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Shorter Length of Stay Keeps the Doctor Away?

About the Influence of the Length of Hospital Stay on the Recovery

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***Abstract*—Since at least the 1960s, the average length of stay in German hospitals has been declined. Early discharge can cause health risks for the patient and incurs cost risks for health insurers. Otherwise, a shorter length of stay can also indicate more efficient and better care in hospitals. The aim of this research project is therefore to investigate whether the decreasing length of stay has an effect on the quality of care provided by hospitals, and whether a shorter length of stay in inpatient care results in an increase in follow-up outpatient care. Routine data will be used.**

I. Research question and motivation

SINCE at least the 1960s, the average length of stay (ALOS) of patients in German hospitals has been declined (see [1]), and almost halved since the early 1990s (see [2] and [3]). It is assumed that the introduction of Diagnosis Related Groups (DRGs) in hospital reimbursement in 2003 was an additional driver of this development (see [4] and [5]). Compared to previously used equal daily reimbursement rates, the DRG system reduces a hospital's profit if a patient stays longer. The upper bound of the length of stay in a DRG determines up to which length of hospital stay a flat rate is paid (see [6]). As soon as the duration of stay in an individual case exceeds the upper bound, additional payments are made. However, these additional payments are unprofitable for the hospital (see [7]). This creates an economic incentive for hospitals to discharge patients as early as possible (see [8] and [9]). In order to counteract early and premature discharges for cost reasons, hospitals have to accept reductions in the per-case flat rates if the length of stay falls below the lower bound due to early discharge or transfer to another hospital (see [10]). As a result, hospitals generate the greatest profit per case at the lower bound. This is illustrated in Fig. 1. The difference between the amount of the flat rate payment per case **P** and the costs of the hospital stay **K** is greatest at the point of the lower bound **DRG_L**. Depending on the slope of the hospital's cost curve, profit is generated up to the point of the upper bound **DRG_U**.

Early discharge from the hospital can cause health risks for the patient and incurs cost risks for health insurers (see [11]). If, for example, more outpatient treatment, nursing care or readmission to hospital becomes necessary (*revolving door effect*), this can increase the total costs for the payer (see [12]).

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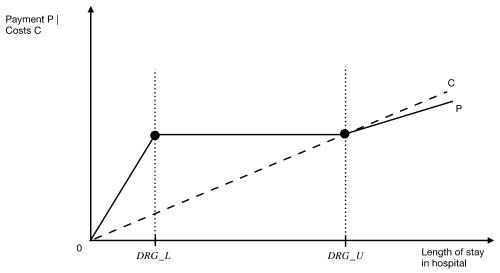

Fig. 1. Hypothetical relation between costs and returns

Source: Own representation

The implementation of the length of stay boundaries follows the objective of more efficient care in hospitals in terms of the *pay for performance* principle (see [13]). On the other hand, there is the concern that an excessively shortened length of stay will lead to underuse and misuse of care and an increased workload for medical staff (see [14] and [15]). Whether the DRG system leads to changes in the quality of care due to earlier discharge of patients is therefore still controversial and not clearly evident (see [16]).

The aim of this research project is therefore to investigate whether the decreasing length of stay has an effect on the quality of care provided by hospitals in Germany and whether a shorter length of stay in inpatient care results in an increase in follow-up outpatient care. More specifically, we aim to answer the following research questions:

1) Does the decreasing length of hospital stay have an effect on the quality of care or on the patient's health status after discharge?
2) Is a shorter length of stay substituted for increased follow-up outpatient care?

II. Brief literature review

Current scientific literature provides little clarity on the potential relationship between individual length of stay and a patient's quality of care. Previous studies could only show associations for specific areas of health care. If the length of stay is reduced solely on grounds of economic considerations, premature discharge can have negative health effects on the patient. Cases like these are also referred to as *bloody discharge* (see [11]). In the REDIA study by von Eiff *et al.* ([11]), the authors examined the effects of the introduction of the G-DRG system on rehabilitation. The authors argue that because of shorter hospital stays, orthopedic patients start rehab earlier and in poorer health. Nevertheless, the treatment goals of the rehab process could be achieved. The authors explain this with the increased treatment effort by the medical staff in the rehab facilities.

Other studies assess a decreasing length of stay less critically, as this can be interpreted as an indicator of an increase in process quality (see [17]). The patient's desired state of health is achieved more quickly through better treatment. Thus, improved treatment quality could also lead to a decrease in length of stay. That a decreasing length of stay could have no negative effects, but even positive effects, is suggested by the studies of Kehlet and Wilmore ([18]), of Husted *et al.* ([19]) & of Barmer GEK ([20]).

As already mentioned, since the introduction of the DRG-based reimbursement system in Germany, the length of stay has continued to decrease each year (see [3]). It should be noted that the length of stay was already declining before the introduction of the DRG-based system (see [16] and [1]). Therefore, it is still unclear whether the introduction of the DRG-based reimbursement system has an impact on length of stay. This makes research on the effects of this system on quality of care also interesting with regard to length of stay, since the reduction of length of stay is an objective of the introduction of the DRG-based system that has not yet been sufficiently evaluated.

In principle, too little empirical research has been done to investigate this relationship. Therefore, no reliable statements can be made yet. Research to date has essentially been based on structured quality reports. For Germany, for example, Fürstenberg *et al.* (see [21] as well as [22]) observed a general decline in post-hospital mortality in the period between 2004 and 2010. The effect of the DRG-based system and the length of stay on the quality of care remained unclear. The overall picture among international research is currently similarly unclear (see [23]). An overview of international literature is listed in Table I.

International research concerning other countries with DRG systems there also indicates a given shift from inpatient care to outpatient care structures (see [24]) and [25]). A shift from inpatient to outpatient care influenced by decreasing length of stay has not yet been observed in Germany. Therefore, it is still unclear whether patients show increased use of outpatient services as a result of earlier hospital discharges.

III. Data

Routine data from the research database of the WIG2 Scientific Institute for Health Economics and Health Systems Research [35] will be used primarily to answer the research questions. Routine data are the accounting data of the statutory health insurances. The pseudonymized personal reference of the data is of central importance for answering the research question of this thesis. This makes it possible to trace the individual treatment paths of the insured and thus analyze the influence of the length of stay. Since the methodology used requires the largest possible sample, the entire available scope of the research database will be used for the estimation. The observation of the individuals should take place on a monthly basis. Alternatively, the observation can be done quarterly, as this corresponds to the rhythm of ambulatory care.

These data are to be supplemented with the publicly available data on DRGs from the German Institute for the Hospital Remuneration System (InEK).

IV. Methodology

At the center of the empirical analysis is the investigation of the potential relationship between hospital length of stay and quality of care, as well as variables related to outpatient follow-up treatment. Because quality of care is not directly reflected in the data, recovery indicators such as mortality, medication use, complications, or comorbidities will be used as proxies. These indicators can provide information on whether and to what extent the patient's state of health has changed after hospitalization, depending on the length of stay. In addition, variables on further treatment, such as outpatient follow-up treatment (e.g., physician visits) and hospital readmission, can provide information on whether a shorter length of stay results in a shift in the care structure (e.g., from inpatient care to outpatient care). Quality indicators and variables for follow-up treatment are summarized below as outcome indicators. Simple OLS regressions of the length of stay on the indicators, as stated in model 1, would likely be biased as differences in characteristics between hospitals as well as seasonal variations most likely have an impact on outcome indicators and on the individual length of stay.

$$\mathbf{E_i} = \alpha_0 + \alpha_1 \cdot length_i + \theta_{\mathbf{X}} \cdot \mathbf{X_i} + \eta_i \tag{1}$$

with

$\mathbf{E_i}$	Vector of indicators for post stationary recovery or for quality of medical treatment
$length_i$	Length of stay for patient i
X_i	Vector of different control variables
η_i	Error term

Source	Country	Findings
[26]	USA	No effect of the DRG system on quality of care detected.
[27]	USA	No effect of the DRG system on quality of care detected.
[28]	USA	Shift from inpatient hospital care to lower-cost providers.
[29]	USA	Unclear whether the DRG system leads to a reduction in quality of care. Suggestive evidence for premature discharge.
[30]	USA	Unclear whether the DRG system leads to a reduction in quality of care. Suggestive evidence for premature discharge. (Rate of unstably discharged patients increased from 10% to 15% within 3 years after introduction of the DRG-based system).
[24]	Norway	Suspicion of treatment preference for patients with milder orthopedic diagnoses. Also, evidence of a shift from inpatient care to outpatient care.
[31]	Great Britain	No effect of the DRG system on quality of care detected.
[32]	Japan	DRG system introduction is associated with lower mortality and higher readmissions.
[25]	Great Britain	Expansion of better reimbursed hip TEP procedures compared to less highly reimbursed procedures. Also, evidence of a shift from inpatient care to outpatient care.
[33]	France	No effect of DRG system on readmissions after surgical procedures.
[34]	Switzerland	DRG system is associated with lower mortality and higher readmissions.

TABLE I
INTERNATIONAL LITERATURE

We expect that the model behind the structural equation 1 would be still biased by unobserved factors and that the exogeneity assumption is thus violated even if we control for hospital and time fixed effects. An example of an uncontrolled influencing factor of this kind is the varying adaptation of new treatment methods between hospitals, as well as the varying adaptation of technical innovations in medical care. Also, unobservable variables (such as the actual health status of patients, actual quality of care or the cost structure of hospitals) or measurement errors (incorrectly or incompletely maintained database) could lead to biases and violation of the exogeneity assumption. By means of an instrument variable estimation, an attempt can be made to counteract this problem. The upper and lower bounds of stay of the billed DRGs will be used as instruments for this purpose. As Figure 1 already illustrates, these boundaries are expected to have a relevant influence on the individual length of stay, since they determine the area of the greatest profit for the hospital. The boundaries applicable for a particular year are specified externally by the InEK in the respective previous year. The actual length of stay of the calculation hospitals from the respective previous year is used as the basis for this determination. Therefore, these calculation hospitals potentially have the opportunity to influence the length of stay boundaries in the next year with their discharge and transfer behavior. However, we do not assume that this potential influence is intentional or particularly high. For this to be the case, the calculation hospitals would have to behave strategically in a coordinated manner to increase the length of stay and the costs per case in the same way. However, such behavior seems rather unlikely. Furthermore, the overall trend towards decreasing length of stay and case costs do not suggest such behavior. It can therefore be assumed that the length-of-stay boundaries are set externally by InEK and that the calculation hospitals have little or no influence. Accordingly, these quasi-experimental circumstances result in the following stages of the IV-regression:

$$\begin{aligned} \text{First stage: } Length_i = &\beta_0 + \beta_2 \cdot DRG\_L_i + \\ &\beta_3 \cdot DRG\_U_i + \theta_{\mathbf{X}} \cdot \mathbf{X_i} + u_i \end{aligned} \tag{2}$$

$$\text{Second stage: } \mathbf{E_i} = \gamma_0 + \gamma_1 \cdot \widehat{Length}_i + \theta_{\mathbf{X}} \cdot \mathbf{X_i} + \epsilon_i \tag{3}$$

with

DRG_L_i	Lower limit length of stay per billed DRG
DRG_U_i	Upper limit length of stay per billed DRG
u_i, ϵ_i	Error terms

V. Next Steps

We consider the following points as the next main steps for our research project. First, quality indicators for individual diseases and procedures will be identified by means of a literature search. At the time of writing, the scope of research includes quality indicators for procedures such as appendectomies, transcatheter aortic valve implantation and the insertion of artificial hip joints. We are currently concentrating on these three medical procedures, since they are very common, and therefore we expect to have a high number of observations in the database. In a further step, the relevant DRGs will be derived from the relevant procedures and diagnoses to be included in the regression. Based on this, the dataset will be compiled and validated. After compiling the data, the described analyses can be performed and the results will be described.

References

[1] Statistisches Bundesamt, *Data about hospitals and benefit or rehabilitation facilities 1992 (in German)*. Wiesbaden: Fachserie 12: Gesundheitswesen, Reihe 6.1, 1992.

[2] B. Augurzky and A. Beivers, "Digitization and investment financing (in german)," in *Krankenhaus-Report 2019: Das digitale Krankenhaus*, J. Klauber, M. Geraedts, J. Friedrich, and J. Wasem, Eds. Berlin, Heidelberg: Springer, 2019, pp. 67–82. doi: 10.1007/978-3-662-58225-1_5

[3] Statistisches Bundesamt, *Hospital data 2017 (in German)*. Wiesbaden: Fachserie 12: Gesundheitswesen, Reihe 6.1.1, 2018.

[4] A. Beivers and L. Waehlert, "Control of the quantity dynamics according to the KHSG: Implications for hospitals (in German)," in *Entrepreneurship im Gesundheitswesen II: Geschäftsmodelle – Prozesse – Funktionen*, M. A. Pfannstiel, P. Da-Cruz, and C. Rasche, Eds. Wiesbaden: Springer Fachmedien, 2018, pp. 123–137. doi: 10.1007/978-3-658-14781-5

[5] T. Reinhold, K. Thierfelder, F. Müller-Riemenschneider, and S. N. Willich, "Health economic effects of the drg introduction in germany - a systematic overview (in german)," *Das Gesundheitswesen*, vol. 71(05), pp. 406—312, 2009. doi: 10.1055/s-0028-1119399

[6] InEK GmbH, *Proposal procedure for the integration of medical, scientific and other expertise in the further development of the G-DRG system (in German)*, 2019. [Online]. Available: www.g-drg.de/G-DRG-Vorschlagsverfahren2

[7] W. Fiori, H.-J. Lakomek, K. Buscham, H. Lehmann, A. Fuchs, F. Bessler, and N. Roeder, "Hospital financing 2015 - important aspects for internal rheumatology (in german)," *Zeitschrift für Rheumatologie*, vol. 74, pp. 447—455, 2015. doi: 10.1007/s00393-015-1605-2

[8] A. Geissler, M. Wörz, and R. Busse, "German hospital capacity in an international comparison (in german)," in *Krankenhaus-Report 2010: Krankenhausversorgung in der Krise?*, J. F. Jürgen Klauber, Max Geraedts, Ed. Stuttgart: Schattauer, 2010, pp. 25–40.

[9] G. Neubauer, "On the economic control of hospital care under drg flat rates (in german)," in *Krankenhaus-Report 2003: G-DRGs im Jahre 1*, H. S. Jürgen Klauber, Bernt-Peter Robra, Ed. Stuttgart: Schattauer, 2003, pp. 101–119.

[10] InEK GmbH, *Final report 2006 (in German)*, 2006. [Online]. Available: https://www.g-drg.de/Archiv/DRG_Systemjahr_2006_Datenjahr_2004#sm7

[11] W. Von Eiff, S. Schüring, B. Greitemann, and M. Karoff, "Redia - effects of the drg introduction on rehabilitation (in german)," *Die Rehabilitation*, vol. 50, no. 04, pp. 214–221, 2011. doi: 10.1055/s-0031-1275720

[12] Deutscher Ethikrat, "Patient welfare as an ethical benchmark for the hospitals (in german)," *Stellungnahme vom 5.April 2016*, 2016. [Online]. Available: https://www.ethikrat.org/fileadmin/Publikationen/Stellungnahmen/deutsch/stellungnahme-patientenwohl-als-ethischer-massstab-fuer-das-krankenhaus.pdf

[13] J. Friedrich, W.-D. Leber, and J. Wolff, "Base case values - on the price and productivity development of stationary services (in german)," in *Krankenhaus-Report 2010: Krankenhausversorgung in der Krise?*, J. F. Jürgen Klauber, Max Geraedts, Ed. Stuttgart: Schattauer, 2010, pp. 127–47.

[14] Alliance for hospitals instead of factories (in German), *Fakten und Argumente zum DRG-System und gegen die Kommerzialisierung der Krankenhäuser*, Maintal, 2019. [Online]. Available: https://www.krankenhaus-stattfabrik.de/196

[15] M.-L. Müller, "Mid-term evaluation from the perspective of the german nursing council (in german)," in *Auswirkungen der DRG-Einführung in Deutschland. Standortbestimmung und Perspektiven*, F. Rau, N. Roeder, and P. Hensen, Eds. Stuttgart: W. Kohlhammer Verlag, 2009, pp. 32–36.

[16] R. Milstein and J. Schreyögg, "Empirical evidence on the effects of the introduction of the g-drg system (in german)," in *Krankenhaus-Report 2020: Finanzierung und Vergütung am Scheideweg*, J. Klauber, M. Geraedts, J. Friedrich, J. Wasem, and A. Beivers, Eds. Berlin, Heidelberg: Springer, 2020, pp. 25–39. doi: 10.1007/978-3-662-60487-8_2

[17] S. Hilgers, *DRG reimbursement in German hospitals: effects on length of stay and quality of treatment (in German)*. Springer-Verlag, 2011. doi: 10.1007/978-3-8349-6242-3

[18] H. Kehlet and D. W. Wilmore, "Fast-track surgery," *British Journal of Surgery*, vol. 92, no. 1, pp. 3–4, 2005. doi: 10.1002/bjs.4841

[19] H. Husted, G. Holm, and S. Jacobsen, "Predictors of length of stay and patient satisfaction after hip and knee replacement surgery: fast-track experience in 712 patients," *Acta orthopaedica*, vol. 79, no. 2, pp. 168–173, 2008. doi: 10.1080/17453670710014941

[20] Barmer GEK, "Hospital report 2010 (in german)," *Schwerpunktthema: Trends in der Endoprothetik des Hüft-und Kniegelenks. Schriftenreihe zur Gesundheitsanalyse*, vol. 3, 2010.

[21] T. Fürstenberg, M. Laschat, K. Zich, S. Klein, P. Gierling, H.-D. Nolting, and T. Schmidt, "G-drg accompanying research: final report of the second research cycle (2006–2008) (in german)," *Berlin: IGES*, 2011.

[22] T. Fürstenberg, M. Laschat, K. Zich, S. Klein, P. Gierling, T. Schmidt, and H.-D. Nolting, "G-drg accompanying research: final report of the third research cycle (2008–2010) (in german)," *Deutsche Krankenhaus-Verlagsgesellschaft, Düsseldorf*, 2013.

[23] J. O'Reilly, R. Busse, U. Häkkinen, Z. Or, A. Street, and M. Wiley, "Paying for hospital care: the experience with implementing activity-based funding in five european countries," *Health economics, policy and law*, vol. 7, no. 1, pp. 73–101, 2012. doi: 10.1017/S1744133111000314

[24] P. E. Martinussen and T. P. Hagen, "Reimbursement systems, organisational forms and patient selection: evidence from day surgery in norway," *Health Economics, Policy and Law*, vol. 4, no. 2, pp. 139–158, 2009. doi: 10.1017/S1744133109004812

[25] I. Papanicolas and A. McGuire, "Do financial incentives trump clinical guidance? hip replacement in england and scotland," *Journal of health economics*, vol. 44, pp. 25–36, 2015. doi: 10.1016/j.jhealeco.2015.08.001

[26] C. K. Davis and D. J. Rhodes, "The impact of drgs on the cost and quality of health care in the united states," *Health Policy*, vol. 9, no. 2, pp. 117–131, 1988. doi: 10.1016/0168-8510(88)90029-2

[27] M. W. Rich and K. E. Freedland, "Effect of drgs on three-month readmission rate of geriatric patients with congestive heart failure." *American Journal of Public Health*, vol. 78, no. 6, pp. 680–682, 1988. doi: 10.2105/ajph.78.6.680

[28] M. A. Sager, D. V. Easterling, D. A. Kindig, and O. W. Anderson, "Changes in the location of death after passage of medicare's prospective payment system," *New England Journal of Medicine*, vol. 320, no. 7, pp. 433–439, 1989. doi: 10.1056/NEJM198902163200705

[29] W. H. Rogers, D. Draper, K. L. Kahn, E. B. Keeler, L. V. Rubenstein, J. Kosecoff, and R. H. Brook, "Quality of care before and after implementation of the drg-based prospective payment system: a summary of effects," *Jama*, vol. 264, no. 15, pp. 1989–1994, 1990.

[30] J. Kosecoff, K. L. Kahn, W. H. Rogers, E. J. Reinisch, M. J. Sherwood, L. V. Rubenstein, D. Draper, C. P. Roth, C. Chew, and R. H. Brook, "Prospective payment system and impairment at discharge: the quicker-and-sicker'story revisited," *Jama*, vol. 264, no. 15, pp. 1980–1983, 1990.

[31] S. Farrar, D. Yi, M. Sutton, M. Chalkley, J. Sussex, and A. Scott, "Has payment by results affected the way that english hospitals provide care? difference-in-differences analysis," *Bmj*, vol. 339, 2009. doi: 10.1136/bmj.b3047

[32] H. Hamada, M. Sekimoto, and Y. Imanaka, "Effects of the per diem prospective payment system with drg-like grouping system (dpc/pdps) on resource usage and healthcare quality in japan," *Health Policy*, vol. 107, no. 2-3, pp. 194–201, 2012. doi: 10.1016/j.healthpol.2012.01.002

[33] A. Vuagnat, E. Yilmaz, A. Roussot, V. Rodwin, M. Gadreau, A. Bernard, C. Creuzot-Garcher, and C. Quantin, "Did case-based payment influence surgical readmission rates in france? a retrospective study," *BMJ open*, vol. 8, no. 2, pp. 1–9, 2018. doi: 10.1136/bmjopen-2017-018164

[34] A. Kutz, L. Gut, F. Ebrahimi, U. Wagner, P. Schuetz, and B. Mueller, "Association of the swiss diagnosis-related group reimbursement system with length of stay, mortality, and readmission rates in hospitalized adult patients," *JAMA network open*, vol. 2, no. 2, pp. 1–12, 2019. doi: 10.1001/jamanetworkopen.2018.8332

[35] WIG2 Scientific Institute for Health Economics and Health Systems Research. (2020) WIG2 Research database. [Online]. Available: https://www.wig2.de/analysetools/wig2-forschungsdatenbank.html