 59	7	3 – 4.9	0		
60 – 69	12	≥ 5.0	3		
70 – 74	15	Sodium (mEq/l):			
75 – 79	16	≥ 145	1		
≥ 80	18	125 – 144	0		
Systolic Blood Pressure:		< 125	5		
< 70 mmHg	13	HCO3- (mEq/l):			
70 – 99 mmHg	5	< 15	6		
100 – 199 mmHg	0	15 – 19	3		
≥ 200 mmHg	2	≥ 20	0		

SAPS II score = sum of value score above
Baseline risks (intercepts): -7.7631

Logit = -7.7631 + (0.0737 * SAPS II score) + (0.9971 * ln ((SAPS II score) + 1))
Predicted probability of death (in-hospital) = $(e^{logit}) / (1+e^{logit})$

Model 3
The SAPS II Expanded scoring system [3].

Variable	Points
Original SAPS II score	0.0742 * SAPS II
Age: <40 years	0
Age: 40 – 59 years	0.1639
Age: 60 – 69 years	0.2739
Age: 70 – 79 years	0.3690
Age: >79 years	0.6645
Male	0.2083
Female	0
LOS hospital before ICU admission	
<24 hours	0
1 day	0.0986
2 days	0.1944
3 – 9 days	0.5284
>9 days	0.9323
Patient's location before ICU	
Emergency room	0
Ward in same hospital	0.2606
Other hospital	0.3381
Medical patient	0.6555
Other specialty	0
No intoxication	1.6693
Intoxication	0

SAPS II (Exp) score = sum of value score above
Baseline risks (intercepts): -14.4761

Logit = -14.4761 + (0.0844* score) + 6.6158* (log(score+1))
Predicted probability of death (in-hospital) = $(e^{logit}) / (1+e^{logit})$

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Model 4
The Mortality Probability Model II_0 ($MPMII_0$) [4].

Variables	Beta values if variable is present
Medical or unscheduled surgery admission	1.19098
Metastatic neoplasm	1.19979
Cirrhosis	1.13681
Chronic renal insufficiency	0.91906
C.P.R. prior to admission	0.56995
Coma (Glasgow 3 – 5)	1.48592
Heart Rate ≥ 150	0.45603
Systolic Blood Pressure ≤ 90 mmHg	1.06127
Acute renal insufficiency	1.48210
Cardiac dysrhythmia	0.28095
Cerebrovascular incident	0.21338
Gastrointestinal bleeding	0.39653
Intracranial mass effect	0.86533
Mechanical ventilation	0.79105
Age	

Baseline risks (intercepts): 5.46836

Logit = sum Beta + (age * 0.03057) – 5.46836
Predicted probability of death (in-hospital) = $(e^{logit}) / (1+e^{logit})$

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Model 5

The SAPS 3 admission score sheet (Part I) [5,6].

Box I	0	3	5	6	7	8	9	11	13	15	18
Age, years	<40		>=40<60				>=60<70		>=70<75	>=70<80	>=80
Co-Morbidities		Cancer therapy[2)]		Chron, HF (NYHA IV), Haematological cancer[3) 4)]		Cirrhosis, AIDS[3)]		Cancer[5)]			
Length of stay before ICU admission. days[1)]	<14			>=14<28	>=28						
Intra-hospital location before ICU admission			Emergency room		Other ICU	Other[6)]					
Use of major therapeutic options before ICU admission		Vasoactive drugs									

Box II		0	3	4	5	6
ICU admission: Planned or Unplanned			Unplanned			
Reason(s) for ICU admission	please see Part 2 of the scoresheet					
Surgical status at ICU admission		Scheduled surgery			No surgery[7)]	Emergency surgery
Anatomical site of surgery	please see Part 2 of the scoresheet					
Acute infection at ICU admission				Nosocomia[8)]	Respiratory[9)]	

Box III	15	13	11	10	8	7	5	3	2	0	2	4	5	7	8
Estimated Glasgow Coma Scale (lowest), points	3-4			5		6			7-12	>=13					
Total bilirubine (highest), mg/dL										<2		>=2<6	>=6		
Total bilirubine (highest), µmol/L										<34.2		>=34.2 <102.6	>=102.6		
Body temperature (highest) Degrees Celsius						<35				>=35					
Creatinine (highest), mg/dL										<1.2	>=1.2<2			>=2<3.5	>=3.5
Creatinine (highest), µmol/L										<106.1	>=106.1< 176.8			>=176.8 <309.4	>=309.4
Heart rate (highest) beats/minute										<120			>=120 <160	>=160	
Leukocytes (highest), G/L										<15	>=15				
Hydrogen ion concentration (lowest), pH								<=7.25		>7.25					
Plateletes (lowest), G/L		<20			>=20<50		>=50<100			>=100					
Systolic blood pressure (lowest), mm Hg			<40		>=40<70			>=70<120		>=120					
Oxygenation[10)11)]			PaO2/ FiO2 <100 and MV			PaO2/ FiO2 = 100 and MV	PaO2/60 and no MV			PaO2>=60 and no MV					

The definition for all variables can be found in detail in Apendix C of th ESM. For names and abbreviations which are differing from those in the ESM, explanations are given beow. Generally, it should be noted that no mutually exclusive conditions exist for the following field: Comorbidities, Reasons for IU admission, and Acute infection at ICU admission. Thus, if a patient has more than one condition listed for a specific variable, points are assigned for all applicable combinations.

1 This variable is calculated from the two data fields: ICU Admision date and time-Hospital admission date and time (see Appendix C of the ESM)
2 Cancer Therapy refers to the data deinitions in Appendix C of the ESM: Co-Morbidities: hemotherapy, Immunosupression other, Radiotherapy, Steroid treatment
3 If a patient has both conditions he/she gets double points.
4 Chronic HF (NYHA IV)/Haematological cancer refer both to the data definitions in Appendix C of the ESM: Co-Morbidities: Chronic heart failure class IV NYHA, Haematological cancer.
5 Cancer refers to the data definitions in Appendix C of the ESM: Co-Morbidities: Metastatic cancer.
6 Other refers to the data definitions in Appendix C of the ESM: Intra-hospital location before IU admission: Ward, Other.
7 No surgery refers to the data definitions in Appendix C of the ESM: Surgical Status at ICU Admission: Patient not submitted to surgery.
8 Nosocomial refers to the data definitions in Appendix C of the ESM: Acute infection at ICU Admission–Acquisition: Hospital-acquired.
9 Respiratory refers to the data definitions in Appendix C of the ESM: Acute infection at ICU Admission–Site: Lover respiratory tract: Pneumonia, Lung asbcess, other.
10 PaO^2/FiO^2 refers to the data definitions in Appendix C of the ESM: Arterial oxygen partial pressure (lowest), Inspiratory oxygen concentration.
11 MV refers to the data definitions in Appendix C of the ESM: Ventilatory support and mechanical ventilation.

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Model 5
The SAPS 3 admission score sheet (Part II) [5,6].

ICU admission *	16
Reason(s) for ICU admission	
Cardiovascular: Rhythm disturbances **	-5
Neurologic: Seizures **	-4
Cardiovascular: hypovolemic hemorrhagic shock, hypovolemic non hemorrhagic shock Digestive: Acute abdomen, Other ***	3
Neurologic: Coma, stupor, obtuned patient, delirium, confusion	4
Cardiovascular: Septic shock, anaphylactic shock, mixed and undefined shock	5
Hepatic: Liver failure	6
Neurologic: Focal neurologic deficit	7
Digestive: Severe pancreatitis	9
Neurologic: Intracranial mass effect	10
All Others	0
Anatomic site of Surgery	
Transplantation surgery: Kidney, liver, pancreas, other transplantation	-11
Trauma: Isolated or multiple	-8
Cardiac surgery: CABG without valve repair	-6
Neurosurgery: Cerebrovascular accident	5
All others	0

*: Every patient gets an offset of 16 points for being admitted (to avoid negative SAPS 3 Scores).
***: If both reasons for admission are present, only the worse value (-4) is scored.
***: If patients has both condition, he/she gets double points
SAPS 3 score = sum of value score above (part I and part II together)
Baseline risks (intercepts): -32.6659

Logit = -32.6659 + ln (SAPS 3 score + 20.5958) * 7.3068
Predicted probability of death (in-hospital) = $(e^{logit}) / (1+e^{logit})$

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Model 6
The Mortality Probability Model III (MPM III) [7].

Variables	Beta values if variable is present
Coma (Glasgow 3 – 5)	2.050514
Heart rate ≥ 150 beats/min	0.433188
Systolic Blood Pressure ≤ 90 mmHg	1.451005
Chronic renal failure	0.5395209
Cirrhosis	2.070695
Metastatic neoplasm	3.204902
Acute renal failure	0.8412274
Cardiac dysrhythmia	0.8219612
Cerebrovascular incident	0.4107686
GI bleeding	-0.165253
Intracranial mass effect	1.855276
Age (per year)	0.0385582
CPR prior to ICU admission	1.497258
Mechanical ventilation	0.821648
Medical/unscheduled surgical admission	0.9097936
Zero factors (except age) from above	-0.4243604
Full code	-0.7969783
Age* Coma/deep stupor	-0.0075284
Age* Systolic Blood Pressure ≤ 90	-0.0085197
Age* Cirrhosis	-0.0224333
Age* Metastatic neoplasm	-0.0330237
Age* Cardiac dysrhythmia	-0.0101286
Age* Intracranial mass effect	-0.0169215
Age* CPR prior to ICU admission	-0.011214

Baseline risks (intercepts): -5.36283

Logit = sum Beta + -5.36283
Predicted probability of death (in-hospital) = $(e^{logit}) / (1+e^{logit})$

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B BRAUN
MODUTEC

Chapter 9

General discussion:

General summary and Future perspective

GENERAL SUMMARY

Intensive care unit (ICU) treatment of surgical patients comes with major disadvantages which have to be justified by an acceptable short- and long-term outcome. Outcome research focuses on endpoints and survival is the primary endpoint. Scoring systems designed to rate the severity of an illness are being used to assess the risk of dying for an individual patient (ICU and/or hospital) and to allow comparisons of hospital units to identify different standards of care. During the last decennia, the major ICU scoring systems have broadened their parameters markedly and increased their statistical accuracy for predicting in-hospital death.

In **Chapter 2**, we evaluate the prognostic accuracy of six prediction models [APACHE II Score, SAPS II, SAPS II(Expanded), SAPS 3, MPM II_0 and MPM III] for the assessment in an adult surgical ICU (SICU; St. Elisabeth Hospital between 1995 and 2000, 1821 patients) in the Netherlands. Secondly, we describe the accuracy of the APACHE II model to identify patients at risk of dying in the first five years after ICU discharge. Accurate overall mortality prediction was found for the APACHE II, SAPS II, SAPS 3 and MPM models. Discrimination [area under the receiver operating characteristic curve (ROC AUC)] was best for the SAPS 3 and MPM III models and worst for the APACHE II model. Calibration [Hosmer-Lemeshow goodness-of-fit test and calibration plots] was poor for all six prediction systems. There was a significant improvement in calibration for the APACHE II, SAPS II, SAPS II(Exp) and MPM II systems after adjusting the baseline risks (intercepts) of each model to the local situation. The SAPS 3 and MPM III systems did not show much improved calibration, as the former was already good in the lower probability groups. The APACHE II model could be helpful to identify patients at risk of dying during the five years after ICU discharge.

The Society of Critical Care Medicine's Quality Indicators Committee ranked ICU readmission, next to short-term mortality, within 48 hours as the top indicator for judging ICU quality and is considered to reflect premature discharge. In **Chapter 3** we have investigated different variables which could be associated with readmission to the surgical ICU (total of 1979 patients, single ICU admission and ICU readmission together) in the same cohort of patients as investigated in chapter 2. We also describe the long-term survival and health-related quality of life (HrQoL; EuroQol-6D) of these readmitted patients over a period of more than 10 years, with mean follow-up of 8 years. One-hundred-forty-one patients (7%) were readmitted to the SICU. The main causes of readmission were respiratory decompensation followed by cardiac conditions. Readmitted patients were older, mostly suffering from a vascular or gastro-intestinal surgical disease; they had a significantly higher initial admission APACHE II and SAPS 3 score and significantly more comorbidities. We found an independent association with readmission for type of admission and need for mechanical ventilation, in all different surgical classifications except in the general surgery. Long-term mortality was higher compared to the non-readmitted population. Nevertheless, readmitted patients had the same mean HrQoL score compared to non-readmitted patients.

ICU outcome (inter alia short-term mortality, readmission rate and ICU length of stay) depends on the quality of care, as described in previous chapters. Recent literature has mentioned an association between ICU outcome and ICU organization. **Chapter 4** reports the influence of an organizational change of a SICU (University Medical Center of Utrecht, period 2000-2004), and the subsequent interventions and adjustments to obtain favourable results. To meet the budget cuts of the surgical division, a reduction of the number of SICU beds from ten to eight with a corresponding reduction of nursing staff was implemented. In the subsequent period culminating in the year 2002, problems arose in the collaboration between medical and nursing staff. This led to fierce discussions on the floor. Supported by external mediators, structures/work ethics/collaborative behaviour/communication and organization of the SICU were reviewed and restructured at the end of 2002. One-thousand-four-hundred-seventy-seven patients were admitted to the SICU, covering 1601 admissions. The admission characteristics, mean APACHE II score and TISS points were not significantly different throughout the years. The median ICU length of stay (LOS) in the admission year 2002 was significant longer and the crude ICU mortality higher compared to the two admission years before. The adjusted mortality (ICU standardized mortality ratio) was also worse in 2002, however, statistically not different. After the intervention (2003 and 2004) a statistically better result (ICU mortality and LOS) was achieved, compared to 2002.

During the last decennia, around the world (mostly in Europe) specialized ICUs were transformed into general units which consist of a mixed patient-disease population.

Together with this transition, a reorganization is seen from the known 'open ICU format' towards a referred 'closed ICU format' (critical care physician setting). In the literature the debate continues whether these changes improve the quality of care. In **Chapter 5** we report such a transition of a specialized SICU into a general mixed 'closed format' ICU, with all its differences in population, immediate outcome and influence on performance measures. In our four-year inclusion period (2004-2007) a total of 2420 patients have been admitted to the SICU of our (university) hospital. After the reorganization (end of 2005), patients were older and had less comorbidities. The ICU-admission was more elective of nature and patients were more in need of mechanical ventilation. The population changed from mostly surgical patients to a mixed general ICU population, which comprises mostly of cardiac and cardiosurgical patients. We saw better results in all outcomes (lower mortality and LOS and fewer ICU-readmissions). The overall predicted mortality rate (PMR) decreased significantly. However, the ICU standardized mortality ratio (ICU-SMR) remained unchanged. The complete cohort contained 752 surgical admissions. Between both periods, no difference was seen in short-term mortality, PMR, ICU-SMR, ICU length of stay and severity of illness score (APACHE II score). Surgical patients outcome did not differ comparing all surgical patients of the 3 units combined between both periods.

Apart from ICU short-term patient outcome, critical care patients ideally have 'good' long-term outcome that equals the normal population. So far, most studies focused on ICU or hospital mortality as the major outcome measure. In **Chapter 6** we describe the long-term survival of more than 10 years follow-up of the same cohort of patients admitted to a SICU (St. Elisabeth Hospital; 1995-2000) as used in chapters 2 and 3. We investigated the effects of age, gender and underlying disease on this long-term survival. We included 1822 patients, of which 936 (51%) had died within 11 years (all-cause mortality). Age, gender, APACHE II score, the need for dialysis and surgical classification were independently associated with long-term survival. Mortality increased with increasing age of admittance to the ICU, whereas female patients had a lower chance to die. Pre-admission morbidity did not influence long-term outcome. Long-term mortality rates in various surgical classification groups varied between 29% for trauma and 80% for patients with gastro-intestinal conditions. The negative effect on mortality persisted beyond 5 years in the gastro-intestinal, oncological, general surgical and/or high-aged patients. The mortality rate increased two-fold in comparison to the general population.

Apart from mortality, quality of life evaluation after intensive care becomes more and more of interest. In **Chapter 7**, we outline the long-term (>6 years) HrQoL of surgical patients admitted to the SICU. We address the influence of different surgical classifications on this long-term health status and make comparisons with the general population. HrQoL was measured with the EuroQoL-6D questionnaire after a mean follow-up of 8 (range 6-11) years. Of the 834 patients alive at the end of follow-up, HrQoL was measured in 575 (69%) patients. For all surgical classifications combined, nearly half of all the patients still suffered from problems in the dimensions mobility, usual activity, pain and cognition. Compared to an age- and sex-matched general population the HrQoL was worse. Oncological surgery patient had the best and vascular patients had the worst HrQoL. Trauma and vascular surgery patients showed significantly more problems in mobility, self-care, usual activities and cognition.

FUTURE PERSPECTIVE

The intensive care unit (ICU) is a hospital unit providing continuous surveillance and highly specialized care to acutely ill patients, either medical or surgical, whose conditions are life-threatening and require comprehensive care. Established approximately five decades ago, the ICU is now an essential part of hospital care. It presents itself as the discipline that aims to help patients with extended needs of care and organ support.

Intensive care faces economic challenges. Therefore evidence proving both effectiveness and efficiency, i.e. cost-effectiveness, of delivered care is needed. ICUs consume a significant proportion of health care resources, accounting for up to 20% of a hospital's cost [1-6]. By 2005, critical care medicine (CCM) costs in the United States were estimated to be $81.7 billion accounting for 4.1% of the national health expenditures that are its self 0,66% of the gross domestic product. The US spends 15% of the gross domestic product on healthcare (9-11% in Germany, France and Canada; 7-8% in Spain and the United Kingdom). Medical admissions and intensive care costs are predicted to grow all over the developed world [2,5,7-16]. Life expectancy in developed countries continues to increase, and many countries have rapidly aging populations, potentially placing a greater demand on medical services overall, and critical care in particular.

All countries struggle to optimize quality of care while minimizing costs. Today, the quality of care is an important issue in the health care debate [18,19]. Evaluation of clinical performance is a prerequisite for the assessment of both the effectiveness and efficiency of care [20]. Various sectors of the Dutch health care system have been pursuing means of rendering the quality of their services more transparent under the Health Care Transparency Program (e.g. Program “Zichtbare Zorg”) [21,22]. During the last years these programmes support the health care sector to improve the quality of care [23,24]. As of 2010 medical physicians are required by law to reveal certain outcome results [25-27]. Several reasons have been mentioned for transforming the health care system of today into the transparent health care system of the future [28]:

1. Patients can choose a particular institution based on the quality of care information.
2. Health insurance companies may use the information for health care purchasing.
3. Monitoring and evaluation of quality of care of different hospitals.
4. The possibility for health care providers to improve their quality.

The introduction of Health Care Transparency Programs arose several questions [29,30]: How do we measure quality of care, and how accurate and representative is this measurement? In this chapter, some possible solutions for these situations in the quality of critical care medicine are discussed. Some of the discussed issues already have had its influence on ICU outcomes, but will continue to do so on further improving the quality of intensive care in the future.

The quality of intensive care performance

The goal of intensive care is to provide the highest quality treatment in order to achieve the best outcome for critically ill patients [31]. All patients carry both an intrinsic risk (disease-related) and an extrinsic risk (care-related) at the same time [31,32]. An example of an intrinsic risk is the development of sepsis in a patient with infectious complications after abdominal surgery, and for extrinsic risk could be the association of the high nurses-workload with ICU mortality. There is an ever-increasing recognition of the wide variation in the quality of care across ICUs and its effect on outcome. Indicators to measure the quality of care are increasingly being used and focus on patient outcome [33]. Finding a reliable method to quantify the performance of single ICUs has been a difficult quest in the last 30 years. Until today, one of the most used ICU performance measurements is the standardized mortality

ratio (SMR). The SMR has been developed in a period that the evaluation of quality of care was done exclusively through primary patient outcome (short-term mortality). Some authors have evaluated the use of SMR as an indicator of ICU quality of care and debated its specific relevance [32,34,35]. The SMR value gives insight in the observed mortality compared with the associated predicted mortality, but it does not in the health status of these patients.
However, a patient alive at the end of hospital stay is no longer enough. The health-related quality of life (HrQoL), defined as the degree to which a patient's health status affects the subjective evaluation of his or her satisfaction with life, seems to be a better indicator, especially from the patient-centred view [36]. ICU and hospital survival will always have an important role in the evaluation of performance at the moment different units or hospitals are being benchmarked. Consequently, in the last decennia the quality of life (QoL) has gained great interest when not only physicians but also the patients' relatives mention patient outcome. Therefore, QoL clearly challenges survival whenever we address secondary (long-term) patient outcome.

Hypothetically, performance should be evaluated through the combination of survival (SMR) and the health status (QoL) at the time of discharge. As yet, this combination of both outcome measurements has not been used in a single benchmark value. This requires further research. Difficulties are being foreseen when using health status as a performance-benchmark [37], because of the great diversity in intrinsic risk that patients carry in all the different ICUs (i.a. specialized units, general mixed units). How should we use health status as performance-benchmark? Will we only cross-section the mean health status value of a given cohort against the general population norm, or will we compare individual outcome with individual pre-admission values? The latter will invariably provide more patient oriented and thus clinically relevant outcome values, but also result in an administrative burden. A third possibility is to compare such an individual QoL value with a predicted individual health status.
The ability to predict a patient's QoL after ICU admission could be useful in many ways. Firstly, it could help patients and their relatives to make decisions. Secondly, it could help families to prepare themselves to care for the patient after hospital discharge. Thirdly, it could help critical care physicians to give useful information, avoid unrealistic expectations, and - possibly - decide whether or not to proceed treatment. Fourthly, it could help society to realize in which ICUs patients have a

good chance of recovery and give health policy makers and insurance companies the insight in the needs of the ICUs [37,38].
A completely different benefit, in the use of HrQoL as a performance-benchmark, could be the possibility of follow-up evaluation of the patients' health status after ICU or hospital discharge. Post-ICU patients are known to express a reduced HrQoL compared to the general population. Although, our study suggests that this effect may be long-lasting, it is still not clear to what extend and how long this reduced HrQoL persists. Therefore, a continuous survey as part of regular after care for each individual patient, would be the ideal way to investigate this, and gives the possibility to better manage patients in which HrQoL does not increase as expected. Future research should focus on predicting QoL. The moment when outcome research can predict the short-term (ICU discharge) QoL of a critically ill patient during the first 24 hours of ICU admission; It will give physicians and health care policy makers an up-to-date and reliable evaluation of quality of care in the ICU during the upcoming years.

Outcome prediction models: shall we continue in the same way?
Each new development in critical care treatment over the past 30 years has been implemented to improve the quality of care. Therefore, the extrinsic risks that patients carry should be as low as possible. Ideally, quality of care performance research should give more information about the extrinsic risks rather than the intrinsic ones. Nowadays, ICU performance evaluation is becoming increasingly difficult because of the presence of an increasing variety in case mix for all the different intensive care units. Since the development of prediction mortality models in the early 1980s, physicians have tried to normalize certain ICU population differences through the use of severity of illness measurements. At the time a general outcome prediction model (GOPM) had been developed, the intrinsic risk has been adjusted in such a way that after their application in the evaluation of the quality of care performances mainly illuminate the extrinsic risk factors. Most published approaches quantifying the performance of ICUs adopt more or less the same procedures: the development of a GOPM and its calibration in a suitable database. Such models are then applied to different cohorts of ICU patients, and the comparison of the predicted number of deaths with the actual number is used as a reference for the clinical performance of the unit [20]. For more than 30 years, outcome research in critical care has been relying heavily on these risk adjustment methods (GOPM) to assess and quantify the risk of patients who are admitted to our ICUs. Using several GOPMs this methodology

has become the ‘gold standard’ to compare ICUs across different geographical areas or within a specific individual nation, or other specific subgroups. Several risk adjustment systems have been developed or have undergone an update and are used in daily practice. Hospital death rates would be particularly useful if patients and physicians could use the statistics for a given diagnosis to select a hospital that offers the best prospect of survival. If the data are only partially corrected for differences in the health status of patients, then they must be used with caution [14,39].

In the use of general outcome prediction models, several limitations should be considered.

1. Most systems give a single estimate, known as the standardized mortality ratio (SMR). A single estimate considers the performance of an ICU to be constant over the whole spectrum of the severity of illness. In other words, an ICU with a ‘good’ performance (low SMR) is assumed to be uniformly good for both low-risk and high-risk patients; likewise, an ICU with a ‘bad’ performance (high SMR) is assumed to be uniformly bad. However, this assumption is likely not true, since performance can vary not only between ICUs but also within the same unit across patients and doctors [20]. Several studies have provided conclusive evidence that the clinical performance of ICUs may vary over the spectrum of severity of illness [20,31,40-43].
2. Debate continues whether higher than predicted mortality (high SMR) is a warning about the quality of care or rather reflects a difference of case mix between hospitals [39]. Statistics purporting to measure effectiveness of care from hospital death rates should be modified to account for diversity in patient mix [39]. Only then the debate may be improved. In the past, GOPMs have been revised or even updated to newer versions to predict expected death more accurately and improve corrections for case mix differences. However, before a new GOPM version is used, many years have elapsed. Although, the newer third and fourth versions of the APACHE prognostic model have been developed many years ago [44-46], the APACHE II score is still one of the prediction models most widely used [14,47]. For critical care physicians there are three overall GOPMs for predicting overall mortality and used for performance evaluations: the APACHE model [44-46,48], the MPM system [49-51] and the SAPS model [42,43,52-54]. These scoring systems differ in the choice and the relative weight given to patient characteristics and physiological parameters [33]. Because there is no consensus which GOPM should be used, they seem to be used randomly. We have studied the accuracy of

the existing models in a single surgical cohort (the APACHE II and the SAPS 3 models seem the best suitable [with regard to discrimination and calibration] for a surgical ICU population, certainly after adjustment of the baseline risk). Nevertheless, more research needs to be done to further improve prediction models, especially for a specific group of patients.

3. There should be more consensuses in which GOPM must be used for which type of ICUs (general mixed unit, specialized unit, or even in different sub-populations). Quality of care performance evaluation should be done with the same - and ideally most reliable - outcome prediction model for each intensive care unit. Within the Netherlands, this last item has been addressed: Since the year 2008, all 61 participating ICUs in the NICE registry started using the APACHE IV prognostic model [33].

Variations in case-mix, ICU demographics, clinical and non-clinical factors not addressed by the present severity of illness scores must be quantified to improve the accuracy of future prediction models. If the variation between ICUs is important, it will impair the stability of the equations used to compute predicted mortality and preclude the use of indirect standardization in the evaluation of differences between ICUs. The models consider the relation between performance and severity of illness as constant, although performance can vary within ICUs according to the degree of severity of illness in patients [55].

Readmission to the ICU: Can we predict patients at risk for readmission?

The Quality Indicators Committee of the Society of Critical Care Medicine recommended that readmission within 48 hours is a leading performance indicator of the quality of intensive care medicine [56]. Readmitted patients are most often the sickest in the ICU; therefore, it is an unexpected and unfavourable event for the patient, which is associated with a more severe outcome [57-66]. Moreover, a strategy to reduce premature discharges in patients at high risk of in-hospital death could result in a reduction of post-ICU mortality (Daly *et al.*: 39% reduction in mortality) [67,68]. In times of great pressure on the ICU capacity, should we not be more careful in deciding which patient may be discharged and who has a greater risk of readmission? Ideally, such decisions are made on sound criteria, rather than subjective parameters. In the last 10 years several authors have proven that it is difficult to analyze and predict readmittance-risk for ICU patients in general [57-61].

We have also tried to predict the risk for readmission by using patients' characteristics over the first 24 hours of their ICU admission, but we hardly found any independent factors for the risk of readmission. Hypothetically, the risk of readmission should not be calculated/analyzed from the physiological parameters on the first admission day, since they reflect the worst possible phase of illness. ICU patients benefit most from the critical treatment during their first 24 hours and, therefore, their severity of illness score decreases from day to day until discharge. Various authors concluded that patients readmitted to the ICU had a higher severity of illness score at the time of initial ICU discharge compared to single ICU admission patients [59,60,69]. Ideally perhaps, severity of illness is scored on a daily base and discharge is initiated from these values. Unfortunately, these severity of illness scores have not been validated after the first 24 hours of ICU admission. The Sequential (Sepsis-related) Organ Failure Assessment score (SOFA score), is used to track a patient's status during the stay in an ICU (also validated to be used after 24 hours). The SOFA score is a scoring system to determine the extent of a person's organ function or rate of failure [70-73]. This particular score has been validated to predict ICU mortality [74]. Nevertheless, the possible association with readmission has not been evaluated as yet. Currently, there are hardly any systematic studies of how daily severity of illness score changes from admission to initial discharge predict ICU readmission [48,61]. Besides the severity of illness score there is an association between nursing workload and post-ICU mortality [75,76]. The Therapeutic Intervention Scoring System (TISS) has been widely applied to assess workload and resource allocation in intensive care, measuring treatment intensity [77]. Consequently, attempts have been made to use TISS scores to categorize the level of care that patients require, even to evaluate the care required after ICU discharge [78,79]. Several authors have shown an association of the TISS value of the last ICU day with post-ICU mortality [75,76,80,81], and therefore, indirectly, the association with ICU-readmission. Smith *et al*. concluded in their research that the mean TISS scores in patients readmitted to the ICU were significantly higher than in patients who did not require readmission [76]. Since a couple of years Spanish physicians have shown great interest in this topic and developed the Sabadell score system, a modification of the McCabe score [82-84]. They have validated the applicability of the Sabadell score as a system for classifying patients' ward survival at discharge from the ICU [85]. They even found an association of the Sabadell score with ICU readmission. Unfortunately, the lack of reliable predictors of ICU readmission precludes the clinical usefulness of this variable. However, this information may improve the ability to predict the readiness for discharge for individual patients and improve the efficiency of intensive care units. Would critical care physicians have more information about patients' disease-status when they use a combination of the TISS, the severity of illness score and the Sabadell score as prediction measurement for ICU discharge readiness? This value could also give an indication if the patient could be discharged to the normal ward or that he should first be admitted to a step-down unit (high dependency unit). An accuracy study of the TISS, severity of illness and the Sabadell scores to identify and weigh the specific variables for readmission, should be done in the nearby future.

Should there be a separate ICU for critically injured patients?

The contribution of organizational structure - in a wide variety of settings - for the delivery of critical care to patients has been subjected to study since the mid-1980s [86-90,91-94]. The preponderance of evidence suggests that intensivist-directed patient management is associated with a decreased length of ICU stay, decreased hospital length of stay, and most likely decreased mortality. In the last two decennia, the mixed population general ICU with a 'closed format' setting has gained in favour compared to the specialized critical care units with an 'open format' setting, especially in Europe [1,93-99]. Therefore, critical care physicians have taken responsibility for the treatment of critically ill patients, and more and more specialized units are embedded in the intensive care department. These units are subsequently transformed into overall general units with a mixed population of different diseases. Although there seems to be more positive results towards the general mixed ICU within a 'closed format' setting in the literature [1,89,91-93,100-105], we have not shown any benefit of the general mixed ICU on surgical patient outcome in this thesis. Does this mean that we have to reorganise all specialized surgical units, even if those units are already working in accordance with the 'closed format' setting? Several authors state that we should not reform all of our specialized surgical ICUs [106-110]. Over one quarter of trauma patients are cared for in an ICU during their hospital admission in the United States [111]. The care provided in this setting plays a major role in ensuring survival following injury and might significantly influence functional outcomes. Nathens *et al.* have concluded that closed ICUs with a surgeon intensivist had the best outcome in the care of the critically injured trauma patient compared with the non-surgeon intensivists [106]. Park *et al.* suggested that improved clinical outcomes and decreases in costs and length of stay are directly related to a separate closed trauma unit [107]. The American College of Surgeons Committee on Trauma (ACS COT), whose criteria is used for the verification of trauma centers, suggests that the surgeon assuming initial responsibility for the care of the injured patient should maintain that responsibility throughout the acute care phase of hospitalization, including the ICU [112]. Timing in treatment (especially re-operations in the first 48 hours) of the critically injured patient is of great importance; and who is better to understand these circumstances than the surgeon intensivist (with experience in trauma surgery)? In a perfect world, should a trauma center have the capability of a separate specialized intensive care unit for trauma patients ('closed format') next to its standard general mixed ICU? Critically injured patients requiring admission to the ICU often have multi-system injuries that require technically advanced medicine including resuscitation from shock. Trauma surgical critical care teams often consult multiple specialists to provide the complex care necessary to treat the most severely injured. It is true that this kind of advanced medicine is indeed available at each Level I trauma center general ICU. However, would the experience of highly trained personnel (trauma nurses, senior surgical residents, trauma fellows) contribute even more to a better patient outcome? With this kind of highly trained and experience personnel the possibility exists to perform small operations on the unit itself without having to wait and transport the critically injured patient to an operation theatre. To address this issue, we suggest to start a nationwide survey to analyse the critically injured patient outcome of all eleven Dutch trauma centers combined. This should give critical care physicians and surgeons specialized in trauma insight in the question whether patient outcome could gain from separate trauma units in the Netherlands or give us the conclusive information whether we should continue combining all specialized care units together.

Addressing the topics mentioned above, it is necessary to understand that more research must be done before accurate and validated indicators that measure quality of (ICU and Hospital) care are available. Reliable data can only be obtained if registration is done by dedicated, trained personnel, ideally supervised by independent observers to reduce the various forms of bias. As long as registration is done by insufficiently trained doctors and nurses who are not given time to do so, transparency will demotivate them. As mentioned before, the evaluation of quality of care aims to bring transparency for the general population (future patients), health care workers, policy makers and insurance companies. Nevertheless, the best benefit of such indicators would be the ability for health care decision makers and insurance companies to compare different hospitals. True improvement of health care is achieved by the intrinsic motivation of health care workers to do so.

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Chapter 10

Dutch summary and Future perspective

NEDERLANDSE SAMENVATTING (summary in dutch)

Intensive care unit (ICU) behandeling van chirurgische patiënten is duur en risicovol. Deze zorg kan dus alleen gerechtvaardigd worden wanneer de korte en lange termijn resultaten aanvaardbaar zijn. Outcome onderzoek richt zich op eindpunten en overleving is het primaire eindpunt van ICU-zorg. Scoringssystemen, die bedoeld zijn om ziekte-ernst te kwantificeren, worden bij individuele patiënten (op de IC en/of in het ziekenhuis) gebruikt om de a priori kans op overlijden te berekenen. Op populatieniveau geven dergelijke systemen de mogelijkheid om de kwaliteit van zorg tussen ziekenhuizen onderling te vergelijken. De laatste decennia hebben de grote ICU scoringssystemen het aantal parameters vergroot. Hierdoor is de betrouwbaarheid voor het voorspellen op sterfte in het ziekenhuis verbeterd.

In **Hoofdstuk 2** evalueren we de betrouwbaarheid van zes overlevings-predictiemodellen [APACHE II score, SAPS II, SAPS II (Expanded), SAPS 3, MPM II_0 en MPM III] in een volwassen chirurgische Intensive Care Unit (SICU; St. Elisabeth Ziekenhuis tussen 1995 en 2000; totaal 1821 patiënten) in Nederland. De APACHE II, SAPS II, SAPS 3 en MPM modellen blijken de overleving nauwkeurig te kunnen voorspellen, maar de discriminatie [oppervlakte onder de receiver operating characteristic curve (ROC AUC)] was het meest accuraat in de SAPS 3 en MPM III modellen. Het APACHE II model bleek het minst nauwkeurig. Calibratie [Hosmer-Lemeshow goodness-of-fit test en calibratie percelen] was in geen van de zes predictiesystemen adequaat. Een significante verbetering in calibratie van de APACHE II, SAPS II, SAPS II (Exp) en MPM II_0 systemen werd waargenomen na het aanpassen van de baseline risks (intercept) van elk afzonderlijk model. De calibratie van de SAPS 3 en MPM III systemen verbeterde niet, omdat deze modellen reeds een nauwkeurige voorspelling gaven in de groepen met de laagste kans op sterfte. Tevens bleek het APACHE II model betrouwbaar om patiënten met een verhoogde kans op overlijden tijdens de eerste vijf jaar na ICU ontslag te identificeren.

Behalve de sterfte op korte termijn, stelt de Society of Critical Care Medicine's Quality Indicators Committee dat heropname op een ICU binnen 48 uur na ontslag daarvan, een belangrijke indicator is voor de kwaliteit van de geleverde ICU behandeling. Tevens worden de patienten die binnen 48 uur op een ICU heropgenomen worden beschouwd als te vroeg ontslagen tijdens hun initiële ICU opname. In **Hoofdstuk 3** hebben we verschillende variabelen onderzocht die geassocieerd kunnen zijn met heropname op een chirurgische intensive care (in totaal van 1979 patiënten; enkele opname en ICU heropname gecombineerd) in hetzelfde cohort van patiënten als gebruikt in hoofdstuk 2. Daarnaast beschrijven we ook de lange termijn overleving en kwaliteit van leven (door middel van de EuroQol-6D enquête) van deze patiënten na een gemiddelde follow-up van 8 jaar. Honderdéénenveertig patiënten (7%) werden heropgenomen op de SICU. De belangrijkste oorzaken voor heropname waren respiratoire insufficiëntie gevolgd door cardiale aandoeningen. Deze patiënten waren ouder en hadden voornamelijk vasculaire of gastro-intestinale aandoeningen, bij aanvang van de eerste opname significant hogere APACHE II en SAPS 3 scores en aanzienlijk meer comorbiditeit. We vonden een associatie met heropname voor type ICU-opname (initiële), beademing en alle verschillende chirurgische classificaties (behoudens de algemene chirurgie). Hoewel de lange termijn sterfte in vergelijking met de niet-heropgenomen patiënten hoger was, bleef de kwaliteit van leven tussen beide groepen vergelijkbaar.

Korte termijn sterfte, heropname ratio en opnameduur worden beschouwd als outcome parameters van ICU zorg die de kwaliteit van zorg weerspiegelen. Recente studies hebben een associatie tussen outcome en de ICU organisatie aangetoond. **Hoofdstuk 4** beschrijft de invloed van een organisatorische verandering van een SICU (Universitair Medisch Centrum Utrecht, periode 2000-2004) en de daaropvolgende interventies en aanpassingen. Het aantal (SICU-)bedden werd gereduceerd van tien naar acht, met een overeenkomstige vermindering van de verpleegkundige formatie. In de daaropvolgende periode, culminerend in het jaar 2002, ontstonden problemen in de samenwerking tussen medisch en verplegend personeel. Ondersteund door externe bemiddelaars werd de organisatie van de SICU eind 2002 hervormd. In de studieperiode werden 1477 verschillende patiënten in 1601 opnames op deze chirurgische unit behandeld. De opname karakteristieken en gemiddelde APACHE II en TISS scores bleken gedurende de jaren niet te verschillen. In het jaar 2002 bleken de mediane ICU opnameduur (LOS) en de ruwe mortaliteit significant hoger dan tijdens de twee jaren ervoor. De aangepaste mortaliteit (ICU gestandaardiseerde mortaliteit ratio) was in 2002 ook slechter, desalniettemin, statistisch niet verschillend. Echter na de interventie (2003 en 2004) normaliseerden deze outcome parameters weer.
Over de gehele wereld, maar vooral in Europa, zijn de laatste decennia gespecialiseerde ICUs veranderd in zogenaamde general units. De opgenomen populatie is niet langer afkomstig uit een specifieke discipline, maar uit een veelheid aan poortspecialismen.

Deze ontwikkeling wordt in belangrijke mate veroorzaakt en gesteund door de transformatie van een ‘open ICU format’ naar een ‘closed ICU format’ waarin de intensive care arts de hoofdbehandelaar wordt. In de literatuur is nog steeds geen eenduidig antwoord te vinden op de vraag of deze verandering de kwaliteit van de zorg verbetert. In **Hoofdstuk 5** rapporteren we over de veranderingen in diversiteit van de opgenomen populatie en de invloed op de short-term outcome en kwaliteit van zorg indicatoren ten gevolge van de reorganisatie van een gespecialiseerd SICU naar een general ‘closed format’ ICU. In de studieperiode (2004-2007) werden in totaal 2420 patiënten opgenomen op de SICU van het Universitair Medisch Centrum Utrecht. Na de reorganisatie (eind 2005), waren patiënten gemiddeld ouder en hadden minder comorbiditeiten. De ICU opname was meer electief en de patiënten waren meer afhankelijk van beademing. De populatie veranderde van met name chirurgische patiënten naar één met grote diversiteit, voornamelijk bestaand uit cardiologische en cardiochirurgische patiënten. We zagen betere uitkomsten in alle dimensies van short-term outcome (lagere mortaliteit en LOS en minder ICU-heropnames). De totale voorspelde mortaliteit (PMR) daalde aanzienlijk. Echter de ICU gestandaardiseerde mortaliteit ratio (ICU-SMR) bleef onveranderd. Ons volledige cohort bevatte 752 chirurgische opnames. Tussen beide periodes werd geen verschil gezien in de korte termijn overleving, PMR, ICU-SMR, ICU opnameduur en de APACHE II score. De outcome van chirurgische patiënten verschilde niet tussen beide periodes wanneer de 3 ICU’s gecombineerd werden vergeleken.

Naast overleving op korte termijn streeft men ook naar een ‘goede’ patiënten outcome op de lange termijn, die idealiter nagenoeg gelijk behoort te zijn aan de normale populatie. Tot nu toe zijn de meeste studies gericht op de IC of ziekenhuis mortaliteit als de belangrijkste uitkomstmaat. In **Hoofdstuk 6** beschrijven we de lange termijn overleving van meer dan 10 jaar follow-up van hetzelfde cohort patiënten welke opgenomen is op een SICU (St. Elisabeth Ziekenhuis; 1995-2000) zoals gebruikt in de hoofdstukken 2 en 3. We onderzochten de effecten van leeftijd, geslacht en de onderliggende ziekte op de lange termijn overleving. In deze periode werden 1822 patiënten opgenomen, waarvan er 936 (51%) overleden waren na 11 jaar. Leeftijd, geslacht, APACHE II score, de noodzaak van dialyse en chirurgische classificatie bleken onafhankelijk geassocieerd met de lange termijn overleving. De kans op overlijden nam toe met de leeftijd van de patiënt. Vrouwelijke patiënten hadden een kleinere kans op sterfte. Comorbiditeiten bleken geen invloed te hebben op het lange termijn resultaat. De lange termijn sterfte in de verschillende chirurgische classificaties varieerde van 29% voor trauma patienten en 80% voor patiënten met gastro-intestinale aandoening. Het negatieve effect op de mortaliteit hield langer dan 5 jaar aan, vooral bij patiënten met een gastro-intestinale, oncologische of algemene chirurgische aandoening en bij patienten met een hoge opname leeftijd. Het sterftecijfer bleek twee maal zo hoog te zijn in vergelijking met de algemene bevolking.

Naast de kwantitatieve uitkomstmaten (percentage overleving), wordt steeds meer waarde gehecht aan de kwaliteit van levens na intensieve zorg. In **Hoofdstuk 7** worden de resultaten gepresenteerd van een onderzoek naar de kwaliteit van leven op de lange termijn (> 6 jaar) van chirurgische patiënten opgenomen op de SICU. Hierin beschrijven wij de invloed van de verschillende categorieën van chirurgische ziektebeelden op de gezondheidstoestand en worden de resultaten vergeleken met de algemene bevolking. Kwaliteit van leven werd gemeten door middel van de EuroQol-6D enquête na een gemiddelde follow-up van 8 (bereik 6-11) jaar. Van de 834 patiënten, in leven op het einde van de follow-up duur, hebben is de gezondheidstoestand van 575 (69%) patiënten gemeten. Wanneer we alle chirurgische classificaties combineren had bijna de helft van alle patiënten nog steeds last van problemen in de dimensies mobiliteit, pijn, cognitie en in het uitvoeren van dagelijkse activiteiten. Vergeleken met patiënten van eenzelfde leeftijd en geslacht van de gematchte bevolking verkeerden deze patiënten in een slechtere gezondheidstoestand. Oncologische patiënten hadden de beste en vasculaire patiënten de slechtste kwaliteit van levensscore. Trauma en vasculaire chirurgische patiënten vertoonden statistisch meer problemen in mobiliteit, zelfzorg, cognitie en in het uitvoeren van dagelijkse activiteiten.

FUTURE PERSPECTIVE in het Nederlands

De intensive care unit (ICU) is een specifieke ziekenhuisafdeling waar acuut en ernstig zieke patiënten, permanente bewaking en hooggespecialiseerde zorg krijgen. De eerste ICUs zijn ongeveer vijf decennia geleden ontwikkeld en anno 2011 vormt de ICU een essentieel deel van de ketenzorg in een ziekenhuis. De ICU kenmerkt zich door zeer arbeidsintensieve en complexe verzorging en verpleging. Bewaking en ondersteuning van met name de pulmonale en hemodynamische lichamelijke functies worden gedaan met behulp van specifieke apparatuur en medicatie. Dit maakt intensive care geneeskunde tot de duurste vorm van zorg.
Niet alleen is het budget dat kan worden besteed aan intensive care beperkt, tevens kleven vaak grote risico's aan de behandeling en is de uitkomst van zorg niet altijd even goed voorspelbaar. Daarom wordt de ICUs in toenemende mate gevraagd om inzicht te geven in de effectiviteit en efficiëntie (kosten-effectiviteit). ICUs verbruiken een aanzienlijk deel van het budget van de gezondheidszorg, goed voor maximaal 20% van de kosten van het ziekenhuis [1-6]. In 2005 werden de kosten van intensive care zorg (critical care medicine; CCM) in de Verenigde Staten geschat op $81,7 miljard, goed voor 4,1% van de nationale uitgaven voor gezondheidszorg en 0,66 van het bruto binnenlands product. De VS besteedt 15% van het bruto binnenlands product aan de gezondheidszorg (9-11% in Duitsland, Frankrijk en Canada; 7 -8% in Spanje en van het Verenigd Koninkrijk). Men verwacht dat de kosten van medische opnames en ICU zorg de komende jaren verder zullen toenemen in de 1^{e} en 2^{e} wereld [2,5,7-16]. Door de wens van de samenleving om langer te leven en de technologische vooruitgang blijft de levensverwachting in ontwikkelde landen de komende jaren toenemen. Daarnaast kenmerken deze landen zich door een dalend geboortecijfer. Beide factoren resulteren in een snel vergrijzende bevolking, waardoor de druk op de curatieve gezondheidszorg in zijn geheel en op de intensive care zorg in het bijzonder zullen toenemen.
Niet alleen in Nederland, maar ook in andere landen, streeft men naar optimalisatie van de verhouding tussen kwaliteit en kosten van zorg. Hoewel zorgprofessionals van oudsher veel tijd en energie steken in de evaluatie van hun handelen en daarmee een basis leggen voor verbetering, wordt de kwaliteit van de gezondheidszorg ook een steeds belangrijker onderwerp in het politieke debat [18,19]. In de maatschappelijke discussie ligt de focus vaak op toegankelijkheid en kostenbeheersing, dus kosten-effectiviteit van de gezondheidszorg [20]. Zo tracht de overheid middels het

gezondheids-zorgprogramma 'Zichtbare Zorg' naar een transparanter zorgstelsel te komen waarin de kwaliteit van geleverde zorg controleerbaar wordt waardoor externe partijen zoals verzekeraars selectief kunnen inkopen [21-24]. Sinds 2010 zijn artsen wettelijk verplicht om bepaalde outcome resultaten te openbaren [25-27]. Niet alleen biedt transparantie de mogelijkheid voor individuele zorgaanbieders om hun kwaliteit te verbeteren, voor benchmarking tussen instituten en voor zorgverzekeraars om redelijke kwaliteit voor redelijke kosten in te kopen, ook biedt het patiënten de mogelijkheid om op basis van openbare informatie omtrent kwaliteit te kiezen voor een bepaalde instelling (ziekenhuis en/of ICU) [28].

Zoals te verwachtten leidde de invoering van diverse programma's die transparantie beogen ook tot weerstand en twijfels [29,30]: Hoe meten we de kwaliteit van de zorg, en hoe accuraat en representatief zijn dergelijke metingen? Onderstaand benoem ik een aantal mogelijke oplossingen, die invloed kunnen hebben op de verbetering van de kwaliteit van de intensive care geneeskunde. Sommige van de besproken onderwerpen hebben in het verleden al invloed gehad op de ICU outcome. Deze items zullen echter een blijvend effect hebben op de verdere verbetering van de kwaliteit van intensive care zorg in de toekomst.

De kwaliteit van de performance van intensive care zorg indicatoren

Het doel van intensive care geneeskunde is om de hoogst haalbare kwaliteit van zorg te leveren bij ernstig zieke patiënten [31]. Dergelijke behandelingen hebben intrinsieke (ziektegerelateerde) en extrinsieke (zorggerelateerde) risico's op hetzelfde moment gedurende de opname [31,32]. Een voorbeeld van een intrinsiek risico is de ontwikkeling van sepsis bij een patiënt met infectieuze complicaties na een buikoperatie en voor het extrinsiek risico is de associatie van werklast van ICU-verpleegkundigen met mortaliteit. In toenemende mate wordt onderkend dat er grote variaties in de kwaliteit van de ICU zorg bestaan hetgeen een effect heeft op de uitkomst. Indicatoren om de kwaliteit van zorg te meten worden steeds vaker gebruikt en zijn met name toegespitst op de gezondheid van de patiënt [33]. De ontwikkeling van methoden om de prestaties van verschillende ICUs te kwantificeren zodat betrouwbare onderlinge vergelijking mogelijk wordt, is lastig gebleken. Tot op heden, is de gestandaardiseerde mortaliteit ratio (SMR) één van de meest gebruikte indicator om ICU performance te meten. De SMR is ontwikkeld in een periode dat kwaliteit van zorg uitsluitend werd geëvalueerd met behulp van primaire uitkomstmaten (korte termijn sterfte).

De betrouwbaarheid ervan als indicator voor ICU kwaliteit van de zorg is door verschillende auteurs onderzocht [32,34,35]. De SMR vergelijkt de waargenomen mortaliteit met de bijbehorende voorspelde mortaliteit.
Een patiënt in leven aan het einde van een ziekenhuis of ICU opname is echter niet langer genoeg. In toenemende mate verwacht de samenleving ook dat een patiënt in de periode na de ziekenhuis opname een zinvol leven heeft. Populair gezegd: veel mensen gaan liever dood dan dat zij als een kasplantje verder moeten leven. Om aan deze wens tegemoet te komen dient bij modellen die de kwaliteit van zorg meten ook de kwaliteit van leven van de patiënt meegewogen te worden. De gezondheidgerelateerde kwaliteit van leven (Health-related Quality of Life; HrQoL), gedefinieerd als de mate waarin de gezondheidstoestand van de patiënt van invloed is op de subjectieve beoordeling van zijn of haar tevredenheid met het leven, is een gevalideerde indicator die in deze behoefte zou kunnen voorzien [36]. Omdat SMR betrekking heeft op de korte termijn en HrQoL het lange termijn resultaat meet, zijn beide parameters complementair.

Idealiter zal de ICU performance bepaald worden door een gewogen combinatie van overleving (SMR) en gezondheidsstatus (QoL) metingen op het moment van ontslag. Tot op heden is een dergelijke combinatie van outcomemetingen nog niet gedaan, laat staan gevalideerd voor een enkele benchmark value. Dit vereist eerst nader onderzoek. Wanneer de gezondheidsstatus als prestatie-benchmark wordt gebruikt, moet gecorrigeerd worden voor de grote diversiteit in het intrinsieke risico dat patiënten kunnen hebben, de zogenaamde case mix correctie [37]. Het is de vraag of hiertoe de gemiddelde gezondheidsstatus van een bepaald cohort moet worden afgezet tegen de algemene bevolking, of dat de individuele waarde vergeleken moet worden met de individuele pre-admission score. Dit laatste zal resulteren in een meer patiëntgerichte (en dus een grotere klinisch relevante) outcome, maar ook in een veel grotere administratieve last. Een derde mogelijkheid is om dergelijke individuele QoL waarde te vergelijken met een voorspelde individuele gezondheidstoestand score.
In vele opzichten kan het nuttig zijn om de QoL van een patiënt te voorspellen na een ICU opname. Ten eerste zou deze gegevens intensive care artsen kunnen helpen om adequate informatie te verstrekken, om onrealistische verwachtingen te vermijden, en om - eventueel - al dan niet over te gaan tot of af te zien van een bepaalde behandeling. Ten tweede zou het (familieleden van) patiënten kunnen helpen om bepaalde beslissingen te nemen en zich voor te bereiden op de toekomst, bijvoorbeeld

ten aanzien van de aankomende zorg(status) van de patiënt na ontslag. Ten derde kan dergelijke informatie de samenleving helpen om inzicht te krijgen in welke ICUs patiënten een goede kans hebben op herstel. Tot slot kan het beleidsmakers en verzekeringsmaatschappijen inzicht verschaffen in de behoeften van de ICUs [37,38]. Een ander voordeel van het gebruik van QoL als een prestatie-benchmark, zou de mogelijkheid van een follow-up evaluatie van de gezondheidstatus van patiënten na ICU ontslag zijn. Het is bekend dat patiënten na ICU ontslag een verminderde QoL hebben in vergelijking met de algemene bevolking. Hoewel onze single center studie suggereert dat dit effect langdurig is, blijven de mate en periode waarin deze verminderde QoL aanhoudt onduidelijk. Een doorlopende enquête als onderdeel van de reguliere nazorg voor elke individuele patiënt, zou een ideale manier zijn om dit te onderzoeken. Tevens geeft een dergelijke follow-up de mogelijkheid om betere en adequatere nazorg op maat te leveren aan patiënten waarbij de HrQoL achter blijft. Toekomstig onderzoek zal zich moeten richten op het voorspellen van de kwaliteit van leven. Op het moment dat outcome onderzoek de korte termijn (ICU ontslag) QoL kan voorspellen van een ernstig zieke patiënt gedurende de eerste 24 uur van ICU opname, zal het artsen en beleidsmakers up-to-date en betrouwbare informatie geven over de kwaliteit van ICU zorg voor de aankomende jaren.

Outcome predictiemodellen: doorgaan op dezelfde manier?

Tal van ontwikkelingen in de intensive care geneeskunde gedurende de afgelopen decennia hebben de kwaliteit van de zorg verbeterd. De extrinsieke risico’s waaraan patiënten blootstaan worden hierdoor zo laag mogelijk gehouden. Idealiter zou prestatie onderzoek (kwaliteit van zorg) meer informatie over de extrinsieke risico’s moeten geven. De evaluatie van ICU prestaties wordt echter steeds complexer door een toename van het aantal variabelen en variëteit in case mix op alle verschillende intensive care units. Sinds de eerste ontwikkelingen van predictiemodellen voor mortaliteit in de jaren 80, hebben artsen geprobeerd om verschillen tussen ICU populaties te normaliseren door ‘ziekte ernst gradatie’ metingen te introduceren. Door de verfijning van de algemene outcome predictiemodellen (General Outcome Prediction Models; GOPM) kan steeds beter gecorrigeerd worden voor de intrinsieke risico’s, waardoor analyses die zich richten op de extrinsieke risicofactoren steeds betrouwbaarder worden. De manier waarop de meeste gepubliceerde predictiemodellen de ICU prestaties kwantificeren is min of meer identiek. Eerst wordt een GOPM model ontwikkeld en gekalibreerd in een geschikte database.

Dergelijke modellen worden vervolgens toegepast op verschillende cohorten van intensive care patiënten. Het aantal voorspelde overledenen wordt vergeleken met het werkelijk geobserveerde aantal. Deze gegevens worden gebruikt als referentie voor de klinische prestaties van een dergelijke unit [20]. Een dergelijke meetwijze is in de afgelopen decennia uitgegroeid tot de 'gouden standaard' om ICUs te vergelijken tussen verschillende geografische gebieden, of binnen specifieke landen, of zelfs binnen specifieke subgroepen. Diverse predictiemodellen zijn opnieuw ontwikkeld of hebben een update ondergaan en worden in de dagelijkse praktijk gebruikt. Ziekenhuis sterftecijfers zouden handig kunnen zijn indien patiënten en artsen deze statistieken zouden kunnen gebruiken om voor bepaalde diagnoses het ziekenhuis te selecteren dat de beste vooruitzichten op overleving biedt. Als de gegevens slechts ten dele gecorrigeerd worden voor de verschillen in de gezondheidstoestand van de patiënt, dan moeten ze met voorzichtigheid gebruikt worden [14,39].

Algemene outcome predictiemodellen hebben echter beperkingen waarmee rekening gehouden moet worden.

1. De meeste systemen geven slechts een enkele waarde/schatting (de gestandaardiseerde mortaliteit ratio SMR) die betrekking heeft over de hele populatie. Deze enkele schatting suggereert dat de prestaties van een ICU constant zijn in zowel low-risk als high-risk patiënten. Deze veronderstelling is waarschijnlijk niet correct [20,31,40-43]. Prestaties tussen bepaalde ICUs kunnen namelijk variëren, maar ook binnen een unit zijn er verschillen tussen patiënten en artsen [20].
2. Vooralsnog blijft onduidelijkheid bestaan of een hogere dan voorspelde mortaliteit (hoge SMR score) indicatief is voor de kwaliteit van de geleverde zorg of juist het verschil in case mix tussen verschillende ziekenhuizen weerspiegelt. Er wordt gesuggereerd dat meer rekening gehouden moet worden met de diversiteit in case mix voordat ziekenhuis sterftecijfers een betrouwbare maat kunnen zijn voor de kwaliteit van zorg [39]. De ontwikkeling, update en implementatie cyclus van dergelijke GOPMs kost echter vele jaren. Hoewel de 3^{e} en zelfs 4^{e} versie van het APACHE predictiemodel vele jaren geleden al ontwikkeld zijn [44-46], blijft de APACHE II score nog steeds één van de meest gebruikte predictiemodellen [14,47]. Voor de intensive care geneeskunde zijn er drie GOPMs die de verwachte mortaliteit voorspellen en al deze modellen worden gebruikt voor prestatie-evaluaties: het APACHE model [44-46,48], het MPM systeem [49-51] en het SAPS model [42,43,52-54]. Deze scoringssystemen verschillen onderling voor wat betreft

de keuze en relatieve waarde waarmee patiëntenkarakteristieken en fysiologische parameters gescoord worden [33]. Ondanks de onderlinge verschillen worden deze modellen willekeurig en naast elkaar toegepast op alle ICU patiënten. We hebben de betrouwbaarheid van deze modellen bij diverse chirurgische patiënten onderzocht (de APACHE II en de SAPS 3 modellen lijken het beste geschikt te zijn [met betrekking tot discriminatie en kalibratie] voor gebruik in een chirurgische ICU populatie, met name na de aanpassing van de baseline risico's). Niettemin is meer onderzoek nodig om (de toepasbaarheid van) deze predictiemodellen te verbeteren, vooral voor het gebruik bij specifieke patiëntengroepen.

3. Tot slot moet rekening gehouden worden met en eventueel gecorrigeerd worden voor het type ICU (general mixed, gespecialiseerde unit of zelfs in verschillende sub-populaties). Het zou mogelijk kunnen zijn dat een GOPM wel op een bepaald type ICU, maar niet op een ander toepasbaar is. Omdat kwaliteit van zorg evaluaties tussen ziekenhuizen uiteindelijk alleen kunnen plaatsvinden door het gebruik van maar één - en idealiter het meest betrouwbare - predictiemodel, dient voor het type ICU te worden gecorrigeerd. In Nederland wordt sinds 2008 het APACHE IV prognostisch model gehanteerd in de NICE-registratie, een survey waaraan alle 61 ICUs deelnemen [33].

Variaties in de case-mix, ICU demografische, klinische en niet-klinische factoren waarvoor nog niet wordt gecorrigeerd in de huidige 'ziekte ernst' risicosystemen, moeten worden toegevoegd om de betrouwbaarheid van de predictiemodellen en daarmee kwaliteitsevaluatie tussen ICUs en ziekenhuizen onderling te verbeteren. De huidige predictiemodellen vooronderstellen dat de relatie tussen performance en 'ziekte ernst' constant is, echter de prestaties kunnen variëren binnen ICUs naar gelang van 'ziekte ernst' gradatie bij patiënten [55].

Heropname op de ICU: Kunnen we het risico op ICU heropname voorspellen?

De Society of Critical Care Medicine's Quality Indicators Committee stelt dat heropname op een ICU binnen 48 uur na ontslag een belangrijke indicator is voor de kwaliteit van de geleverde ICU zorg [56]. Uit diverse studies blijken de heropgenomen patiënten de meest ernstig zieken te zijn met een slechtere outcome [57-66]. Daarnaast kan de strategie om het aantal patiënten dat 'vroegtijdig' van de ICU ontslagen wordt te verlagen, leiden tot een vermindering van post-ICU en totale ziekenhuis mortaliteit (Daly *et al.*: 39% reductie in sterfte) [67,68]. Ook in periodes met grote druk op de intensive care capaciteit, zou een patiënt naar een afdeling ontslagen moeten worden op basis van onderbouwde criteria. Het belangrijkste ontslagcriterium vooralsnog is het subjectieve gevoel van de intensive care arts. Helaas is uit meerdere onderzoeken in het recente verleden gebleken dat het moeilijk is om het risico op ICU heropname te voorspellen [57-61]. Ook wij hebben geprobeerd om dit risico te voorspellen met behulp van patiëntenkarakteristieken in de eerste 24 uur van hun ICU opname. Echter ook wij vonden nauwelijks onafhankelijke factoren die geassocieerd konden worden met het heropnamerisico. Daarnaast is het überhaupt de vraag of het risico van heropname berekend kan worden uit de fysiologische parameters gedurende de eerste opnamedag. Juist in dat etmaal maken ICU patiënten de slechtst mogelijke fase van hun ziekte door en profiteren zij het meest van de continue behandeling en bewaking. De ‘ziekte ernst’ score daalt idealiter dagelijks tot het uiteindelijke ontslag. Diverse onderzoekers zijn tot de conclusie gekomen dat de patiënten die uiteindelijk heropgenomen worden op de ICU, een hogere ‘ziekte ernst’ score hadden op het moment dat ze ontslagen werden naar de afdeling na hun initiële ICU opname in vergelijking met patiënten met maar een enkele ICU opname [59,60,69]. Mogelijk zou een dagelijkse evaluatie van de ‘ziekte ernst’ score op een dagelijkse basis zinvol zijn waarbij het ICU ontslag niet zozeer geïnitieerd kan worden op basis van de absolute waardes maar op basis van de snelheid van het gemeten herstel. Vooralsnog zijn dergelijke scores niet gevalideerd voor de periode na de eerste 24 uur van ICU opname. De Sequential (Sepsis-related) Organ Failure Assessment score (SOFA score) wordt gebruikt om een toestand van de patiënt te beoordelen en om te evalueren gedurende de ICU opname (deze score is gevalideerd om gebruikt te worden ook na 24 uur). De SOFA score is een scoringssysteem om de mate van patiënt orgaanfunctie of de mate van uitval te bepalen [70-73]. Deze score is ook gevalideerd om gebruikt te worden om de ICU mortaliteit te voorspellen [74]. Desalniettemin, een mogelijke associatie met ICU heropname is nog niet onderzocht. Momenteel zijn er nauwelijks systematische onderzoeken verricht naar hoe een dagelijkse ‘ziekte ernst’ score verandert van opname tot ontslag in relatie tot het voorspellen van ICU heropname [48,61]. Naast deze score is er ook een associatie tussen de verpleegkundige werkbelasting en de kans op overlijden in de periode na ontslag van de ICU [75,76]. Men heeft getracht de verpleegkundige werklast te kwantificeren in het zgn. Therapeutische Interventie Scoring Systeem (TISS) [77]. Deze methode wordt onder ander toegepast om de toewijzing van zorgmiddelen op de intensive care te beoordelen en te verantwoorden. Met behulp van de TISS scores is ook gepoogd om het niveau van de noodzakelijke

patiëntenzorg te categoriseren, zelfs om in kaart te brengen welke zorg er nodig is na ICU ontslag [78,79]. Verscheidene auteurs hebben aangetoond dat de TISS score op de laatste ICU dag is geassocieerd met de post-ICU mortaliteit [75,76,80,81], en daarmee indirect ook met een mogelijke ICU-heropname. Smith *et al*. concludeerden in hun onderzoek ook dat de gemiddelde TISS scores bij patiënten heropgenomen op de ICU significant hoger waren in vergelijking met patiënten waarbij geen heropname nodig was [76]. Ook een aantal Spaanse collega's heeft belangstelling voor dit onderwerp gehad en zij hebben de Sabadell score ontwikkeld [82-84]. Dit is een modificatie van een reeds bestaand scoringssysteem, de zgn. McCabe score. De Sabadell score is vervolgens gevalideerd om te kunnen dienen als systeem voor het classificeren van patiënten overlevingsrisico's op de afdeling na ICU ontslag [85]. Men vond zelfs een associatie tussen die Sabadell score en de kans op ICU heropname. Het ontbrak helaas aan betrouwbare predictiefactoren voor ICU heropname en sluit indirect de klinische bruikbaarheid van dit systeem uit. Het is echter de vraag of op basis van dergelijke informatie het risico op ICU heropname beter ingeschat kan worden en zodoende gebruikt kan worden als ontslagcriterium; laat staan dat met een dergelijk systeem de efficiëntie van de intensive care verbeterd kan worden.
Mogelijk zou een combinatie van de TISS, de 'ziekte ernst' score en de Sabadell score kunnen leiden tot een waarde waarmee de ziektestatus van een patiënt in relatie tot de timing van ICU ontslag kan worden ingeschat. Een dergelijke waarde zou ook richting kunnen geven aan het benodigde zorgniveau van de ontvangende afdeling: een algemene afdeling of een step-down unit (Medium Care unit). Hiervoor zou een uitgebreide studie naar de associatie van specifieke variabelen van de TISS, 'ziekte ernst' en de Sabadell scores met de mogelijke predictie op heropname gedaan moeten worden.

Moet er een aparte ICU opgezet worden voor ernstig gewonde (trauma-)patiënten?
Sinds de jaren '80 is het effect van wijze waarop de ICU is georganiseerd - in een breed scala aan structuren - op de geleverde intensive care zorg geëvalueerd [86-94]. Het overgrote deel van deze studies suggereert dat behandeling en management door een intensivist geassocieerd is met een kortere opnameduur (ICU en ziekenhuis) en een lagere mortaliteit. Vooral in Europa heeft de 'general ICU' met een 'mixed population' en een 'closed format' structuur de laatste twee decennia de voorkeur verkregen boven gespecialiseerde units met een 'open format' structuur [1,93-99]. Dientengevolge hebben breed opgeleide intensive care artsen de behandeling van

ernstig zieke patiënten overgenomen en zijn steeds meer gespecialiseerde units ingebed in een algemene intensive care afdeling. Deze units zijn vervolgens getransformeerd tot ‘overall general units’ met een ‘mixed population’ met een grote verscheidenheid aan allerlei ziektebeelden. Hoewel in de literatuur [1,89,91-93,100-105] voornamelijk positieve resultaten beschreven worden over dergelijke general units met een ‘closed format’ management, hebben wij geen voordeel waargenomen van de general mixed ICU op de outcome van chirurgische patiënten in dit proefschrift. Betekent dit dat we alle gespecialiseerde chirurgische units moeten reorganiseren, zelfs indien deze units reeds gestructureerd zijn in overeenstemming met de ‘closed format’ management? Verscheidene auteurs stellen dat niet alle gespecialiseerde chirurgische ICUs gereorganiseerd moeten worden [106-110]. Ruim een kwart van de trauma-patiënten wordt opgenomen op de ICU gedurende hun ziekenhuisopname in de Verenigde Staten [111]. De directe geleverde zorg op deze intensive care afdeling aan patiënten met ernstig letsel speelt een belangrijke rol bij het behalen van overleving en zou de functionele outcome kunnen beïnvloeden. Nathens *et al*. hebben geconcludeerd dat de ‘closed format’ ICU onder leiding van een chirurg-intensivist de beste resultaten behaalt in de behandeling van ernstig gewonde trauma-patiënten in vergelijking met een niet-chirurg intensivist [106]. Park *et al*. hebben gesuggereerd dat betere klinische patiëntenresultaten behaald kunnen worden (verlaging in de kosten en kortere ICU opnameduur) indien patiënten met een ernstig lichamelijk letsel opgenomen worden op een aparte, gesloten Trauma Unit [107]. Het American College of Surgeons Committee on Trauma (ACS COT), die de criteria voor level-indeling van traumacentra vaststelt, suggereert dat de chirurg primair verantwoordelijk is voor de behandeling van de gewonde patiënt in de acute zorgfase van de ziekenhuisopname, met inbegrip van de ICU [112]. Timing van de behandeling (met name re-operaties binnen de eerste 48 uur) van de trauma-patiënt is van cruciaal belang; wie is beter in staat om (de stappen in) de noodzakelijke behandeling te overzien dan de chirurg-intensivist (met uitgebreide ervaring in de traumachirurgie)? In een ideale setting, dient een traumacentrum de mogelijkheid te hebben van een aparte gespecialiseerde intensive care unit voor trauma-patiënten (‘closed format’) naast de standaard general mixed ICU. Ernstig gewonde patiënten die op de ICU opgenomen zijn hebben vaak letsels van multipele organen en/of orgaansystemen waarvoor een zeer technisch en geavanceerde behandeling noodzakelijk is, met inbegrip van resuscitatie bij shock. Intensive care teams gespecialiseerd in traumachirurgie consulteren zelfstandig meerdere specialisten om de complexe zorg in te zetten bij dergelijke ernstig gewonde patiënten. Het is waar dat dit soort geavanceerde zorg inderdaad beschikbaar is op iedere general mixed intensive care unit in elk Level I traumacentrum. Zou echter de ervaring van hoog opgeleid personeel (trauma verpleegkundigen, senior chirurgische arts-assistenten, trauma fellows) niet kunnen bijdragen tot een betere prognose van de patiënt met ernstig letsel? Met een dergelijk goed opgeleide en ervaren personele bezetting ontstaat de mogelijkheid om kleine ingrepen uit te voeren op de intensive care afdeling zelf, zonder te hoeven wachten op capaciteit van en/of transport naar een operatiekamercomplex. Om de meerwaarde van een dergelijke organisatievorm helder te krijgen dient een landelijk onderzoek te worden ingezet naar de uitkomst van zorg bij alle trauma-patiënten opgenomen op de ICUs van alle 11 Nederlandse traumacentra (gecombineerd). Alleen een dergelijk onderzoek zou antwoord kunnen geven op de vraag of trauma-patiënten beter af zijn indien zij opgenomen worden op een aparte, gespecialiseerde trauma-unit in Nederland en zal intensive care artsen en chirurgen die gespecialiseerd zijn in de traumachirurgie de doorslaggevende informatie geven of er doorgegaan moet worden met de reorganisatie van alle gespecialiseerde zorg units.

In het kader van bovenbeschreven onderwerpen, is het noodzakelijk dat verder onderzoek gedaan wordt naar accurate en gevalideerde indicatoren die de kwaliteit van de ICU- en ziekenhuiszorg transparant maken. Daarvoor zijn grootschalige registraties noodzakelijk. Dergelijke registraties leiden alleen tot betrouwbare resultaten en conclusies indien ze uitgevoerd worden door daartoe specifiek opgeleid en gemandateerd personeel om de kans op bias ("de slager die zijn eigen vlees keurt") zo laag mogelijk te houden. Zolang dergelijke registraties en evaluaties worden uitgevoerd door niet-specifiek geschoolde artsen en verpleegkundigen, die niet de tijd krijgen om dit te doen, zal de beoogde transparantie van zorg alleen leiden tot window-dressing. De evaluatie van de kwaliteit van zorg heeft tot doel duidelijkheid te scheppen voor de (toekomstige) patiënten en werknemers in de gezondheidszorg, beleidsmakers en ziektekostenverzekeraars. De beoogde transparantie zal er in het beste geval toe leiden dat instanties die benedenmaatse zorg leveren door toezichthouders, beleidsmakers of verzekeraars gedwongen worden hun activiteiten te staken. Echte verbetering van de kwaliteit van gezondheidszorg – dus het verleggen van de maat waarlangs getoetst wordt - zal alleen bereikt worden door de intrinsieke motivatie van professionals zelf om de zorg te verbeteren.

Chapter 11

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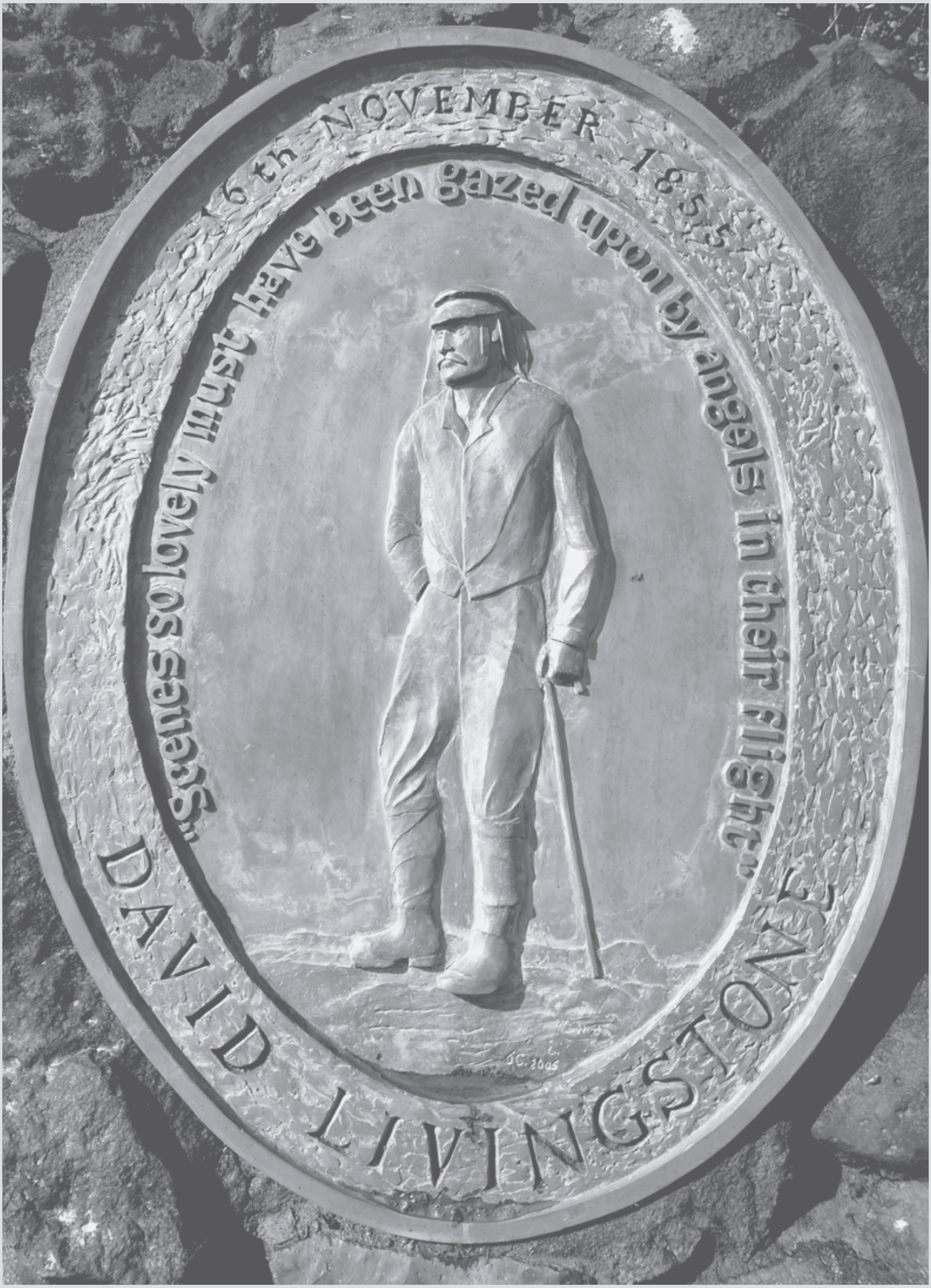
BEDANKT! BEDANKT! BEDANKT!


16 th NOVEMBER 1855
"Scenes so lovely must have been gazed upon by angels in their flight"
DAVID LIVINGSTONE

CURRICULUM VITAE AUCTORIS

Timmi Kai Timmers was born on May 27th 1981 in Utrecht, The Netherlands. In 1999, he graduated from the Gymnasium at the Blaukapel College in Utrecht. He was admitted to Utrecht University's medical school in 1999. During his rotations, he started to develop interest for surgery. For an elective in trauma surgery and emergency medicine he arranged an internship at the Chris Hani Baragwanath Hospital in Johannesburg, South Africa in 2004. During this internship, he started research under supervision of the Department of Surgery of the University Medical Center Utrecht. Eventually, he started his PhD research project under the supervision of Prof. Dr. L.P.H. Leenen (Department of Surgery, University Medical Center Utrecht), Prof. Dr. K.G.M. Moons (Department of Epidemiology, Julius Center Utrecht) and Dr. M.H.J. Verhofstad (Department of Surgery, Sint Elisabeth Hospital Tilburg) in his last year of medical school.

After graduating from medical school in 2006, he worked as an intern in the Sint Elisabeth Hospital's general surgery department Tilburg in the years 2007 until 2009 and for another two years in the Department of Surgery in the University Medical Center Utrecht (2009 and 2010). Besides the full-time function of surgical intern in both hospitals he continued working at his PhD research.

Recently, January 2011, he has started his residency in general surgery in the University Medical Center Utrecht under the supervision of Prof. Dr. I.H.M. Borel Rinkes. The last four years of his residency are scheduled at the Meander Medical Center Amersfoort under the supervision of Dr. A.J. van Overbeeke.

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