

SUPPLEMENTAL MATERIAL

Supplement to:

Association of ICU Room Characteristics with Mortality and Length of Stay

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eTable 1 Increased length of stay risk in non-survivors			
<i>Index Variables</i>	β	95% CI	<i>P</i>
Single room	1.70	0.11-3.28	0.036
High visibility room	0.04	-1.62-1.70	0.961
Distance to nurses' charting area	-0.02	-0.27-0.24	0.887
Distance to doctors' charting area	0.01	-0.15-0.18	0.860
<i>Covariates</i>			
Female sex	-0.01	-1.07-1.09	0.987
SAPS II	-0.09	-0.13-(-0.04)	< 0.001
Vasopressors	-0.86	-2.40-0.69	0.279
Mechanical ventilation	1.20	-0.06-2.45	0.062
Admission: medical (vs. surgical)	-1.46	-2.99-0.06	0.059

β = regression coefficient; CI = confidence interval; SAPS II = Simplified Acute Physiology Score II

eTable 2 Mortality and length of stay risk assessments excluding cases in shared rooms that never had a roommate during their ICU stay

Mortality

<i>Index variables</i>	<i>HR</i>	<i>95% CI</i>	<i>P</i>
Single room	0.95	0.78-1.16	0.641
High visibility room	1.06	0.86-1.30	0.602
Distance to nurses' charting area	1.02	0.98-1.05	0.357
Distance to doctors' charting area	0.99	0.97-1.01	0.206
Covariates			
Female sex	0.85	0.74-0.97	0.018
SAPS II	1.05	1.04-1.05	< 0.001
Vasopressors	1.58	1.30-1.93	< 0.001
Mechanical ventilation	1.03	0.88-1.21	0.712
Admission: medical (vs. surgical)	1.37	1.12-1.67	0.002

Length of stay (survivors)

<i>Index variables</i>	<i>β</i>	<i>95% CI</i>	<i>P</i>
Single room	0.22	-0.63-1.08	0.610
High visibility room	-0.02	-0.91-0.88	0.973
Distance to nurses' charting area	0.00	-0.14-0.14	0.995
Distance to doctors' charting area	0.02	-0.07-0.11	0.684
Covariates			
Female sex	0.76	0.17-1.34	0.012
SAPS II	0.06	0.03-0.08	< 0.001
Vasopressors	1.97	1.25-2.69	< 0.001
Mechanical ventilation	3.12	2.41-3.83	< 0.001
Admission: medical (vs. surgical)	-1.77	-2.65-(-0.89)	< 0.001

HR = hazard ratio; CI = confidence interval; SAPS II = Simplified Acute Physiology Score II; β = regression coefficient

eTable 3 Sensitivity analyses according to type of ventilation

Mortality risk	No ventilation			Non-invasive ventilation			Mechanical ventilation		
Index Variables	HR	95% CI	P	HR	95% CI	P	HR	95% CI	P
Single room	0.96	0.56-1.65	0.887	1.11	0.68-1.81	0.678	0.83	0.66-1.03	0.087
High visibility room	0.77	0.43-1.40	0.393	1.20	0.73-1.98	0.470	1.10	0.87-1.40	0.425
Distance to nurses' charting area	1.01	0.93-1.09	0.911	1.07	0.98-1.15	0.123	1.00	0.96-1.04	0.956
Distance to doctors' charting area	0.97	0.92-1.01	0.149	0.96	0.92-1.00	0.072	1.00	0.98-1.02	0.993
Covariates									
Female sex (vs. male)	0.81	0.55-1.18	0.268	0.76	0.55-1.05	0.102	0.92	0.79-1.06	0.262
SAPS II	1.04	1.03-1.05	< 0.001	1.05	1.04-1.06	< 0.001	1.04	1.04-1.05	< 0.001
Vasopressors	2.09	1.41-3.08	< 0.001	1.75	1.23-2.49	0.002	1.27	0.97-1.66	0.082
Admission: medical (vs. surgical)	2.70	1.49-4.90	0.001	1.21	0.74-1.98	0.458	1.23	0.99-1.54	0.063
Increased length of stay risk	No ventilation			Non-invasive ventilation			Mechanical ventilation		
Index Variables	β	95% CI	P	β	95% CI	P	β	95% CI	P
Single room	0.30	-0.47-1.06	0.451	2.29	-0.45-5.03	0.101	0.75	-0.68-2.18	0.306
High visibility room	0.31	-0.52-1.13	0.468	0.44	-2.34-3.21	0.758	-0.53	-2.11-1.04	0.508
Distance to nurses' charting area	0.04	-0.09-0.16	0.575	-0.16	-0.61-0.30	0.497	0.09	-0.18-0.35	0.523
Distance to doctors' charting area	-0.01	-0.08-0.06	0.796	0.11	-0.16-0.38	0.408	-0.01	-0.18-0.16	0.891
Covariates									
Female sex (vs. male)	0.35	-0.19-0.88	0.207	1.06	-0.78-2.90	0.259	1.03	0.05-2.01	0.040
SAPS II	0.06	0.04-0.08	< 0.001	0.01	-0.07-0.09	0.785	0.04	0.00-0.08	0.076
Vasopressors	0.95	0.26-1.65	0.007	2.02	-0.02-4.06	0.053	2.45	1.25-3.65	< 0.001
Admission: medical (vs. surgical)	-2.44	-3.22-(-1.67)	< 0.001	-1.17	-4.00-1.65	0.415	-0.53	-1.99-0.94	0.481

HR = hazard ratio; CI = confidence interval; SAPS II = Simplified Acute Physiology Score II; β = regression coefficient

eTable 4 Sensitivity analyses according to admission to medical vs. surgical ICU

Mortality	Medical			Surgical		
Index Variables	HR	95% CI	P	HR	95% CI	P
Single room	0.82	0.63-1.07	0.142	0.71	0.43 -1.17	0.174
High visibility room	0.92	0.70-1.23	0.581	2.12	1.07-4.21	0.032
Distance to nurses' charting area	1.01	0.97-1.05	0.678	0.96	0.79-1.17	0.693
Distance to doctors' charting area	0.99	0.97-1.01	0.164	1.09	0.92-1.29	0.343
Covariates						
Female sex	0.79	0.66-0.94	0.009	1.04	0.86-1.27	0.643
SAPS II	1.04	1.04-1.05	< 0.001	1.05	1.04-1.05	< 0.001
Vasopressors	1.59	1.25-2.01	< 0.001	1.68	1.20-2.36	0.003
Mechanical ventilation	1.01	0.83-1.23	0.934	1.21	0.94-1.56	0.143
Length of stay (survivors)						
Index Variables	β	95% CI	P	β	95% CI	P
Single room	0.93	-0.06-1.91	0.065	0.30	-1.45-2.05	0.737
High visibility room	0.20	-0.84-1.23	0.711	-0.54	-3.64-2.56	0.734
Distance to nurses' charting area	0.06	-0.09-0.21	0.439	0.44	-0.48-1.36	0.349
Distance to doctors' charting area	0.02	-0.06-0.09	0.619	-0.32	-1.17-0.52	0.453
Covariates						
	0.46	-0.20-1.13	0.169	1.04	0.13-1.94	0.024
SAPS II	0.06	0.03-0.09	< 0.001	0.04	0.00-0.08	0.040
Vasopressors	2.15	1.28-3.02	< 0.001	1.27	0.24-2.30	0.016
Mechanical ventilation	3.34	2.49-4.20	< 0.001	2.88	1.86-3.89	< 0.001

HR = hazard ratio; CI = confidence interval; β = regression coefficient; SAPS II = Simplified Acute Physiology Score II; β = regression coefficient

Information on institutional and regulatory conditions

"Nurse and physician training in Germany"

In Germany, ICU nurse training starts with the three-year general nursing qualification and is followed by a specialized intensive care and anesthesia education program that typically lasts about 2 years and includes both classroom and practical clinical training.

Medical doctors complete a five-year university medical program followed by a one year of practical hospital training. After final exams, the medical license is achieved. Postgraduate specialty training is then entered as resident physician, which typically lasts 5 years for both internal medicine and anesthesiology. During this time, they train under supervision and must meet defined procedural and clinical requirements set by regional medical chambers. Board certification for the respective specialty is achieved by completion of an exam after the training period is completed. For subspecialty qualifications such as intensive care medicine, an additional training of 1,5 years is needed before board certification can be earned.

ICU staffing and charting areas

*National requirements for nurse-to-patient ratios are set by the government: in adult intensive care units generally 1 nurse is required per 2 patients in day shifts and 1 nurse per 3 patients in night shifts. To ensure that these requirements are met in our facility, the nursing staff of all four participating ICUs is centrally coordinated to compensate for any absences. Every patient room of the included ICUs features a digital workstation where electronic files can be reviewed and documentation can be completed; these workplaces are shared by nurses and doctors. Nurses' dedicated digital workstations outside of patient rooms are labeled as nurses' charting area, see **Figure 1**. All nurses' charting areas are equipped with telemetry monitors that transfer recorded vital signs and corresponding alarms.*

Uninterrupted presence of at least one medical trainee (resident physician post-graduate years 2 to 5) per ICU is guaranteed by a 3-shift system on all ICUs included in this analysis, their workstations are located in the room labeled doctor's office. For each of the ICUs, a board-certified intensivist conducts daily rounds together with residents. Anytime outside of these hours, at least one intensivist is available on call for the two medical ICUs and one for the two surgical ICUs.

Separate charting areas for nurses and doctors reflect differences in workflow, with nurses typically requiring closer proximity to patients for monitoring, whereas physicians typically use more centralized or collaborative workspaces for episodic documentation and decision-making. However, clinical workflows at the ICU are dynamic and both nurses using the doctors' charting area and vice versa happen frequently. The separate analysis for this study is thus also due to the fact that one charting area has direct line of sight to patients' rooms while the other does not. Labelling of the charting areas refers to the intended (and most common) use of the individual charting areas"

Institutional acute care system and ICU allocation

The acute care system at Mannheim University Hospital is structured in such a way that patients with acute critical illnesses are initially treated in the emergency department. After initial diagnostics and treatment, they are then transferred to one of the four intensive care units. As a rule, this distribution is based on the specialist expertise required for the respective disease. In exceptional cases, due to capacity reasons, patients may be admitted to one of the other intensive care units instead of the one originally intended, as there are no intensive care beds within the emergency department and transfer to an intensive care unit without significant delay may then take precedence over specialist assignment. This decision is coordinated by a medical professional who is aware of the occupancy rates of all intensive care units in the hospital, in consultation with the doctors in the emergency departments and the wards involved. If necessary and possible, the patient may be transferred to the originally intended intensive care unit during their further stay in intensive care.

Room allocation at the ICU

Room allocation in the designated ICU is then carried out in consultation with the nursing staff and doctors on duty there. This decision is guided by availability and general considerations. There are no concrete institutional standards or specified rules on any of the included ICUs. An exemption of this was that during some episodes of the COVID pandemic, nurses were assigned to care only for COVID or non-COVID patients, when both conditions were treated on the same ICU. During these episodes, patients suffering from COVID were usually assigned to the single rooms at the back of the ward in an attempt to decrease crossing of pathways of COVID and non-COVID nurses and thus reduce the risk of infection for non-COVID patients.

Otherwise, while for patients with need for isolation single rooms are the only option, patients without the need for isolation can be assigned to a single or shared room. If more than one room is available, the decision can be multifaceted and is based on the shared general or situation-specific considerations by the staff on duty. For example, if additional devices (i.e. ventilation, renal replacement therapy, ECMO, etc.) are needed, a larger room (see floor plan, **Figure 1**) may be preferred. This could lead to the choice of a shared room, when spaces between beds allow for placement of devices. Patients with increased need of staff presence (i.e. current or previous cardiopulmonary resuscitation, noninvasive ventilation, patients with hyperactive delirium) may be assigned to rooms with increased visibility and/or proximity to nurses' and doctors' charting areas.

Intensive and intermediate care units

The two medical ICUs care for patients with any internal and neurological conditions requiring monitoring or treatment that exceeds the limits of acute care wards with telemetry or the stroke unit. There were no medical intermediate care units at our institution during the investigated period. The two surgical ICUs mainly care for patients following complex surgery, with severe infections, severe acute respiratory distress syndrome (including requiring veno-venous ECMO), or multiple trauma following accidents. Any surgical patients requiring monitoring but without need for vasopressor therapy, ventilation (including non-invasive ventilation) or altered mental status are usually admitted to the intermediate care units that were not included in this analysis.

Acute care wards

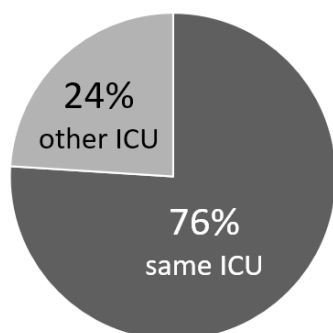
Acute care wards at our institution primarily consist of 2 and 4 bed rooms, with only 1 to 2 single bed rooms per 30 patients. For isolation purposes, a single patient may be accommodated in a 2 bed room in acute care wards, or cohort isolation may be performed.

Cardiac surgery patients

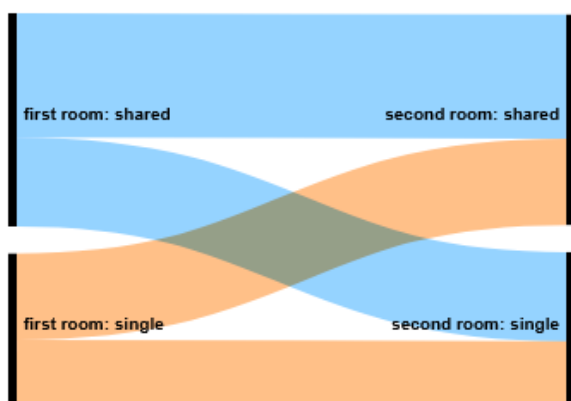
Departments for abdominal, thoracic, vascular, head/neck, gynecologic, urologic, and orthopedic surgery are located at our institution. There is, however, no department of cardiac surgery at our institution. Patients requiring cardiac surgery can be immediately transferred to one of the two centers that are available within a 20 km radius of our institution.”

Descriptive analyses of cases excluded due to room change

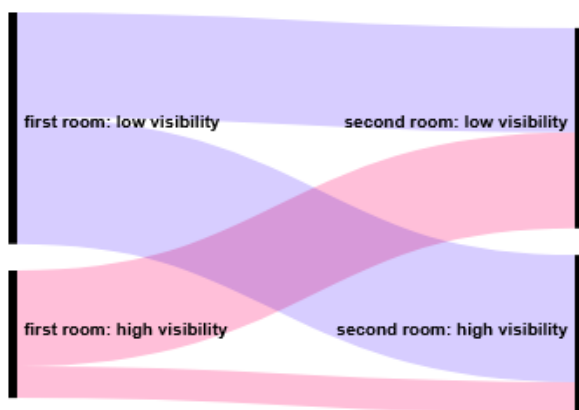
Of the 1,532 cases that were excluded due to room change, 24% (n = 376) changed beds due to a transfer to another ICU at the same institution, see **eFigure 1**. Out of the 76% (n = 1156) that changed rooms on the same ICU, transfer data are displayed in **eFigures 2** and **3**.



eFigure 1 Room change ICU destination.



eFigure 2 Changes from and to single and shared rooms



eFigure 3 Changes from and to high and low visibility rooms