ORIGINAL ARTICLE

Achieving Minimum Caseload Requirements—an Analysis of Hospital Discharge Data From 2005–2011

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SUMMARY

Background: The German Federal Joint Committee (the highest decision-making body of physicians and health insurance funds in Germany) has established minimum caseload requirements with the goal of improving patient care. Such requirements have been in place for five types of surgical procedure since 2004 and were introduced for total knee endoprosthesis surgery in 2006 and for the care of low-birth-weight neonates (weighing less than 1250 g) in 2010.

Method: We analyzed data from German nationwide DRG statistics (DRG = diagnosis-related groups) for the years 2005–2011. The procedures that were performed were identified on the basis of their operation and procedure codes, and the low-birth-weight neonates on the basis of their birth weight and age. The treating facilities were distinguished from one another by their institutional identifying numbers, which were contained in the DRG database.

Results: In 2011, there were 172 838 hospitalizations to which minimum caseload requirements were applicable. 4.5% of these took place in institutions that did not meet the minimum requirement for the procedure in question. The percentage of institutions that did not meet the minimum caseload requirement for complex pancreatic surgery fell significantly from 64.6% in 2006 to 48.7% in 2011, and the percentage of pancreatic surgery cases treated in such institutions fell over the same period from 19.0% to 11.4%. A significant reduction in the number of institutions treating low-birth-weight neonates was already evident before minimum caseload requirements were introduced. For all other types of procedure subject to minimum caseload requirements, there has been no significant change either in the percentage of institutions meeting the requirements or in the percentage of cases treated in such institutions.

Conclusion: After taking account of the potential bias due to the identification of institutions by their institutional identifying numbers, we found no discernible effect of minimum caseload requirements on care structures over the seven-year period of observation, with the possible exception of a mild effect on pancreatic procedures.

► **Cite this as:**

Peschke D, Nimptsch U, Mansky T: Achieving minimum caseload requirements: an analysis of hospital discharge data from 2005–2011. *Dtsch Arztebl Int* 2014; 111: 556–63. DOI: 10.3238/arztebl.2014.0556

Many observational studies have shown that the outcomes of some surgical procedures are correlated with caseload (1–10). For this reason, the German Federal Joint Committee (G-BA) has established minimum caseload requirements for certain types of elective procedure for which this has been demonstrated. Minimum caseload requirements for hepatic and renal transplantation, complex esophageal and pancreatic surgery, and stem cell transplantation went into effect in 2004. Total knee replacement surgery has been subject to minimum caseload requirements since 2006, and the care of neonates weighing less than 1250 g at birth (whether born prematurely or at term) since 2010 (11, 12). Thus, such requirements have been established for seven different types of procedure.

The minimum caseload requirements for total knee replacement surgery were suspended in 2011 after legal battles (13). The minimum caseload requirement for the care of low-birth-weight neonates was to be increased in 2011 from 14 to 30 cases per year, but this planned increase was also suspended, and the old requirement of 14 cases per year is still in effect (14). The minimum caseload requirements are formally binding on all hospitals that are permitted to charge the German statutory health-insurance carriers for their services. The relevant regulation states: “If an institution is not expected to meet the minimum caseload requirement for an elective procedure, then the procedure may not be performed in that institution, starting in the year that the requirement goes into effect” (§5 Mm-R). The regulation also provides for certain general exceptions to the rule. When a particular type of procedure is established in an institution and the staff performing the procedure in that institution changes, the new team is allowed up to two years to meet the caseload requirement; three years are allowed when the procedure is new to the institution. Moreover, comprehensive coverage of the population must be provided (15).

Research on this topic to date has centered on changes in the care situation from 2004 to 2006. Over this period, there was no major change in the number of hospitals providing care, and 1% to 31% of patients (depending on the procedure) were operated on in

TABLE 1

Types of procedure, minimum caseload requirements, and developments 2005–2011

Type of procedure		2005	2006	2007	2008	2009	2010	2011
Hepatic transplantation (incl. living-donor partial donation)* ¹	Minimum caseload	10	20	20	20	20	20	20
	Number of cases	5799* ²	1020	1131	1091	1079	1231	1172
	Treating institutions	519 * ²	35	31	37	28	33	31* ³
	Mean caseload	11.2	29.1	36.5	29.5	38.5	37.3	37.8
	Percentage of institutions meeting caseload requirement	22%	46%	55%	43%	61%	58%	55%
Renal transplantation	Minimum caseload	20	25	25	25	25	25	25
	Number of cases	2639	2747	2909	2740	2769	2892	2877
	Treating institutions	50	51	47	47	47	42	49
	Mean caseload	52.78	53.86	61.89	58.30	58.91	68.86	58.71
	Percentage of institutions meeting caseload requirement	78%	75%	81%	74%	74%	88%	73%
Complex esophageal surgery	Minimum caseload	5	10	10	10	10	10	10
	Number of cases	3186	3248	3358	3524	3588	3618	3673
	Treating institutions	445	399	426	426	411	427	411
	Mean caseload	7.2	8.1	7.9	8.3	8.7	8.5	8.9
	Percentage of institutions meeting caseload requirement	42%	30%	27%	28%	32%	30%	32%
Complex pancreatic surgery* ¹	Minimum caseload	5	10	10	10	10	10	10
	Number of cases	8904	8327	9149	9299	9714	10 005	10 577
	Treating institutions	760	697	673	667	699	680	678
	Mean caseload	11.7	11.9	13.6	13.9	13.9	14.7	15.6
	Percentage of institutions meeting caseload requirement	55%	35%	44%	45%	46%	47%	51%
Stem cell transplantation	Minimum caseload	12±2	25	25	25	25	25	25
	Number of cases	5537	6178	5733	5954	6064	6367	6725
	Treating institutions	97	96	97	96	97	96	91
	Mean caseload	57.1	64.4	59.1	62.0	62.5	66.3	73.9
	Percentage of institutions meeting caseload requirement	69%	65%	65%	64%	58%	65%	65%
Total knee replacement	Minimum caseload	none* ⁴	50	50	50	50	50	50* ⁵
	Number of cases	118 243	124 682	134 767	141 876	145 116	143 495	141 928
	Treating institutions	1041	999	985	996	1004	1015	1024
	Mean caseload	113.6	124.8	136.8	142.5	144.5	141.4	138.6
	Percentage of institutions meeting caseload requirement	68%	79%	85%	86%	87%	87%	84%
Care of low-birth-weight neonates	Minimum caseload	none* ⁶	none* ⁶	none* ⁶	none* ⁶	none* ⁶	14	14
	Number of cases	6035	5801	5981	5646	5732	6378	5886
	Treating institutions	465	433	403	370	369	371	347
	Mean caseload	13.0	13.4	14.8	15.3	15.5	17.2	17.0
	Percentage of institutions meeting caseload requirement	32%	33%	36%	38%	40%	41%	44%

*¹ Not including institutions that only performed post-mortem organ removal. Post-mortem organ removals performed in the institutions included here were counted in the tallies.

*² There was a change in included codes (OPS definition) for this procedures between 2005 and 2006 that affected the case numbers.

*³ Of the 31 treating institutions, 24 carried out transplants; the remainder only performed living-donor partial resections or resections of liver transplants as independent procedures. These procedures are counted in the minimum caseload requirement.

*⁴ Minimum caseload requirement introduced in 2006; 50 cases used as basis for comparative calculations for the year 2005.

*⁵ Minimum caseload requirement suspended in 2011.

*⁶ Minimum caseload requirement introduced in 2010; 14 cases per year used as basis for comparative calculations for the years 2005–2009

hospitals that did not meet the minimum caseload requirement for the procedure in question (16).

Further changes in the care situation from 2006 onward have not been assessed until now. We therefore studied developments with respect to the affected procedures over the years 2005–2011. This study is based on hospital billing data; the billing units were identified on the basis of the institutional identifying numbers that the hospitals used for billing.

Materials and methods

In this study, we performed a monitored remote data analysis on the complete federal DRG statistics (DRG = diagnosis-related groups) for individual cases that was obtained from the research data centers of the German federal and state statistical offices (17). The DRG statistics covered all hospitalizations billed according to the DRG system. Each of the ca. 17 million inpatient treatments carried out in Germany per year can be evaluated in this way. The main exceptions are psychiatric and psychosomatic cases, which are not covered by DRG statistics but are, in any case, irrelevant to the issue of minimum caseload requirements (for more on this, see *eMethods*). The documentation of every case included a main diagnosis, additional diagnoses, the procedures performed (coded according to the Operations and Procedures Classification—*Operationen- und Prozedurenschlüssel*, OPS), the reason for discharge, and the anonymized institutional identifying number of the hospital (18–21) (further details in *eMethods*).

Cases of treatment that were subject to minimum caseload requirements were identified in these data on a case-by-case basis by means of the OPS codes for each type of procedure that were established by the G-BA for the procedure and year in question. For hepatic transplantation and pancreatic surgery, the G-BA definition also includes the OPS codes for post-mortem organ removal (5–503.0 hepatectomy, post mortem; 5–525.4 pancreatectomy, post mortem [for transplantation]). These codes were included in the analysis to determine whether the minimum caseload requirements, as set by the G-BA, were actually reached if the institutions also performed transplantations. Treating institutions that performed only post mortem hepatectomy and pancreatectomy were not considered in the analysis, however, because a reduction in the number of organ donations cannot be a goal of regulations that establish minimum caseload requirements. In the OPS, the category of liver transplantation contains both post-mortem and living-donor transplantation, and these were both tallied to determine the caseload, as is stipulated in the minimum caseload regulation. Institutions that performed only living-organ donations without any coded transplantations were counted as independent institutions.

Neonates weighing less than 1250 g at birth were identified in the database by their birth weight and an age of 28 days or less (22).

Treating (or, more precisely, billing) institutions were distinguished from one another by their institutional identifying numbers (*Institutionskennzeichen*, IK numbers). This was the basis for the tallying of case numbers for each institution. The German Federal Statistical Office considers a billing institution for the purpose of DRG statistics to be a “hospital providing inpatient services that are reimbursable in the DRG system (hospitals that are spread over multiple sites but have a single institutional identifying number are counted only once)” (23). The number of such billing institutions differs slightly from the number of hospitals contained in the register of basic data for German hospitals (*Grunddaten der Krankenhäuser*, [24]), which is usually cited as the number of hospitals in Germany.

In 2011, the register of basic data for German hospitals counted a total of 2045 hospitals, of which 1736 were general hospitals and the remaining 309 were either hospitals with exclusively psychiatric and psychotherapeutic (and also neurological) beds or else day clinics and night clinics, which are not subject to minimum caseload requirements and generally do not bill in the DRG system.

The DRG statistics for 2011 are derived from a total of 1601 billing institutions with different IK numbers. This number is a bit lower than the number of hospitals in the basic data register, although it should be remembered that not all general hospitals bill according to the DRG system. For reasons of data protection, we cannot determine what institutions account for the difference, as it is not permitted for individual hospitals to be identifiable.

Both collections of statistics revealed a drop in the number of hospitals over the course of the study. The basic hospital data showed that, in 2005 and 2011, there were 1846 and 1736 general hospitals, respectively; the DRG statistics for the same years contained 1,725 and 1,601 IK numbers, respectively). The current study is based on ‘billing institutions’ in the sense used in the DRG statistics. It should be borne in mind that one hospital can have multiple IK numbers, while, conversely, a single IK number can refer to treatment at multiple, geographically separated sites.

We used generalized linear regression models weighted by the annual total number of billing institutions and cases to search for linear trends in the number of treating institutions in each year, the percentage of such institutions that did not meet the minimum caseload requirements, and the number of cases treated in them. For the determination of trends, only the statistics from 2006 onward were considered, because different caseload requirements and definitions were in effect in 2005.

In *eMethods*, we describe additional subgroups of the types of procedures that were subject to minimum caseload requirements (*eTable*).

Results

In 2011, 172 838 cases, or 1.0% of all inpatient cases in the DRG statistics, were subject to minimum caseload requirements. Depending on the type of

TABLE 2

Characteristics of patients and treating institutions, broken down by fulfillment or non-fulfillment of minimum caseload requirements

	Minimum caseload achieved							Minimum caseload not achieved						
	2005	2006	2007	2008	2009	2010	2011	2005	2006	2007	2008	2009	2010	2011
Hepatic transplantation (including partial liver donation from a living donor)*														
Treating institutions	116	16	17	16	17	19	17	403	19	14	21	11	14	14
Cases	4462	922	1058	1019	1036	1186	1078	1337	98	73	72	43	45	94
Mean number of cases	38	58	62	64	61	62	63	3	5	5	3	4	3	7
Mean age	57	46	48	48	48	47	48	63	51	52	54	55	53	55
Percent female	44%	36%	36%	39%	35%	36%	33%	47%	49%	33%	35%	45%	48%	28%
Renal transplantation														
Treating institutions	39	38	38	35	35	37	36	11	13	9	12	12	5	13
Cases	2611	2717	2861	2645	2693	2862	2817	28	30	48	95	76	30	60
Mean number of cases	67	72	75	76	77	77	78	3	2	5	8	6	6	5
Mean age	49	50	50	49	50	50	50	44	42	55	49	53	50	54
Percent female	39%	38%	38%	37%	36%	37%	37%	18%	47%	35%	35%	28%	40%	27%
Complex esophageal surgery														
Treating institutions	186	118	116	121	131	127	130	259	281	310	305	280	300	281
Cases	2677	2251	2323	2455	2615	2589	2634	509	997	1035	1069	973	1029	1039
Mean number of cases	14	19	20	20	20	20	20	2	4	3	4	3	3	4
Mean age	62	62	62	63	63	63	63	64	65	65	66	66	66	65
Percent female	20%	24%	23%	23%	22%	22%	22%	25%	27%	27%	28%	25%	27%	22%
Complex pancreatic surgery*														
Treating institutions	420	247	297	302	322	320	348	340	450	376	365	347	360	330
Cases	8208	6748	7816	7979	8444	8658	9369	696	1579	1333	1320	1270	1347	1208
Mean number of cases	20	27	26	26	26	27	27	2	4	4	4	4	4	4
Mean age	61	61	62	62	62	63	63	61	63	63	63	64	64	64
Percent female	42%	42%	43%	44%	43%	45%	44%	40%	44%	43%	43%	46%	43%	43%
Stem cell transplantation														
Treating institutions	67	62	63	61	56	62	59	30	34	34	35	41	34	32
Cases	5380	5796	5405	5587	5609	6036	6359	157	382	328	367	455	331	366
Mean number of cases	80	93	86	92	100	97	108	5	11	10	10	11	10	11
Mean age	47	48	48	48	49	50	50	53	55	50	52	52	53	56
Percent female	38%	38%	38%	38%	37%	38%	38%	29%	38%	39%	36%	40%	38%	34%
Total knee replacement														
Treating institutions	703	794	837	861	874	879	859	338	205	148	135	130	136	165
Cases	110 535	120 321	131 576	138 774	141 739	140 018	137 502	7708	4361	3191	3102	3377	3477	4426
Mean number of cases	157	152	157	161	162	159	160	23	21	22	23	26	26	27
Mean age	70	70	70	70	70	69	69	70	70	70	70	70	70	70
Percent female	69%	69%	68%	67%	67%	66%	65%	70%	67%	68%	68%	67%	65%	67%
Treatment of low-birth-weight neonates														
Treating institutions	147	145	145	140	147	151	152	318	288	258	230	222	220	195
Cases	4958	4864	5113	4878	5014	5692	5301	1077	937	868	768	718	686	585
Mean number of cases	34	34	35	35	34	37	35	3	3	3	3	3	3	3
Mean age	882	884	883	878	884	891	885	897	921	901	920	925	936	930
Percent female	49%	49%	49%	49%	49%	48%	49%	50%	49%	49%	50%	50%	50%	49%

*Institutions performing only post-mortem organ removal are not included

The percentage of treating institutions that did not meet minimum caseload requirements, over time;

*¹Institutions that only performed post-mortem organ removal have been excluded;

*²two-tailed p-value for linear trend (2006–2011), <0.05

FIGURE 1

procedure group, 16.1% to 68.4% of the performing institutions did not meet the minimum caseload requirements for the procedure in question; 4.5% of the 172 838 cases were performed in such institutions.

The number of cases per year rose for all types of procedure studied except the care of low-birth-weight neonates (*Table 1*). There was a continuous, significant decline in the number of institutions treating low-birth-weight neonates (from 465 to 347); this was the only such decline noted for any of the types of procedure subject to minimum caseload requirements. Accordingly, the percentage of institutions that met the minimum requirement of 14 low-birth-weight infants treated per year rose significantly from 31.6% in 2005 to 43.8% in 2011 ($p < 0.0001$).

For all other types of procedure, the number of treating institutions varied only slightly over time, without significant trends (*Table 1*). No concentration of care in a smaller number of institutions was seen. The observed increases in the mean case numbers per institution and per year were accounted for in large part by increases in the total number of cases treated, with a relatively stable number of treating institutions. Only in the case of pancreatic surgery the increase in total delivered care resulted in a significant decrease in the percentage of institutions that failed to meet the minimum caseload requirement ($p = 0.012$) (*Figure 1*). The number of pancreatic operations performed in such institutions decreased significantly, as did the number of low-birth-weight treatments in institutions that did not meet the minimum caseload requirement for such treatment (*Figure 2*).

The percentage of institutions that met the minimum caseload requirements rose significantly from 2006 to 2011 both for pancreatic surgery (35.4% to

51.3%) and for the treatment of low-birth-weight neonates (33% to 44%). There was no significant rise for any of the other five types of procedure. The figures for 2006 and 2011, respectively, were: for hepatic transplantation, 45.7% and 54.8%; for renal transplantation, 74.5% and 73.5%; for esophageal surgery, 29.6% and 31.6%; for stem cell transplantation, 64.6% and 64.8%; for knee replacement surgery, 79.5% and 83.9% (*Table 1*).

There were no systematic differences in patient sex ratios between institutions that did and did not meet the minimum caseload requirements. There were, however, systematic differences with respect to age: in institutions that did not meet the minimum caseload requirements for hepatic transplantation, esophageal surgery, and stem cell transplantation, the average age was slightly higher (*Table 2*).

Discussion

The major strength of this study is the completeness of the database. The analyses presented here are based on complete billing data for each of the procedures in question, and, therefore, the parent population of all relevant inpatient cases was evaluated, rather than only a sample. The evaluation was thus hospital-independent and unaffected by the hospitals' own determinations or self reporting as to whether they met the minimum caseload requirements (as found, for example, in the hospitals' legally mandated quality-assurance reports).

On the other hand, the use of this extensive set of data also results in a major limitation of the study. In the DRG statistics of the German Federal Statistical Office, the distinction of one institution from another is made on the basis of IK numbers, i.e., the institutions

FIGURE 2

The percentage of cases treated in institutions that did not meet minimum caseload requirements, over time;
¹Institutions that only performed post-mortem organ removal have been excluded;
²two-tailed p-value for linear trend (2006–2011), <0.05

considered in this study are single units with respect to billing. This definition does not correspond exactly to that of the approved German hospitals that can be found in other statistical databases.

A billing institution, as indicated in the DRG statistics, may correspond to only a part of a hospital. This can lead to underestimation of the number of institutions that met the minimum caseload requirements. The opposite, however, may also be the case: multiple hospital sites can share a billing (IK) number, and this can lead to overestimation of the number of institutions that met the minimum caseload requirements.

The overall number of billing institutions in the DRG statistics turns out to be slightly lower than the number of hospitals in the basic hospital data. Moreover, the number of institutions has declined over time in both statistics, perhaps because of mergers or a preferential loss of smaller institutions. Either mechanism would tend to result in an overestimation of the number of institutions that met the minimum caseload requirements.

As “hospitals” are defined differently in each database, studies based on different databases can yield divergent results not only regarding the overall number of hospitals, but also regarding the percentage of hospitals that met minimum caseload requirements for any particular type of procedure (see, for example, the article by von de Cruppé et al. in this issue [25]).

When interpreting the findings of this study and similar studies, one must bear in mind that the definitions of individual procedures covered by minimum caseload requirements may have changed over the period of observation in such a way as to affect the number of procedures subject to the requirement (e.g.,

hepatic transplantation, from 2005 to 2006); that some of the minimum caseload thresholds were increased by the G-BA between 2005 and 2006; and that hospitals performing pancreatic and esophageal surgery exclusively on children are exempt from such requirements. All of these things were considered in the present study.

With the use of these methods, this study of the seven types of procedure that were subject to minimum caseload requirements from 2005 to 2011 revealed that the percentage of patients treated in institutions that did not meet such requirements dropped significantly in response to the requirements for only one of the seven types of procedure, namely, complex pancreatic surgery. A comparable, steady drop over the years 2005 to 2011 was observed for the care of low-birth-weight neonates but cannot be considered an effect of the minimum caseload requirement, which, in this case, was not introduced until 2010.

As for the number of institutions performing each of the procedures in question, slightly more institutions performed total knee replacement surgery in 2011 than in 2006 (a rise from 999 to 1024 institutions), but, in 2011, 16.1% of them failed to meet the minimum caseload requirement. On the other hand, the number of institutions caring for low-birth-weight neonates fell over the same period from 433 to 347, even though a minimum caseload requirement was only introduced in 2010. No statistically significant increases or decreases in the number of performing institutions were seen for any of the other five types of procedure.

Previously published findings on the implementation of minimum caseload requirements in the years 2004–2006 are consistent with those reported here.

Geraedts et al. concluded at that time that their observation period had been too short to permit any robust conclusion about the efficacy of minimum caseload requirements (16). The present findings clearly show that minimum caseload requirements have had no discernible effect on care structures over a seven-year period, except for a possible, mild effect on pancreatic surgery, as revealed by an analysis of the treating and billing institutions. The observed changes in preterm neonatal care cannot be due to the minimum caseload requirements, as they mostly took place before the requirements went into effect in 2010. For none of the other types of procedure was there any decline in the number of institutions performing it, although this was intended when the minimum caseload requirements were introduced and might have been expected to occur. One can only speculate about why the minimum caseload requirements appear to have had so little effect.

A possible weakness of this study is that the evaluation was based on billing institutions (IK numbers). As recent years have seen more hospital mergers than hospital split-ups, one might have expected to see an artefactual decrease in the number of institutions that failed to meet the minimum caseload requirements. It is also conceivable that the institutions that failed to meet the minimum caseload requirements were actually exempt from them under the stated exceptions to the minimum caseloads regulation. This would then have to have been true for the entire period of observation (because of the lack of observed change after the minimum caseload requirements were introduced). This, in turn, would indirectly imply that there was no need for the minimum caseload requirements in this case.

It is, however, also conceivable that the monitoring and implementation mechanisms for minimum caseload requirements are currently inadequate because too little attention is paid to this matter in the annual budget negotiations of hospitals and health insurance carriers, and on the state governmental level.

If minimum caseload requirements are wanted, they should also be implemented. The current state of regulation seems not to have achieved this aim. The causes of failure to meet the minimum caseload requirements should be examined in each of the affected institutions, or in a sampling of them, so that appropriate conclusions can be drawn about monitoring mechanisms, the legal formulation of minimum caseload requirements, and, possibly, a more accurate definition of the procedures that are to be covered by them.

Conflict of interest statement

The academic department of structural advancement and quality management in health care in which the authors work is funded by Helios Kliniken GmbH.

Manuscript submitted on 12 December 2013, revised version accepted on 2 July 2014.

Translated from the original German by Ethan Taub, M.D.

KEY MESSAGES

- Minimum caseload requirements for hepatic and renal transplantation, complex pancreatic surgery (such as pancreatectomy), complex esophageal surgery (such as esophagectomy), and stem cell transplantation went into effect in 2004. Total knee replacement surgery has been subject to minimum caseload requirements since 2006, and the care of neonates weighing less than 1250 g at birth since 2010. In 2011, 172 838 of the 17 708 910 inpatient treatments in the DRG statistics were subject to minimum caseload requirements.
- This study, based on the billing institutions that are identifiable from DRG statistics, showed no reduction in the percentage of institutions that failed to meet minimum caseload requirements over a six-year period, with the exception of a small, significant reduction for pancreatic surgery. The observed reduction in the percentage of institutions that did not meet minimum outcome requirements for the care of low-birth-weight neonates occurred mainly before these requirements were introduced.
- The percentage of cases treated in institutions that did not meet minimum caseload requirements was relatively low in 2011. It was 8% for liver transplantation (out of 1172 patients total), 2% for renal transplantation (of 2877), 28% for esophageal surgery (of 3673), 11% for pancreatic surgery (of 10 577), 5% for stem cell transplantation (of 6725), 3% for total knee replacement (of 141 928), and 10% for the care of low-birth-weight neonates (of 5886).
- These findings show that minimum caseload requirements in Germany—as far as can be determined from a statistical analysis of DRG statistics—have not had any major influence on the care situation. This may be because the institutions that do not meet the requirements are actually exempt from them, but it also seems likely that the requirements are inadequately implemented.

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eMethods, eTables:
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Achieving Minimum Caseload Requirements—an Analysis of Hospital Discharge Data From 2005–2011

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Detailed description of materials and methods

In this study, we analyzed the DRG statistics of the research data centers of the German federal and state offices of statistics using monitored remote data processing (17). The DRG statistics contain individual case data on all inpatient cases billed according to the DRG system. These data are reported by the hospitals once a year to the Institute for the Hospital Reimbursement System (*Institut für das Entgeltsystem im Krankenhaus*). A selected list of features is reported to the Federal Statistical Office. Data in this database from the year 2005 onward have been made available by the federal and state offices of statistics for scientific evaluation (17). Such evaluations are carried out by means of SAS programs created by the scientific users themselves that can access the data stored at the Federal Statistical Office.

Each of the approximately 17 million cases of treatments billed under the DRG system each year is accessible to evaluation via this database. The main types of cases not contained in the database are those of specialized psychiatric and psychosomatic units that do not bill under the DRG system. Such cases are irrelevant to the topic of the present study, as the existing minimum caseload requirements do not apply to them.

Further types of cases not included in the database are, for example, those of German military hospitals (insofar as they are not billed under the DRG system) and prison hospitals. These exceptions are likewise irrelevant to the topic of the present study, as the minimum caseload requirements to not apply to these cases either.

For all cases covered, the DRG statistics contain information on the main and additional diagnoses, the procedures performed (coded according to the German Operations and Procedures classification—*Operationen- und Prozedurenschlüssel*, OPS), the reason for discharge, and the billing institution, identified by its institutional identifying number (see Methods in the main text) (18–21). This information suffices to enable the determination whether each billing institution met its minimum caseload requirements. Thus, the present study was performed by applying a uniform algorithm to a single database that covered all inpatient treatments in all German hospitals (i.e., the statistical parent population of inpatient cases). There was no need to amalgamate data from multiple databases, so issues of compatibility of different databases did not arise. All analyses were performed with SAS Version 9.3 statistics software.

Cases to which the minimum caseload requirements applied, according to the pertinent legal regulation (§ 137 SGB V), were

identified by the OPS codes that the German Federal Joint Committee (G-BA) determined to be applicable to the procedure in question for the year in question; these are published in Appendix 1 of the regulation. Because the OPS undergoes continuous revision, with frequent changes of content, there have been small changes over the period 2005–2011 in the OPS codes that needed to be considered for all types of procedure subject to minimum caseload requirements, with the sole exception of renal transplantation. The only change of this type that had a major quantitative effect was seen in the area of hepatic transplantation: the G-BA decided to exclude OPS code 5–502 (anatomical [typical] hepatic resection) from 2006 onward, with the result that, in 2006, 4779 fewer hepatic cases were subject to minimum caseload requirements than in the preceding year (an 82.4% drop from 2005 to 2006) (11).

Neonates weighing less than 1250 g at birth, whether born prematurely or at term, were identified in the database from their birth weight and from an age of 28 days or less, corresponding to the WHO definition of a “neonate” (22). Quantitative trends in the treatment of low-birth-weight neonates from the year 2005 onward were analyzed in relation to the minimum caseload requirement of 14 cases per year, even though this requirement did not go into effect until 2010. Similarly, quantitative trends in total knee replacement surgery were analyzed from 2005 onward, even though the corresponding minimum caseload requirement did not go into effect until 2006 (11).

The minimum caseload requirements for complex esophageal surgery and for stem cell transplantation do not apply to institutions that exclusively treat children (15). The G-BA does not state the precise age limit of “childhood” for the purpose of this regulation; in the present study, we excluded institutions from consideration if all the patients they treated with these two types of procedure were under 20 years old.

A treating institution, for the purpose of the present analysis, was held to be equivalent to a single institutional identifying number (IK number); in other words, all cases with the same IK number were considered to have been treated in the same institution. This method of data analysis may have caused bias of either of two different types, or both:

Hospitals that are geographically distributed over multiple sites, but have only a single IK number, were only counted once (as in the official DRG statistics). This would tend to cause an overestimation of the number of cases per institution, and therefore an underestimation of the number of

institutions that failed to meet the minimum caseload requirements.

On the other hand, single-site hospitals that bill via multiple IK numbers were counted as multiple institutions. This would tend to cause an underestimation of the number of cases per institution, and therefore an overestimation of the number of institutions that failed to meet the minimum caseload requirements (26).

Both of these constellations are rather rare, as shown by a comparison of a hospital count based on the IK numbers in the DRG statistics of the Federal Statistical Office with the number of hospitals provided in the “basic hospital data” that are also maintained by this office (23, 24). The former of the two constellations is by far the more common in the real world. This implies that the present study probably overestimates the percentage of institutions that actually met the minimum caseload requirements—in other words, any bias, if present, is likely to be in the direction opposite to the central findings of the study. The validity of these findings is thus unaffected.

Table 1 contains a year-by-year listing of the percentages of institutions that met the minimum caseload requirements. The supplementary eTable shows how many institutions met the requirements only halfway and how many performed more than twice the required number of cases for each of the types of procedure specified.

Results: further details

The minimum caseload requirements set by the G-BA for hepatic transplantation and complex pancreatic surgery also included post-mortem organ removal in the tallies for each of these types of procedure. The number of institutions whose procedures in the category of hepatic transplantation were confined to post-mortem hepatectomy varied from 27 to 63, depending on the year; the comparable figure for post-mortem pancreatectomy was 2 to 3 institutions, depending on the year. The annual number of post-mortem organ removal procedures in each of these two categories was always either one or two per institution. The analysis in the present study took no account of institutions exclusively performing post-mortem organ removal, because minimum caseload requirements are clearly not intended to apply to “donor clinics” of this type. Moreover, post-mortem organ removal procedures are billed differently from other types of procedure and may not have been fully coded in the available DRG database.

In the institutions studied that performed both hepatic and pancreatic transplantation procedures on organ recipients and transplantations on brain-dead organ donors, the post-mortem organ

removals accounted for a mean of 2.11% of all hepatic transplant procedures and 0.17% of all complex pancreatic operations.

The minimum caseload requirement for hepatic transplantation includes living-donor partial hepatectomy for transplantation (OPS code 5–503.*) in the tally of procedures; thus, institutions performing procedures with this OPS code were included in the analysis of the present study. In 2011, 31 institutions performed hepatic transplantations and/or living-donor partial hepatectomy: 24 performed hepatic transplantation (OPS key 5–504.*), while the remaining 7 performed only living-donor partial hepatectomy for transplantation or liver-transplant resection as an independent procedure (OPS codes 5–503.1 through 5–503.y).

The 24 institutions performing hepatic transplantation that were identified from the DRG data correspond in number to the transplant centers listed in the 2011 annual report of the German Foundation for Organ Transplantation (*Deutsche Stiftung Organtransplantation*, DSO) (27) and to those listed in the quality report of the AQUA Institute for 2011 (28).

49 institutions billing for renal transplantation were identified from the DRG data; the AQUA institute reported 43 hospitals performing renal transplantation in 2011, the DSO 41. This discrepancy cannot be accounted for by hospitals that exclusively performed donor nephrectomies, because such procedures are not included in the tally of cases for the minimum caseload requirement (here the rule for renal transplantation differs from that for hepatic transplantation). The discrepancy cannot be definitively explained without de-anonymization of the IK numbers, which is not permissible. Conceivably, some cases of renal transplantation performed in the context of a close cooperation between different institutions may have been billed under multiple IK numbers.

For a deeper analysis of the caseload problem, we also determined the number of institutions meeting each caseload requirement not even halfway, or fulfilling it with more than twice the number of cases required. The percentage of institutions that failed to meet the minimum caseload requirement even halfway was lower in 2011 than in 2005 for every type of procedure studied, but the change was significant only for pancreatic surgery ($p = 0.012$) and low-birth-weight neonatal care ($p = 0.0057$). On the other hand, the number of institutions meeting their requirements with more than twice the required number of cases rose significantly for hepatic transplantation ($p = 0.011$), esophageal surgery ($p = 0.015$), pancreatic surgery ($p = 0.0072$), and low-birth-weight neonatal care ($p = 0.021$). The highest percentages of institutions of this type in the year 2011 were found for total knee replacement (50.8%) and renal transplantation (49.0%) (eTable).

eTABLE

Treating institutions broken down by their annual case numbers in relation to minimum caseload requirements (MCR)

Type of procedure		2005	2006	2007	2008	2009	2010	2011
Hepatic transplantation (including living-donor partial hepatectomy)	Minimum caseload requirement	10	20	20	20	20	20	20
	Number of treating institutions	519	35	31	37	28	33	31
	* ¹ caseload > 2 x MCR		29%	35%	32%	39%	42%	42%
	* ² MCR ≤ caseload ≤ 2 x MCR		17%	19%	11%	21%	15%	13%
	* ³ MCR/2 ≤ caseload < MCR		11%	13%	5%	4%	6%	16%
	* ⁴ caseload < MCR/2		43%	32%	51%	36%	36%	29%
Renal transplantation	Minimum caseload requirement	20	25	25	25	25	25	25
	Number of treating institutions	50	51	47	47	47	42	49
	* ¹ caseload > 2 x MCR	52%	41%	47%	47%	49%	57%	49%
	* ² MCR ≤ caseload ≤ 2 x MCR	26%	33%	34%	28%	26%	31%	24%
	* ³ MCR/2 ≤ caseload < MCR	Xxx* ⁵	0%	Xxx* ⁵	9%	6%	Xxx* ⁵	Xxx* ⁵
	* ⁴ caseload < MCR/2	Xxx* ⁵	25%	Xxx* ⁵	17%	19%	Xxx* ⁵	Xxx* ⁵
Complex esophageal surgery	Minimum caseload requirement	5	10	10	10	10	10	10
	Number of treating institutions	445	399	426	426	411	427	411
	* ¹ caseload > 2 x MCR	21%	8%	9%	9%	10%	10%	10%
	* ² MCR ≤ caseload ≤ 2 x MCR	21%	22%	19%	19%	21%	20%	21%
	* ³ MCR/2 ≤ caseload < MCR	16%	24%	21%	22%	20%	22%	24%
	* ⁴ caseload < MCR/2	42%	47%	52%	49%	48%	48%	44%
Complex pancreatic surgery	Minimum caseload requirement	5	10	10	10	10	10	10
	Number of treating institutions	760	697	673	667	699	680	678
	* ¹ caseload > 2 x MCR	34%	16%	18%	19%	18%	20%	22%
	* ² MCR ≤ caseload ≤ 2 x MCR	21%	19%	27%	26%	28%	27%	30%
	* ³ MCR/2 ≤ caseload < MCR	15%	21%	18%	19%	17%	19%	17%
	* ⁴ caseload < MCR/2	30%	44%	38%	36%	33%	34%	31%
Stem cell transplantation	Minimum caseload requirement	12±2	25	25	25	25	25	25
	Number of treating institutions	97	96	97	96	97	96	91
	* ¹ caseload > 2 x MCR	53%	36%	37%	36%	37%	38%	42%
	* ² MCR ≤ caseload ≤ 2 x MCR	16%	28%	28%	27%	21%	27%	23%
	* ³ MCR/2 ≤ caseload < MCR	14%	14%	14%	17%	18%	15%	15%
	* ⁴ caseload < MCR/2	16%	22%	21%	20%	25%	21%	20%
Total knee replacement	Minimum caseload requirement	none* ⁶	50	50	50	50	50	50
	Number of treating institutions	1,041	999	985	996	1,004	1,015	1,024
	* ¹ caseload > 2 x MCR	41%	45%	50%	52%	54%	53%	51%
	* ² MCR ≤ caseload ≤ 2 x MCR	26%	35%	35%	34%	33%	34%	33%
	* ³ MCR/2 ≤ caseload < MCR	14%	8%	6%	6%	7%	7%	9%
	* ⁴ caseload < MCR/2	18%	12%	9%	7%	6%	6%	7%
Treatment of low-birth-weight neonates	Minimum caseload requirement	none* ⁷	none* ⁷	none* ⁷	none* ⁷	none* ⁷	14	14
	Number of treating institutions	465	433	403	370	369	371	347
	* ¹ caseload > 2 x MCR	17%	18%	18%	19%	19%	25%	25%
	* ² MCR ≤ caseload ≤ 2 x MCR	14%	15%	18%	18%	21%	16%	19%
	* ³ MCR/2 ≤ caseload < MCR	12%	11%	11%	10%	9%	8%	8%
	* ⁴ caseload < MCR/2	57%	56%	53%	52%	51%	51%	48%

*¹ Institutions with more than twice the required caseload

*² Institutions meeting the caseload requirement with at most twice the required caseload

*³ Institutions that failed to meet the caseload requirement, but performed at least half of the required number of cases

*⁴ Institutions that performed fewer than half of the required number of cases

*⁵ The Federal Statistical Office does not release case numbers lower than 3 for publication, for reasons of legally mandated data protection

*⁶ Minimum caseload requirement introduced in 2006; a minimum of 50 cases was used to analyze the data from 2005

*⁷ Minimum caseload requirement introduced in 2010; a minimum of 14 cases was used to analyze the data from 2005–2009