

ОБЩЕСТВЕНИ КОМУНИКАЦИИ И ИНФОРМАЦИОННИ НАУКИ
PUBLIC COMMUNICATIONS AND INFORMATION SCIENCES

**ORGANIZATION AND MANAGEMENT OF INFORMATION ON THE CAPACITY
UTILIZATION OF HOSPITAL BEDS ON DIFFERENT WEEKDAYS**

Dennis Komossa

University of Library Studies and Information Technologies

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Abstract: *The study analyses the organisation and management of information on inpatient bed utilisation by weekday at two hospitals in Essen. It aims to identify day- and time-dependent occupancy patterns to support action-oriented management of admissions, discharges, capacity and staffing, especially from Monday to Friday. The analysis is based on retrospective data from over 610,000 patients (2023–2024), using documented occupancy days and length-of-stay timestamps differentiated by department and weekday. Results show significantly higher occupancy on weekdays, with peaks from Tuesday to Thursday, and a clear decline at weekends. A daily peak between 7 a.m. and 2 p.m. is linked to overlaps between admission and discharge processes. During these periods, targeted information and communication structures are essential to reduce the risk of breakdowns. Blocked beds further influence practical occupancy. A weak but significant correlation is found between reason for admission and day of admission. Overall, the study highlights the importance of time- and day-specific capacity planning and information processes for evidence-based hospital management.*

Keywords: *information management; hospital management; hospital organization; hospital information process; capacity utilization*

INTRODUCTION

Hospitals are medical institutions in the healthcare system in which illnesses, suffering, or physical injuries of persons are treated through medical, nursing, and therapeutic services (§ 2 para. 1 KHG). These treatment services are offered 24 hours a day, 7 days a week, year-round, in hospitals, and are provided as needed. This means that capacities must be maintained during this time, even though utilization is subject to strong demand fluctuations. In particular, the treatment period can be classified into two categories. On the one hand, there are emergency patients, who are unknown in advance and not plannable. On the other hand, there are elective patients, i.e., selected and plannable patients who visit the hospital at a previously determined time of treatment (cf. Ostwald/Neumeyer 2023, 87). Treatments can be classified as fully inpatient, partially inpatient, or outpatient services. In fully inpatient services, patients remain in the hospital for at least one night and necessarily use the existing hospital beds. The use of beds is not necessary for partially inpatient services, in which patients receive treatment services only during the day and spend the night in their personal environment at home, or for outpatient services, in which the treatment services relate to a stay of several hours (cf. Behrends/Vollmöller 2020, 60).

Hospitals in Germany are nowadays service companies (cf. Goepfert 2013, 32). The gradual economization in German hospitals has taken hold since the 1980s. The economization process is based on reforms to hospital and health policy to introduce an economic way of thinking into German health expenditures through market-oriented health economists (cf. Flintrop 2014, A1930). In Germany, health expenditures in 2022 amounted to 497.7 billion euros, which corresponds to an average of 5,939 euros per inhabitant. Overall, this corresponds to 12.8% of Germany's gross domestic product (cf. Destatis 2024). By gross domestic product (GDP), Germany has the highest healthcare expenditure among the 27 EU member states. The average in the European Union is 10.4% of the respective gross domestic product. Luxembourg has the lowest share at 5.6% (cf. Destatis 2025).

Hospital financing in Germany has been based since 1972 on a dual system of reimbursement

for operating and investment costs (§ 17b para. 1 SGB V). Reimbursement of operating costs for both fully and partially inpatient treatment, as well as for the use of infrastructure, has, since several reforms in 2004, been financed through case-based lump-sum payments (cf. Klauber/Geraedts 2020, 191). With the help of these case-based lump-sums, a nationwide standardized remuneration is implemented, which is adjusted only once a year by a new case-based lump-sum catalogue and the remunerative base rate (cf. Behrends/Vollmöller 2020, 13). Investment costs for construction and medical-technical facilities are financed by the respective federal states in Germany. In recent years, due to tight budgetary resources, the federal states have not fully complied with this obligation. This, in turn, means that hospitals must finance the necessary investments through equity or borrowed funds, which are co-financed by operating cost reimbursement revenues (cf. Graumann/Schmidt-Graumann 2016, 52). Economization and the dual financing system necessitate the optimal use of personnel and infrastructure capacities. One indicator for the optimal use of personnel and infrastructural capacity in the hospital is high bed occupancy (cf. Hentze/Kehres 2010: 316). The study aims to examine the capacity utilization of inpatient bed occupancy across weekdays in relation to the hospital's information and communication processes. From this, discrepancies and patterns should be identified to conclude typical bed occupancy and potentially available capacity. Based on these discrepancies and patterns, communication and information processes can be adjusted to mitigate the risk of communication breakdowns during occupancy peaks. The study results can serve as a basis for strategic information and decisions, for example, in patient management or staff planning.

RESEARCH METHODOLOGY

The study on the influence of weekdays on the capacity utilization of inpatient bed occupancy in the information and communication process was conducted at both sites of the Alfried Krupp Hospital in Essen. The analysis is based on retrospective data from 18 medical departments collected between January 2012 and July 2024. The Alfried Krupp Hospital has a long institutional history. The origins date back to 1870, when the Krupp company built a hospital with around 100 beds for its employees. In subsequent decades, the facility was continuously expanded to a capacity of 1,200 beds and equipped with state-of-the-art medical technology of its time. From 1920 onward, it was opened to the general population. During the Second World War, the original site was relocated due to heavy artillery shelling, although permanent operation at the alternative site could not be maintained (cf. Brüggemeier 1990). In 1963, Alfried Krupp von Bohlen und Halbach initiated the construction of a new hospital, which commenced operations in 1980 with 560 beds under the name "Alfried Krupp Hospital" (cf. Wörner 1974, pp. 840–842). As part of a structural realignment, the Evangelical Hospital Lutherhaus Essen was integrated into the Alfried Krupp Hospital in January 2008. Since then, the two sites have operated under the names "Alfried Krupp Hospital Rüttenscheid" and "Alfried Krupp Hospital Steele" (cf. Hesse 2008).

Based on systematic data collection and statistical analysis of this large dataset, a quantitative research method is employed. The aim is to achieve a representative and realistic result using the extensive database (cf. Genau 2019). The application of the quantitative research method is particularly suitable because relevant capacity data are available at the individual, hospital-specific level. In addition, there is a lack of scientific literature and empirical studies on capacity management in German hospitals following the global COVID-19 pandemic, underscoring the need for independent data collection. Thus, the period 2023 to 2024 is selected from the available data for the capacity analysis. During this period, a total of 610,000 movement data points and timestamps from inpatients form the database. The measurement periods of patient presence and bed occupancy run from 01.01.2023 to 31.12.2024. This period comprises 731 calendar days, including 105 Mondays, 105 Tuesdays, 104 Wednesdays, 104 Thursdays, 104 Fridays, 104 Saturdays, and 105 Sundays. For the analysis of the relationship between weekdays and capacity utilization, 4,596 days are available. Of these, 657 Mondays, 657 Tuesdays, 657 Wednesdays, 656 Thursdays, 656 Fridays, 656 Saturdays, and 657 Sundays.

A central measurement instrument of the study is bed occupancy (1). It also serves as a busi-

ness management indicator for assessing economic efficiency and as an indicator of actual capacity utilization in the inpatient sector (cf. Destatis 2024).

$$\text{Bed occupancy} = \frac{\text{Occupied bed days}}{(\text{Beds} \cdot \text{Calendar days})} \cdot 100 \quad (1)$$

The timestamps in the datasets provide, for each patient, the earliest time t_{\min} at 00:00 a.m. and the latest time t_{\max} at 11:59 p.m. The period between t_{\min} and t_{\max} denotes the duration of the patient's hospitalization (2). To determine bed occupancy at time t , it is checked whether t lies within the individual stay interval from t_{\min} to t_{\max} . If this is the case, the condition is coded as 1, indicating that the bed is occupied at that time. If time t lies outside the stay interval, the condition is coded with 0, and the bed is considered unoccupied.

$$IF(AND(t_{00:00 \text{ a.m.}}^{11:59 \text{ p.m.}} \leq t_{\min}; t_{00:00 \text{ a.m.}}^{11:59 \text{ p.m.}} \geq t_{\max}); 1; 0) \quad (2)$$

An established method for determining the relationship between two variables is the Pearson correlation coefficient (3). The result can take values between -1 and +1. A negative value, i.e., less than 0, indicates a negative relationship between the variables. A positive value greater than 0 suggests a positive relationship. The closer the correlation value is to 0, the weaker the relationship between the two variables (cf. Studyfix 2024).

$$r_{xy} = \frac{s_{xy}}{s_x \cdot s_y} \quad (3)$$

Compliance with the quality criteria of quantitative research – validity, reliability, and objectivity – is ensured. The legally required and standardized documentation ensures validity in accordance with § 21 para. 1 KHEntgG, which enables a valid representation of real treatment processes. Reliability results from standardized data collection, which enables high measurement accuracy and reproducibility. Statistical tools are used for analysis, including IBM SPSS Statistics and Microsoft Excel. Objectivity is also ensured, as the datasets are used unchanged and the studies are conducted using standardized mathematical procedures.

To investigate the influence of weekdays on the capacity utilization of inpatient bed occupancy in the hospital, a research question and associated research hypotheses are formulated.

Is there an influence of weekdays on patient admissions?

Null hypothesis H0 = There is no relationship between patient admissions and weekdays.

Alternative hypothesis H1 = There is a relationship between patient admissions and weekdays.

RESULTS

The bed plan shows the maximum number of beds that can be operated at both sites of the Alfried Krupp hospitals. These are $n1 = 233$ and $n2 = 546$ beds. These beds serve as the basis for occupancy calculations. For the period from 01.01.2024 to 31.12.2024, the following occupancy results:

$$n1 = 67,772 / (233 \cdot 366) \cdot 100 = 79.47$$

$$n2 = 165,608 / (546 \cdot 366) \cdot 100 = 82.87$$

Total bed occupancy thus amounts to $n1 = 79.47\%$ and $n2 = 82.87\%$. However, this calculation uses 366 days and therefore represents an entire year, without differentiation by individual weekdays. Thus, a new calculation is necessary.

At site A, a clearly recognizable pattern in bed occupancy emerges over the course of the week. Occupancy starts at 80.00% on Monday and increases over the following days, reaching 83.08% by Wednesday. On Thursday, occupancy remains high at 83.08%; however, the decline begins from this point. On Friday, occupancy initially falls to 78.90% and continues to decrease over the weekend. On Saturday, only 73.49% is reached, and on Sunday, 73.64%. Overall, beds

are well utilized primarily on weekdays, whereas occupancy declines significantly on weekends. A typical weekly utilization pattern is also evident at site B. The week begins with an occupancy of 82.42% on Monday and rises to 87.55% by Wednesday. On Thursday, occupancy remained at 87.24%, almost unchanged from the previous day, but it had already declined slightly. Toward the weekend, the figures continue to drop. On Friday, bed occupancy is 83.40%, and on Saturday, it falls to 76.75%. On Sunday, occupancy reached the lowest level of the week at 75.33%. Thus, it is also apparent at site B that weekday occupancy is high, and that weekend occupancy declines (cf. Table 1).

Table 1. Bed occupancy by weekday

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Site A	80.00	83.51	83.80	83.08	78.90	73.49	73.64
Site B	82.42	87.53	87.55	87.24	83.40	76.75	75.33

For the analysis of bed occupancy, a more detailed examination is required, as differences in occupancy across medical departments and by time of day and weekday are to be expected. Furthermore, blocked beds should be included. The reasons for blocking beds include staffing shortages, infrastructure problems, or patient-specific measures. They thus describe situations in the hospital in which a patient's bed cannot be temporarily occupied, thereby making the resource unavailable for a period. They affect either all beds of a patient room with single-, double-, or triple-bed rooms or only parts of it, for example, the blocking of one bed in a double room (cf. DGKH 2022: 36–38). Because the specified formula refers to occupied bed days for existing patients, bed blockings are excluded from the above-mentioned occupancy. For a more detailed examination, bed blockings should be considered to more effectively present capacity utilization.

To present effective capacity utilization, bed blockings are considered in addition to the regular bed occupancy of medical departments, based on patient numbers. Because a straightforward assignment of blocked beds to specific medical departments is not possible, they are shown separately in the occupancy chart. The occupancy of individual medical departments is presented as a proportion of the site's available beds. A colored area marks each medical department, while blocked beds are shown in red. On the y-axis of the stacked area chart, occupancy is shown as a percentage ranging from 0 to 100%. The x-axis shows the time course from Monday 0:00 to Sunday 23:59 in 4-hour intervals. The area between 100% and the top occupancy line represents unused capacities.

At site A (n1), stable bed occupancy between about 70% and 85% is observed over most of the week. The three medical departments 1 (orange), 2 (grey), and 3&10 (yellow) show largely uniform occupancy, with only minor fluctuations by time of day. The uniform occupancy suggests elective, plannable patient care. From late Friday evening onward, a clear trend toward declining bed occupancy is evident. This reduction continues into Saturday and is most pronounced on Sunday. The medical departments 3&10 (yellow), 14 (green), 15 (blue), and 16 (brown) are particularly affected. The reduction in occupancy affects medical departments 1 (orange) and 2 (grey) to a lesser extent. This suggests that elective procedures and the resulting inpatient admissions are reduced, or even suspended, on weekends. Presumably, primarily emergencies, long-term patients, or patients with medically non-deferrable stays remain. Bed occupancy shows only minor fluctuations over the week – occupancy peaks at over 90% on Tuesday, Wednesday, and Thursday, at around 8 a.m. The increase in occupancy begins at 7 a.m. and steadily levels off until 2 p.m. This indicates overlap among patients during admission and discharge. The patterns shown, including the significant weekend decline, are typical of inpatient care facilities in which elective treatment services are primarily provided on weekdays. The remaining weekend occupancy reflects a concentration of acute medical and non-deferrable care needs (cf. Figure 1).

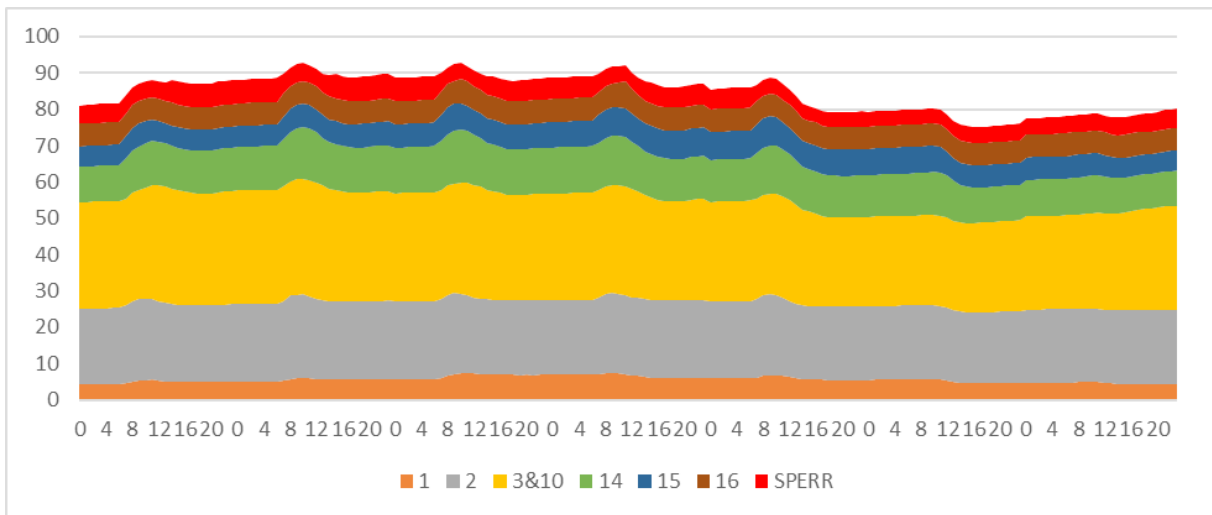


Fig. 1. Effective Bed Occupancy from 01.01. to 31.12.2024 (Site A)

At site B (n2), total occupancy over the week ranges mostly between 80% and 95%, indicating a high baseline utilization of available beds. Compared with site A (n1), significantly stronger departmental differentiation is evident, resulting in a more differentiated occupancy structure. Departments 2 (grey), 4 (yellow), 6 (green), 11 (dark blue), and 12 (dark green) account for most of the bed occupancy throughout the week. A striking pattern is observed in the cyclically recurring peaks, which reach 100% occupancy on Tuesday, Wednesday, and Thursday at around 8 a.m. The rise in occupancy begins at 7 a.m. and steadily levels off until 2 p.m. These peaks suggest time-of-day-limited resource bottlenecks arising from overlaps in patient volumes during the admission and discharge processes. From Friday evening onward, an apparent decline in total occupancy is evident. This development continues steadily throughout Saturday and reaches its low point on Sunday. In doing so, the occupancy shares decrease across almost all departments. The larger medical departments, such as 4 (yellow), 6 (green), 11 (dark blue), and 12 (dark green), are particularly affected, as their area shares decrease noticeably.

The remaining weekend baseline occupancy is primarily driven by the large inpatient departments, suggesting emergency or long-term occupancy. The complete decline of elective services over the weekend thus also becomes structurally visible.

The stacked chart illustrates a highly differentiated occupancy structure that follows a clearly rhythmical course over the week. Cyclical occupancy peaks during the week, and a significant decline toward the weekend indicates a largely elective, planned inpatient care model. Furthermore, the differentiated colored areas suggest that smaller medical departments also contribute to occupancy but are less affected by weekday fluctuations. The clear weekend structure, with reduced occupancy, indicates a classical organizational form of inpatient care facilities, with services concentrated on weekdays (Monday to Friday; cf. Figure 2).

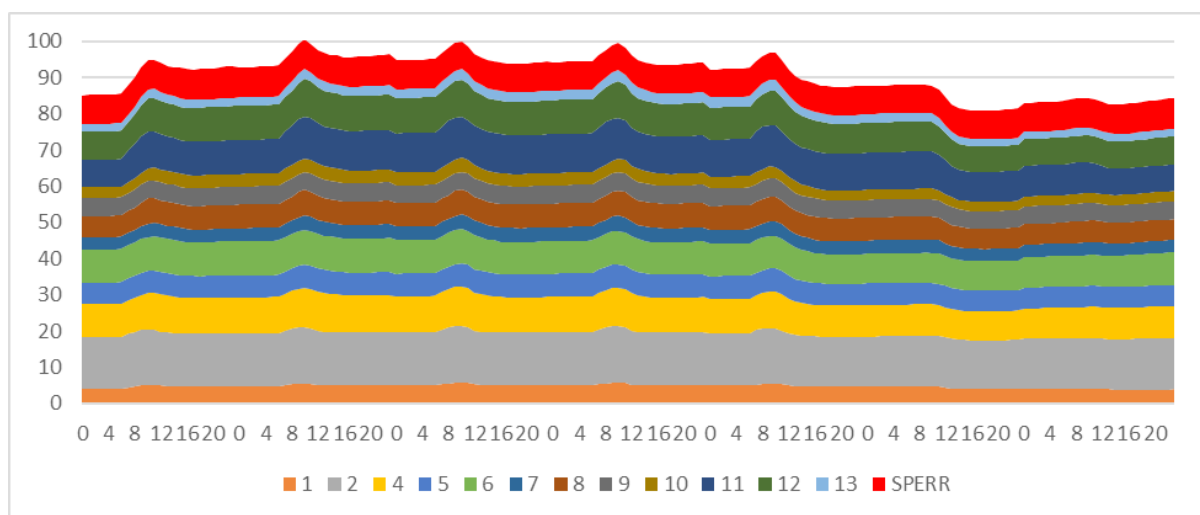


Fig. 2. Effective Bed Occupancy from 01.01. to 31.12.2024 (Site B)

The Pearson correlation coefficient is tested using $n = 477,099$, covering the entire available period from January 2012 to July 2024. The relationship of the independent variable “AufnGrundZusatz,” the reason for admission, with the dependent variables “AufnWochentag,” the weekday of patient admission, “AufnMonat,” the month of patient admission, “AufnFerien,” the vacation periods at the time of patient admission, “AufnGesetzFeiertag,” the statutory holidays, as well as “AufnSonstigeTage,” the other religious, festive, or cultural days at the time of patient admission, is examined.

The study results indicate a significant but weak relationship between reasons for admission and patient admission days ($r = 0.165$). The p-value of the two-sided significance is 0.000 and is therefore below the significance level of 1% ($\alpha = 0.01$). The null hypothesis, which assumes no relationship between reason for admission and weekday, can thus be rejected. A statistically significant relationship is also observed for the number of patient admissions (p-value: 0.000). However, the correlation coefficient (0.008) is negligible. The null hypothesis is rejected because the relationship, although weak, is statistically significant. For vacation periods, there is also a significant but minimal correlation ($r = 0.016$, $p = 0.000$). Thus, the null hypothesis is also rejected based on the relationship. A similar situation applies to statutory holidays. The correlation coefficient is 0.055, indicating a weak relationship. Since the p-value is 0.000, which is below the 1% significance level ($\alpha = 0.01$), the null hypothesis can be rejected. The relationship differs from other religious, festive, or cultural days. The correlation coefficient is only 0.004, indicating a near-zero association. In addition, the p-value is 0.011, whereas the significance level is 1% ($\alpha = 0.01$); therefore, the null hypothesis cannot be rejected. A significant relationship cannot be demonstrated (cf. Table 2).

Table 2. Correlations between Admission Reason and Days/Months of Admission

		Admission Weekday	Admission Month	Admission During Holidays	Admission on Public Holidays	Admission on Other Days
Admission Reason	Pearson-correlation	0.165	0.008	0.016	0.055	0.004
	Significance. (2-tailed)	0.000	0.000	0.000	0.000	0.011
	n	477,099	477,099	477,099	477,099	477,099

CONCLUSIONS/DISCUSSION

The study examines inpatient bed capacity utilization across weekdays and times of day in two hospitals in Essen, providing well-founded, data-driven insights into hospital occupancy patterns.

Based on over 610,000 inpatient movement records from 2023 to 2024, a significant weekly pattern was identified: bed occupancy peaks consistently on weekdays, particularly from Tuesday to Thursday, while a marked decline occurs over the weekend. These findings suggest that elective patient admissions are carried out almost exclusively on weekdays, reflecting the structural realities of hospital organization and staff availability. Particularly noteworthy is the clustering of peak occupancy between 7 a.m. and 2 p.m., indicating overlapping admission and discharge processes. These time windows are critical for resource utilization and personnel management, and for mitigating the risk of short-term bottlenecks, as multiple processes in the hospital typically converge on a time-critical information hub, e.g., admissions, discharges, and surgical preparations. To prevent these peak loads from being perceived as overload, a targeted information and communication structure is required. What is crucial in this time window is that all involved professional groups have shared, identical information about the current situation, so that responsibilities can be defined. For this purpose, standardized information can help to avoid communication breakdowns. In this context, the timing and content of transmitted information are crucial for maintaining the quality of communication and information processing during occupancy peaks between 7 a.m. and 2 p.m. In addition, blocked beds, for example, due to staff shortages or patient-related restrictions, significantly influence effective capacity utilization. This likewise requires a separate process for communication and information. Including these beds in the analysis proves essential for a realistic assessment of hospital occupancy. Statistical analysis using the Pearson correlation coefficient further confirms a significant, albeit weak, association between the reason for admission and the weekday of admission. This correlation was identified using 477,099 patient admissions from January 2012 to July 2024.

Thus, the study not only provides a snapshot of inpatient bed utilization but also establishes a foundation for structured and evidence-based planning, control, and capacity management. Despite the robust and meaningful insights, several areas for future research emerge. Given that most patient care occurs on weekdays and that these patients are likely to be on sick leave during this period, indirect costs accrue to the German economy. These costs are not yet accounted for in the statistics, or in the fact that Germany has the highest healthcare spending among all 27 EU countries. Future studies could examine the broader economic impacts and whether utilizing available weekend capacity could lead to significant cost reductions.

Future research may also focus on linking prospective data analysis with real-time monitoring to develop simulation-based predictive models for capacity management. Moreover, extending the analysis to additional hospitals – such as supra-regional or university hospitals – would be beneficial in uncovering differences in occupancy patterns and in deriving a best-practice model. Furthermore, studies should examine the extent to which peak workloads, particularly between 7 a.m. and 2 p.m., affect patient safety and quality of care or contribute to increased workloads for healthcare personnel.

The key findings of this study lie in the visualization of time-of-day and weekday-specific capacity utilization, as well as in the integration of closed beds as a limiting factor in total utilization. These insights make a valuable contribution to evidence-based resource management in inpatient care by highlighting the importance of time- and day-based capacity planning. This enables hospitals to deploy staff – who account for the largest share of fixed costs due to their availability – more efficiently across all days and times of the week, and to plan elective procedures more strategically.

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ОРГАНИЗАЦИЯ И УПРАВЛЕНИЕ НА ИНФОРМАЦИЯТА ЗА ИЗПОЛЗВАНЕТО НА КАПАЦИТЕТА НА БОЛНИЧНИТЕ ЛЕГЛА В РАЗЛИЧНИ ДНИ ОТ СЕДМИЦАТА

Резюме: Изследването анализира организацията и управлението на информацията за използването на болничните легла по дни от седмицата в две болници във федерална провинция Есен, Германия. Целта е да се идентифицират зависими от деня и времето модели на заетост, които да подпомогнат управлението на приемите, изписванията, капацитета и персонала, особено от понеделник до петък. Анализът се основава на ретроспективни данни за над 610 000 пациенти (2023–2024), като използва документирани дни на заетост и времеви данни за продължителността на престоя, разграничени по отделения и дни. Резултатите показват значително по-висока заетост през делничните дни, с пик от вторник до четвъртък, и отчетлив спад през уикендите. Дневен пик между 7:00 и 14:00 ч. е свързан с припокриване на процесите по прием и изписване. В тези периоди целенасочените информационни и комуникационни структури са ключови за намаляване на риска от сригове в комуникацията. Блокираните легла също влияят върху реалната заетост. Установена е слаба, но значима корелация между причината за прием и деня на прием. Като цяло изследването подчертава значението на планирането на капацитета според деня и времето и ролята на информационните процеси за основаното на данни болнично управление.

Ключови думи: управление на информацията; управление на болници; организация на болници; информационни процеси в болниците; използване на капацитета

Денис Комоса, докторант

Университет по библиотекознание и информационни технологии

София, България

E-mail: dennis_komossa@gmx.de