An integrated formula for determining the admission capacity in medical studies in reference to patients

Volkhard Fischer, Ingo Just

For most university study programmes, the determination of admission capacity depends on the availability of teaching staff. Medical schools commonly verify this calculation by determining admission capacity based on patients. Since the latter usually yields a smaller value, it is then the deciding factor for the admissions procedure at German medical schools and its judicial review. The Hannover Medical School has a permanent working group dedicated to improving this procedure because the patients' participation in medical instruction is limited in its scope and availability and cannot be increased by mere actions taken by administrators. For these reasons, the determination of a patient-based admission capacity for a medical study programme must be as reliable as possible. This project report puts forth a proposal to improve the traditional procedure by considering patient-based teaching holistically.

1 Introduction

A central pillar of academic medical education is instruction using patients. This instruction takes place in Germany and most European countries at the advanced semester level after covering the basic principles of the natural sciences. Because German law mandates that medical schools at state universities must educate as many students as possible, the medical schools are obliged to allocate the maximum admission capacity for each study programme. The calculation of the admission capacity of a medical school is based on the available teaching staff and the number of patients treated during the previous year (Niedersächsisches Ministerium für Wissenschaft und Kultur, 2018). Usually, the patient-based capacity determination yields the smaller value and thus the admission capacity to be set.

Since the mid-1980s, a standard model consisting of three calculation steps has been defined for the patient-based capacity determination (Lohfert et al., 1986). The aim is to use the time expected in the next academic years during which patients are available for instruction to teach as many students as possible. To calculate this, the available time with patients is divided by the time needed with patients by one student during their medical studies.

First, the admission capacity is calculated using the number of inpatients treated in the year before. Along with the number of treatment days for these patients, this first formula includes only the number of curricular hours required by German law for bedside teaching and patient suitability for such instruction; it does not include any other teaching formats using patients that are required by the German Medical Licensing Act (Approbationsordnung für Ärzte/ÄApprO).

In a second step, the number of students to be admitted is defined using the number of outpatients treated in the previous year in relation to the number of bedside teaching hours and the suitability of the outpatients. Figure 1 shows the original formula for this. De facto, however, only its set result (one study place for 1,000 new outpatient admissions) is used. Only half of the maximum possible outpatient teaching capacity calculated in this manner is added to the calculated inpatient teaching capacity.

The third step of the calculation entails an addition of student admission spaces for instruction involving patients that is taught outside the main university hospital at external teaching hospitals or general practitioners. While a recommendation exists for how to handle this final step, medical schools do, in fact, follow highly different mathematical approaches which often do not follow the same logic as the first two steps of the calculation.

The formulas are presented in Figure 1. What makes the patient-based determination of capacity special are the connections it makes between the quantities set by the curriculum (hours of instruction: v, group size: p) and those factors determined by patients (probability of suitability: L, patient resilience: b, frequency of examination: H) and those by the institution (beds occupied during daytime: tbB, outpatient new admissions: NZ). German administrative courts generally do not question this approach even though the model assumes that each patient is essentially suitable for bedside teaching purposes in each clinical specialty regardless of sex or reason for hospital stay.

Figure 1: The three traditional calculation steps to determine the patient-based admission capacity for a medical study programme

(1) $$kAp_s := tbB \bullet \frac{L_s \bullet b_s \bullet 24}{(v \bullet 12)/p}$$

(2) $$kAp_a := NZ \bullet \frac{L_a \bullet H_a \bullet (24/48)/A_a}{(v \bullet 12)/p}$$

$$kAp_a := \frac{\mathrm{NZ}}{1000} \div (kAp_s \bullet 0{,}5)$$

(3) $$kAp_e := (kAp_s + kAp_a) \bullet \frac{CAp_e}{CAp}$$

Whereby

Supply		**Demand**	
tbB	= beds occupied during daytime	n	= hours per week per semester
NZ	= outpatient new admissions	p	= number of students per patient
tpk	= outpatients per day	CAp	= proportion of curriculum with patient-based instruction
L	= probability of patients' suitability	$X_{s,\ ts,\ a}$	= inpatients, semi-inpatients, outpatients
b	= resilience of patients		
H	= frequency of examination	$X_{i,\ e}$	= internal, external
A	= number of patients per hour	**kAp**	**= clinical admission capacity**

Admittedly, it is only under certain conditions that this normative approach correctly reflects the actual bedside instruction given to medical students at a medical school. In particular, curricular models that provide for another mix of inpatients and outpatients can lead to distorted results (Fischer & Haller, 2010).

The formula also applies obsolete parameters and contains errors and breakdowns in logic (Lohfert, 2010). As these logical breakdowns and errors can affect the quality of education, this paper compares the standard model with an alternative mathematical model which is just as amenable to judicial review as the traditional one but which has only one formula, instead of three that are interpreted differently depending on the particular administrative court. The alternative mathematical model follows the same basic principle: The amount of patient time available is placed in relation to the necessary patient time needed to educate a student in order to calculate the maximum number of students to be educated.

2 The traditional way to determine the patient-related admission capacity

2.1 Legislative framework

Currently, the ÄApprO stipulates that during the third to fifth year of medical study 476 hours of instruction must be taught using patients (BMG, 2017). Half of this instruction should take place as patient demonstrations in groups of six and the other half as patient exams in groups of three. How many of these 476 hours must be taught using outpatients and how many using inpatients is left open by the ÄApprO.

Furthermore, students are required to complete block placements lasting between one and up to six weeks in surgery, internal medicine, paediatrics and gynaecology/obstetrics under the conditions imposed by the routine practice of clinical and outpatient care, and a block placement in general practice lasting at least two weeks. This aspect will be dramatically changed in 2025 when a newly revised ÄApprO will come into force (BMG & BMBF, 2017).

Separate from university study but still a pre-requisite to sit for the second part of the state medical exam between the fifth and sixth years of study, each student must demonstrate four months of clinical clerkships (*Famulatur*) at a freely chosen hospital or other medical facility providing outpatient care.

The entire sixth year of study is spent at the university hospital, an independent teaching hospital, or a teaching practice with a focus on patient-based instruction, whereby all students must complete four months each in surgery, internal medicine and an elective subject.

In addition to the learning of theory and the placements in the natural sciences and the theoretical clinical subjects, the patient-based instruction is meant to ensure the quality of the medical education. Even though the number of hours spent receiving bedside instruction is not high from the perspective of the individual student, particularly during the first five years of study, proper resource planning is of utmost importance. To illustrate this clearly, Table 1 shows the hours of patient-based teaching per student for bedside teaching and block placements juxtaposed against lectures. Moreover, the number of hours which must be offered by a medical school to educate a cohort of 330 students is also listed.

Table 1: Hours spent on patient-based teaching per individual student and student cohort

	per student			per cohort	
Curricular Parts	**hours**	**hours in % of the programme**	**group size**	**hours for 330 students**	**hours in % of the programme**
Lecture	1,624	29.1%	180	2,977	0.4%
Bedside Teaching (UaK)	476	8.5%	4	39,270	5.3%
Block Placements (BP)	280	5.0%	2	46,200	6.2%
Total	5,574	100.0%		744,927	100.0%

Of the four forms of patient-based instruction defined by the ÄApprO (UaK, BP, PJ, F), only the 476 hours of bedside teaching (UaK) are included in the patient-based capacity determination. The Capacity Regulations (Kapazitätsverordnung/KapVO) do not provide any further justification for why the determination of admission capacity is limited exclusively to this teaching format. In the case of the clinical clerkships, it can be argued that they are not formally part of the medical study programme and that they are usually completed outside of the university hospital. In terms of the education and learning which take place in the placement year, it can also be argued that this does not have to be completed at the university hospital, but rather could also be performed at an external teaching hospital.

However, there is no obvious justification for why the block placements cannot be included in the calculation of capacity. The number of hours to be taught may not be precisely defined, but perhaps even more than bedside teaching this form of patient-based teaching focuses on future medical practice in the healthcare system.

The traditional patient-based capacity determination must be urgently revised, not only because the new amendment of the ÄApprO (BMG & BMBF, 2017) is expected to expand teaching at external outpatient institutions and even stipulate instruction using simulated patients. For, unlike in the teacher-based capacity determination that is used for all university study programmes in Germany, a very important fact exists regarding medical study: The necessary time spent on patient-based instruction represents a voluntary contribution by patients which is offered free of charge. This resource should be used with care and in a targeted manner. In 2016, we formed the only research group on this topic in Germany to date because the traditional approach has logical inconsistencies that have been repeatedly litigated before the administrative courts.

2.2 Problems of the traditional approach

When implementing the required instruction hours in practice, the constraints related to this kind of teaching often represent large obstacles. The required group sizes can only be met if enough patients are willing to serve as demonstration or examination objects during instruction. This may not be the case because in the determination of capacity, no distinction is made between internal medicine patients, psychiatric patients, surgical patients or gynaecological patients. And even if, spread out over a calendar year, a sufficient number of otorhinolaryngology patients are suitable and willing to participate in teaching, this may by no means be the case during any given week of the semester. Such natural fluctuations can be accounted for in the curricular planning done by medical faculties. In addition, students can have a modifying effect through their individual areas of focus.

It is somewhat different with the standard requirements that stem from the Capacity Regulations (KapVO) and not the Medical Licensing Act (ÄApprO). The KapVO indirectly requires, via the formula system shown in Figure 1, that a third of patient-based teaching must take place using outpatients. Although the first empirical test of this standard rule at the national level for all 36 medical schools, performed by the firm Lohfert & Lohfert in 1986, showed that, in reality, the outpatient capacity was lower than the standard required by a factor of 10. A more recent empirical check by Lohfert & Lohfert for the Hannover Medical School (MHH) revealed that in 2010, the standard requirement still overestimated the real-world practicability by a factor of three (Lohfert & Lohfert, 2011).

The decision handed down by the Higher Administrative Court in Lüneburg, Germany, regarding the MHH variation of the traditional formula in Figure 1 also changed nothing about the standard requirements (OVG Lüneburg, 2016). The problem here is relatively easy to understand: Step 1 of the formula determines for which number of study spaces the usable patient-based teaching time can be exhausted using the inpatients. Step 2 determines the additional number of study spaces which can be created if outpatients are included in medical instruction. If this theoretically available outpatient-based teaching time cannot be used, whether due to organisational reasons or because the actual patients are more severely ill than the standard supposes, then the deficit in the needed patient-based teaching time must be compensated for by stronger inclusion of the inpatients. This represents, however, an adverse burden on individual inpatients and can be in violation of the ÄApprO, which states that unreasonable demands on patients in connection with teaching must be avoided (Section 2 subsection 3).

There are also problematic requirements in the third step of the patient-based capacity determination (Fischer, 2018). The interpretation, chosen by the administrative board

of the then central office for university admissions and presented in Figure 1, only uses mathematical parameters for teacher-based capacity determination. Together with the premise that basically each patient is interchangeable with every other patient for the purpose of medical instruction, this rule always results in an over-proportionate increase in the admission capacity when medical instruction is given at external healthcare institutions. If, for example, a medical school must hold instruction in gynaecology at an external institution because its own women's health clinic does not have a sufficient number of patients for instruction in gynaecology & obstetrics, then the medical school will not only have to admit more students and educate them in psychiatry and ophthalmology, but also in gynaecology, the very subject marked by the critical shortcoming that made outsourcing instruction necessary in the first place.

In addition to these weaknesses specific to single formulas, the traditional patient-based capacity determination has a whole series of weak points, the most obvious of which is the fact that the patient-determined quantities are based in part on standards from the 1970s and in part on empirical data from the mid-1980s. For even the obsolete differentiation between the different patient groups and the different time units in the determination of admission capacity using inpatients and outpatients could be corrected with a little good will (Fischer, 2012).

3 The integrated formula to determine the patient-related admission capacity

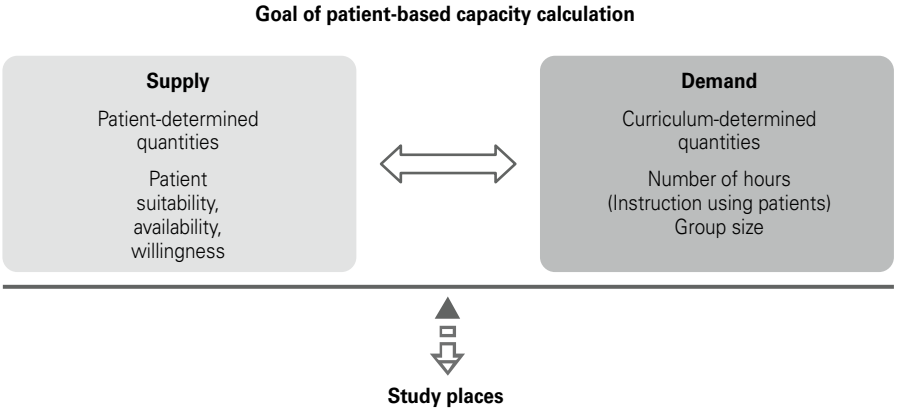
3.1 Basic principle

The task each determination of admission capacity for a university study programme needs to achieve is a balance between what can be supplied and the demand for resources to carry out the study programme. The result of these determinations is the number of admissible students in each academic year. These are the relevant resources for a medical study programme:

- Teaching staff and/or teaching load of the faculty members versus the demand for teaching time,
- The patients and/or the time with patients available for teaching versus the demand for time with patients, and
- Classroom spaces and/or spaces that can be used for teaching versus the demand for spaces.

The second aspect is the crucial factor for admission capacity at almost all German medical schools regarding the clinical phase of study. To determine this balanced state, a series of constraints must be taken into consideration, of which the most important ones for the patient-based capacity determination are given in Figure 2 below.

Figure 2: The basic principle of every patient-based determination of admission capacity



Only the current ÄApprO gives consideration to these constraints. The formulas set down in the KapVO, and presented in simplified form in Figure 1, for other constraining conditions do not, at present, necessarily result from the ÄApprO – the basis for quality assurance in university study. Although the formulas in the KapVO allow recognition of certain further-reaching ideas about quality assurance in medical education, these ideas have not yet been explicitly formulated. Added to this is that only parts of them can be derived from the ÄApprO. Likely not least due to its complexity, the traditional formula system was not adjusted in 2002 to accommodate the introduction of the block placements in the ÄApprO, although in these blocks differential diagnostics and the therapy of the most important clinical pictures are taught under the routine conditions of clinical and ambulant medicine, in what is clearly meant to be a patient-based education. With the next revision of the ÄApprO, additional patient-based teaching formats will be introduced and existing formats expanded to include other patient groups (BMG, 2020). As a consequence, even more problems with the traditional patient-based capacity determination will arise in the future. Such problems could be mitigated, if not avoided altogether, by following a different approach to the basic principle of patient-based determination of admission capacity (Fischer & Just, 2017).

3.2 The integrated formula

The traditional capacity determination calculates the number of entire study places separately for each type of patient treatment (inpatient, outpatient, or outside the university hospital). This subdivision corresponded feasibly with the billing method used in the 1980s. The fact that this took into consideration the length of treatment for these three patient groups according to the particular university hospital's billing system (days, written notes, none) also fits. Since 2003, there has been no example

curriculum prescribing in detail the number of hours for each clinical subject at all medical schools. For all that can be expected from the Master Plan for Medical Studies 2020 (BMG & BMBF, 2017) and the new amendment of the ÄApprO (BMG, 2020), the ÄApprO will continue to follow this approach.

It then stands to reason that the institution-based quantities contained in the traditional formula system should be combined into one formula. This offers a way to include patient groups that are currently still excluded, such as patients who receive inpatient care but are not admitted full-time, thereby falling into a category in-between inpatient and outpatient ("semi-inpatient"). By following this proposed strategy, the risk described above of overburdening individual patient groups could be avoided because no longer would each partial supply of patients be compared in relation to the full demand, but rather the full supply would be compared only once to the full demand.

If this new approach is applied to the still meaningful parameters of the current method, it quickly becomes clear that, although a university hospital can have data on the suitability of its own patients and their willingness to participate in teaching medical students, this information may not be available for external healthcare institutions or medical practices. It is not important here if the patient-determined quantities in Figure 1 involve 35- to 45-year-old parameters (Lohfert et al., 1986; Sachverständigengruppe, 1975), or if they are presently being updated as part of another project at individual university hospitals, or if the particular university hospital undertakes to do so at its own cost, as MHH did in 2009–2011 (Lohfert & Lohfert, 2011). By accepting admission to a medical school, students are committing to an entire course of study at a specific university. If a medical school then outsources patient-based teaching duties, it can very well be the case that the medical school will need to compensate the external teaching hospital for the use of its medical personnel for educational purposes and this must be taken into account in the teacher-based capacity determination. When calculating the patient-based capacity determination, however, the scarce resource in this context is the uncompensated time given by individual patients. How many patients a teaching hospital needs to treat so that 10 hours of instruction can be offered is of no significance to the medical school which has outsourced its teaching. The teaching hospital supplies 10 hours, the medical school demands 10 hours. All that needs to be shown in the formula is that the outsourced external hours may not be counted as part of the internal demand. Nevertheless, the admission capacity increases as a matter of course because there are fewer hours of patient-based teaching at the university hospital.

Figure 3: Conversion of outpatient new admission into contacts with outpatients per day

$$tpK := \frac{NZ \bullet H_a \bullet A_a}{365}$$

The units of time which are billed for inpatient, outpatient, and semi-inpatient care have to be brought into line with each other (Figure 3), the result is the integrated formula given in Figure 4. The complete derivation of this formula can be obtained from the authors.

Figure 4: Formula for integrated determination of the patient-based admission capacity

$$kAp := \frac{\left((tbB_s \bullet L_s \bullet b_s) + (tbB_{ts} \bullet L_{ts} \bullet b_{ts}) + (tpK \bullet L_a \bullet b_a\right)}{\left((V_s / p_s) + (V_{ts} / p_{ts}) + (V_a / p_a)\right)} + \frac{(V_e / p_e)}{(V_e / p_e)}$$

Simply as a result of viewing all patient groups together as a whole and taking any outsourced teaching regarding the same scarcity factor (patient time) into account, this uniform determination of a patient-based admission capacity avoids the major disadvantage of the traditional approach: That excessive demands are placed on inpatients when patient groups do not meet the standard size.

This critique of the current approach to determining capacity cannot be satisfactorily dealt with using the traditional formula system. The integrated formula proposed here reduces complexity without compromising differentiation. This is demonstrated in the following section for the bedside teaching (UaK).

3.3 Some exemplary calculations

Between 2013 and 2016, the MHH recorded an average of 1,129.74 daily occupied beds and 119,823.5 outpatient new admissions per year, or 1,050.51 outpatient contacts per day. If one compares both calculation methods for these patient data, one should distinguish different distributions of teaching hours among inpatients and outpatients. Although this does not play a role in the traditional formula, our alternative proposal does take this into account. Five exemplary hourly distributions for bedside teaching (UaK) in the first five years of study are presented in Table 2. Example I represents exactly the normative requirement for the bedside teaching as specified in the KapVO. Example II represents the ratio of bedside teaching with inpatients and outpatients reported by Lohfert & Lohfert (2011) without outsourcing; Example III has increased outpatient teaching compared to the normative setting, and Example IV simulates the MHH ratios with outsourced teaching in 2010. In Example V, bedside teaching is partially outsourced but is otherwise oriented towards the normative setting. In our view, however, only Examples II and IV reflect hourly distributions that can be found in reality.

The normative model calculates an inpatient admission capacity of 177.2 places plus 119.82 places based on the outpatients for all examples. Since the outpatient supple-

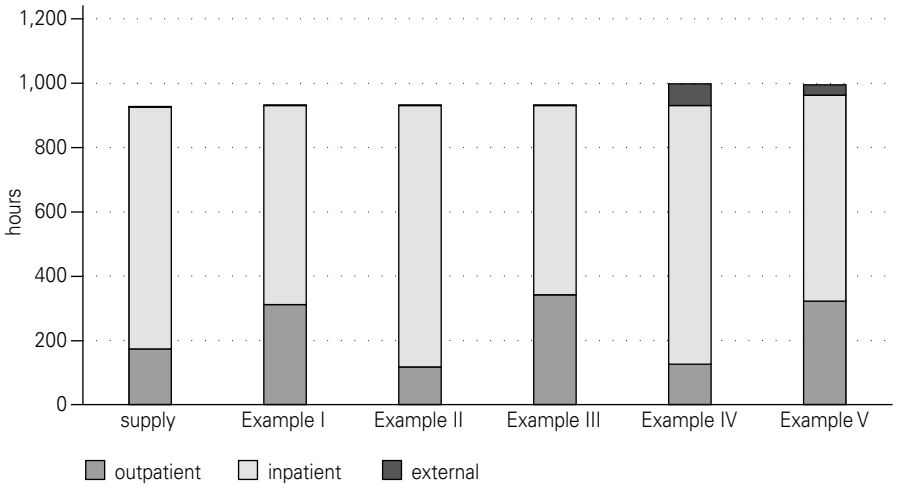
ment is capped at 50% of the inpatient capacity, the internal capacity in the normative model is 265.80 places. This is increased by 8.93 places for outsourced teaching in Examples IV and V.

Table 2: Distribution of patient-based teaching on different patient groups and the corresponding accommodation capacity

	Hours with			Capacity
Example	Inpatients	Outpatients	External patients	kApi
I	317	159	0	217.98
II	416	60	0	217.98
III	301	175	0	217.98
IV	400	60	16	225.56
V	301	159	16	225.56

The calculation results for our formula vary for inpatient capacity (kAps) and outpatient capacity (kApa). Since the number of teaching hours changes correspondingly within the examples, the joint internal capacity is 217.98 places (kApi). Only in Examples IV and V can 7.58 more students be accommodated because 16 hours were outsourced.

Figure 5: Comparison of supply and demand for patient time for bedside teaching in different patient groups.



A comparison of the patient time available for bedside teaching with the patient time demanded is not possible in the normative formula because the total number of hours is calculated for each part. The comparison of supply and demand determined within

our alternative approach is shown in Figure 5. It illustrates why our impression that only Examples II and IV would be encountered in reality corresponds with the assumption of the Higher Administrative Court in Lüneburg that a traditional calculation of the accommodation capacity might not be appropriate for avoiding the overuse of patient groups.

4 Conclusion

The relative proportion of instruction given using patients is not high from the perspective of an individual student, particularly during the first five years of study, if, as intended by the ÄApprO, the three-month nursing placement and the four-month clinical elective are not defined as part of the medical study programme. However, the tying up of the associated resources looks quite different from the perspective of the medical faculty and society, as the right column in Table 1 shows for different student cohort sizes. This is why the determination of admission capacity based on patients has such a large significance for medical study programmes.

Because the cost-free participation of patients in medical instruction is not available to an unlimited extent and cannot be increased by any action taken by administrators, the calculation of a patient-based admission capacity should be as reliable as possible for medical study without increasing the degree of complexity in the calculation. The integrated formula presented here uses the same parameters as the traditional separate formulas, such that it does not require any basic shift in thinking. Nevertheless, the integrated formula offers an opportunity to more flexibly respond to future differentiated educational concepts.

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Information about the authors:

Prof. Dr. Ingo Just
Hannover Medical School
Dean of Studies for Medicine and Master's Programmes
Dean of Studies office, OE 9136
D-30623 Hannover, Germany
Email: just.ingo@mh-hannover.de

PD Dr. Volkhard Fischer
Hannover Medical School
Dean of Studies office, OE 9136
D-30623 Hannover, Germany
Email: Fischer.volkhard@mh-hannover.de

Ingo Just is professor and head of institute of toxicology. Since 2011 he is dean of studies for medicine and master's programmes.

Volkhard Fischer is a research assistant in the Office of the Dean of Studies and heads the Academic Controlling working group. His research interests concern capacity determination, examination quality and evaluation of studies and teaching.