

Supplementary Digital Content 1

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This supplementary material has been provided by the authors to give readers additional information about their work.

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Supplementary Methods: Deviations from the SAP in the statistical analysis

There were two deviations from the SAP in the final statistical analysis.

First, in the Cox regression model with interaction effects, the premedication before intervention was grouped into two categories (no premedication vs. any premedication) instead of three categories (no premedication vs. benzodiazepine vs. clonidine), as the model could not be fitted to the data otherwise.

Second, the surgical category “transplant” was combined with “other interventions” in all models, since only one patient underwent a transplant procedure.

Supplementary Table S1: Hospital characteristics

| Hospital data | | | | |
|---|-----------------------|------------------------------|-----------------------------|---------------------------------|
| | | All hospitals (n=177) | | |
| Type of hospital | All hospitals (n=177) | Tertiary hospital | Academic secondary hospital | Non-academic secondary hospital |
| Number of hospitals n (% of total) | 177 (100%) | 101 (57%) | 53 (30%) | 23 (13%) |
| Hospital beds | | | | |
| n (% of total) | 131081 (100%) | 91816 (70%) | 30889 (23.6%) | 8376 (6.4%) |
| min-max | 15-2800 | 60-2800 | 15-2398 | 116-850 |
| mean (SD) | 741 (540) | 909 (572) | 583 (440) | 364 (219) |
| median (IQR) | 650 (300-1064) | 800 (508-1268) | 500 (275-803) | 300 (200-486) |
| ICU beds | | | | |
| n (% of total) | 8075 (100%) | 5781 (71.6%) | 1814 (22.5%) | 480 (5.9%) |
| min-max | 0-295 | 5-295 | 2-140 | 0-171 |
| mean (SD) | 45 (43) | 57 (46) | 34 (28) | 21 (35) |
| median (IQR) | 35 (15 to 61) | 50 (23 to 78) | 26 (15 to 40) | 12 (8 to 20) |
| Availability of a pre-interventional geriatric care model | | | | |
| Number of hospitals n (% of total) | 35 (19.8%) | 18 (10.2%) | 11 (6.2%) | 6 (3.4%) |
| Number of pre-interventional geriatric care model beds | | | | |
| n (% of total) | 2076 (100%) | 1309 (63.1%) | 558 (26.9%) | 209 (10.1%) |
| min-max | 6-623 | 6-623 | 10-197 | 10-120 |
| mean (SD) | 59 (107) | 73 (141) | 51 (58) | 35 (42) |
| median (IQR) | 25 (16 to 55) | 35 (19 to 54) | 25 (12 to 61) | 18 (12 to 53) |
| Availability of a post-interventional geriatric care model | | | | |
| Number of hospitals n (% of total) | 38 (21.5%) | 19 (10.7%) | 13 (7.3%) | 6 (3.4%) |
| Number of post-interventional geriatric care model beds | | | | |
| n (% of total) | 1355 (100%) | 624 (46.1%) | 548 (40.4%) | 183 (13.5%) |
| min-max | 2-197 | 5-122 | 2-197 | 5-120 |
| mean (SD) | 36 (43) | 33 (34) | 42 (56) | 31 (45) |
| median (IQR) | 21 (10 to 37) | 21 (10 to 39) | 25 (12 to 46) | 12 (7 to 50) |

Supplementary Table S2: Other comorbid conditions and laboratory values

| | All patients (n = 9497) |
|---|-------------------------|
| Clinical characteristics, No. (%)^{a, b} | |
| Ascites within 30 days prior to intervention ^c | 96 (1.0%) |
| Systemic sepsis within 48 hours before intervention | 261 (2.8%) |
| Systemic inflammatory response syndrome | 143 (1.5%) |
| Sepsis | 103 (1.1%) |
| Septic shock | 15 (0.2%) |
| Ventilator depended within 48 hours before intervention | 83 (0.9%) |
| Disseminated cancer ^c | 510 (5.4%) |
| Dyspnoea ^c | 2625 (27.7%) |
| With moderate exertion | 2311 (24.4%) |
| At rest | 314 (3.3%) |
| History of severe COPD ^c | 756 (8.0%) |
| Dialysis within 2 weeks prior to surgery | 134 (1.4%) |
| Acute renal failure | 346 (3.6%) |
| Laboratory values | |
| Haemoglobin ^c , median (IQR), g/dl | 12.5 (11.1 to 13.7) |
| Haemoglobin ^c , mean (SD), g/dl | 12.3 (2.0) |
| Haematocrit ^c , median (IQR), % | 38.0 (34.0 to 41.0) |
| Haematocrit ^c , mean (SD), % | 40.0 (10.0) |
| Creatinine ^c , median (IQR), mg/dL | 1.0 (0.8 to 1.3) |
| Creatinine ^c , mean (SD), mg/dL | 1.2 (0.9) |
| Albumin ^c , median (IQR), g/dl | 3.6 (3.1 to 4.1) |
| Albumin ^c , mean (SD), g/dl | 3.6 (0.8) |

SI conversion factors: To convert haemoglobin to mmol/L, multiply values by 0.621. To convert haematocrit to L/L, multiply values by 0.01. To convert creatinine to $\mu\text{mol/L}$, multiply values by 88.4. To convert albumin to g/L, multiply values by 10.

Abbreviations: COPD=Chronic obstructive pulmonary disease; IQR=interquartile range; SD=standard deviation.

^a Percentages may not total 100 because of rounding.

^b Assessed according to the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) risk assessment.

^c Missing data: Ascites, n = 1; disseminated cancer, n = 3; dyspnoea, n = 21; history of severe COPD, n = 2; haemoglobin, n = 1863; haematocrit, n = 2564; creatinine, n = 2083; albumin, n = 7314.

Supplementary Table S3: Chronic medication of patients

| All patients (n = 9497) | |
|--|-------------|
| Chronic medication, No. (%) | |
| ACE inhibitor or ARB ^a | 4955 (52.2) |
| Beta blocker ^a | 3776 (39.8) |
| Antiplatelet therapy ^a | 3582 (37.7) |
| Anticoagulants ^a | 2470 (26.0) |
| Antidepressants ^a | 1230 (13.0) |
| Benzodiazepines ^a | 1213 (12.8) |
| Steroid use for chronic condition ^a | 564 (5.9) |
| Neuroleptics ^a | 486 (5.2) |
| Z-drugs ^{a,b} | 426 (4.5) |

Abbreviations: ACE=angiotensin-converting enzyme; ARB=angiotensin II receptor blocker.

^a Missing data: Steroid use, n=3; anticoagulants, n=6; all remaining medications, n=5. ^b Z-drugs are non-benzodiazepine hypnotics comprising zaleplon, zolpidem and zopiclone.

Supplementary Table S4: Pairwise comparisons for categorical variables of the multivariable Cox regression for all-cause mortality until day 30 (main text table 4)

| | | Model with multiply imputed data |
|--|------------------------------|---|
| Pairwise comparison | Estimated HR (95% CI) | P Value |
| Severity of intervention | NA | 0.02 |
| Major vs. Minor | 1.56 (1.05 to 2.33) | 0.03 |
| Intermediate vs. Minor | 1.18 (0.79 to 1.77) | 0.41 |
| Urgency intervention | NA | <0.001 |
| Urgent vs. Elective | 2.17 (1.66 to 2.84) | <0.001 |
| Emergency vs. Elective | 4.17 (3.09 to 5.64) | <0.001 |
| Interventional category | NA | <0.001 |
| Abdominal vs. Interventional | 1.42 (0.87 to 2.33) | 0.16 |
| Cardiovascular and thoracic vs. Non-surgical procedure | 1.20 (0.72 to 1.99) | 0.48 |
| ENT and ophthalmic vs. Non-surgical procedure | 0.35 (0.16 to 0.79) | 0.01 |
| Gynaecological and urological vs. Non-surgical procedure | 0.52 (0.28 to 0.95) | 0.03 |
| Neurosurgical vs. Non-surgical procedure | 1.84 (1.00 to 3.38) | 0.049 |
| Orthopaedic, trauma, plastic vs. Non-surgical procedure | 0.73 (0.44 to 1.20) | 0.22 |
| Other vs. Non-surgical procedure | 1.71 (0.90 to 3.26) | 0.10 |
| All surgical procedures vs. Non-surgical procedures | 0.95 (0.61 to 1.49) | 0.84 |
| Referring facility | NA | <0.001 |
| Other Hospital vs. Home (lives independent) | 3.07 (2.07 to 4.56) | <0.001 |
| Rehabilitation vs. Home (lives independent) | 0.57 (0.14 to 2.34) | 0.44 |
| Nursing home vs. Home (lives independent) | 1.59 (1.18 to 2.14) | 0.002 |
| Other vs. Home (lives independent) | 2.13 (1.46 to 3.11) | <0.001 |
| Anaesthesia technique ^a | NA | 0.28 |
| Combined vs. General | 0.87 (0.60 to 1.26) | 0.46 |
| Regional vs. General | 0.88 (0.64 to 1.20) | 0.41 |
| Sedation vs. General | 0.67 (0.42 to 1.06) | 0.08 |
| Premedication | NA | 0.017 |
| None vs. Clonidine | 1.39 (0.19 to 10.20) | 0.74 |
| None vs. Benzodiazepine | 1.71 (1.18 to 2.49) | 0.005 |

Abbreviations: CI, confidence interval; ENT, Ear, nose and throat; HR, hazard ratio; NA, not applicable; vs., versus.

^a Combined anaesthesia is defined as a combination of at least two of the three categories: general anaesthesia, sedation, or regional anaesthesia.

Supplementary Table S5: Sensitivity analyses of multivariable Cox regression for all-cause mortality until day 30

| Independent variable | Model with complete data ^a | | Model with multiply imputed data and all interactions | |
|---------------------------------------|---------------------------------------|---------|---|---------|
| | Estimated HR (95% CI) | P Value | Estimated HR (95% CI) | P Value |
| Age | 1.04 (1.01 to 1.07) | 0.002 | 1.05 (0.97 to 1.13) | 0.25 |
| Sex (male) | 1.46 (1.16 to 1.84) | 0.001 | 1.42 (1.15 to 1.76) | 0.001 |
| Severity of intervention | NA | 0.05 | NA | 0.12 |
| Major vs. Minor | 1.58 (1.01 to 2.46) | 0.04 | 1.69 (0.96 to 2.97) | 0.07 |
| Intermediate vs. Minor | 1.23 (0.79 to 1.93) | 0.36 | 1.28 (0.74 to 2.24) | 0.38 |
| Urgency intervention | NA | <0.001 | NA | <0.001 |
| Urgent vs. Elective | 2.33 (1.74 to 3.12) | <0.001 | 2.14 (1.64 to 2.81) | <0.001 |
| Emergency vs. Elective | 4.22 (3.03 to 5.88) | <.0001 | 4.15 (3.07 to 5.61) | <0.001 |
| Frailty ^b | 2.41 (1.89 to 3.07) | <0.001 | 2.59 (1.28 to 5.22) | 0.008 |
| Interventional category | NA | <0.001 | NA | <0.001 |
| Referring facility | NA | <0.001 | NA | <0.001 |
| Transfusion of plasma | 2.17 (1.38 to 3.42) | <0.001 | 2.11 (1.37 to 3.23) | <0.001 |
| Transfusion of platelets | 1.83 (0.94 to 3.57) | 0.07 | 2.12 (1.16 to 3.86) | 0.02 |
| Transfusion of red blood cells | 1.96 (1.43 to 2.70) | <0.001 | 1.93 (1.43 to 2.61) | <0.001 |
| Anaesthesia technique ^c | NA | 0.27 | NA | 0.26 |
| Multimorbidity ^d | 1.84 (1.20 to 2.81) | 0.005 | 1.87 (1.26 to 2.77) | 0.002 |
| Limited mobility TUG test | 2.26 (1.33 to 3.84) | 0.003 | 2.2 (1.24 to 3.88) | 0.007 |
| Premedication | NA | 0.08 | NA | NA |
| None vs. Clonidine | 1.19 (0.16 to 8.79) | 0.86 | NA | NA |
| None vs. Benzodiazepine | 1.57 (1.06 to 2.32) | 0.03 | NA | NA |
| No premedication before intervention | | | 3.85 (<0.0001 to 3705.97) | 0.70 |
| Age*Premedication before intervention | NA | NA | NA | 0.81 |
| Frailty*Premedication | NA | NA | NA | 0.96 |

| Independent variable | Model with complete data ^a | | Model with multiply imputed data and all interactions | |
|---|---------------------------------------|---------|---|---------|
| | Estimated HR (95% CI) | P Value | Estimated HR (95% CI) | P Value |
| before intervention | | | | |
| Anaesthesia technique*Severity intervention | NA | NA | NA | 0.26 |

Abbreviations: CI, confidence interval; HR, hazard ratio; NA, not applicable.

^a 8365 observations for model with complete data.

^b Frailty was classified as present if at least four of the following six markers were present: Mini-Cog total score of ≤ 3 points; albumin level of ≤ 33 g l⁻¹; >1 fall in the last 6 months; haematocrit level of $<35\%$; preoperative functional status is partially dependent or totally dependent; and ≥ 3 comorbidities present (according to Robinson et al.¹ and Oresanya et al.²)

^c Anaesthesia techniques were categorized in four groups as general anaesthesia, regional anaesthesia (comprising epidural, spinal and other regional), sedation, or a combination of any of the three previous categories.

^d Following the definition by the WHO 2015, multimorbidity was defined as the presence of at least two chronic conditions. We considered the following comorbidities: Diabetes mellitus, chronic renal failure, ischaemic heart disease, chronic heart failure or cardiomyopathy, hemiplegia, chronic respiratory failure, cancer, dementia, mild cognitive impairment, cardiac arrhythmia or heart blocks, peripheral vascular disease, COPD, chronic alcohol abuse, transplanted organ(s), cerebrovascular disease, other cognitive complaints, hypertension requiring medication.

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Supplementary Table S6: Pairwise comparisons for categorical variables of the multivariable Cox regression for all-cause mortality until day 30 including ICU admission variables

| | | Model with multiply imputed data |
|--|------------------------------|---|
| Pairwise comparison | Estimated HR (95% CI) | P Value |
| Severity of intervention | NA | 0.39 |
| Major vs. Minor | 1.24 (0.83 to 1.86) | 0.30 |
| Intermediate vs. Minor | 1.07 (0.72 to 1.60) | 0.74 |
| Urgency intervention | NA | <0.001 |
| Urgent vs. Elective | 2.07 (1.58 to 2.71) | <0.001 |
| Emergency vs. Elective | 3.57 (2.63 to 4.83) | <0.001 |
| Interventional category | NA | <0.001 |
| Abdominal vs. Interventional | 1.52 (0.93 to 2.48) | 0.09 |
| Cardiovascular and thoracic vs. Non-surgical procedure | 1.30 (0.78 to 2.15) | 0.31 |
| ENT and ophthalmic vs. Non-surgical procedure | 0.44 (0.19 to 0.98) | 0.045 |
| Gynaecological and urological vs. Non-surgical procedure | 0.63 (0.34 to 1.16) | 0.14 |
| Neurosurgical vs. Non-surgical procedure | 1.99 (1.09 to 3.64) | 0.025 |
| Orthopaedic, trauma, plastic vs. Non-surgical procedure | 0.92 (0.56 to 1.51) | 0.74 |
| Other vs. Non-surgical procedure | 2.09 (1.09 to 3.99) | 0.026 |
| All surgical procedures vs. Non-surgical procedures | 1.11 (0.71 to 1.74) | 0.65 |
| Referring facility | NA | <0.001 |
| Other Hospital vs. Home (lives independent) | 2.91 (1.96 to 4.32) | <0.001 |
| Rehabilitation vs. Home (lives independent) | 0.60 (0.15 to 2.46) | 0.48 |
| Nursing home vs. Home (lives independent) | 1.66 (1.23 to 2.24) | 0.001 |
| Other vs. Home (lives independent) | 2.15 (1.47 to 3.13) | <0.001 |
| ICU admission | NA | <0.001 |
| Planned ICU admission vs. no ICU admission | 1.92 (1.47 to 2.50) | <0.001 |
| Unplanned ICU admission vs. no ICU admission | 3.57 (2.38 to 5.26) | <0.001 |
| Unplanned ICU admission vs. planned ICU admission | 1.85 (1.25 to 2.78) | 0.002 |
| Anaesthesia technique ^a | NA | 0.53 |
| Combined vs. General | 0.92 (0.64 to 1.33) | 0.65 |
| Regional vs. General | 0.96 (0.70 to 1.32) | 0.82 |
| Sedation vs. General | 0.72 (0.46 to 1.14) | 0.16 |
| Premedication | NA | 0.008 |
| None vs. Clonidine | 1.37 (0.19 to 10.00) | 0.75 |
| None vs. Benzodiazepine | 1.79 (1.23 to 2.63) | 0.002 |

Abbreviations: CI, confidence interval; ENT, Ear, nose and throat; HR, hazard ratio; ICU, Intensive care unit; NA, not applicable; vs., versus.

^a Combined anaesthesia is defined as a combination of at least two of the three categories: general anaesthesia, sedation, or regional anaesthesia.

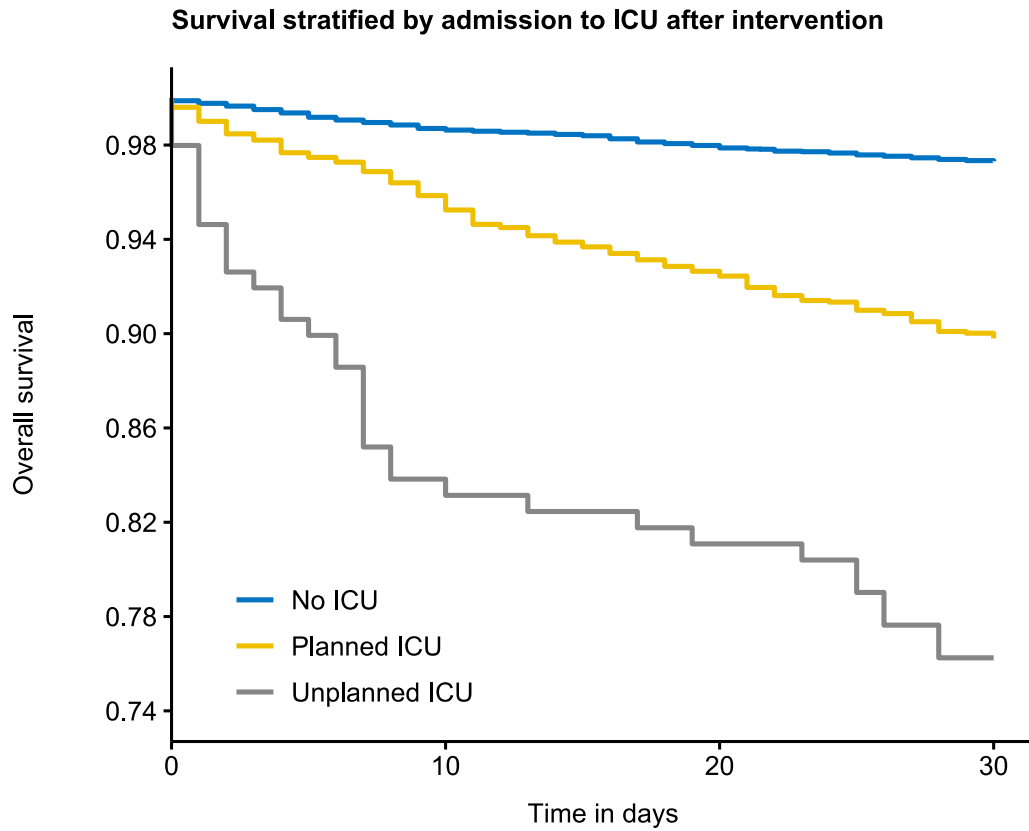
Supplementary Table S7. Cardiopulmonary resuscitation before in-hospital death

| In-hospital death before day 30 | All patients (n = 295) | Missing data (n) |
|--|-------------------------------|-------------------------|
| | No. of total (%) | |
| and CPR before in-hospital death | 118 of 295 (40.0) | 2 |
| and planned admission to ICU immediately after intervention | 124 of 295 (42.0) | 0 |
| and planned admission to ICU immediately after intervention and CPR within the hospital stay ^a | 64 of 124 (51.6) | 1 |
| and unplanned ICU admission at any time-point after intervention until day 30 | 81 of 295 (27.5) | 0 |
| and unplanned ICU admission at any time-point after intervention until day 30 and CPR within the hospital stay ^a | 37 of 81 (45.7) | 0 |
| and admission to a unit with geriatric support at any time-point after intervention until day 30 | 47 of 295 (15.9) | 0 |
| and admission to a unit with geriatric support at any time-point after intervention until day 30 and CPR within the hospital stay ^a | 7 of 47 (14.9) | 1 |

Abbreviations: CPR=cardiopulmonary resuscitation; ICU=Intensive care unit

^aCPR was performed before death but the exact time-point of CPR within 30 days after intervention is unknown. Also it is unknown whether the patient was still on this unit during death or not.

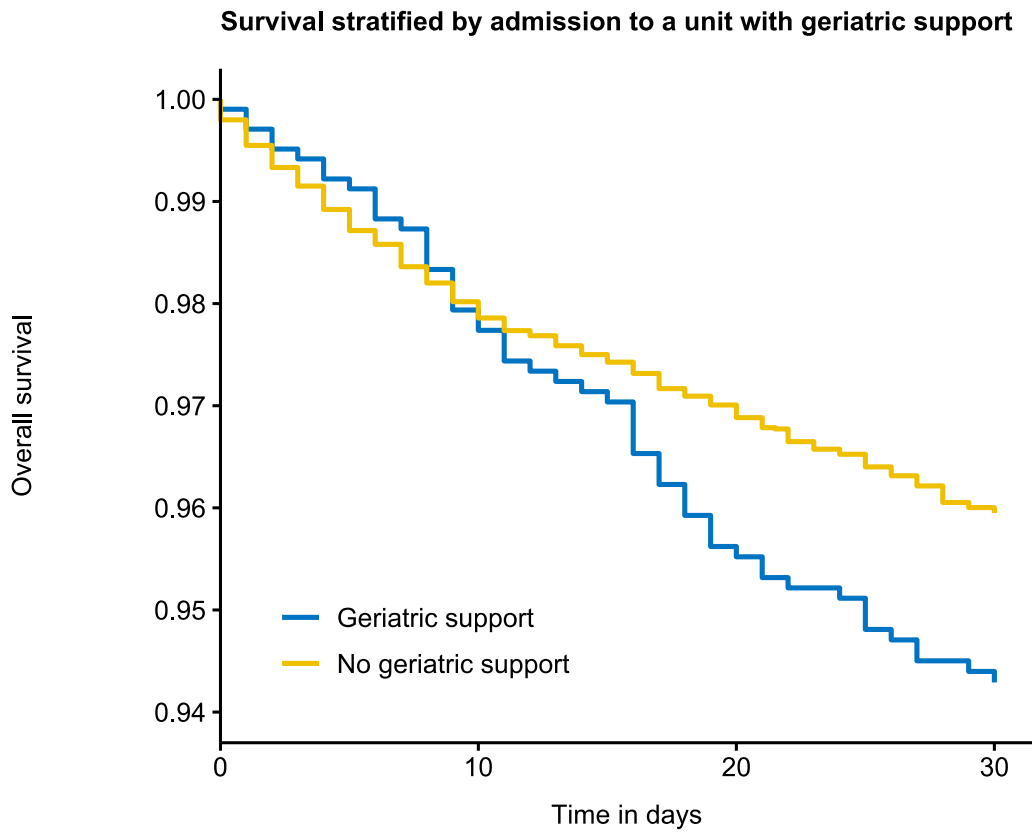
Supplementary Figure S1. Kaplan-Meier survival curves stratified by admission to ICU directly after the procedure.



| | Number at risk | | | |
|---------------|-----------------------|------|------|------|
| No ICU | 7839 | 7431 | 7328 | 6821 |
| Planned ICU | 1508 | 1414 | 1347 | 1223 |
| Unplanned ICU | 149 | 122 | 118 | 104 |

| | Cumulative number of events | | | |
|---------------|------------------------------------|-----|-----|-----|
| No ICU | 9 | 104 | 161 | 203 |
| Planned ICU | 6 | 71 | 112 | 150 |
| Unplanned ICU | 3 | 25 | 28 | 35 |

Supplementary Figure S2. Kaplan-Meier survival curves stratified by admission to a unit with geriatric support within 30 days after the procedure.



| | Number at risk | | | |
|----------------------|------------------------------------|------|------|------|
| Geriatric support | 1030 | 984 | 944 | 873 |
| No geriatric support | 8464 | 7983 | 7849 | 7276 |
| | Cumulative number of events | | | |
| Geriatric support | 1 | 23 | 45 | 57 |
| No geriatric support | 17 | 177 | 256 | 331 |