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Surgical care for the aged: a retrospective cross-sectional study of a national surgical mortality audit

Jennifer Allen,[1,2] John B North,[1] Arkadiusz Peter Wysocki,[3] Robert S Ware,[2] Therese Rey-Conde[1]

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[1]Queensland Audit of Surgical Mortality, Royal Australasian College of Surgeons, Brisbane, Queensland, Australia
[2]School of Population Health, The University of Queensland, Brisbane, Queensland, Australia
[3]Department of Surgery, Logan Hospital, Brisbane, Queensland, Australia

Correspondence to
Dr Therese Rey-Conde; Therese.Rey-Conde@surgeons.org

ABSTRACT

Objectives: It is assumed that increased age signifies increased surgical care. Few surgical studies describe the differences in care provided to older patients compared with younger patients. We aimed to examine the relationships between increasing age, preoperative factors and markers of postoperative care in adults who died in-hospital after surgery in Australia.

Design: This retrospective cross-sectional study extracted data from a national surgical mortality audit—an independent, peer-reviewed process.

Setting: From January 2009 to December 2012, 111 public and 61 private Australian hospitals notified the audit of in-hospital deaths after general anaesthetic surgery or if the patient was admitted under a surgeon.

Participants: Notified deaths totalled 19 723. We excluded deaths if patients were brain dead, younger than 17 years or never had an operation (n=11 376). From this baseline population, we divided 11 201 deaths into three patient age groups: youngest (17–64 years), medium (65–79 years) and oldest (≥80 years).

Outcome measures: Univariable and multivariable logistic regression analyses determined the relationships between increasing age and the measured preoperative factors and postoperative variables.

Results: The baseline population's median age was 78 years (IQR 66–85), 43.7% (4892/11 201) were 80 years or older and 83.4% (9319/11 173) had emergency admissions. The oldest group had increased trauma and emergency admissions than the medium and youngest age groups. Seven of the eight measured markers of postoperative care demonstrate strong and significant relationships with increasing age. The oldest group compared with the medium group had decreased rates of: unplanned returns to theatre (11.2% (526/4709) vs 20.2% (726/3586)), unplanned intensive care admissions (16.3% (545/3350) vs 24.0% (601/2504)) and treatment in intensive care units (59.7% (2689/4507) vs 76.7% (2754/3590)).

Conclusions: The oldest patients received lower levels of care than the medium and youngest age groups.

Strengths and limitations of this study

- This study benefited from using data from a large national surgical mortality audit that encompasses all surgical specialties and is multicentred.
- Data were systematically collected using a standard data tool from 90% of Australian surgeons ensuring a high level of clinical accuracy and very low numbers of loss to follow-up.
- No patient selection bias was present, as the data consisted only of surgical patients that died in-hospital and all surgical deaths are reported to the audit.
- There is a lack of knowledge of the comparator population who had surgery and survived, and therefore the results obtained may not be generalisable to the total surgical population.
- Confounding may be present due to differences in patient characteristics in the three age groups.

INTRODUCTION

Older patients generally require more surgical services relative to younger patients[1] as a consequence of the ageing process and accumulation of chronic disease.[2 3] As life expectancy and population numbers increase,[4 5] so will the requirement for elective and emergency surgical services.[1 2 6–8] But surgical care for the older patient is complex. The presence of comorbidities in older patients complicates surgical decision-making,[9] and is reported to be associated with increases in postoperative complications[10 11] due to the patients functional, physiological, psychological and social effects.[2 8 12]

There is a scarcity of data about overall surgical management in older patients. Few surgical studies[8 13] have described the differences in care provided to older patients compared with that provided to younger patients. Boumendil *et al*[8] found that elderly patients in France had fewer admissions to intensive care than younger patients. Most studies discuss technical surgical procedures on elderly patients, rather than postoperative care for this age group.[1 6]

Surgical literature is inconsistent in defining old age, with ≥65,[14] ≥75[3] and ≥80 years[8]

all being used. Old age is sometimes used as an independent predictor for surgical morbidity and mortality, but it is reported as having both minimal[15 16] and increased effect[2 10]—possibly because researchers assess the impact of chronological age in a dichotomous fashion using an arbitrary age.

This study aimed to examine the relationships between increasing age, particularly old age, preoperative factors and markers of postoperative care in adult surgical patients who died in-hospital after surgery.

To do this effectively, the audit data were divided into three age groups: youngest (17–64 years), medium (65–79 years) and oldest (≥80 years). We describe the differences in preoperative factors and postoperative care provided to these patients who died.

METHODS

This retrospective cross-sectional study analysed data collected in the Australian and New Zealand Audit of Surgical Mortality (ANZASM), between 1 January 2009 and 31 December 2012. This study covers all of Australia, which has a population of 22.9 million people.[17] During the study period, there were ~8.4 million patient separations[18] from hospital after surgery. No baseline patient population data were available for patients discharged alive from hospital after surgery. The audit data are provided by treating surgeons and 94% (4268/4540) of Australian surgeons participate in the audit.[19]

Hospitals included in the audit are teaching hospitals that perform surgery that requires an anaesthetist. The full audit process is published[20] (see online supplementary 1) and briefly described here. Hospitals report in-hospital deaths to the audit, independent of the surgeons, if patients were under the care of a surgeon at the time of death. Reported deaths also include patients palliated postoperatively either at the same hospital or an associated facility. Audit data are systematically collected using a standard data collection form (designed by surgeons) which covers all aspects of surgical care (see online supplementary 2—not for publication). The treating surgeon completes the form, which is de-identified and assessed by external peer surgeons. When required, forms were sent for secondary assessment. Some variables have minor denominator variation as not every question was always answered. Preoperative and postoperative variable answers are based on hospital medical record notes. Surgeon assessors use their professional judgement and clinical evidence when answering subjective questions on the form. Clinical incidents in the audit are defined as areas in healthcare that the surgeon believed could be improved or different; or should have been better; or adverse events.

For the analysis, cases were excluded if forms were pending from the treating surgeon and if the patient: never had surgery, had an American Society of Anaesthetists (ASA) class of VI (organ donor), was admitted for non-operative terminal care and was younger than 17 years of age. We extracted preoperative and postoperative variables from the audit database.

Preoperative variables included: patient age (categorised as youngest, 17–64 years; medium, 65–79 years; and oldest, ≥80 years), gender, type of admission (emergency or elective), the presence of one or more comorbidities, malignancy status, involvement of trauma, ASA class, patient transfer, delay in diagnosis and surgical specialty.

Postoperative markers of care variables included: fluid balance problems, unplanned return to theatre, unplanned intensive care unit (ICU) admission, treated in ICU, clinical incidents, postoperative complication, infection present at death and if retrospectively the surgeon would have done anything differently when managing the patient.

We divided the included audit data into three age groups for several reasons: the discrepant definitions of old age in the literature; our opinion that 65 years is not a true cut-off mark for old age and the biological differences found with increasing age.

Selection bias for reporting of deaths is not present, as deaths are reported independent of the surgeons. Classification bias is not present as death is an end point. Reporting bias may be present for clinical incidents (these are reported retrospectively by the surgeon) and malignancy (a result of missing data, which have been theoretically corrected using multiple imputation).

External validation of the audit data

The sensitivity of the audit reporting process was externally validated. The deaths reported to the audit were compared with the total number of postoperative mortalities in Australia using Australian Institute of Health and Welfare (AIHW) data.[21]

Ethical approval

No ethical approval was sought as ANZASM is a protected quality assurance activity under Part VC of *the Health Insurance Act 1973* (gazetted August 2011). New Zealand data are excluded in this analysis.

"According to the policy activities that constitute research at the Australian and New Zealand Audit of Surgical Mortality, this work met criteria for operational improvement activities exempt from ethics review."

Statistical analysis

We calculated ORs for each variable, comparing by age group (ie, youngest vs medium, youngest vs oldest and medium vs oldest). Summary statistics are presented as median (IQR) for continuous variables and frequency (percentage) for categorical variables. The association between continuous variables and age was calculated using the Mann-Whitney U test. The association between categorical variables and age was calculated with Fisher's exact test.

We calculated the association between age and both preoperative factors and surgical complications using

both univariable and multivariable logistic regression. In all multivariable models, gender, ASA class, type of admission and presence of malignancy were included as covariables except for the outcomes gender (where gender is excluded as a covariable), admission type (where admission type is excluded as a covariable) and presence of malignancy (where presence of malignancy is excluded as a covariable). Owing to the relatively high amount of missing data for the variable malignancy, multiple imputations using logistic regression was used to impute 20 sets of values. The covariables used in the imputation were gender, type of admission (emergency/elective), presence of comorbidities (yes/no), whether patient was transferred (yes/no) and whether diagnosis was delayed (yes/no). The univariable association between presence of malignancy and age was assessed using imputed malignancy data. In all multivariable logistic regressions, imputed malignancy data were used. For all other variables, missing items were excluded from analyses. Regression results are presented as OR and 95% CIs. Significance values were based on two-tailed tests, with $p<0.05$ considered statistically significant. We performed all analyses using SPSS V.19 (IBM, Armonk, New York, USA) and Stata V.12.1 (StataCorp, College Station, Texas, USA).

RESULTS

This Australia-wide surgical mortality audit included 61 private and 111 public teaching hospitals that notified the audit of their surgical deaths (this covered 20% of private hospitals and 99% of public teaching hospitals). Treating surgeons at the participating hospitals completed forms for their own cases, with a loss to follow-up rate of 2.4% (482 of 19 723). Seventy-five per cent (74.6%, 11 376/15 021) of the included deaths were considered to be the baseline population of which 98.5% (11 201 of 15 021) were categorised by age group. The sensitivity of the reporting process was externally validated by comparison with AIHW data and this showed a 97.6% correlation—14 659 deaths reported to AIHW compared with 15 021 in the audit. To

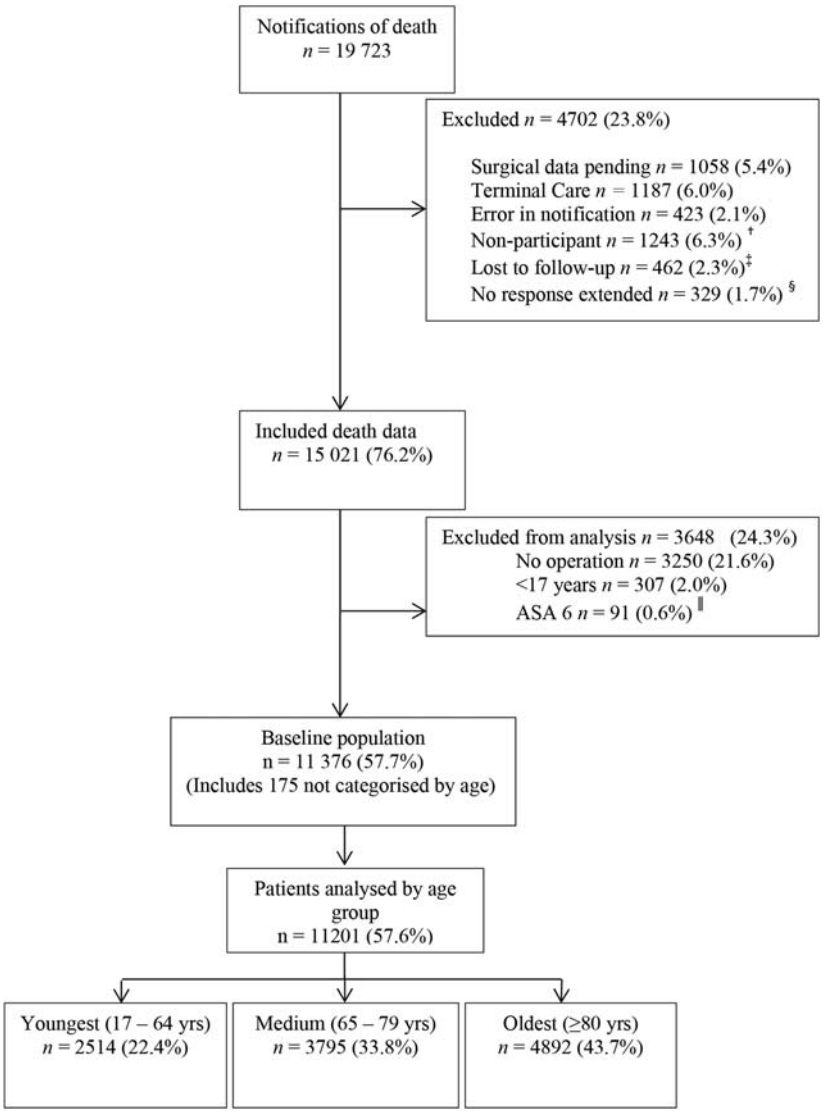

Figure 1 Flow chart of included mortality data.
†Cases from non-participating surgeons.
‡Cases not returned after 2 years from notification, despite regular reminders, were considered "lots to follow-up".
§Cases not returned, but <2 years, therefore not "lost of follow-up".
‖Patients classed as American Society of Anaesthesiologists (ASA) 6 are brain-dead.

Table 1 Patients' characteristics of the baseline population and by age group

Patient characteristics	Baseline population Number (%) (n=11 376)*	Youngest Age 17–64 Number (%) (n=2514)†	Medium Age 65–79 Number (%) (n=3795)†	Oldest Age 80+ Number (%) (n=4892)†
Median age (years) (IQR)	78.0 (66–85)	54.0 (43–60)	74.0 (69–77)	86.0 (83–90)
Sex‡				
Female	5081/11 373 (44.7)	952/2514 (37.9)	1526/3795 (40.2)	2531/4892 (51.7)
Male	6292/11 373 (55.3)	1560/2514 (62.1)	2269/3795 (59.8)	2361/4892 (48.3)
Type of admission‡				
Elective	1854/11 173 (16.6)	382/2467 (15.5)	807/3717 (21.7)	637/4822 (13.2)
Emergency	9319/11 173 (83.4)	2084/2467 (84.5)	2909/3717 (78.3)	4185/4822 (86.8)
Malignancy‡				
Malignancy not present	5255/7755 (67.8)	1220/1698 (71.8)	1588/2566 (61.9)	2301/3264 (70.5)
Malignancy present	2287/7755 (29.5)	455/1612 (28.2)	938/2493 (37.6)	882/3296 (26.8)
Malignancy unknown	213/7755 (2.8)	42/1698 (2.4)	50/2566 (1.9)	86/3264 (2.6)
ASA class‡				
1	262 (2.4)	223 (8.9)	341 (0.9)	147 (0.3)
2	886 (8.1)	219 (8.7)	319 (8.4)	264 (5.4)
3	3644 (33.4)	458 (18.2)	1203 (31.7)	1722 (35.2)
4	4889 (44.9)	978 (38.9)	1730 (45.6)	2284 (46.7)
5	1218 (11.2)	561 (22.3)	501 (13.20	592 (12.1)
Comorbidity				
Comorbidity present	9687/10 768	1774/2435	3427/3740	4801/4866
	90.0	72.9	91.6	98.7
Length of hospital stay—median days (IQR)‡	8 (3–17)	8 (3–20)	11 (5–23)	9 (4–19)
Length of time from operation to death median days (IQR)	7 (2–16)	6 (1–14)	8 (2–18)	7 (2–15)
Surgical specialty§				
General	4496/11 376 (39.5)	965/2514 (38.4)	1662/3795 (43.8)	1869/4892 (38.2)
Neurosurgery	1484/11 376 (13.0)	787/2514 (31.3)	501/3795 (13.2)	196/4892 (4.0)
Orthopaedics	2282/11 376 (20.0)	131/2514 (5.2)	429/3795 (11.3)	1722/4892 (35.2)
Cardiothoracic	699/11 376 (6.1)	214/2514 (8.5)	338/3795 (8.9)	147/4892 (3.0)

*Baseline population (includes 175 patients not categorised by age).
†Patients categorised by age.
‡Missing items (denominator variation) applicable to the baseline population: sex=3, type of admission=203, malignancy=3621, ASA=477, length of stay=3414.
§Smaller specialties not listed.
ASA, American Society of Anaesthesiologists.

demonstrate the differences in care by age, 22.4% (2514) were categorised as youngest, 33.9% (3795) as medium and 43.7% (4892) as oldest (figure 1).

Patient characteristics for the baseline population and by age group are shown in table 1. The baseline population's median age was 78 years (IQR 66–85) and less than a quarter of the patients had an elective admission. Nearly half the patients (44.9%, 4889/10 899) had a preoperative incapacitating systemic disease that posed a constant threat to life (ie, ASA4 class). Preoperatively surgeons expected 13% of the patients would die and 87% had less than expected risk of death regardless of age.

Patients in the oldest group (table 1) were more likely to be female (51.7% (2531/4892)) compared with the baseline population (44.7% (5081/11 376)) as well as the medium (37.9% (952/2514)) and youngest groups (40.2% (1526/3795)). The prevalence of comorbidities increased with increasing age (72.9% (1774/2435) vs 91.6% (3427/3740) vs 98.7% (4801/4866)). The median length of hospital stay was longest for the medium group (11 vs 9 days in the oldest and 8 days in the youngest group).

Analysed preoperative variables (table 2) demonstrated a significant influence of age on gender, emergency admission, presence of malignancy, presence of at least one or more comorbidity and whether the patient was transferred. There was no significant influence of age on evidence of trauma. Adequate discrimination and calibration of all logistic regression models was attained.

Figure 2 illustrates the trends of the analysed markers of postoperative care reported in table 3. More than 90% of these markers of care showed a statistically significant and strong relationship with increasing age. These findings were evident in both univariable and multivariable analyses. The oldest patients received less care than the medium age group. The oldest patients were less likely to have postoperative complications reported (33.6%, 1621/4824) than the middle (40.5%, 1504/3711) but more likely than the youngest age group (30.3%, 737/2433).

DISCUSSION

We found that decreased patterns of postoperative care occurred in the oldest patients when we divided the patients into three age groups. The differences in care between these groups were statistically significant.

Most of the postoperative markers of care analysed (seven of the eight) demonstrated lower levels of aggressive intervention and resource use. These interventions included admissions to intensive care, when the patients were over 80 years of age. The oldest patients were treated differently from the younger patient groups. Despite being admitted with increased incidence of trauma and more extensive comorbidities, they had fewer postoperative complications diagnosed and shorter length of hospital stay before death than the middle-aged group.

Table 2 Comparison of preoperative factors of oldest against youngest and medium age patients

	Age groups			Youngest versus medium		Youngest versus oldest		Medium versus oldest	
Preoperative factors (%)	Youngest Age 17–64 n=2514	Medium Age 65–79 n=3795	Oldest Age 80+ n=4892	Univariable OR (95% CI) p Value	Multivariable OR (95% CI) p Value	Univariable OR (95% CI) p Value	Multivariable OR (95% CI) p Value	Univariable OR (95% CI) p Value	Multivariable OR (95% CI) p Value
Female (%)	952/2514 (37.9%)	1526/3795 (40.2%)	2531/4892 (51.7%)	1.10 (0.99 to 1.22) 0.062	1.14 (1.00 to 1.31) 0.053	1.75 (1.59 to 1.94) <0.001*	1.59 (1.40 to 1.81) <0.001*	1.59 (1.46 to 1.74) <0.001*	1.39 (1.25 to 1.55) <0.001*
Emergency admission (%)	2084/2467 (84.5%)	2909/3717 (78.3%)	4185/4822 (86.8%)	0.66 (0.58 to 0.76) <0.001*	0.72 (0.60 to 0.87) <0.001*	1.20 (1.05 to 1.38) 0.007*	1.34 (1.11 to 1.61) 0.002*	1.82 (1.63 to 2.05) <0.001*	1.85 (1.59 to 2.14) <0.001*
Malignancy present (%)	455/1612 (28.2%)	938/2493 (37.6%)	882/3296 (26.8%)	1.54 (1.34 to 1.76) <0.001*	1.31 (1.14 to 1.52) <0.001*	0.93 (0.81 to 1.06) 0.275	0.85 (0.73 to 0.98) 0.025*	0.60 (0.54 to 0.68) <0.001*	0.64 (0.57 to 0.72) <0.001*
Comorbidity present (%)	1774/2435 (72.9%)	3427/3740 (91.6%)	4801/4866 (98.7%)	4.08 (3.52 to 4.72) <0.001*	3.07 (2.56 to 3.70) <0.001*	27.52 (21.21 to 35.71) <0.001*	22.05 (15.76 to 30.86) <0.001*	6.75 (5.15 to 8.84) <0.001*	6.33 (4.46 to 8.98) <0.001*
Patient transferred (%)	814/2436 (33.4%)	1070/3719 (28.8%)	1175/4833 (24.3%)	0.80 (0.72 to 0.90) <0.001*	0.89 (0.76 to 1.01) 0.075	0.64 (0.58 to 0.71) <0.001*	0.53 (0.47 to 0.61) <0.001*	0.80 (0.72 to 0.88) <0.001*	0.65 (0.58 to 0.74) <0.001*
Delay in diagnosis (%)	205/2409 (8.5%)	349/3674 (9.5%)	411/4809 (8.6%)	1.13 (0.94 to 1.35) 0.190	1.33 (1.07 to 1.65) 0.009*	1.00 (0.84 to 1.19) 0.958	0.86 (0.69 to 1.06) 0.160	0.89 (0.77 to 1.03) 0.128	0.83 (0.68 to 1.00) 0.047*
Trauma† (%)	88/371 (23.7%)	93/532 (17.5%)	252/645 (39.1%)	1.15 (0.90 to 1.48) 0.257	1.09 (0.84 to 1.43) 0.507	1.21 (0.96 to 1.53) 0.103	1.17 (0.90 to 1.51) 0.233	1.05 (0.86 to 1.29) 0.617	1.07 (0.86 to 1.33) 0.556

Reference group: the youngest age group is always the point of comparison (youngest vs medium; youngest vs oldest and medium vs oldest).
*Statistically significant (p<0.05).
†New question in data collection tool (denominators are lower).

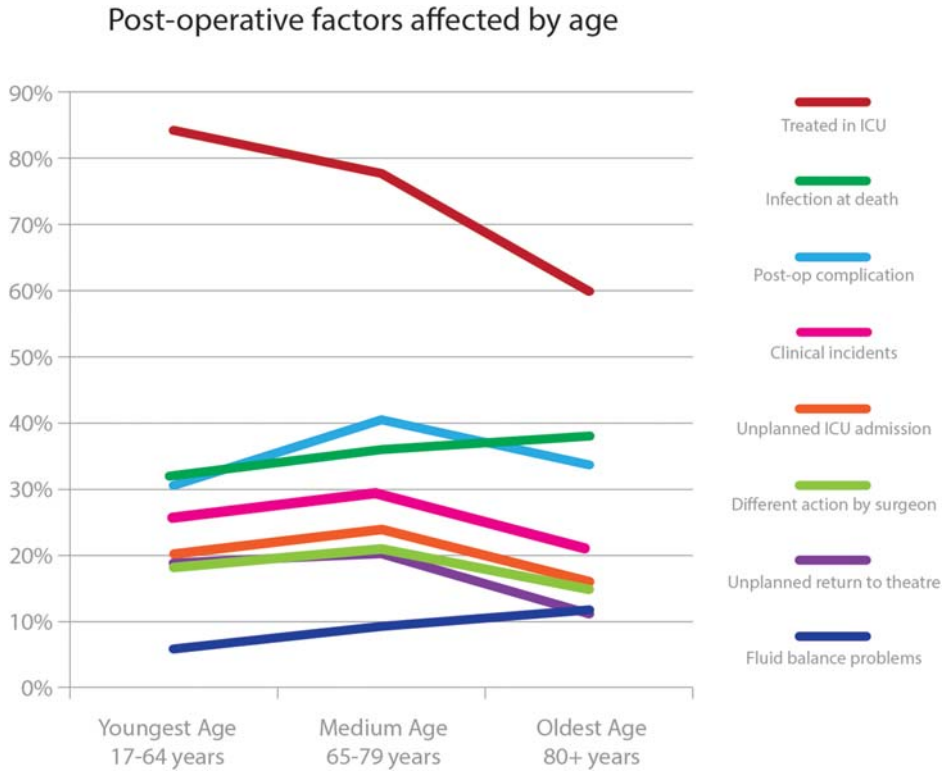

Figure 2 Trends of postoperative factors versus age (2009–2012).

The medium age group (65–79 years) died in a setting of high resource use: highest rates of interhospital transfers, postoperative complications, clinical incidents, unplanned returns to theatre, unplanned intensive care admissions and they had the longest length of hospital stay. Interestingly, this group had the lowest rate of trauma but the highest rate of malignancy, which may have influenced the decisions for ongoing aggressive treatment.

The levels of care in the youngest age group (17–64 years) parallel the levels of care in the oldest age group (80+ years); however, the level of care for both of these age groups was lower than the care given to the medium age group (65–79 years).

Only a few publications have assessed the use of postoperative intensive care for older surgical patients.[8 13 22 23] Data from the USA, National Surgical Quality Improvement Program, an oft-quoted data base, does not include ICU admission.[7 24] Our findings are similar to Boumendil *et al*[8] who reported decreased admission rates to ICU in patients 80 years and older (10% compared with 29% for patients aged 65–79 years). Recently, however, Nguyen *et al*[23] reported that the expected benefits of medical or unplanned surgical ICU admissions of patients aged 80 years and older are particularly weak and that the admission of these categories of patients to ICU is questionable. Admission to an ICU is often rationalised due to high operational costs whatever the age group,[25] and may be influenced by the presence of malignancy and its staging.[26] Because our data showed that the oldest group had the lowest prevalence of malignancy and the lowest admission to ICU, it is clear that factors other than the diagnosis influenced the decision for ICU admission.

Comorbidities in older patients are reported as being associated with increases in postoperative complications.[10 11] The management decisions with these patients may be influenced by the patients' functional, physiological, psychological and social conditions.[2 8 12] But our data showed that detection of postoperative complications was lowest in the oldest age group, despite virtually all having multiple comorbidities. Our data suggest that there may be a culture of less intensive investigation, monitoring and possible failure to intervene in the elderly group. From our data, it is difficult to determine the appropriateness of these levels of care because the study is based on after death self-reporting. Guidelines and scoring systems have been developed to ascertain the point at which 'intervention' is appropriate, that is, when surgery or aggressive intervention is futile. The use of scoring systems is rarely quoted by self-reporting surgeons in the data of this mortality audit. This suggests that such systems should be used in the mostly elderly surgical population on an everyday basis.

The greatest strength of this study is its large sample size. This ensured the robustness of the data and the ability to make broad statements concerning the findings. It encompassed all surgical specialties, is multicentred covering approximately 70% of Australian surgical hospitals—both private and public.[27] Over 90% of Australian surgeons participated[19] as part of the Continuing Professional Development Program of the Royal Australasian College of Surgeons. Data were systematically collected using a standard data tool.

Table 3 Comparison of postoperative factors of oldest against youngest and medium age patients

Postoperative factors	Age groups: Youngest Age 17–64 n=2514	Medium Age 65–79 n=3795	Oldest Age 80+ n=4892	Youngest versus medium: Univariable OR (95% CI) p Value	Multivariable OR (95% CI) p Value	Youngest versus oldest: Univariable OR (95% CI) p Value	Multivariable OR (95% CI) p Value	Medium versus oldest: Univariable OR (95% CI) p Value	Multivariable OR (95% CI) p Value
Fluid balance problems (%)	136/2308 (5.9%)	325/3543 (9.2%)	548/4654 (11.8%)	1.61 (1.31 to 1.98) <0.001*	1.53 (1.18 to 1.98) 0.001*	2.13 (1.75 to 2.59) <0.001*	1.71 (1.34 to 2.19) <0.001*	1.32 (1.14 to 1.53) <0.001*	1.12 (0.94 to 1.33) 0.218
Unplanned return to theatre (%)	439/2331 (18.8%)	726/3586 (20.2%)	526/4709 (11.2%)	1.09 (0.96 to 1.25) 0.182	1.12 (0.94 to 1.33) 0.188	0.54 (0.47 to 0.62) <0.001*	0.56 (0.47 to 0.69) <0.001*	0.50 (0.44 to 0.56) <0.001*	0.50 (0.43 to 0.58) <0.001*
Unplanned ICU admission (%)	329/1618 (20.3%)	601/2504 (24.0%)	545/3350 (16.3%)	1.24 (1.06 to 1.44) 0.006*	1.02 (0.86 to 1.21) 0.830	0.76 (0.65 to 0.89) <0.001*	0.67 (0.57 to 0.80) <0.001*	0.62 (0.54 to 0.70) <0.001*	0.66 (0.57 to 0.76) <0.001*
Treated in ICU (%)	1973/2410 (81.9%)	2754/3590 (76.7%)	2689/4507 (59.7%)	0.73 (0.64 to 0.83) <0.001*	0.73 (0.61 to 0.88) 0.001*	0.33 (0.29 to 0.37) <0.001*	0.30 (0.25 to 0.36) <0.001*	0.45 (0.41 to 0.50) <0.001*	0.41 (0.36 to 0.47) <0.001*
Different action by surgeon (%)	295/1586 (18.6%)	518/2466 (21.0%)	490/3295 (14.9%)	1.16 (0.99 to 1.36) 0.062	1.04 (0.88 to 1.24) 0.586	0.76 (0.65 to 0.90) 0.001*	0.74 (0.62 to 0.88) <0.001*	0.66 (0.57 to 0.75) <0.001*	0.71 (0.61 to 0.82) <0.001*
Clinical incidents (%)	446/1719 (26.0%)	729/2594 (28.1%)	745/3436 (21.7%)	1.12 (0.97 to 1.28) 0.119	1.04 (0.89 to 1.21) 0.603	0.79 (0.69 to 0.90) 0.001*	0.76 (0.66 to 0.89) <0.001*	0.71 (0.63 to 0.80) <0.001*	0.74 (0.65 to 0.84) <0.001*
Postoperative complication (%)	737/2433 (30.3%)	1504/3711 (40.5%)	1621/4824 (33.6%)	1.57 (1.41 to 1.75) <0.001*	1.45 (1.25 to 1.68) <0.001*	1.16 (1.05 to 1.29) 0.004*	1.16 (1.01 to 1.34) 0.037*	0.74 (0.68 to 0.81) <0.001*	0.80 (0.71 to 0.90) <0.001*
Infection present at death† (%)	155/474 (32.6%)	251/699 (35.9%)	347/935 (37.1%)	1.15 (0.90 to 1.48) 0.257	1.08 (0.82 to 1.40) 0.578	1.21 (0.96 to 1.53) 0.103	1.13 (0.88 to 1.45) 0.346	1.05 (0.86 to 1.29) 0.617	1.05 (0.85 to 1.30) 0.666

Reference group: the youngest age group is always the point of comparison (youngest vs medium; youngest vs oldest and medium vs oldest).
*Statistically significant (p<0.05).
†New question in data collection tool (denominators are lower).
ICU, intensive care unit.

No patient selection bias was present, as the cohort consisted only of surgical patients who died in-hospital, and all in-hospital surgical deaths are reported to the audit. The sensitivity of deaths reported to the audit is high and was externally validated against those reported to AIHW over the same period. Reported audit deaths were higher than the AIHW which included perioperative deaths, while the audit included all patients who died while admitted under a surgeon's care even if no operations were performed. Surgeons self-reported the data—ensuring a high level of clinical accuracy. The numbers of forms that were 'lost to follow–up' were very low. Data entry accuracy was checked and conformed to recognised criteria.[28] We addressed confounding by using multivariable analysis.

Notwithstanding the above, this study has several limitations. These include a database designed to audit in-hospital surgical deaths that was not designed for clinical research. The database allows minor denominator variation but includes in-hospital surgically related deaths only and no morbidity data. The design excludes patients who had local anaesthesia, patients who had surgery and survived, or who were subsequently transferred to an external palliation facility. Therefore, there is a lack of knowledge of the comparator population who had surgery and survived. Moreover, there were no frailty assessment scores or other mental or functional assessment modalities. Confounding may be present due to differences of patients within the surgical subspecialties. The collection of comorbidities prevalent in each surgical subspecialty was not included in the analysis. The reasons why care was given or withheld were not assessed. The variable 'detection of postoperative complications' may be subject to bias and may well be under-reported in hospitals. Reporting bias could be present due to surgeons' self-reporting, but in effect, the ANZASM process limits this, because of the random review of 14% of cases. These reviews compare the surgeons' self-reporting with hospital medical records, and discrepancies are very rare.

We should look for the explanations for our findings outside of the surgical mortality database. We postulate that in the oldest age group, care may be less aggressive, or appropriately scaled down. This may be due to expectations of poor outcome, concerns of futility of care or settings of competing comorbidities. Also perceived future quality of life issues may influence decisions by care givers, especially in the presence of malignancy, which in this data set at least 30% were missing. The surgical audit does not collect variables to test the validity of these observations.

These results need to be confirmed with future studies to determine: the treatment and admission of older surgical patients in ICUs, the prompt detection of postoperative complications in the oldest and whether the levels of intervention in the oldest are clinically appropriate. Our unexpected findings showing that the medium age group died with the highest level of care also require further study.

CONCLUSION

This national mortality audit data uniquely identified complex relationships between advancing age and postoperative care in adults who died following surgery. We showed strong decreases in resource use in the oldest group. We demonstrated a decrease in levels of postoperative care in patients 80 years or older. These findings may indicate a willingness to offer an operation on presentation, but early withdrawal of treatment if complications occur—rather than initial instigation of palliative care. As a result, surgical costs may increase at a lower rate than expected if older people continue to have fewer complex postoperative interventions.

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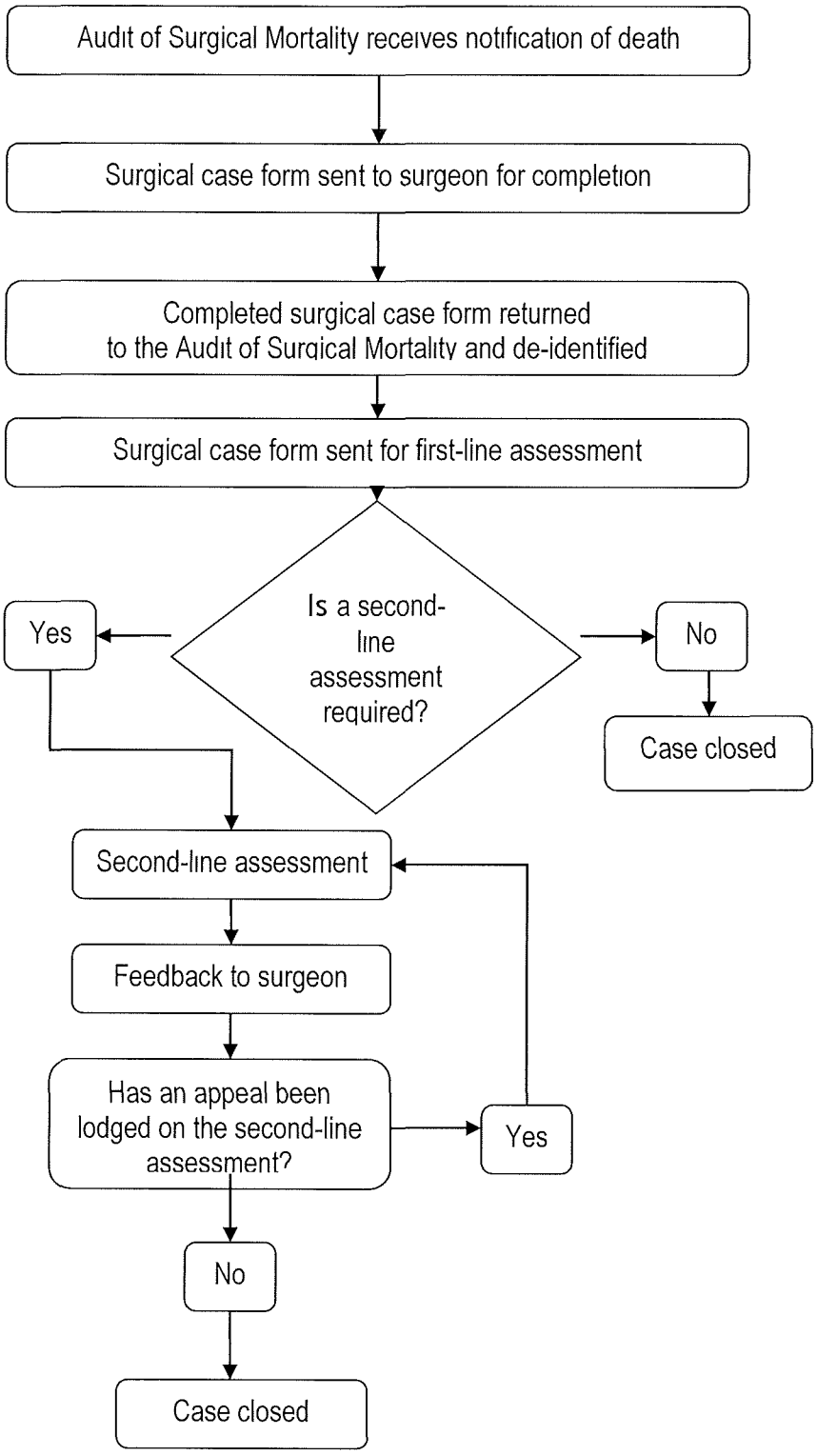
Supplement 1: Australian and New Zealand Audit of Surgical Mortality process



Surgical Case Form

Royal Australasian College of Surgeons

Important

1) Please do not destroy this form
2) Please do not copy this form
3) Please return this form to the audit office (in reply paid envelope provided)

By submitting this form to the Mortality Audit, I agree that Australian and New Zealand Audit of Surgical Mortality (ANZASM) may inform the Professional Standards Department of my involvement with the surgical mortality audit, to confirm my compliance with Continuing Professional Development (CPD) requirements.

Exclusion for terminal patients

Please complete this section for all patients

Was this patient admitted for terminal care?

- [ ] YES
- [ ] NO (please go to page 2 and complete ALL questions on this form)

Was an operation performed on this terminal patient?

- [ ] YES (please go to page 2 and complete ALL questions on this form)
- [ ] NO (this patient is EXCLUDED from the audit; do NOT complete this form.) Return this form to the audit office.

All identifiers will be removed by the Audit office on receipt of this completed form

Study ID:

Gender:

DOB:

Admission Date:

Date of Death:

Discharge Date:

Specialty:

Hospital ID:

Patient name:

UMRN:

Hospital:

Consultant surgeon:

Name of any Surgeon(s)/Trainee(s) to whom individual feedback should be sent:

Anaesthetist(s) – please name:

Study Number

1

Status of **surgeon** completing form:

- Consultant ☐
- Fellow ☐
- International Medical Graduate ☐
- SET trainee ☐
- Service Registrar ☐
- GP surgeon ☐

Specialty of consultant surgeon in charge of patient:

- General ☐
- Vascular ☐
- Urology ☐
- Neurosurgery ☐
- Orthopaedics ☐
- Otolaryngology Head and Neck ☐
- Ophthalmology ☐
- Paediatrics ☐
- Obstetrics and Gynaecology ☐
- Plastic ☐
- Oral/Maxillofacial ☐
- Cardiothoracic ☐
- Other (specifiy) ☐

.....

2

Patient **age**..... Patient **sex** Male ☐ Female ☐ Patient **admitted** by a surgeon Yes ☐ No ☐

Aboriginal/Torres Strait Islander **descent?** Yes ☐ No ☐

Admission Type	Elective ☐	Emergency ☐	
Hospital Status	Private ☐	Public ☐	Co-location ☐
Patient Status	Private ☐	Public ☐	Veteran ☐

3a

Main surgical **diagnosis** on admission *(as suspected by clinicians after initial assessment)*

Confirmed main surgical diagnosis *(taking into account test results, operations, post mortem etc)*

Final cause of **death** *(taking all information into account, including post mortem)*

3b

Was a **malignancy** present, even if not the main diagnosis? Yes ☐ No ☐ Unknown ☐

What was the nature of the malignancy? .....

Was metastatic disease present? Yes ☐ No ☐ Unknown ☐

Did malignancy contribute to death? Yes ☐ No ☐ Unknown ☐

4

Were there significant **co-existing** factors increasing risk of death? Yes ☐ No ☐
*(**Tick** all that apply)*

Cardiovascular	☐	Neurological	☐	Age	☐
Respiratory	☐	Advanced malignancy	☐	Other (specify)	☐
Renal	☐	Diabetes	☐	Other factors	
Hepatic	☐	Obesity	☐	.....	

5 **ASA Grade**

ASA 1 - A normal healthy patient ☐

ASA 2 - A patient with mild systemic disease ☐

ASA 3 – A patient with severe systemic disease which limits activity, but is not incapacitating ☐

ASA 4 – A patient with an incapacitating systemic disease that is a constant threat to life ☐

ASA 5 – A moribund patient who is not expected to survive 24 hrs, with or without an operation ☐

ASA 6 – A brain-dead patient for organ donation ☐

6 Was the patient **transferred** pre-op? Yes ☐ No ☐ Hospital transferred from.....

*If **NO**, go to Q7* Distance (km) .....

Was there a delay in transfer? Yes ☐ No ☐

Any problems with transfer? Yes ☐ No ☐

Was the transfer appropriate? Yes ☐ No ☐

Was level of care during transport appropriate? Yes ☐ No ☐

Was there sufficient clinical information? Yes ☐ No ☐

7 Was there a **pre-op delay/error** in confirmation of main surgical diagnosis? Yes ☐ No ☐
*If **NO**, go to Q8*

Was the delay associated with: GP ☐ Medical Unit ☐ Surgical Unit ☐ Other (specify) ☐

Was this due to: *(tick all that apply)* .....

Inexperience of staff ☐ Results not seen ☐

Failure to do correct test ☐ Unavoidable factors ☐

Misinterpretation of results ☐ Other (specify) ☐ .....

8a Was this patient **treated** in a critical care unit **(ICU or HDU)** during this admission? Yes ☐ (go to Q8b) No ☐ (continue)

Should this patient **have been provided critical care** in:

Intensive Care Unit (ICU)? Yes ☐ (continue) No ☐ (go to Q9)

High Dependency Unit (HDU)? Yes ☐ (continue) No ☐ (go to Q9)

Why did this patient **not receive critical care?** (tick all that apply and then go to Q9)

No ICU/ HDU bed available ☐

Admission refused by critical care staff ☐

No critical care unit in the hospital ☐

Active decision not to refer to critical care unit ☐

Not applicable ☐

8b Was the surgical team **satisfied** with the critical care unit (ICU or HDU) management of this patient? Yes ☐ (go to Q9) No ☐ (specify reasons below)

Specify.....

.....

.....

9 **Please describe the course to death (or attach report)**
(use back of form if required)

10 **Was an operation performed within 30 days of death or during the last admission?** Yes ☐ No ☐
*If **YES**, go to question 11. If **NO**: (tick as necessary)*

It was not a surgical problem ☐

Active decision not to operate ☐ → Was this a consultant's decision? Yes ☐ No ☐

Patient refused operation ☐ → Was a decision made to limit treatment? Yes ☐ No ☐

Rapid Death ☐

*If **NO** operation was performed, please go to Q19*

11 Surgeon's view (before any surgery) of overall **risk of death**

Minimal ☐ Small ☐ Moderate ☐ Considerable ☐ Expected ☐

12 Description of **operation(s)** (including relevant radiological or endoscopic procedures)

Operation (1) Date ..... /..... / ..... Start time.....:..... (24hr clock) Estimated length (hours) of operation ☐

.....

.....

.....

.....

Operation (2) Date ..... /..... / ..... Start time.....:..... (24hr clock) Estimated length (hours) of operation ☐

.....

.....

.....

.....

Operation (3) Date ..... /..... / ..... Start time.....:..... (24hr clock) Estimated length (hours) of operation ☐

.....

.....

.....

.....

13 **Timing of operation**

	1st Op	2nd Op	3rd Op
Elective	☐	☐	☐
Immediate (< 2 hours)	☐	☐	☐
Emergency (< 24 hours)	☐	☐	☐
Scheduled emergency (> 24 hours after admission)	☐	☐	☐

14

		1st Op	2nd Op	3rd Op
Was there an **anaesthetist** present at the operation?	Yes	☐	☐	☐
	No	☐	☐	☐
Was the **operation abandoned** on finding a terminal situation?	Yes	☐	☐	☐
	No	☐	☐	☐
	N/A	☐	☐	☐

15

Grades of surgeons making decisions, operating, assisting and present in theatre

	1st Op				2nd Op				3rd Op			
	Decide	Operate	Assist	In Theatre	Decide	Operate	Assist	In Theatre	Decide	Operate	Assist	In Theatre
Consultant												
Fellow												
International Medical Graduate												
SET trainee												
Service Registrar												
GP surgeon												

16

Was there a definable **post-operative** complication? Yes ☐ No ☐
*If **NO**, go to Q17*

Surgical **complications** relating to present admission *(please tick all that apply)*

Anastomotic leak ☐ site → Oesophageal ☐ Pancreas/biliary ☐ Colorectal ☐
Gastric ☐ Small Bowel ☐

Procedure related sepsis ☐ Tissue ischaemia ☐
Significant post-op bleeding ☐ Vascular graft occlusion ☐
Endoscopic perforation ☐ Other (specify) ☐

.....

.....

Was there a **delay in recognising** post-operative complications? Yes ☐ No ☐

17

Do you consider **management** could have been **improved** in the following areas?

Pre-operative management/preparation	Yes ☐	No ☐	Intra-operative/technical management of surgery	Yes ☐	No ☐
Decision to operate at all	Yes ☐	No ☐	Grade/experience of surgeon deciding	Yes ☐	No ☐
Choice of operation	Yes ☐	No ☐	Grade/experience of surgeon operating	Yes ☐	No ☐
Timing of operation *(too late, too soon, wrong time of day)*	Yes ☐	No ☐	Post operative care	Yes ☐	No ☐

18 Was there an **anaesthetic component** to this death? Yes ☐ No ☐ Possibly ☐

Was death within 48 hours of **last anaesthetic?** Yes ☐ No ☐ Don't know ☐

PLEASE COMPLETE FOR ALL PATIENTS

19 Was a **post-mortem** examination performed?

Yes – hospital ☐ Yes – coroner ☐ No ☐ Refused ☐ Unknown ☐

If Yes, have you read the PM report at the time of completing this form? Yes ☐ No ☐

If Yes, did the post mortem contribute additional information, which if known, may have changed management? Yes ☐ No ☐

If No or Refused, would you have preferred a post mortem? Yes ☐ No ☐

20 Was **DVT prophylaxis** used? Yes ☐ No ☐

*If **YES** (tick all that apply)*

Heparin (any form) ☐ Aspirin ☐ TED Stockings ☐

Warfarin ☐ Sequential compression device ☐ Other (specify) ☐

.....

*If **NO**, state reasons:* Not appropriate ☐ Active decision to withhold ☐ Not considered ☐

*and please comment on why **NOT** used* .....

.....

.....

21

An area for CONSIDERATION is where the clinician believes areas of care COULD have been IMPROVED or DIFFERENT, but recognises that it may be an area of debate.
An area of CONCERN is where the clinician believes that areas of care SHOULD have been better.
An ADVERSE EVENT is an unintended injury caused by medical management rather than by disease process, which is sufficiently serious to lead to prolonged hospitalisation or to temporary or permanent impairment or disability of the patient at the time of discharge, or which contributes to or causes death.

Were there any areas for **CONSIDERATION**, of **CONCERN** or **ADVERSE EVENTS** in the management of this patient? Yes ☐ (please describe below) No ☐ (please go to Q22)

Important: *Below please describe the 2 most significant events and list any other events.*

1. (please describe most significant event) .....

.....

Area of:	Which:	Was it preventable?	Associated with?
Consideration ☐	Made no difference to outcome ☐	Definitely ☐	Audited Surgical team ☐
Concern ☐	May have contributed to death ☐	Probably ☐	Another Clinical team ☐
Adverse event ☐	Caused death of patient who would otherwise be expected to survive ☐	Probably not ☐	Hospital ☐
		Definitely not ☐	Other (please specify) ☐
			.....

2. (please describe the second most significant event).....

.....

Consideration ☐	Made no difference to outcome ☐	Definitely ☐	Audited Surgical team ☐
Concern ☐	May have contributed to death ☐	Probably ☐	Another Clinical team ☐
Adverse event ☐	Caused death of patient who would otherwise be expected to survive ☐	Probably not ☐	Hospital ☐
		Definitely not ☐	Other (please specify) ☐
			.....

List other events .....

.....

22

Was there an **unplanned return** to theatre?	Yes ☐	No ☐	Don't know ☐
Was there an **unplanned admission** to a critical care unit?	Yes ☐	No ☐	Don't know ☐
Was there an **unplanned readmission** within 30 days of surgery?	Yes ☐	No ☐	Don't know ☐
Was **fluid balance** an issue in this case?	Yes ☐	No ☐	Don't know ☐
Was there an issue with **communication** at any stage?	Yes ☐	No ☐	Don't know ☐

If yes, describe at what stage there was an issue with communication .....

.....

.....

.....

23 Was the **antibiotic regimen** appropriate? Yes ☐ No ☐ Don't know ☐

24a Did this patient die with a **clinically-significant infection**? Yes ☐ (continue) No ☐ (go to question 25)

Was this infection acquired: before this admission ☐ (go to question 24b) or during this admission ☐ (continue)

If acquired **during** this admission, was the infection: acquired pre-operatively ☐ or a surgical-site infection ☐ or acquired post-operatively ☐ or other invasive-site infection ☐

24b Was the **infection**: ☐ pneumonia ☐ systemic infection ☐ septicaemia ☐ other

Was the infective organism identified? Yes ☐ No ☐ (go to question 25)

What was the organism? .....

25 **In retrospect, would you have done anything differently?** Yes ☐ No ☐

*If **YES**, please specify* .....

Additional comments

THANK YOU

FOR OFFICE USE

Date sent .....

Date coded / entered .....

Date sent to FLA .....

No further action ☐

Medical records requested .....

Date sent to SLA .....

Case completed .....

Date received .....

Entered by ..... Checked by .....

Date received from FLA .....

For assessment ☐

Medical records received .....

Date received from SLA .....

Coding: Yes=1, No=2, Don't know=3

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