ОБЩЕСТВЕНИ КОМУНИКАЦИИ И ИНФОРМАЦИОННИ НАУКИ
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ORGANIZATION AND MANAGEMENT OF INFORMATION BETWEEN SURGICAL CAPACITY AND HOSPITAL BED OCCUPANCY

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Abstract: *The study examines the organization and management of information regarding surgical capacity and inpatient bed occupancy in German hospitals. The study is conducted at two German hospital sites, using 480,000 anonymized and standardized patient data from 2012 to July 2024, as well as 190,000 surgical data from 2013 to July 2024. The analysis focuses on the factors influencing elective and emergency surgeries, their effects on length of stay, and their distribution across weekdays. Using quantitative methods, including descriptive statistics and the Pearson correlation coefficient, significant anomalies could be identified. Surgeries from elective admissions are intensely concentrated on Tuesday and Wednesday, while surgeries from emergency admissions increase on weekends. In addition, there are significant correlations between operation duration and inpatient length of stay (r = 0.516) and between preoperative length of stay and total length of stay (r = 0.477). The study provides a valuable contribution to evidence-based resource management in the inpatient sector and highlights the relevance of efficient OR planning for capacity management. The study shows that optimising the information and communication process, through targeted management of surgical capacity in coordination with structural and personnel resources, not only improves the quality of care but also optimizes hospital utilisation.*
Keywords: *information management; hospital organisation and management; hospital information process; capacity utilisation; surgical capacities*

INTRODUCTION

Diseases, ailments, or physical injuries of persons are treated in hospitals, which are medical institutions in the healthcare system, through medical, nursing, and therapeutic services (§ 2 para. 1 KHG). Hospital treatments can be provided as complete inpatient, partial inpatient, or outpatient services. Full inpatient stays include at least one overnight stay, partial inpatient treatments are limited to the day without an overnight stay, and outpatient services are provided on an hourly basis without requiring an overnight stay (cf. Behrends/Vollmöller 2020, 60). A portion of medical treatment services is performed in operating rooms. The operating room is a specialized facility in a hospital or medical practice where surgical procedures are performed by opening the skin or mucous membranes, and where primary wound care is provided to patients. In the hospital, the operating room is usually located in an operating suite, which in turn has an anteroom with an airlock and changing rooms that serve as vestibules, separating it from the outside area. This separation is necessary due to the high hygiene standards (cf. DocCheck 2020). As a rule, the procedure is performed under anaesthesia, whereby the entire body or parts of the body are rendered insensate for a limited period by medications (cf. BDA 2018). The highest remuneration in hospital financing is attributable to treatment services involving surgical procedures (cf. Bremer 2015). In German hospital financing, health insurance funds and federal states share costs; therefore, it is also referred to as dual hospital financing. The health insurance funds are responsible for reimbursing operating and treatment costs. In the inpatient sector, these are based on the catalogue of case-based lump sums in the Diagnosis-Related Groups system for somatic care (cf. Bundesministerium für Gesundheit 2021). The catalogue assigns a fixed point value to each treatment service. The corresponding euro value per point is specified by the state base case value, which is determined annually in negotiations between representatives of health insurance funds and hospitals in each federal state. The annual developments in personnel and material costs in the hospital are also of

decisive importance in the negotiations. An intra-year adjustment of the state base case value is not provided for (cf. GKV-Spitzenverband, 2022). The investment costs of hospitals, i.e., for long-term fixed assets or construction measures, are financed by the federal states, independently of the case-based lump sums. Funding is provided either as a lump-sum amount determined by hospital size or through individual funding upon application for specific projects (cf. vdek 2021). The federal states have fulfilled their obligation to finance investments to an increasingly limited extent. From 1991 to the present, financing has declined by 18%. As a result, an investment backlog has emerged in recent years in the German hospital landscape, meaning that many necessary investments for modernization, for example, in buildings and medical technology, could not be carried out. Therefore, outdated technology and building structures are prevalent across many hospital areas (cf. DKG 2021). The economization of the healthcare system and dual hospital financing require the most efficient use of personnel and infrastructure resources. A key indicator of the effectiveness of this resource utilization is bed occupancy, which can be interpreted as a measure of the optimal use of available capacity (cf. Hentze/Kehres 2010: 316). The study aims to examine the impact of inpatient bed occupancy on surgical capacity across weekdays and to examine information and communication processes in the hospital. From this, discrepancies and patterns should be identified to conclude typical bed occupancy and potentially available capacity. The study results can serve as a basis for strategic information and decision-making, for example, in patient flow management or personnel planning, so that the analytical focus is designed to enable the results to be used as management information.

RESEARCH METHODOLOGY

The study on the influence of surgical capacities on inpatient bed occupancy in the information and communication process was conducted at both sites of Alfried Krupp Hospital in Essen. The basis of the analysis is retrospectively collected patient data from 18 medical departments covering the period from January 2012 to July 2024. Available are 480,000 anonymized and standardized case records with over 100 different variables relating to patient and hospital information. Furthermore, 190,000 anonymized and standardized surgical data are available from the period from January 2013 to July 2024. The institution itself dates to the late 19th century, when the Krupp company built a hospital for its workforce in 1870. Over the decades, the institution experienced continuous expansion of its capacity, successive modernization of its technical equipment, and increased accessibility to the general public. The impacts of the Second World War led to a temporary relocation of the site, whereby operations could not be maintained (cf. Brüggemeier 1990). In the 1960s, Alfried Krupp von Bohlen und Halbach ultimately initiated the construction of a modern clinic, which opened in 1980 with a capacity of 560 beds (cf. H. O. Wörner 1974, 840 –842). An institutional expansion occurred in 2008 through the integration of the Evangelical Hospital, Lutherhaus Essen. Since then, the two sites have been referred to as “Alfried Krupp Hospital Rüttenscheid” and “Alfried Krupp Hospital Steele” (cf. Hesse 2008). The dataset covers all inpatient admissions and surgical data from 01.01.2013 to 31.07.2024. Over this period of 4,234 days, the weekdays are distributed as 604 Mondays, 605 Tuesdays, 605 Wednesdays, 604 Thursdays, 604 Fridays, 604 Saturdays, and 604 Sundays. Inpatient hospitalization means that patients remain in the hospital for at least one day and one night, resulting in at least one day of length of stay (cf. Behrends/Vollmöller 2020: 60). For the initial data overview using the average number of operations per weekday, the period from 01.01.2024 to 31.07.2024 is selected, since the preceding period of the Covid-19 pandemic cannot be used. In connection with the COVID-19 pandemic, elective patient admissions were significantly reduced across all hospitals in Germany in accordance with § 22 para. 1 sentence 1 KHG, so that free capacities were available for emergency patients, on whom a special focus was placed. For the study on the influence of surgical capacity on inpatient bed occupancy in the information and communication process in the hospital, a quantitative research method is employed. This methodology enables the collection and evaluation of large datasets, thereby yielding a generalizing statement about the relationships and patterns among the variables (cf. Genau 2019). The analytical approach includes descriptive statistics, which serve to

structure the presentation and preparation of the collected data. Using frequency analyses, the central characteristics of the data distribution are captured. These include, in particular, measures of central tendency and measures of association between variables. Typical key figures for measures of central tendency include, among others, the arithmetic mean (1), colloquially referred to as the average, and the total (2), which is the sum of all individual values (cf. Studyfix 2024).

$$\bar{X} = \frac{a_1 + a_2 + \ldots + a_n}{n} \tag{1}$$

$$n = \sum_{k=1}^{n} k = \frac{n(n+1)}{2} \tag{2}$$

Furthermore, the percentage ratio (3), which is among the measures of frequencies and reflects the distribution of shares within the total, is applied (cf. Bortz/Schuster 2010: 39-40).

$$p\% = \frac{W}{G} \tag{3}$$

To analyse the relationship between two variables, the Pearson correlation coefficient is used (4). This statistical parameter ranges from -1 to +1. A negative value indicates an inverse relationship, whereas a positive value indicates a direct relationship between the variables. A correlation coefficient close to zero indicates a weak or non-existent linear association between the characteristics considered (cf. Studyfix 2024).

$$r_{xy} = \frac{s_{xy}}{s_x \cdot s_y} \tag{4}$$

The three central quality criteria of quantitative research, validity, reliability, and objectivity, are considered within the framework of this study. Validity is established by the legally mandated transmission of data in accordance with § 21 para. 1 of the Hospital Remuneration Act (KHEntgG), which ensures a standardized and substantively accurate representation of inpatient care services and surgical documentation (cf. InEK 2024). Reliability is ensured by using uniform recording and structuring of the aforementioned data, thereby ensuring consistent measurement and reproducible analytical results. Established software tools, such as IBM SPSS Statistics and Microsoft Excel, are used for statistical analysis. The objectivity of the investigation is ensured, as the data are used without intervention and evaluated using transparent, mathematically sound procedures. To investigate the organization and management of information on surgical capacity and inpatient bed occupancy within the hospital, the study formulates research questions and hypotheses.

Is there an influence of the duration of surgery on the length of stay?

Null hypothesis $H_0.1$ = There is no relationship between the utilised surgical capacities and the length of stay.

Alternative hypothesis $H_1.1$ = There is a relationship between the utilised surgical capacities and the length of stay.

Is there an influence of the preoperative length of stay on the total length of stay?

Null hypothesis $H_0.2$ = There is no relationship between preoperative length of stay and total length of stay.

Alternative hypothesis $H_1.2$ = There is a relationship between preoperative length of stay and total length of stay.

RESULTS

Significant for the study on the influence of surgical capacity on inpatient bed occupancy is the total number of inpatient surgeries across weekdays and by department. Based on the available data, fluctuations in utilization and potential resource reserves within the allocation structure are evident. To determine the average number of surgeries on regular working days (Monday = 1 to Friday = 5) in the period from 01.01.2024 to 31.07.2024, excluding public holidays, a categorization of admission reasons is carried out. Electively planned admission types are aggregated into

category 1, and emergency admissions into category 7. This simplified dichotomization enables a clear separation between elective and emergency-related surgeries. For site A (n1), it is shown that on all weekdays and across all departments, elective surgeries clearly dominate over emergency surgeries. The highest total number of elective procedures occurs on Wednesday (18.0), followed by Tuesday (17.9). The lowest elective values occur on Monday (14.8) and Thursday (14.9). In contrast, emergency procedures show overall lower case numbers, but a slight increase toward the end of the week. While 3.5 emergency surgeries were performed on Monday, this value rises to 4.6 by Friday. The ratio of elective to emergency surgeries favours elective procedures on all days, with the ratio most pronounced on Wednesday at approximately 7:1 and lowest on Friday at approximately 3.3:1. Differentiation by medical departments reveals further relevant differences. In department 1, the number of elective procedures is highest on Wednesday at 4.4, whereas the number of emergency surgeries remains consistently low, ranging from 0.3 to 0.5. Department 2 shows a marked increase in elective procedures on Tuesday (6.7) and Thursday (5.7), with emergency procedures on these days also comparatively high at 2.8 and 2.7, respectively. In department 14, the volume of elective surgeries is constant, with a slight increase on Thursday to 4.0; by contrast, emergency procedures remain very low. Particularly striking is the development in department 15. While elective procedures peak on Tuesday at 6.3, they decline to 2.5 on Thursday. At the same time, the number of emergency surgeries in this department rises to 0.9 by Friday, representing the highest emergency value in this department (cf. Table 1).

Table 1. Average surgeries per weekday (Site A)

Weekday	**1**		**2**		**3**		**4**		**5**	
Admission type/ Department	**1**	**7**	**1**	**7**	**1**	**7**	**1**	**7**	**1**	**7**
1	2.5	0.3	2.8	0.4	4.4	0.4	2.6	0.3	2.9	0.5
2	3.9	2.1	6.7	2.8	4.2	1.0	5.7	2.8	4.8	2.7
14	2.5	0.4	2.1	0.2	3.4	0.5	4.0	0.6	2.5	0.5
15	5.9	0.7	6.3	0.5	6.0	0.6	2.5	0.3	5.3	0.9
Total	**14.8**	**3.5**	**17.9**	**4.0**	**18.0**	**2.5**	**14.9**	**4.0**	**15.4**	**4.6**

For site B (n2), it is shown that, across all weekdays, elective surgeries are significantly more frequent than emergency surgeries. Elective procedures remain constant, ranging from 28.1 on Thursday to 32.4 on Tuesday. In contrast, emergency surgeries exhibit greater variability, increasing from 6.5 on Tuesday to 10.5 on Friday. A more differentiated analysis of the medical departments reveals distinct constellations. Without anomalies, elective procedures in department 1 remain constant between 4.3 and 4.5 across weekdays, and emergencies between 0.7 and 0.8. In department 2, however, a marked fluctuation is evident. Elective procedures increase significantly from Monday at 5.4 to Wednesday at 8.0, then decline slightly to 6.5 on Friday. In parallel, emergency procedures increase over the course of the week, particularly on Friday, to 5.7. Department 7 shows lower total numbers than the other departments, but displays a slight increase in elective procedures over the week, from 1.1 on Monday to 2.0 on Friday. Emergency surgeries remain constant and low in this department. In department 8, elective surgeries increased from Monday at 3.8 to Thursday at 4.6, followed by a slight decline on Friday to 4.5. Emergency numbers remain moderate and vary only slightly. A notable development is seen in department 11. Elective surgeries decrease significantly over the week, from 16.1 on Tuesday to 10.6 on Thursday, whereas emergency surgeries remain consistently low between 0.5 and 0.8 (cf. Table 2).

Table 2. Average surgeries per weekday (Site B)

Weekday	1		2		3		4		5	
Admission type / Department	**1**	**7**	**1**	**7**	**1**	**7**	**1**	**7**	**1**	**7**
1	4.5	0.7	4.3	0.7	4.5	0.8	4.3	0.7	4.3	0.8
2	5.4	3.1	6.4	2.6	8.0	5.6	7.0	4.0	6.5	5.7
7	1.1	1.2	1.4	1.4	1.2	0.8	1.7	1.1	2.0	2.0
8	3.8	1.2	4.1	1.0	4.2	1.1	4.6	0.9	4.5	1.4
11	16.0	0.5	16.1	0.8	11.6	0.7	10.6	0.7	11.9	0.7
Total	**30.7**	**6.7**	**32.4**	**6.5**	**29.5**	**9.1**	**28.1**	**7.4**	**29.1**	**10.5**

However, not all patients undergo surgery as part of hospital treatment. From 2013 to 2024, the data show the development of the proportions of patients operated on in the hospital, again using the standard categorization of elective admissions (category 1) and emergency admissions (category 7). For n1, a moderate yet continuous increase in the proportion of operated patients is observed initially. In 2013, the proportion of electively admitted patients who underwent surgery remained 54%. This proportion increased to 58% by 2019. During 2020 to 2022, which were shaped by the COVID-19 pandemic, the operational proportion ranged from 62% to 69%. After the end of the COVID-19 pandemic, the proportion decreases slightly again but remains between 62% and 63%, which is significantly above the 2013 level. Among patients admitted as emergencies, the proportion increased from 23% in 2013 to 30%-35% from 2020 onward.

For n2, a continuously increasing development is shown. The proportion of electively admitted and operated patients initially increases steadily from 44% in 2013 to 52% in 2021. Only at the end of the period shaped by the Covid-19 pandemic, in 2022, an increase to 58% is recorded. In the two subsequent years, 2023 and 2024, the proportion is 60%. The proportion of emergency admissions with surgery, however, has increased only slightly from 19% to 22%, and over several years it has even decreased to 17% (cf. Table 3).

Table 3. Ratio of patients with surgery

	Site A			Site B		
Admission type/ Year	**1**	**7**	**n1**	**1**	**7**	**n2**
2013	54%	23%	44%	44%	19%	37%
2014	55%	23%	43%	44%	18%	37%
2015	57%	24%	44%	45%	18%	38%
2016	59%	25%	45%	46%	17%	37%
2017	54%	25%	43%	48%	17%	36%
2018	59%	25%	45%	50%	17%	36%
2019	58%	27%	44%	50%	17%	36%
2020	62%	30%	48%	51%	20%	38%
2021	64%	32%	51%	52%	21%	38%
2022	69%	35%	55%	58%	21%	41%
2023	62%	34%	51%	60%	22%	42%
2024	63%	30%	49%	60%	22%	42%
Total	**56%**	**27%**	**45%**	**48%**	**19%**	**37%**

The relationship between the total length of hospital admission (variable “Vwd”) and the utilised surgical capacity (variable “OPBeginnEnde”) can be examined using the Pearson correlation coefficient. Data on patients who underwent surgery during their hospital stay are used. Thus, 187,863 data points are available. For n = 187,863, a correlation coefficient r = 0.516 is observed at the significance level p = 0.000. The values indicate a statistically significant association between longer operating time and longer length of stay. The correlation coefficient is above 0.500, indicating a strong relationship and clear relevance. Thus, the null hypotheses that there is no relationship

between surgery duration and length of stay, and between length of stay and bed occupancy, can be rejected. However, this does not imply that a causal relationship can be assumed, as additional factors may be at play (cf. Table 4).

Table 4. Correlation between length of stay and surgery duration

		Vwd
OPBeginnEnde	Pearson Correlation	0.516
	Sig. (2-tailed)	0,000
	n	187,863

One of these further influencing factors can be the so-called preoperative length of stay. This preoperative length of stay may result from bottlenecks in surgical capacity, which prevent surgery and require patients to wait. It is reported as waiting time in days; i.e., the preoperative length-of-stay count begins only after at least one day and one night have elapsed. If patients undergo surgery on the same day despite a several-hour waiting period, no preoperative length-of-stay days accrue. Preoperative length-of-stay days are disadvantageous from both patients' and hospitals' perspectives, as resources tied up during this period are neither reimbursed nor otherwise available for care. Optimal utilisation of surgical capacity can help reduce or avoid preoperative inpatient days.

To investigate the relationship between length of stay (variable "Vwd") and preoperative length of stay (variable "TagePraeOP"), the statistical test of the Pearson correlation coefficient is used again. Data on patients' preoperative length of stay during hospital admission are used. Thus, 95,514 data points are available. For n = 95,514, a correlation coefficient r = 0.477 is observed at the significance level p = 0.000. The values indicate a statistically significant association: preoperative length of stay is associated with longer postoperative length of stay. The correlation coefficient is close to 0.500, indicating a relatively strong and relevant relationship. Thus, the null hypothesis that there is no relationship between preoperative length of stay and length of stay, or between preoperative length of stay and bed occupancy, can be rejected. Again, no causal relationship should be assumed, as additional influencing factors may be present (cf. Table 5).

Table 5. Correlation between length of stay and preoperative length of stay

		Vwd
TagePraeOP	Pearson Correlation	0.477
	Sig. (2-tailed)	0,000
	n	95,514

CONCLUSIONS/DISCUSSION

The study provides reliable insights into the influence of surgical capacity on inpatient bed occupancy in German hospitals, based on data from two sites. For understanding organisation and management, the identified patterns mustn't merely represent "statistical findings" but instead planning- and communication-relevant information structures: the distribution of elective and emergency-related surgeries across weekdays reflects a recurring control rhythm that materialises in bed occupancy. The results show that surgeries from elective admissions are primarily concentrated on the working days Tuesday and Wednesday. It is reasonable to assume that on these days, optimization of the information and communication process goes hand in hand with targeted control and planning of surgical capacity, coordinated with structural and personnel resources.

The increase in surgeries of patients admitted as emergencies at the end of the week, especially on Fridays, indicates increasing urgency and a more urgent need for care. The particularly marked increase from 2020 onward will presumably reflect a pandemic-related effect, as elective patient admissions, including surgeries, were suspended or postponed during the COVID-19 pandemic.

In subsequent years, a further special effect may arise from catch-up effects following previously postponed procedures or from changes in indication-setting favouring surgical measures. This suggests a corresponding adjustment to resource planning, particularly with respect to emergency readiness, staff availability, and workload. The large sample size of operated patients (n = 187,863) increases the explanatory power of the analysis and reduces the likelihood of a spurious result. A significant positive correlation between the duration of surgical procedures and total inpatient length of stay (r = 0.516) and between preoperative length of stay and total length of stay (r = 0.477) was identified, underscoring the relevance of surgical processes for hospital occupancy capacity. Nevertheless, a correlation does not imply a causal relationship. Additional influencing factors, such as the severity of the procedure, postoperative complications, or patient-specific risk factors (e.g., age or comorbidities), may co-determine this relationship and should be considered in future studies. In addition, the number of preoperative length-of-stay days does not result exclusively from limited surgical capacity; it may also reflect that, in emergency patients, the need for surgical treatment is recognized only with a delay. For the preoperative length of stay, the structural specification in the DRG system is also of central importance.

Based on the identified anomalies and patterns, simulations and forecasting models can be developed in subsequent studies that not only enable forward-looking capacity planning for bed occupancy and the OR area, but also systematically map the underlying information and communication processes because capacity management in the hospital depends on the timely, complete, and role-specific transmission of relevant information (e.g., OR schedule, expected OR duration, preoperative waiting time, postoperative monitoring and nursing needs profile, planned discharges) between the actors and systems involved. Overall, the study makes an essential contribution to evidence-based capacity planning by showing at which points in the care process information flows are particularly capacity-relevant and where communication breakdowns can lead to delays and mismanagement. The demonstrated relationship between OR duration, preoperative waiting time, and total length of stay suggests that hospitals could significantly increase their efficiency through communicatively secured OR planning and information-based capacity management. As a result, capacity planning becomes less a purely resource question and more a controlled, information- and communication-based process that delivers the correct information to the right roles at the right time, thereby enabling coordinated action.

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ОРГАНИЗАЦИЯ И УПРАВЛЕНИЕ НА ИНФОРМАЦИЯТА МЕЖДУ ХИРУРГИЧНИЯ КАПАЦИТЕТ И ЗАЕТОСТТА НА БОЛНИЧНИТЕ ЛЕГЛА

Резюме: *Изследването разглежда организацията и управлението на информацията относно хирургичния капацитет и заетостта на болничните легла в германските болници. Изследването е проведено в две германски болници, като са използвани 480 000 анонимизирани и стандартизирани данни за пациенти от 2012 г. до юли 2024 г., както и 190 000 хирургични данни от 2013 г. до юли 2024 г. Анализът се фокусира върху факторите, които влияят върху плановите и спешните операции, тяхното влияние върху продължителността на престоя и разпределението им през делничните дни. С помощта на количествени методи, включително описателна статистика и корелационен коефициент на Пиърсън, бяха идентифицирани значителни аномалии. Операциите от плановите хоспитализации са силно концентрирани във вторник и сряда, докато операциите от спешните хоспитализации се увеличават през уикенда. Освен това съществуват значителни корелации между продължителността на операцията и продължителността на престоя на пациента в болницата (r = 0,516) и между продължителността на престоя преди операцията и общата продължителност на престоя (r = 0,477). Изследването дава ценен принос за управлението на ресурсите в сектора на болничното лечение, основано на доказателства, и подчертава значението на ефективното планиране на операционните зали за управлението на капацитета. Проучването показва, че оптимизирането на процеса на информиране и комуникация чрез целенасочено управление на хирургичния капацитет в координация със структурните и персоналните ресурси не само подобрява качеството на грижите, но и оптимизира използването на болницата.*
Ключови думи: *управление на информацията; организация и управление на болници; информационни процеси в болниците; използване на капацитета; хирургичен капацитет*

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