

# World Journal of *Critical Care Medicine*

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## Generalizable items of quantitative and qualitative cornerstones for personnel requirement of physicians in anesthesia

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### Abstract

Anesthesiologists perform a broad spectrum of tasks. However, in many countries, there is no legal basis for personnel staffing of physicians in anesthesia. Also, the German diagnosis related groups system for refunding does not deliver such a basis. Thus, in 2006 a new calculation base for the personnel requirement that included an Excel calculation sheet was introduced by the German Board of Anesthesiologists (BDA) and the German Society of Anesthesiology and Intensive Care Medicine (DGAI), and updated in 2009 and 2015. Oriented primarily to organizational needs, in 2015, BDA/DGAI defined quantitative and qualitative cornerstones for personnel requirement of physicians in anesthesia, especially reflecting recent laws governing physician's working conditions and competence in the field of anesthesia, as well as demands of strengthened legal rights of patients, patient care and safety. We present a workload-oriented model, integrating core working hours, shift work or standby duty, quality of care, efficiency of processes, legal, educational, controlling, local, organizational and economic aspects for calculating personnel demands. Auxiliary tables enable physicians to calculate personnel demands due to differing employee workload, non-patient oriented tasks and reimbursement of full-equivalents due to parental leave, prohibition of employment, or long-term illness. After 10 years of experience with the first calculation tool, we report the generalizable key aspects and items of a necessary calculation tool which may help physicians to justify realistic workload-oriented personnel staffing demands in anesthesia. A modular, flexible

nature of a calculation tool should allow adaption to the respective legal and organizational demands of different countries.

**Key words:** Anesthesia; Service time; Organization; Personnel requirement; Working time directive; Continuing medical education; Patient rights; Patient safety

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**Core tip:** After 10 years of experience with the first calculation tool, generalizable key aspects and items of an updated calculation tool are presented to help physicians to justify realistic workload-oriented personnel staffing demands in anesthesia. A modular, flexible nature of a calculation tool allows adaption to the respective legal and organizational demands of different countries. A workload-oriented model is presented, integrating core working hours, shift work or standby duty, quality of care, efficiency of processes, legal, educational, controlling, local, organizational and economic aspects. Auxiliary tables reflect differing employee workload, non-patient oriented tasks, parental leave, prohibition of employment, or long-term illness.

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## INTRODUCTION

Anesthesiologists are performing a broad spectrum of tasks. However, in many countries, there is no legal basis for personnel staffing of physicians in anesthesia. Furthermore, taking into account quality of care, it is necessary to calculate the personnel demand by a bottom-up method based on the performed procedures and actions. As in other countries, the German diagnosis related groups (G-DRG) system for refunding does not deliver authoritative staffing recommendations and does not reflect adequately arrangements for staff for 24 h/7 d/365 d a year or aspects of hospitals (central vs decentralized operating theaters, costs for residents and for continuing medical education)<sup>[1]</sup>. Bearing these aspects in mind, the working group "personnel management of German Board of Anesthesiologists (BDA) and German Society of Anaesthesiology and Intensive Care Medicine (DGAI)" published in German language a workload-oriented modular calculation model for personnel staffing of physicians in anesthesia in 2006<sup>[2]</sup> and updates in 2009<sup>[3]</sup> and 2015<sup>[4]</sup>. Thereby, the actual-state of personnel staffing in anesthesia can be compared with the necessary target-state and allows physician staffing on a workload basis. Due to the modular structure, the BDA/DGAI tool enables an individualised systematic analysis for every

type of hospital<sup>[2-4]</sup>. After 10 years of experience with the first version of this calculation tool focusing on quantitative personnel demands, the purpose of this paper is to present generalizable quantitative and qualitative items and a modular structure for a computerised calculation tool for widespread use which may help physicians worldwide to justify realistic workload-oriented personnel staffing requirements in anesthesia under the scope of increasingly complex demands.

## WORKPLACE RELATED PERFORMANCES

Basis of calculation is the orientation on the organization of the Department of Anesthesia. Workplace (in the operating theater) and non-workplace related anesthesiological performances are differentiated. The electronic Excel tool is based on the standards defined in the key issue regarding respective personnel physician staffing of anesthesiological procedures defined by BDA/DGAI<sup>[5]</sup>.

### Example of a calculation tool

Supplementary Tables 1-8 provide an example for an Excel based personnel staffing tool. Relevant calculated data are automatically transferred to the respective next calculation sheets. All input fields are marked in a specific color, e.g., in white. Calculation and text fields are protected by a field protection not allowing inadvertant calculation mistakes and changes. The personnel staffing tool is built up modularly to reflect the individual demand of distinct hospitals. The different calculation sheets are divided into calculation tools and assistant tools. Checklists containing the respective data facilitate the collection of the relevant data before starting with the calculations. The physician staffing tool of BDA/DGAI includes two data checklists [one for the calculation tables (Supplementary Table 1) and one for the auxiliary tables (Supplementary Table 5)], three calculation tables for fulltime equivalents (Supplementary Tables 2-4), and three auxiliary tables (Supplementary Tables 6-8). Calculation tables cover (1) workplace related performances (Supplementary Table 2); (2) non-workplace related performances (Supplementary Table 3); and (3) summary calculation (Supplementary Table 4). Auxiliary tables reflect calculation of personnel staffing regarding the following questions: (1) How can I calculate the annual demand with work-fellows with different annual working times (Supplementary Table 6)? (2) How much time and, thus, personnel do I need for the non-patient related performances (Supplementary Table 7)? and (3) How much reimbursement of full-equivalents due to parental leave, prohibition of employment, or long-term illness do I require (Supplementary Table 8)? For better understanding, we filled the tables with a sample of a virtual hospital.

## WORKPLACE RELATED PERFORMANCES

### Checklist for relevant data

Checklists regarding the data relevant for calculation of

full-time equivalents are helpful for collecting the data necessary for personnel calculation tools. Supplementary Table 1 represents such indispensable data for calculations regarding: (1) workplace related performances (required for Supplementary Table 2); (2) non-workplace related performances (Supplementary Table 3); as well as (3) total calculation (Supplementary Table 4). After gathering the relevant data for the calculation sheets, the respective data can be filled in the input fields (marked in white color in Supplementary Tables 2-4).

### **Calculation of workplace related performances**

For better understanding, we filled Supplementary Table 2 with numbers as a sample, and discuss the background in the following. The first lines serve to find out the gross annual working time per full-time equivalent. To result in the net annual working time, festive seasons and holiday seasons have to be taken into account. Rest allowance reflects holidays and average illness, and have to be defined as percentage of gross annual working time.

The following lines deal with the daily personnel demand due to the company organization of an Anesthesia Department. Workplace related performances reflect operating theater or an otherwise defined workplace (WP) in shift duty. The rationale behind is that in every place where an anesthesiological workplace runs regularly, also the attendance of at least one anesthesiologist is demanded by German law, since it is not allowed that supervised nurses are performing anesthesia by themselves. For these kinds of anesthesiological performances, workplace method puts itself forward for calculation of personnel staffing. The latter also include remote locations, *i.e.*, anesthesiological workplaces, not allocated to an operating theater [*e.g.*, angiography, computed tomography (CT), MRT, interventional radiology, cardiac catheter laboratory, radiation, endoscopy]. The basic time module of the calculation is a single-shift opening of a workplace. Moreover, senior physicians/specialist per a defined number of workplaces can be calculated for supervision/coordination.

### **Single-shift opening time of a workplace**

Workplace opening times are defined according to the standard working hours. Underlying core working hours of full-time equivalents (FE) per week of 40 h for instance, daily workplace opening hours of 8 h reflect 480 min. Accordingly, workplace opening hours of 450 and 540 min result from core working hours of 38.5 and 42 h, respectively. Out of the workplace opening hours, the real time of operating can be derived. Underlying 480 min of daily workplace opening time minus 60 min workplace-related make-ready time, 420 min of real time for operating remain. This calculation can be used in different labor agreement areas or in labor agreement areas with various core working hours per week, if the cumulative annual net working time of the employee and not the daily core working time are considered. This calculation is possible also, if the anesthesia workplace runs single, one and a half, or double shift.

### **One and a half shift and two-shift opening times of a workplace**

One and a half shift and two-shift opening times of a workplace have to take into account time for overlap considering end of surgery/intervention and staff-related make-ready times of the following shift. Therefore, one has to carefully look at the amount of personnel necessary for lunch break due to the act on working hours, how one shift ends up with their tasks including make-ready time and handing over time regarding employees and workplace, and the new shift starts their tasks.

### **Remote locations**

Remote locations imply singular anesthesia workplace, not being placed in an operating theater, which runs recurrently (*e.g.*, angiography, CT, MRT, interventional radiology, cardiac catheter laboratory, radiation, endoscopy). Regarding process optimization, the ultimate organizational principle is to limit the number of simultaneously running remote locations and to organize them on a daily basis.

The following has to be scheduled per day and workplace:  $n$  = number of anesthesia workplaces;  $h$  = units of anesthesia time in minutes or hours place and course of events of the particular remote locations. Further details are determined by the company organization and cannot be specified in a universal model, however should be described orienting, only. It is essential that change of location (with substantial expenditure of time) and, thus, resulting transit times, are deposited in a documentation system or payment is given in lieu of anesthesia time per extra charge. A second essential organizational principle is that remote locations are running during core working times. To arrange for manpower of staff for patients with vital hazards, such as emergency trauma room, emergency caesarean section (call to cut time: 20 min!) outside the operating theater as well as cases of emergency and cardiac resuscitation duty have to be considered regarding numbers and time to spend. Thereby, additional staff can be calculated (Supplementary Table 3).

This way of calculation is very conservative, especially in case of decentralized structures regarding the locations of performances, and acceptable only, if emergencies occur only seldom during core time and during on call duty hours. Physician staffing in emergency ambulance or helicopter should be calculated separately and with one full-time equivalent per 8 h.

### **Integration of workplace related performances**

Differentiated calculation of personnel staffing workplace related performances can be enabled regarding core working hours, on-call duty hours, shift duty and in-house duty as displayed in Supplementary Table 2.

### **Supervision/coordination**

Supplementary Table 2 also allows to state how many qualified employees (senior physician/specialist) become

necessary for supervision/coordination depending on the number of within and outside core working hours simultaneously running workplaces. For example, in Germany, BDA/DGAI stated one senior physician/specialist for 7 simultaneously running center workplaces, one senior physician/specialist for 3 simultaneously running decentralized workplaces, and one senior physician/specialist for 2 simultaneously running cardiac surgery workplaces. It is important to acknowledge that in Germany anesthesiology residents are working alone in an OR mostly after 1-8 wk after starting their residency only supervised by consultants.

In Germany, jurisdiction demands that a patient is entitled to claim specialist standard care during core working hours as well as on-call duty, *i.e.*, medical care with regard to the medical specialist standard of an experienced physician<sup>[6,7]</sup>. If anesthesia is performed by non medical specialists, if medical specialist standard is not ensured qualitatively, an experienced physician has to be available at all times in visual and/or at least in hearing contact<sup>[8]</sup>. Independent of medical aspects it remains valid that the specialist *per se* is not the measure of all things but a quality of care, which in the concrete situation matches that of an experienced physician, thus, residents, as long as not safeguarding quality of care in the concrete situation require surveillance, guidance and supervision by an experienced specialist. Taken together, in daily practice, one anesthesiologist per workplace is definitely not enough. To a greater degree, an auxiliary physician, even without function of supervision, is indispensable for temporary iatric assistance in difficult cases, management of complications, in postanesthesia care unit, iatric demission from the postanesthesia care unit, documentation and interdisciplinary coordination. Regarding the latter points, BDA/DGAI considered for a domain-specific care of patients at least one experienced senior physician or specialist for seven working places per shift as mandatory. In decentralized or interventional areas, this additional senior physician/specialist position may be needful even per two, three or four anesthesia working places. These numbers should be regarded as minimal standards, which may even not be sufficient in hospitals with maximal medical coverage and critically ill patients. In the cardiac surgery area, due to evermore comorbidity, complexity of interventions and perioperative monitoring (*e.g.*, transesophageal echocardiography, TEE), BDA/DGAI advised one senior physician per two workplaces per shift as prerequisite, even, if the workplaces are staffed with specialists. These preceding quality features and criteria for personnel staffing have to be ensured not only on weekdays and core working hours, but also during on call duty, late or night shifts, as well as on weekends and public holidays by the stakeholders of the hospitals<sup>[7]</sup>. Underlying the number of daily running anesthesia workplaces (operating theater including decentralized workplaces) and the respective workplace opening hours, the cumulative annual workplace opening hours can be invoiced. By dividing this annual sum of hours with the net annual working time of a full-time

equivalent (around 1700 h with 42 core working hours per week), the number of full-time equivalents for these workplace-related performances can be calculated.

### **On-call duty**

In one sheet of the calculation tool (Supplementary Table 2), annual demand of personnel regarding on-call duty can be determined for Monday till Thursday, Friday, Saturday and Sunday, as afforded due to the respective legal and collective bargaining agreements in different countries. Basically, time exposure for on-call duties has to be considered. Due to administration of justice by the European Court of Justice, confessing on-call duty in a hospital as working time<sup>[9]</sup>, the following items are in effect by Working Time Act since January 1<sup>st</sup> 2007: (1) workaday working time including on-call duty and rest can be extended to maximally 24 h on the basis of collective bargaining agreements; (2) by no later than 24 h of daily working time an unbroken rest period of at least 11 h is to grant principally; (3) average weekly working time is not allowed to exceed 48 h within the legally (six calendar months) or by collective bargaining agreements (one year) fixed compensation period; and (4) only, if collective bargaining agreements allow, with individual consent of the employee, weekly working time can be extended to more than 48 h.

### **Shift duty**

A calculation tool (Supplementary Table 2) can also reflect personnel staffing on the basis of a company organization in shift duty resulting in net annual working hours' demand. The respective legal working regulations have to be taken into account, *e.g.*, 12.75 h/d at maximum in shift work with at maximum 48 h/wk with standby duty of 54 h at maximum per week in Germany or European countries. For this purpose, a tool differentiating the underlying shift time model is helpful, *e.g.*, early, late and night shift in a 3-shift model.

### **In-house duty**

Since a universal tool cannot reflect all possible company organizational aspects, a modular calculation tool is helpful, which allows representation of specialized in-house duties.

When all the relevant white fields in Supplementary Table 2 for a distinct hospital are filled with the respective data, staff requirement/week and year in hours are summed up and full-time equivalents/year are displayed for the workplace related performances. Real annual personnel demand in hours can be converted to annual full-time equivalents in that the sum of annual hours is divided through the net annual working time hours of an employee.

The presented Supplementary Table 2 reflects the quality of care demanded by the law of the patients rights and jurisdiction, and, thus, contributes to patient safety. In Germany, in 2013, the patients right law § 630a Abs. 2 BGB<sup>[7]</sup> came into effect. Thereby, jurisdiction demands that a patient is entitled to claim specialist standard

care during core working hours as well as on-call duty, *i.e.*, medical care with regard to the medical specialist standard of an experienced physician<sup>[6]</sup>. Taken together, under the aspect of patient quality and safety, personnel staffing is more and more defined by jurisdiction. Thus, the patient is eligible for care due to commonly accepted state of medical science, defined by the respective medical scientific specialist societies. In this regard, in March 2015, the BDA and DGAI published quantitative and qualitative professionally quality standards regarding respective personnel physician staffing for the anesthesia workplace and for non-workplace regarded procedures<sup>[5]</sup>. These standards match the quality of care demanded by the law of the patients rights and jurisdiction. Thereby, these standards serve the patient safety.

## NON-WORKPLACE RELATED PERFORMANCES

### **Checklist for relevant data**

Supplementary Table 1 shows indispensable data for calculations regarding non-workplace related performances.

### **Calculation of non-workplace related performances**

Non-workplace related performances (NWPRP) are listed in Supplementary Table 3. The respective background is discussed in the following. NWPRP are those not primarily bound to an operating theater or a firmly defined working place. Typical NWPRP and standard times are listed in Supplementary Tables 1 and 3. All performances have to be mapped *via* defined standard times or real performance documentations. The respective data can be filled in the input fields (marked in white color) and compared with the suggested standard times.

Consecutively, in the different groups of NWPRP, real annual personnel demand can be converted to annual full-time equivalents (sum of the annual NWPRP in hours divided through net annual working time hours of employee).

### **Pre-anesthetic assessment**

The evaluation of a patient before anesthesia with legally effective informed consent, for surgery or other therapeutic and/or diagnostic interventions, is one of the most important and inalienable characteristics of modern anesthesia, to minimize risks for patients<sup>[10,11]</sup>. Medical history, physical examination, critically compilation and evaluation of results at hand are followed by an adequate and the individual risk profile considering medical and legally acceptable information according to patients right law<sup>[7]</sup>. This should include procedures and proceedings, risks, alternatives and their risks as well as written documentation and legally effective informed consent in planned procedures<sup>[12,13]</sup>. Ordinarily, the latter one has to be performed personally and directly between patient and physician and/or his representative. Time exposure for these tasks can vary greatly, and in case of huge

demand of information and efforts to throw light on the procedures by the patient, may range from 10 min up to more than 60 min. Regarding personnel staffing, in the context of anesthesiologist's consultations, basically, an average time exposure exists of at least 25 min per patient (item 1 in Supplementary Table 3). Consultation of an anesthesiologist outside a pre-assessment clinic has to add transit time, *e.g.*, 10 min. Furthermore, compensation of supervision by senior physicians has to be considered regarding domain-specific deficits of residents or physicians lacking knowledge of specialized procedures.

Moreover, time exposure has to be considered regarding hemotherapeutic actions to be taken, department specific performances, obstetric peridural catheters and emergencies, transportation support, emergency room, in-house emergency calls and resuscitation services, acute pain duties, postanesthesia care unit and holding area, and overlapping initiation of anesthesia.

### **Performance and/or case related double staffing**

In several procedures, double staffing is indispensable to ensure patient safety and adequate medical care (item 19 in Supplementary Table 3). BDA/DGAI recently stated that double staffing should be performed in neonatal and infant surgery (up to 12 mo), sectio caesarea if neonatal care is provided by the anesthesiologist, transplantation of solid organs (liver, heart, lung, pancreas), surgery/interventional care of aortic dissection/aneurysm, aortic arch reparation, patients with/for implantation of cardiac assist systems, medical care of multiple trauma patients, transport/interventions (incl. image diagnostics) of patients with multiple organ dysfunctions, craniotomy in seated position, and neurophysiological monitoring by anesthesiologist<sup>[5]</sup>. These double staffing has to be performed within core working time and during on-call duty, also. For example, the key issue paper of the German Society for Cardiology demands as quality criterion for the performance of transvalvular implantations of aortic valves (TAVI) the integration of at least two anesthesiologists with at least one-year-long experience in anesthesia of TAVI procedures and cardiosurgery in the cardiac-team<sup>[14]</sup>. Moreover, anesthesia on call should be available after TAVI for at least 24 h being ready to start within less than 30 min. In January 2015, the German Federal Joint Committee agreed in a guiding principle on the respective structural, personal and professionally qualified demands regarding the performance of minimal invasive heart valve interventions under the aspect of quality protection<sup>[15]</sup>.

### **Postoperative medical round**

Postoperative medical rounds unequivocally contribute to quality assurance<sup>[16-20]</sup>. Postoperative measurement of arterial oxygen saturation can identify patients with poor prognosis and those requiring intensive care medicine<sup>[19,20]</sup>. Moreover, postoperative medical rounds focus on diagnosis and treatment of postoperative nausea and vomiting (PONV)<sup>[21]</sup>, pain<sup>[22]</sup>, anesthesia-related complications as well as control and removal of catheters applied and

intended for regional anesthesia (peridural and peripheral nerve catheters)<sup>[23,24]</sup>, e.g., postoperative medical rounds can be calculated with at least 10 min per case with a transit time of 5 min in addition, thus, 15 min in total (item 21 in Supplementary Table 3). Again, compensation of supervision by senior physicians has to be considered regarding domain-specific deficits of residents or physicians lacking knowledge of specialized procedures. One should take in mind respective regulatory aspects. E.g., in some countries, refunding of acute postoperative pain therapy demands at least two medical rounds per day per case.

## SUMMARY CALCULATION

Summary calculation of full-time employees per year can be calculated by summing up annual hours for workplace (Supplementary Table 2) and non-workplace (Supplementary Table 3) related performances (automatically transferred to Supplementary Table 4), supplemented with double staffing for first-time employees, compensation for residents, demands of use up overtime without pay contingents, compensation for pregnant employees, and time demand for continuing medical education, administrative provisions and management tasks (Supplementary Table 4).

### Excess and overtime hours

In many hospitals, excess and overtime hours are carried out to yield the annual workload. Regarding excess hours, generally, defined by law, employees cannot be required or allowed to work more than 8 h in a day (or the number of hours in their regular work day if that is longer than 8 h) unless they or their union have agreed in writing that they will work up to a specified number of additional hours in a day. The approval is not required if the weekly limit of 48 h is not exceeded. In Germany, by law, excess hours beyond the regular 8 h in a day are limited to 2 h in a day (at maximum 60 weekly hours in a 6 d week), if within 6 calendar months or 24 wk in average 8 h in a day are worked. Overtime hours include work performed by an employee in excess of a basic workday (typically 8 h a day, 5 d a week) as defined by company rules, job contract, statute, or union (collective) agreement. The European Court of Justice declared that on-call duty with presence at the working place has to be regarded as working time in the sense of directive 2003/88/EG<sup>[9]</sup>, e.g., being in effect by Working Time Act in Germany since January 1<sup>st</sup> 2007. Thereby, on-call duty accounts for working time, which principally is not allowed to exceed 48 h in a week. By special regulations (in Germany so-called "opt-out"), labor agreements allow, with individual consent of the employee, the extension of the weekly working time to more than 48 h.

### Demand of double staffing for first-time employees within first 3 mo

Double staffing for employees within the first 3 mo of residency is mandatory, since they cannot ensure

adequate performance and patient safety within their first months of residency. Adequate initial training has been shown to improve process times<sup>[25]</sup>. These three months include briefing regarding medical devices due to the Medical Devices Act. Additional time expenditure has to be calculated for later briefings in medical devices, instruction into new devices, initial training in specialized domains or upgrade of training events. The minimum relation of coaches and trainees is 0.2.

### Specialized and medicolegal demands regarding residents

Increasing demands by the patients right law and jurisdiction as well as specialized compensation of deficits due to not finalized residency requires, e.g., as stated by BDA/DGAI in Germany, one senior physician/specialist per three working places settled with residents, i.e., 0.33 full-time equivalents per resident (Supplementary Table 4). This ratio may even be higher in remote locations. More and more elderly patients with profoundly greater comorbidity and multimorbidity are operated<sup>[26]</sup>. Incremental complexity of interventions, ultrasound techniques as standard in regional anesthesia and sophisticated monitoring methods, the respective initial, advanced and continuing training as well as escalating supervision and teaching effort have not been adequately incorporated in previous personnel staffing calculations. However, these aspects have to be considered regarding at least necessary quality of patient care and safety. Nowadays, residents expect during and after their postgraduate training authoritative curricula regarding structured continuing medical education, specialist initial skill adaption training and advanced training as well as frequent dialog regarding feedback, advancement and targets<sup>[27]</sup>.

### Students in internship (in Germany called "practical year")

BDA/DGAI indicated one physician in addition per 8 students for teaching of students in the internship (Supplementary Table 4).

### Demand of use of overtime without pay contingents

For summary calculation, demands for excess and overtime hours, additional holidays for alternate shifts, shift work and night employments, as well as compensation for pregnant employees have to be considered<sup>[28]</sup> (Supplementary Table 4). It has to be taken into account that excess and overtime hours increasingly have to be compensated in leisure, and, thus, compensated with additional full-time equivalents. Full-time equivalents have to be given for temporary leave due to pregnancy (Maternity Protection Act; 14 wk around delivery, e.g., in Germany)<sup>[29]</sup> since employers are fully compensated by policy.

### Working time needed for continuing medical education, administration and regulatory decrees

Demand of time for continuing medical education (Supplementary Table 4) and administrative provisions

(Supplementary Table 7) has to be taken into account. Time expenditure regarding regulatory decrees include items such as worker protection, data security, diagnosis related groups, hygiene, devices, hazardous material, ordinance on medical devices, quality management, safety advices for X-rays or transplantation (Supplementary Table 7). Moreover, staff meeting and instructions have to be considered.

For management tasks (Supplementary Table 4), regarding organizational issues, such as budget, investments and staff development, one senior physician per 50 employees has been suggested by BDA/DGAI<sup>[5]</sup>. It was proposed by BDA (DAGI to leave the head of department regularly out in the cold of the workplace related personnel calculation due to his multiple administrative tasks. In relation to the number of full-time equivalents and the amount of administrative and management tasks, he should be released from workplace related tasks.

All these items, in total sum up to yield the net full-time equivalents. Salaried annual equivalents of employees for on-call duties and excess hours have to be subtracted to end up with the total number of full-time equivalents to be staffed minus salaried workload beyond core working hours (Supplementary Table 4).

## AUXILIARY ITEMS

### **Checklist for auxiliary data**

Supplementary Table 5 represents prerequisite data for calculations regarding auxiliary tables concerning (1) work-fellows with different annual working times (Supplementary Table 6); (2) non-patient related tasks (Supplementary Table 7); and (3) reimbursement of full-equivalents due to parental leave, prohibition of employment or long-term illness (Supplementary Table 8). This checklist facilitates filling in auxiliary tables.

### **Auxiliary table calculation of annual demand of work-fellows with different annual working times**

As demonstrated in Supplementary Table 6, the total amount of annual hours needed for personnel staffing can be transferred to an Excel table, in which the amount of the number of existing work-fellows with different daily and weekly working hours can be filled in. By filling in different work-fellows, the missing hours can be adjusted. Thereby, the amount of missing employees manifests, and the lack regarding the missing employees can be filled underlying work-fellows with different annual working times.

### **Auxiliary table calculation of non-patient oriented tasks**

Supplementary Table 5 reflects the non-patient oriented tasks, such as leadership and management functions, working groups, administration, work in committees, work in projects, teaching and regulatory decrees. By filling in the annual prospected time in hours, net full-time equivalents can be quoted in Supplementary Table 7. These data are not basis for staff calculation and are not carried over in the summary calculation

in Supplementary Table 4. However, they facilitate the argumentation for the calculation of distinct items of the calculation tool, such as the senior staff member per x employees (e.g., 50) for management tasks personnel/planning/budget in the total calculation (Supplementary Table 4).

### **Auxiliary table calculation of reimbursement of full-time equivalents due to parental leave, prohibition of employment, long-term illness**

Due to acts on working hours, increases in percentage of female physicians with loss of working hours due to protection of working mothers, paid maternity leave, take-up of family leave by women as well as by men, part-time employment<sup>[30]</sup>, as well as altered estimation to the "work/life balance", the employment market shifted from an offering to a request market<sup>[27]</sup>. Supplementary Table 8 enables the quoting of full-time equivalents to compensate the parental leave time, as prohibition of employment, illness longer than 6 mo, and, thus, to calculate the respective full-time equivalents needed. In Germany, e.g., compensation of staff demand is required regarding parental leave §§ 15-16<sup>[31]</sup>. Every parent has the right to take parental leave between months 3-12, as the case may be between 12 mo the 3<sup>rd</sup> and 8<sup>th</sup> birthday of the child, which increasingly are taken by females and males. In part-time employment and after time-out of more than 6 mo, procedures for competence maintenance and introductory training have to be considered to guarantee quality and patient safety<sup>[32]</sup>.

## CONCLUSION

Calculation of personnel staffing in anaesthesia departments has to be oriented on basic, up to date, specialized and legal demands as well as actual medical and medicolegal quality and patient safety oriented guidelines. Calculation tools such as the presented one may help to calculate the staff to meet these requirements. The present paper does not reflect personnel staffing of intensive care and intermediate care medicine, emergency medicine, chronic pain as well as palliative medicine. Regarding intensive care medicine, a calculation tool and guidelines have been published reflecting specific items in this setting<sup>[33,34]</sup>.

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