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Die Auswirkung relevanter Kompetenzfacetten auf die Fähigkeit der klinischen Entscheidungsfindung von Medizinstudierenden in Abhängigkeit ihrer wahrgenommenen Beanspruchung

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Chapter 2 Published as:

Fürstenberg S[1], Schick K[2], Deppermann J[3], Prediger S[1], Berberat P[2], Kadmon M[4], Harendza S[1]. *Competencies for first year residents – physicians' views from medical schools with different undergraduate curricula*. BMC Medical Education. 2017;17:154. DOI 10.1186/s12909-017-0998-9

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Chapter 4 Published as:

Fürstenberg S[1], Prediger S[1], Kadmon M[4], Berberat P[2], Harendza S[1]. *Perceived strain of undergraduate medical students during a simulated first day of residency.* BMC Medical Education. 2018;18:322. DOI: 10.1186/s12909-018-1435-4

Chapter 5 Under review:

Fürstenberg S[1], Oubaid V[5], Kadmon M[4], Berberat P[2], Harendza S[1]. *Medical knowledge and teamwork predict clinical reasoning skills in undergraduate medical students.* GMS J Med Educ.

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1 Synopsis

1.1 Introduction

At the 118th German Medical Association[1] in 2015, it was described, that the "transfer of knowledge in medical curricula is mainly related to data and facts, but the mediation of communication and humanity is still disregarded. […] Attitude, behavior and language characterize the encounter with the patient. […] If we lose the language in dealing with the patient, we mutate to become medical practitioners of technology, fragmented and fragmenting specialists and substitutable. […] Obstructive conditions include mainly the high workload and the lack of time in everyday care. […] Can attitudes such as empathy and humanity be learned while studying?“ [...] To answer this question, "one would have to systematically set the right signals in the training: support the idealism of the students and show them on the basis of clinical experience that the physician's profession includes the concern for the patient as a whole person, to support students in values and finally to promote organizational structures that allow physicians more time to dedicate to the patient."[1] This approach is very interesting from the perspective of medical education research. If medical students should be able to perceive the patient as a whole person then medical school curricula have to be geared to competencies that comprise that. In addition, the daily work of many physicians in hospitals is characterized by time pressure (in patient visits) and other stressors such as workload or complex medical patients.[2-4] National and international studies also showed that burnout is more prevalent among residents and attendings than in the general population.[6,7] Perceived strain has been identified in work and organizational psychology as a major mediator of the relationship between work load and work quality[3,4] and is directly related to intrapsychic processes. Knowledge deficits, patients’ deaths, and medical errors have also been suggested to play a role in the evolution of burnout.[8] Hence, well-defined social skills[9] and stress resistance should be part of the curriculum.[10]

The aim of this cumulative dissertation was to identify the competencies by experienced physician of medical schools in Germany with different undergraduate curricula (chapter 2) and by medical students in their first and final year (chapter 3). Furthermore, the performance of advanced medical students in the role of beginning residents was evaluated with respect to its underlying competencies (chapter 2) in a 360-degree assessment, which simulated a first work day of residency. During this assessment, participants' perceived psychological strain was evaluated (chapter 4). Additionally, it was determined whether medical students' medical knowledge, adherence to procedures, stress resistance, teamwork or perceived strain might predict their clinical reasoning skills (chapter 5). Factors, which could influence medical competencies (e.g. psychological strain) still encounter a continuing interest in research in the field of work and organizational psychology.

1.1.1 Competency

The definition of competency depends on the respective context. Due to the different use of the term "competency" in different scientific fields there are several definitions. In the medical context professional competency is defined as „the habitual and judicious use of communication, knowledge, technical skills, clinical reasoning, emotions, values, and reflection in daily practice for the benefit of the individual and community".[11] Additionally, competency is defined as the ability to act responsibly and adequately in a given context, integrating complex knowledge, skills and attitudes.[12] Both definitions can be applied to daily work situations of physicians. The CanMEDS model for postgraduate medical education developed by the Royal College of Physicians and Surgeons of Canada includes seven specific roles of physicians based on competencies, which will enable the trainees to fulfil the respective roles in their daily work.[13] This model illustrates these roles and the interconnections of the CanMEDS roles embodied by competent physicians: medical expert,

communicator, collaborator, manager, health advocate, scholar, and professional. To ease the transition from undergraduate to postgraduate medical training, many medical schools are in the process of reshaping their undergraduate medical curriculum from traditional curricula to vertically integrated or competency-based undergraduate medical education.[14] The traditionally not vertically integrated curricula (non-VI) teach topics by discipline in the same year or phase of the curriculum.[16,17] In vertically integrated curricula (VI) the disciplines are arranged around themes which are organized in consecutive years of the curriculum.[16,18] If the CanMEDS framework is used to design a competency-based catalogue of learning objectives for undergraduate medical education like the German NKLM (National Competence Based Catalogues of Learning Objectives for Undergraduate Medical Education)[13] curriculum planners need to be aware that teachers' perceptions of competencies can differ extensively.[20] Furthermore, the perception, which competencies are needed for the first year of residency, might differ among physicians according to the undergraduate curriculum they are used to or according to their specialty or position within a hospital. In study 1 (chapter 2) and 2 (chapter 3) experienced physicians' and also medical students' perspectives on the importance of different competencies needed in first year residents was determined.

Until now, in medical schools knowledge and skills have mostly been acquired and assessed with multiple-choice tests and OSCEs (Objective Structured Clinical Examination). A concept to evaluate medical student's or resident's competencies are the so called Entrustable Professional Activities (EPAs).[21] The scale to evaluate EPAs includes five levels from 'no permission to act' to 'permission to provide supervision to junior trainees'. This entrustment is not an abstract assessment, but implies a judgment related to the clinical environment in which the trainee actually practices.[22] If it is possible to evaluate the processing of various work tasks on a ward on the basis of the EPAs in a realistic

environment, the existing competencies and the level of entrustment can be well represented (Figure 1).

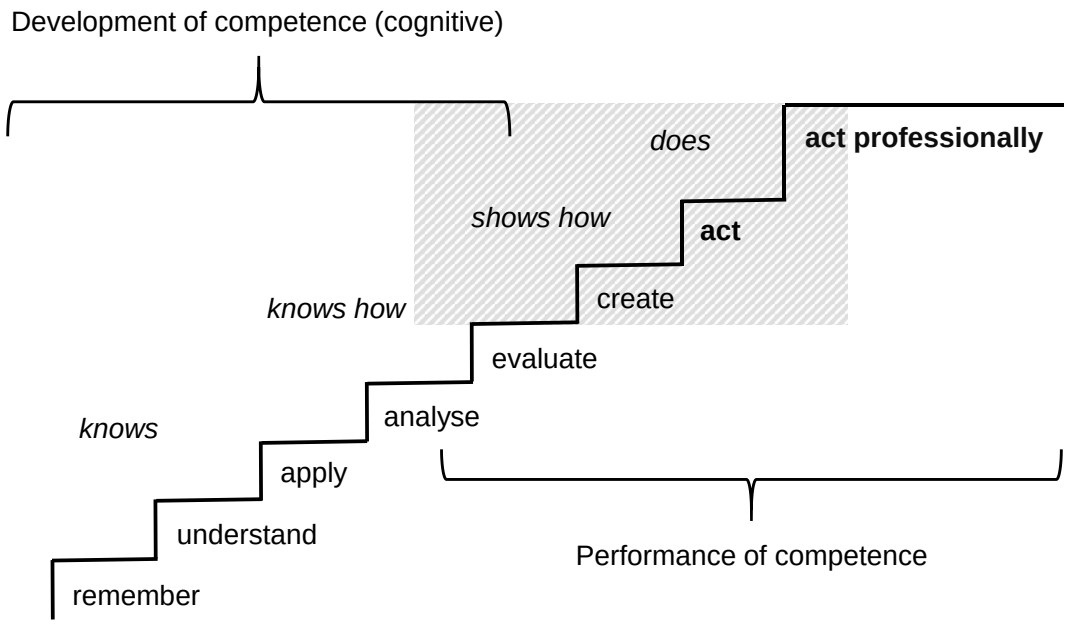

Figure 1: Levels of competency (grey area marks the performance level of the 360-degree assessment)[23]

In addition to communicative and advising competencies for residents, social and interactive skills also play an important role, for instance stress resistance, adherence to procedures, and teamwork. Stress resistance including the facet resilience, is defined as maintaining effective performance, control and goal orientation under pressure or adversity.[24] Stress resistance includes also the absence of physiological symptoms (vegetative, motoric or verbal). The competency adherence to procedures is defined by knowledge and disciplined and correct application of rules. Teamwork includes the facets tolerance, honesty and dependability, and active helpfulness. Tolerance is the ability to tolerate and respect others' intentions and actions that are not shared. Honesty and dependability mean the ability to interact openly, dependably and responsibly with others. This implies to perform tasks and

responsibilities conscientiously and trustworthy. Active helpfulness is the ability to recognize and improve situations that need to be changed for the group or for individual group members.

Medical knowledge alone is not a competency. Nevertheless, it is the basis for thinking processes like clinical reasoning. Clinical reasoning requires declarative (knowing that) and procedural (knowing how) knowledge.[25] In this dissertation the assessed performance of medical students included their clinical reasoning skills, which will be describe in the next section.

1.1.2 Clinical reasoning

From the amount of information provided by patients during history taking and physical examination, physicians have to filter the aspects they need to justify their decisions for the next diagnostic steps or therapeutic recommendations in a comprehensible way.[26] The cognitive process physicians use to investigate patients' problems based on the information gathered from history, physical examination, and sometimes additional test results to make a diagnosis is described as clinical reasoning.[27] Clinical reasoning is also defined as "a dynamic, cyclic, reiterative process in which observation, analysis, synthesis, deduction, induction, hypothesis generation, hypothesis testing, inquiry-strategy design, and the skill of examination are all interrelated."[28] It is a cyclical process that leads to a deeper and deeper understanding of the clinical problem.[29] This cyclic process includes the intuitive and the hypothetic deductive way for making decisions.[30] The intuitive way operates automatically and quickly, with little or no effort and no voluntary control. In clinical reasoning it is called "pattern recognition".[31] The hypothetic deductive way allocates attention to the effortful mental activities, including complex computations. In clinical reasoning it is called "analytical thinking".[31] The operations of this way are often associated with the subjective experience of

action, choice, and concentration. Experienced physicians often use the intuitive way of clinical reasoning. Students and less experienced physicians as well as experienced clinicians when dealing with a complex and atypical case, apply the hypothetic deductive way.[32] Within the diagnostic process, different levels of expertise are associated with different approaches of reasoning.[33] Bordage described levels from 'reduced (no connection between the patients' findings and one's own store of medical knowledge)' to 'compiled (recognizing pattern and associating it with abstruse compiled terms that point to specific symptomatology)'. To aspects which are relevant in the clinical reasoning process are the adequacy of the case presentation with respect to its medical content and with respect to the use of proper medical terminology for symptoms and findings,[34] investigated in study 4 (chapter 5).

Since clinical reasoning takes place while a resident has to perform other tasks psychological strain is a mediating factor of the relationship between work load and work quality[3,4] the perceived strain was determined during the simulated first work day in this project. The definition of psychological strain as well as the resulting consequences are described in the following section.

1.1.3 Psychological strain

Perceived psychological or mental strain is a response produced in the individual to aversive and potentially harmful exposure to stress.[35] Psychological strain can be of physiological, mental, emotional, and social origin.[36] If psychological strain continues for too long or is too intense, fatigue can occur. Fatigue uses physical and psychological resources.[37] A sense of fatigue is a protective function which prevents the overly extensive exhaustion of performance reserves. Apart from fatigue, there may be other mental demands. For Richter and Hacker[38] mental demand is the negative form of strain, which blocks learning processes or mobilization of resources and therefore reduces performance and well-being. Mental

fatigue is fatigue due to a predominantly mental activity and it is a consequence of mental activities requiring information acquisition and processing in particular. It is a state of exhaustion after a long period of activity or increased task difficulty. It can lead to performance fluctuations and spurious actions. A sign of mental fatigue can be a performance decline. Strain and the appearance of health impairments are not directly related, since strain represents reversible functional impairments and does not necessarily affect health which only occurs when the current state of strain is not adequately compensated for a longer period of time,[39] because human performance capacity is limited. If there is a long-lasting imbalance of strain and recovery phases, it can lead, for example, to stress states and thus to health-damaging consequences such as coronary heart disease, vegetative dystonia, high blood pressure or psychosomatic illnesses.[40] If there is a lack of this balance, it can lead to performance reductions. If fatigue and recovery are balanced in the long run and compensation does not succeed, it can lead to severe impairments of function, which limits performance not only temporarily but in a prolonged fashion. In such cases, recovery takes a disproportionately long time and sometimes the original performance cannot be fully restored despite recovery.[37] Fatigue can therefore lead to cognitive errors and subsequently to errors in patient treatment, which endangers high quality patient care. For this reason, in study 3, the strain perception of advanced medical students was recorded during a simulated work day to determine during which of the different phases of the assessment their strain was highest (study 3, chapter 4).

1.2 Summary of publications and manuscripts

1.2.1 Study 1: Competencies for first year residents – physicians' views from medical schools with different undergraduate curricula

Background and aim of this study

Medical curricula for undergraduate education are becoming increasingly competency-based, with the CanMEDS framework serving as the guideline. With this model developed by the Royal College of Physicians and Surgeons of Canada, a widely accepted framework based on competencies allocated to several roles of a physician was established for postgraduate education.[13] Medical schools are switching from traditional curricula to e.g. vertically integrated or competency-based undergraduate medical education[14,15] to ease the transition from undergraduate to postgraduate medical training. The perspectives on competencies needed for the first year of residency might differ among physicians according to the curricular structure of the undergraduate training they are used to or according to their specialty or position within a hospital. The relevance of different competencies for the beginning of a medical career can be assessed in a different way. The aim of this study was to evaluate several competencies with respect to their relevance for the work of a first year resident by physicians with different positions from different universities with different curricula.

Material and analysis

As part of an online survey, 952 surgeons and internists from three German medical schools with different undergraduate medical curricula participated between July and September 2016. Physicians from the University Medical Center Hamburg-Eppendorf (UKE, $n = 475$) and from the Carl von Ossietzky University of Oldenburg ($n = 204$), following a vertically integrated (VI) undergraduate curriculum, and from the Technical University of

Munich (TUM, $n = 269$), following a not vertically integrated (non-VI) undergraduate medical curriculum were asked to rank 25 competencies according to their estimated relevance for a beginning resident. The electronic questionnaire for the ranking of competencies needed for the entrustment first year of residency included sociodemographic data, i.e. physicians' age, gender, position (resident, consultant, supervising attending, department director), and location (Hamburg, Oldenburg, Munich). The residents were not all graduates from the respective medical school. Consultants were board certified specialists with no duties of supervision. The department directors were the heads of the departments. Physicians from all positions were involved in teaching activities (lectures, seminars, bedside teaching) at their respective medical school (between two and four hours a week) and clinical work. The 25 defined competencies[41] relevant for first year residents were placed in random order. Five competencies could be placed in each of the following categories: 'most important' (5 points), 'very important' (4 points), 'important' (3 points), 'less important' (2 points), and 'least important' (1 point). Participants were asked to drag and drop every competency from the left to the right side of the computer screen. Statistical analysis included the calculation of the median (*Mdn*) for each competency for the different groups. Department directors and supervising attendings were merged to one group named 'department directors'. Non-parametric tests (Mann-Whitney U test and Kruskal-Wallis test) were used to analyze differences due to different sample size within the subject-groups.

Results

In total, 202 physicians (21.2%) completed the questionnaire, including 76 physicians from Hamburg (response rate 15.9%), 44 from Oldenburg (response rate 21.6%), and 82 physicians from Munich (response rate 21.2%). Among all physicians, 73 were department directors (age: $M = 47.1$, $SD = 8.4$ years), 34 were consultants (age: $M = 39.2$, $SD = 5.6$ years), and 95 were residents (age: $M = 31.5$, $SD = 3.6$ years). There were no significant differences with

respect to the rank of the top 10 competencies. ‘Responsibility’ was the competency with the highest rank overall. Consultants were found to rank ‘Active listening to patients’ and ‘Written (and digital) account/report to colleagues and supervisors' significantly higher than department directors or residents. The competency ‘Coping with uncertainty' was more relevant for residents than for department directors and consultants. However, for department directors and consultants 'Responsibility' was more important than for residents. Significant differences were also found between disciplines: internists attributed significantly higher importance to ‘Structure, work planning and priorities’ than surgeons, while surgeons evaluated ‘Verbal communication with colleagues and supervisors’ significantly higher than internists. Furthermore, surgeons ranked ‘Attention to psychosocial aspects of health problems’ significantly higher compared with internists. Female physicians evaluated ‘Verbal communication with colleagues and supervisors’ and ‘Structure, work planning and priorities’ significantly higher than male physicians. In contrast, male physicians ranked ‘Scientifically and empirically grounded method of working’ and 'Attention to relatives and caregivers' significantly than female physicians.

Discussion

Physicians from three medical schools with different undergraduate curricula ranked relevant competencies for beginning residents in a similar way. A previous ranking study with clinical educators from two different countries and medical schools with different curricula also showed no significant differences among the top 10 competencies.[42] The high level of agreement within a large cohort of physicians from different medical schools on competencies needed by first year residents might be a first step towards a standardization of competency-based medical education. Each CanMEDS role except the role of ‘Health advocate’[13] was identified among the top 10 competencies summarized in the aspects of management, communication, and professionalism. However, there are interesting differences

between physicians with different professional experience as well as between surgeons and internists. Consultants assessed 'Active listening to patients' and 'Written (and digital) account/report to colleagues and supervisors' to be significantly more relevant for first year residents than department directors and the residents themselves. Consultants might be more aware in their interaction with residents on the ward than department directors and residents that history-taking alone, which requires active listening to a patient, can lead to the correct diagnosis in more than 80%.[43] In internal medicine residency programs the importance of effective history-taking has also been recognized as a valued competency for the quality of patient care.[44] Results of a meta-analysis showed that there are many options to improve the competency of written communication in residency training.[45] The competency 'Coping with uncertainty' was significantly higher ranked by residents than by consultants and by department directors. Coping with uncertainty is not easy to acquire during undergraduate medical training. Patients' recollections of their symptoms can be inconsistent when inquired by different physicians,[46] which can cause feelings of uncertainty in first year residents. Residents working on a ward become aware of the necessity to cope with uncertainty in clinical decision making, which will persist even with increasing medical knowledge.[47] Heuristics might help residents to become more confident with their clinical decisions.[48] Internists ranked aspects of management significantly higher than surgeons. A reason for this could be, that for internists, close interprofessional interaction with nursing staff has been found to involve especially patient management and clinical reasoning competencies.[49] Surgeons, on the other hand, ranked aspects of communication significantly higher than internists, which could be related to the great impact communication errors may have on patient safety in the context of surgery.[50] The generalizability this study's findings to physicians of other specialties is limited since only surgeons and internists were included in

the study. These results should be considered carefully in the planning of competency-based postgraduate education programs.

1.2.2 Study 2: Differences between medical student and faculty perceptions of the competencies needed for the first year of residency

Background and aim of this study

The CanMEDS framework provides a guideline for the design of competency-based postgraduate medical education.[13] Not all competencies are of similar importance at the beginning of the medical career. Supervisors of postgraduate training programs were asked to rate the preparedness for work of their medical graduates.[14] They evaluated students who graduated from a vertically integrated curriculum higher with respect to the capability to work independently, to solve medical problems, to manage unfamiliar medical situation, to prioritize tasks, and to estimate when they need to consult their supervisors. When Dutch medical students from a vertically integrated undergraduate medical curriculum were asked in their final year to rate the importance of competencies related to the seven CanMEDS roles, professionalism and communication received the highest scores.[51] In daily work, supervisors trust their trainees with specific tasks and decide when supervision is needed.[52,53] The aim of this study was to assess whether there are differences between students and supervisors with respect to the relevance of specific competencies for beginning residents. Thus, the range of perspectives on competencies needed for the first year of residency could be provided for curricula planners.

Material and analysis

This study was part of the online survey described in Study 1. It took place in the fall of 2016 and included competencies for first year residents, which had to be ranked according to their

relevance. In this study, medical students in their first (n = 360) and in their final year (n = 368), and physicians (n = 475 surgeons and internists) from the University Medical Center Hamburg-Eppendorf (UKE) were invited to rank 25 competencies according to their relevance for beginning residents. Again, five competencies could be placed in each of the following categories: 'most important' (5 points), 'very important' (4 points), 'important' (3 points), 'less important' (2 points), and 'least important' (1 point). All conditions for an ANOVA were fulfilled. Means and standard deviations were calculated for the different groups of participants. Statistical analysis included both t-tests and a one-way analysis of variance (ANOVA) to study differences between the groups.

Results

Of the 293 medical students and physicians who started the questionnaire, 178 completed it (response rate 14.8%). Fifty-six of the 76 physicians were internists (response rate 15.9%) and 20 were surgeons. There were 36 participating attendings (age: M = 43.3, SD = 10.3 years) and 40 residents (age: M = 31.8, SD = 3.3 years). In total, 102 undergraduate medical students participated (response rate 14.0%). Fifty-five students were in their first year (age: M = 21.6, SD = 4.8 years) and 47 were in their final year (age: M = 28.2, SD = 4.8 years). For both groups, physicians and medical students, 'Responsibility' is the competency, which plays the most important role for the first year of residency. The same eight of the top 10 competencies were identified by students and physicians. Physicians considered the competencies 'Teamwork and collegiality', 'Structure, work planning and priorities', and ‘Written (and digital) account/report to colleagues and supervisors’ to be significantly more relevant for beginning residents than students. For them, the competencies 'Active Listening to patients', ‘Advising patients' and 'Handling emotions of patients and their relatives' were significantly more important. Students ranked ‘Advising patients’ and ‘Handling emotions of patients and their relatives’ with significantly higher scores among the top 10 competencies while these

competencies do not appear within the top 10 of physicians. ‘Scientifically and empirically grounded method of working’, which appeared with a significantly higher rating in the physicians’ list, had a lower rank in the students’ list. While there was only one significant difference between attendings and residents in the higher score of 'Coping with mistakes' by residents, final year students rated 'Structure, work planning and priorities', 'Coping with mistakes' and 'Verbal communication with colleagues and supervisors' as significantly more relevant than first year students. Additionally, first year students rated ‘Respecting privacy and autonomy of the patient’ and ‘Adapted informing of patients’ significantly higher among the top 10 competencies compared with final year students. Other significant differences with higher ratings by final year students were ‘Coping with uncertainty’ and ‘Written (and digital) account/report to colleagues and supervisors’ while first year students ranked ‘Active health promotion’ significantly higher than final year students.

Discussion

The aim of this study was to explore the perspective of physicians and medical students on the importance of 25 competencies in first year of residency. Independently of the level of expertise, competencies like ‘Responsibility’, ‘Empathy and openness’, and ‘Knowing and maintaining own personal bounds and possibilities’ were ranked very highly among the overall top 10 competencies and comprise important aspects of professionalism.[54] Both, medical students and physicians, might have chosen these because they resemble features of a physician’s professional behavior.[55] Medical students ranked competencies connected with direct patient care (e.g. ‘Active listening to patients’, ‘Handling emotions of patients and their relatives’) significantly higher than physicians. The choice of these patient-centered competencies might be due to students’ learning experiences in our undergraduate medical curriculum and their preparedness to practice patient communication, which is rated highly by students from different undergraduate medical curricula.[56] In a medical students’ appraisal of

CanMEDS roles, the communicator role was rated highest and the manager role was rated lowest.[51] In the present study, physicians ranked competencies related to patient management like 'Structure, work planning and priorities' and 'Written (and digital) account/report to colleagues and supervisors' significantly higher than medical students. From their perspective and experience as supervisors, they can judge that management skills are required from the very first day of residency when working in interprofessional teams. However, they seem to be largely undeveloped in undergraduate medical education.[57] Documentation is an important competency of patient management in residency but students feel least prepared for this competency independently of the type of their medical school training.[56] Compared to first year students, final year students were significantly more aware that management competencies play an important role in the first year of residency. These findings are underscored by a study, which acknowledged that final year medical students reported an increase in the management of procedural skills after completing a pre-internship course.[58] Additionally, final year students rated 'Coping with mistakes' and 'Coping with uncertainty' significantly higher for the first year of residency than first year students. 'Coping with mistakes' was also the only competency, which was rated significantly higher by residents compared with attendings. First year medical students rated competencies related to patient care significantly higher than final year students. However, with experience, final year students and young residents learn that mistakes will occur and can occur easily, especially when salient clinical features distract a physician's attention.[59] The competency to cope with mistakes is also important for clinical reasoning strategies where diagnostic errors can occur with analytical and non-analytical thinking.[60] Their understanding of residents' competencies is highly related to patient care, the center of their undergraduate studies being important for their identity formation as future physicians.[61] Competencies, which are particularly important for starting residency should be given special consideration in undergraduate curricular

planning. They should also be made transparent to teachers and students in their relevance. This give curricular planner some insight whether the perspectives of students and physicians resemble the realistic learning situation of first year residents and how the perspectives could be integrated in the undergraduate medical curriculum.

1.2.3 Study 3: Perceived strain of undergraduate medical students during a simulated first day of residency

Background and aim of this study

Residents have been found to perceive high levels of strain and show abnormal burnout scores.[62] Medical students also reported a high degree of strain and even depressive tendencies when entering their clinical rotations.[63] There are studies about the experience of burnout symptoms and their consequences for medical students even already during the final year of undergraduate medical studies.[64] Being stressed during workdays in hospitals can have a negative effect on physicians' delivery of high-quality health care.[65] For that reason, many medical schools worldwide are reshaping their undergraduate medical curricula to become competency-based[19,66,67] and to prepare medical students well for clinical practice providing a seamless linkage from undergraduate education to postgraduate training.[68] A competency-based assessment was developed in a pilot project, which simulated the first workday in a hospital for a beginning resident.[69] In this assessment, medical students in their final year held a consultation hour in the role of a beginning resident, similar to the physician-patient communication training they experience during undergraduate medical education.[70] After that, they had to establish diagnostic and treatment plans[71] while dealing with common disturbances like interprofessional interactions with nursing staff and colleagues. Eventually, they reported about each patient to a supervisor, which is a routine in

hospitals across all disciplines.[72] Whether students experienced strain while performing such tasks is not known. Therefore, a 360-degree assessment based on competencies regarded to be relevant for a first year resident[73] was developed.[74] The aim of this study was to explore the perceived strain of medical students from different undergraduate curricula and at different stages of academic advancement during different phases of an assessment simulating a first day in hospital in the role of a beginning resident.

Material and analysis

Sixty-seven undergraduate medial students participated in the following three phases of a 360-degree examination in the role of a resident in a newly designed assessment:[74] a consultation hour with five simulated patients (one hour) followed by a management phase (two and a half hours), where the participants students could organize the patients' next diagnostic steps and interacted with other health care personnel, and a patient handover where they handed the patients over to a real resident (half an hour). The participating students completed the QCD (Short questionnaire on current disposition) by Müller and Basler,[75] which was modified in the order and polarization of the items and renamed STRAIPER (Strain Perception Questionnaire), after each of the three phases. The questionnaire includes the following six bi-polar items: tension (calm versus tense), doubt (confident versus doubtful), concern (unconcerned versus worried), agitation (unwound versus agitated), discomfort (comfortable versus uncomfortable), and apprehensiveness (relaxed versus apprehensive). The scale includes values from 1 to 6, whereby 1 means a minimum and 6 a maximum of perceived strain in the respective item category. The internal reliability (Cronbach's alpha) of the STRAIPER in this study sample was between .782 and .896. Students from different undergraduate curricula (VI: vertically integrated (University Medical Center Hamburg-Eppendorf, UKE; Carl von Ossietzky University of Oldenburg), $n = 35 + 6$ vs. non-VI: not vertically integrated (Technical University of Munich, TUM), $n = 26$) and

different academic advancement (10^{th} semester, $n = 26$ vs. final year, $n = 41$) were compared. There was a significant difference in university place allocation between students from Hamburg and Munich. Therefore, the data were analyzed with a two-way analysis of covariance (ANCOVA) with university place allocation as covariate to study differences between these groups. Students from Oldenburg were excluded from the calculations comparing participants from the different universities due to the low number of participants ($n = 6$). They were included in the calculations comparing students with different academic advancement.

Results

Students from a VI curriculum and from a non-VI curriculum showed the highest strain level after the management phase compared to the consultation hour and the handover ($p < .001$ and $p < .05$, respectively). No significant difference in perceived strain was found between students from semester 10 compared to final year students with respect to any of the STRAIPER items and the three phases of the assessment. Students from a non-VI curriculum felt significantly ($p < .05$) more tension ($M = 3.85$, $SD = 1.31$) and agitation ($M = 3.77$, $SD = 1.10$) during the consultation hour compared to the handover (tension: $M = 3.16$, $SD = 1.34$; agitation: $M = 3.20$, $SD = 1.26$). On the item level, students from a non-VI curriculum felt significantly more agitated ($M = 3.77$, $SD = 1.11$; $p < .01$, $d = .64$) during the consultation hour compared to students from a VI curriculum ($M = 3.08$, $SD = 1.18$). The university place allocation, which is significantly different between students from a VI and students from a non-VI curriculum had no effect on students' strain perception during any of the assessment phases, tested by the covariance analysis. Neither the day nor the time of the day of the assessment nor the respective evaluation of the different raters or the athletic activity of the students had a significant effect on the students' strain perception.

Discussion

All students felt the highest strain in the 360-degree assessment simulating a first day of residency during the patient management phase independently of their respective undergraduate medical curriculum. Competencies, which are related to management,[76] i.e. prioritizing tasks, interprofessional interaction, and handling of disturbances,[74] were required in this phase simultaneously. Familiar tasks like taking a patient's history and handing a patient over to a colleague, which are practiced during undergraduate medical education,[70,77] caused not as much strain. Management requires to organize and prioritize many tasks at the same time and the more time physicians spent on multitasking the higher is the level of the strain they perceive.[78] To reduce the strain medical students might have felt in the managing phase of the assessment do to interprofessional interaction interprofessional experiences should be integrated further in undergraduate medical education.[79] There was only one significant difference between students from the two universities with different types of curricula. Students from a non-VI curriculum (Munich) reported a higher perception of agitation during the consultation hour compared to students from a VI curriculum (Hamburg). This might have been related to the fact that the assessment took place in Hamburg and students from Munich had to familiarize themselves at first with the location of the assessment. There was no significant difference in perceived strain between students from semester 10 and from the final year, but both groups felt the highest strain levels after the management phase. This could be due to the fact that medical students are hardly ever challenged to prioritize tasks (e.g. during OSCEs) in their undergraduate education, but setting priorities is important competency in the daily routine of a resident's work in emergency departments and on the ward.[80] During the assessment the students were faced with such a situation during the patient management phase. In conclusion, it should be recommend that multitasking situations, including prioritizing tasks and acting in an

interprofessional team seem to be competencies which require a greater focus during undergraduate medical training to reduce strain when confronted with unfamiliar tasks and decisions.

1.2.4 Study 4: Medical knowledge and teamwork predict clinical reasoning skills in undergraduate medical students

Background and aim of this study

The cognitive process physicians use to investigate patients' problems based on the information gathered from history, physical examination, and sometimes additional test results is called clinical reasoning.[27] To select appropriate items for patient presentations, which provide the basis for clinical reasoning, is particularly challenging in clinical work due to the cognitive load, which can be generated with respect to information about patients.[81] The presentation of patient cases in front of others is a necessary requirement for clinical reasoning in the diagnostic process but can be a stressful experience for medical students.[82] Additionally, emotional disturbances or other contextual factors can impact on medical students' clinical reasoning performance.[83,84] Therefore, stress resistance is a desirable characteristic of medical students and is sometimes included in multiple mini-interviews for medical school admission.[85] In addition to contextual factors, personality-specific factors can also influence academic performance.[86] Students were observed to show high scores in procedural skills, which require a certain amount of adherence to procedures[87] during Objective Structured Clinical Examinations (OSCEs). Good teamwork also plays an important and indispensable role in in the4 daily routine on the ward[88] and especially the distribution and exchange of information within a team are crucial for clinical reasoning.[89] The aim of this study was to examine, which factors can predict clinical reasoning skills of

undergraduate medical students with a focus on case presentation during a simulated first work day of residency. My hypothesis is that medical knowledge, perceived strain, stress resistance, teamwork, and adherence to procedures are primary predictors of clinical reasoning skills in the simulated medical context.

Material and analysis

To evaluate, which factors can predict clinical reasoning skills, advanced undergraduate medical students (semester 10 to 12) participated in a 360-degree assessment in the role of beginning residents in a simulated first workday with three phases: a consultation hour, a management phase, and a handover phase. This study with 35 female and 27 male students from the University of Hamburg (n = 32), from the University of Oldenburg (n = 6), and from the Technical University Munich (n = 24) was part of the previous described 360-degree assessment[74] and took place in July 2017. Seventy students participated in the assessment in the role of beginning residents and 62 students summarized the impressions of their patients during the management phase with a Post-Encounter Form (PEF).[34] The students' perceived strain was measured with the Strain Perception Questionnaire (STARIPER) after each of the three phases of the assessment. To assess their clinical knowledge the students completed a 100-questions case-based multiple-choice test.[90] In addition to the 360-degree assessment the students participated in a part of the Group Assessment of Performance (GAP)-test,[91] which is used for testing flight school applicants and includes the following domains of competency: stress resistance (SR), adherence to procedures (AP), and teamwork (TW). The statistical calculations include a multiple linear regression analysis using a regression model with clinical reasoning skills as depend variable and medical knowledge, perceived strain, stress resistance, adherence to procedures, and teamwork as predictors.

Results

Two of the predictors of the regression model, explained approximately 21% of the variance of clinical reasoning skills, i.e. medical knowledge and teamwork (R^2 = .203, $F(5, 62) = 2.844$, p = .023). Medical knowledge could predict clinical reasoning skills (b = .372, $t(62) = 2.788$, p = .007) as well as teamwork (b = .401, $t(62) = 2.521$, p = .015). Teamwork correlates significant with every predictor in the model. The students' perceived strain and adherence to procedures correlate with no other variable. The medical students of this study reached a mean clinical reasoning score of 2.78 (SD = .58), with 5 being the highest score. Of the 100 points, which could be achieved in the multiple-choice test, they reached on average 73.3 (SD = 9.1). The participants showed a mean perceived strain score of 3.87 (SD = .79), a mean stress resistance score of 4.11 (SD = .71), a mean adherence to procedures score of 5.51 (SD = .63), and a mean teamwork score of 3.49 (SD = .83) on a 6-point scale ranging from 1 = very low to 6 = very high. The control variables age, gender, undergraduate curriculum, academic advancement, and high school grade point average had no effect on clinical reasoning skills.

Discussion

In this study, clinical reasoning skills of undergraduate medical students were predicted by two factors: medical knowledge (11%) and teamwork (10%). Medical knowledge is the basis of clinical reasoning. Decision making cannot begin without the necessary knowledge on medical subjects.[92] Tokuda et al. showed that postgraduate students with better knowledge of basic clinical care also showed better clinical reasoning skills in an exam.[93] Particularly in presenting cases, medical knowledge and clinical reasoning are linked, since specialized vocabulary is acquired while students gain experience and improve their understanding of diseases.[72] Clinical judgement and problem-solving skills, which are needed for clinical reasoning, improved successfully in combination with teamwork in pharmaceutical students

while solving patient cases during a simulation.[94] Teamwork also facilitate the development of creative solutions to challenging problems.[95] Even though there was no explicit teamwork task for clinical reasoning implemented in the 360-degree assessment, the medical students could discuss their thoughts on the management of their patients with their supervisor or other health care personnel and they could request laboratory and radiology tests. Furthermore, emotional reactions or other contextual factors like the physician-patient relationship were found to have an impact on clinical reasoning skills.[83] In the present study, medical students' perceived strain did not predict clinical reasoning skills. This could be due to the fact that the students perceived only moderate strain, but not actually stress during the simulated work day. However, no differences could be found with respect to diagnostic accuracy and clinical reasoning arguments between stressed and less stressed students.[96] In the GAP-test, students showed the highest scores for adherence to procedures compared to the scores for the other competencies (stress resistance, teamwork).[91] However, adherence to procedures could not predict clinical reasoning skills in the present study. This suggests that the clinical reasoning process requires additional skills than just carefully following the rules. The clinical reasoning process refers to a thinking process, which includes medical problem solving and medical decision making-skills.[92] Furthermore, it requires the ability to switch from the intuitive to the analytic way of thinking to make correct diagnoses, especially when patient cases are complex.[97] In conclusion, we recommend that students should be supported in developing abilities to work in a team and to acquire long-term knowledge to perform clinical reasoning successfully.

1.3 Overall discussion and conclusion

In this dissertation, a total of four studies investigated competencies and other factors relevant for or influencing first year residents work. In the first two studies, facets of

competency relevant for first year residents were ranked by both experienced physicians from different locations in Germany and by first year medical students. The resulting facets of competency served as the basis of a competency-based assessment, which simulated a resident's first day in hospital. In the third and fourth study, both the perceived strain during different phases of the assessment and the clinical reasoning skills of advanced medical students were assessed. The participating students came from different universities in Germany with different undergraduate curricula and were from semester 10 to semester 12 (final year).

Experienced and teaching physicians from three universities with different undergraduate medical curricula (study 1, chapter 2) did not differ in their ranking of the most relevant facets of competency for first year residents - aspects of management, communication, and professionalism were ranked very high,[76] while first year medical students (study 2, chapter 3) ranked aspects of patient care and empathy within their top 10.[73] These differences are interesting with respect to the expectations of high school graduates starting their medical studies and how these change during the study period towards the final year with extended experiences. In the competency-based assessment, only facets of competency were assessed which were rated as the most relevant for beginning residents by experienced physicians.[74] Due to the high ranking of competencies which are related to management, communication, and professionalism a greater attention should be payed to these competencies in development of undergraduate medical curricula and in selection procedures for medical students. On the one hand, the associated skills could be trained and improved. On the other hand, some of these are factors with trait characteristic that are difficult to change, i.e. empathy[98] and stress resistance or resilience.[99] Distortions regarding the rankings cannot be excluded, for instance, only internists and surgeons were invited. Under certain circumstances it could be shown that e.g. gynecologists need additional facets

of competency like patient education, health promotion, and handling psychosocial problems,[100] which did not appeare in the top 10 competencies rated by internists and surgeons.[73] On the one hand, very few women participated in the ranking study, on the other hand, disproportionately many of these women held a leading position.[101] Nevertheless, compared to the original Delphi study from 2013,[41] no major deviations were observed in the ranking. The ranking of these facets of competency seems to be very stable for first year residents independent of gender and across European countries.

In the third study, the perceived strain (study 3, chapter 4) and the clinical reasoning skills of advanced medical students (study 4, chapter 5) were measured during the competency-based assessment, which took place in Hamburg. During the management phase the participants reported higher perceived strain than during the consultation hour and the patient handover.[84] Differences between students from different curricula (VI vs. non-VI) or students with different academic advancement (semester 10 vs. final year) could only be shown at one time: the students from Hamburg reported less strain than the students from Munich at the beginning of the assessment. This difference might be related to the fact that students from Munich had to familiarize themselves with the location of the assessment while the students from Hamburg were already familiar with the rooms from their OSCEs. Otherwise, there was no difference between these groups. The ad hoc sample raises the question of representativeness.[102] The students were selected for the assessment on first-come, first-served basis. This could be a bias, because it should be assumed that only very motivated students have participated. The calculations took the difference in university place allocation between students from Hamburg and into account. Students from Hamburg had received their university place predominantly by a selection test, while students from Munich had a higher grade point average (GPA) and received their university place by this. To compare students

with a high GPA with students, who gained medical school entrance by a selection test, would be of additional value besides comparing students from different undergraduate curricula.

The results from the first ranking study of experienced physicians have already indicated that first year residents should have obtained management competencies.[76] The assessment simulating a first day of residency representing a maximal simulation of a clinical environment also showed that self-organization and prioritization are crucial to managing a work day in a hospital. The assessment phase that required these competencies was the most demanding one for the participating students.[84] Therefore, management competencies need to be especially included in the undergraduate medical curriculum. Experienced physicians also indicated that aspects of communication and professionalism are relevant for first year residents. In addition, they have ranked the facet of competency teamwork in the top three of their top 10 competencies.[76] Assessing clinical reasoning skills of advanced medical students (study 4, chapter 5) significantly predictable by two factors, i.e. teamwork and medical knowledge.[103] The ability to work with others can support good clinical reasoning, as it includes facets of social sensibility and exchange of information. These competencies can be obtained before the beginning of undergraduate training without knowledge of medical content and this can be displayed, e.g., in selection tests or multiple mini-interviews,[85] which assess psychosocial competencies. During undergraduate medical education, training to improve teamwork should also be included and continued in postgraduate education programs to help residents to improve their clinical reasoning skills. The correlation between the clinical reasoning skills and medical knowledge was expected.[103] Medical knowledge is the basis of clinical reasoning, and decision making cannot begin without the necessary knowledge on medical subjects.[92] Social and interactive skills are very relevant for interaction with other healthcare professionals, but solid medical knowledge is the requirement to solve medical problems.

In this dissertation the most important facets of competency for beginning residents were confirmed to be ‘Responsibility’, ‘Teamwork and collegiality’, ‘Active listening to patients’, ‘Written (and digital) account/report to colleagues and supervisors' and should receive particular attention during final year medical studies. In the role of beginning residents, medical students perceived the highest strain during the management phase of an assessment simulating the first work day in residency. Therefore, particular support should be given to medical students with respect to competencies, which are related with management tasks, e.g. organizational skills, setting priorities. Furthermore, clinical reasoning skills have to be practiced continuously in teams, for instance during case discussions, to expand medical knowledge and to exercise cooperation with colleagues.

List of abbreviations

ANOVA	Analysis Of Variance
ANCOVA	Analysis Of Covariance
AP	Adherence to Procedures
CanMEDS	Canadian Medical Education Directions for Specialists
EPA	Entrustable Professional Activities
GPA	Grade Point Average
M	Mean
Mdn	Median
NKLM	National Competence Based Catalogues of Learning Objectives for Undergraduate Medical Education
Non-VI	Not Vertically Integrated curriculum
OSCE	Objective Structured Clinical Examination
PEF	Post-Encounter Form
QCD	Short questionnaire on current disposition
SD	Standard Deviation
STRAIPER	Strain Perception Questionnaire
SR	Stress Resistance
TUM	Technical University of Munich
TW	Teamwork
UKE	University Medical Center Hamburg-Eppendorf
VI	Vertically Integrated curriculum

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103. Fürstenberg S, Oubaid V, Kadmon M, Berberat P, Harendza S. Medical knowledge and teamwork predict clinical reasoning skills in undergraduate medical students. GMS J Med Educ. [under review]

Medical knowledge and teamwork predict clinical reasoning skills in undergraduate medical students

Abstract

Background

Clinical reasoning refers to a thinking process including medical problem solving and medical decision making-skills. Several studies have shown that the clinical reasoning process can be influenced by a number of factors, e.g. context or personality traits. The aim of this study was to identify factors, which predict clinical reasoning skills of undergraduate medical students in an assessment simulating the first day of residency.

Methods

To investigate factors predicting clinical reasoning skills 70 advanced undergraduate medical students participated in the role of a beginning resident in our assessment, which included a consultation hour, a patient management phase, and a handover. Participants filled out a Post-Encounter Form (PEF) to document their clinical reasoning and the Strain Perception Questionnaire (STRAIPER) to measure their situation-dependent mental strain. To assess medical knowledge the participants completed a 100-questions multiple-choice test. To measure stress resistance, adherence to procedures, and teamwork students took part in the Group Assessment of Performance (GAP)-test for flight school applicants. These factors were included in a multiple linear regression analysis.

Results

Medical knowledge and teamwork predicted clinical reasoning of undergraduate medical students and explained approximately 21% of the variance. Neither age, gender, undergraduate curriculum, academic advancement nor high school grade point average of the medical students of our sample had an effect on their clinical reasoning skills.

Conclusion

Clinical reasoning skills of undergraduate medical students can be predicted by medical knowledge and teamwork. Students should be supported in developing abilities to work in a team and to acquire long-term knowledge for clinical reasoning.

Introduction

Clinical reasoning is the cognitive process physicians use to investigate patients' problems based on the information gathered from history, physical examination, and sometimes additional test results to make a diagnosis.[1] The skills of clinical reasoning need to be developed during undergraduate medical training, e.g. in seminars,[2] and should be refined during postgraduate medical education.[3] The context of clinical encounters has an additional influence on clinical reasoning skills.[4] Within the diagnostic process, different levels of expertise are associated with different approaches of reasoning[5] and include the intuitive and the hypothetic deductive way for making decisions.[6] A particular challenge in clinical work is to manage the cognitive load with respect to information about patients[7] and to select items for patient presentations, which are relevant for clinical reasoning.

Presenting patients in front of others, e.g. during morning report, is a necessary requirement for clinical reasoning in the diagnostic process but can be a stressful experience.[8] Furthermore, students' knowledge and their epistemological believes about it play an important role in how they process and reflect upon new information.[9] Additionally, contextual factors such as emotional disturbances can impact on medical students' clinical reasoning performance.[10] Medical students also reported symptoms of stress and depression with the start of their clinical rotations.[11] These signs of strain perception might influence their clinical reasoning skills negatively, because perceived strain is also a factor that could

influence clinical reasoning performance. If (job) demands becomes strain, performance can be reduced.[12] Therefore, stress resistance is a desired characteristic in medical students, which is sometimes included in multiple mini-interviews for medical school admission.[13] In addition to contextual factors, personality-specific factors can also influence academic performance.[14] During Objective Structured Clinical Examinations (OSCEs), for instance, advanced medical students were observed to show high scores in procedural skills, which require a certain amount of adherence to procedures.[15] Good teamwork also plays an important and indispensable role in in the daily routine on the ward[16] and especially the distribution and exchange of information within a team are crucial for clinical reasoning.[17]

In this study we examined, which factors can predict the clinical reasoning skills of undergraduate medical students in an assessment simulating the first day of residency. We focus particularly on the skill of case presentation, which constitutes the crucial point for clinical reasoning. Based on the current literature we hypothesize that medical knowledge, perceived strain, stress resistance, adherence to procedures and teamwork, which are also relevant factors for aviation personnel, are primary predictors of clinical reasoning skills in our simulated medical context.

Methods

The evaluation of clinical reasoning skills was part of a 360-degree competence assessment of undergraduate medical students in the role of beginning residents in a simulated first workday of residency.[18] Seventy students participated in the assessment. This assessment was based on the selected competences relevant for beginning residents[19] and it represented a maximal simulation of a clinical environment. Participants held a consultation hour with five simulated patients, which was followed by a management phase (2.5 hours), where the participants

could organize their patients' next diagnostic steps and interacted with other health care personnel. Eventually, the participants handed their patients over to a resident in 30 minutes.

To document clinical reasoning skills, 62 students filled out one free text Post-Encounter Form (PEF)[20] per patient during the management phase of the assessment. This form provides a scoring system including the items summary statement, list of problems, list of differential diagnoses, most likely diagnosis, and supporting data for most likely diagnosis. In our study, we focused on the summary statement, which provided the basis for the patient handover. The summary statements were assessed by an experienced physician with respect to two aspects: the adequacy of the presentation of the summary with respect to medical content (rating scale 1) and with respect to the use of proper medical terminology for symptoms and findings (rating scale 2). Rating scale 1 included the following 5-point Likert scale[20]: 1 = 'Unable to summarize', 2 = 'Poor/inadequate summary', 3 = 'Adequate summary', 4 = 'Well summarized, recognizes key details', 5 = 'Outstanding summary, demonstrates understanding'. Rating scale 2, also a 5-point Likert scale, consists of the following scale: 1 = 'Uses lay terms or patient's word', 2 = 'Incorrect use of medical language', 3 = 'Correctly uses some medical terminology', 4 = 'Frequently and correctly uses medical terminology', 5 = 'Advanced fluency in medical terminology, eloquent and concise'.

After each of the three assessment phases, we measured students' perceived strain, a response produced in the individual to aversive and potentially harmful exposure to stress.[21] The students filled out the Strain Perception Questionnaire (STRAIPER),[22] which is based on the QCD (Short questionnaire on current disposition) by Müller and Basler[23] and includes the following bi-polar six items: tension, doubt, concern, agitation, discomfort, and apprehensiveness.

In addition to participating in the 360-degree assessment, all participants completed a case based multiple-choice test with 100 questions to assess their medical knowledge one week before the assessment. This knowledge test was compiled from 1000-freely available United States Medical Licensing Examination Step 2 type items. [24] The selection process of the questions is described elsewhere. [25]

Furthermore, participants of the 360-degree assessment additionally participated one day later in part of the Group Assessment of Performance (GAP)-test[26] used for testing of flight school applicants.[27] It contains a validated 1.5 hours computerized team task to evaluate social and interactive skills. The following domains of competence were assessed: stress resistance (SR), adherence to procedures (AP), and teamwork (TW). A comprehensive description of these domains of competence and their facets was given earlier.[26] The observation of the participants was carried out by two DLR aviation psychologist with more than 15 years and 2000 cases of experience in behavioral observation.

The participants of our study, which took place in July 2017, were 70 advanced undergraduate medical students (semester 10 to 12) from three medical schools with different curricula of 12 semesters who had volunteered to participate. Three students were excluded from the data analysis, because they had not reached their 10th semester yet. Data from five other students were also excluded, because their data sets were incomplete. Data from 62 participants (n = 32 from the University of Hamburg, n = 6 from the University of Oldenburg, n = 24 from the Technical University Munich) were included in our analysis. The mean age of the 35 female and 27 male students was 26.1 ± 2.2 years.

The statistical calculation was performed on SPSS Statistics (version 23) and included a multiple linear regression analysis using a regression model with the following predictors: Medical knowledge, perceived strain, stress resistance, adherence to procedures, and teamwork as well as clinical reasoning skills as depend variable. The significance was set on a p-value < .05.

Results

The mean clinical reasoning skills of the students of our sample were rated as 2.78 (± .58), whereby 5 was the highest score. On average, they reached 73.3 (± 9.1) of 100 possible points in the medical knowledge multiple-choice test. On a 6-point scale ranging from 1 = 'very low' to 6 = 'very high', they showed a perceived strain of 3.87 (± .79), a stress resistance score of 4.11 (± .71), an adherence to procedures score of 5.51 (± .63), and a teamwork score of 3.49 (± .83). All scores are high enough to meet requirement cut-off scores for flight school applicants, except teamwork.

The predictors (medical knowledge, perceived strain, stress resistance, adherence to procedures, teamwork) of the regression model are shown in Figure 1. Two of the predictors, i.e. medical knowledge and teamwork, explained a significant portion (approximately 21%) of the variance of clinical reasoning skills (R^2 = .203, $F(5, 62) = 2.844$, p = .023), shown in Table 1. Medical knowledge could predict clinical reasoning skills (b = .372, $t(62) = 2.788$, p = .007) as well as teamwork (b = .401, $t(62) = 2.521$, p = .015). The intercorrelation of all variables of the regression model is shown in Table 2. There are significant correlations between teamwork and every predictor in our model, whereas perceived strain and adherence to procedures correlate with no other variable. The regression model was controlled by age,

gender, undergraduate curriculum, academic advancement, and high school grade point average, which had no effect on clinical reasoning skills.

Table 1: Multiple regression coefficients to predict clinical reasoning skills

Predictor	*B*	*SE*	β	R^2
Medical knowledge	.024	.009	.372**	.203*
Perceived strain	.093	.083	.140	
Stress resistance	-.241	.127	-.307	
Adherence to procedures	.161	.107	.161	
Teamwork	.260	.103	.401*	

*$p < .05$; **$p < .01$

Table 2: Intercorrelation of all variables of the regression model

	(1)	(2)	(3)	(4)	(5)
(1) Clinical reasoning skills					
(2) Medical knowledge	-.300**				
(3) Perceived strain	.011	-.115			
(4) Stress resistance	.056	.410***	-.070		
(5) Adherence to procedures	.055	-.204	-.121	-.153	
(6) Teamwork	.240*	.271*	-.211*	.621***	-.221*

*$p < .05$; **$p < .01$; ***$p < .001$

Discussion

In our assessment, clinical reasoning skills are predicted by two factors. Medical knowledge explained around 11% of the variance of clinical reasoning skills in our study. It is the basis of clinical reasoning, and decision making cannot begin without the necessary knowledge on medical subjects.[28] In another study, postgraduate students with better knowledge of basicclinical care also showed better clinical reasoning skills in an exam.[29] The more medical students' knowledge increased over the time in a progress test at a medical school with a problem-based curriculum, the greater their clinical reasoning skills were.[30] However, even though third year postgraduate medical students have greater medical knowledge, they were observed to commit similar heuristic errors in clinical reasoning to those of residents in their first year.[31] Proficiency in medical knowledge and clinical reasoning, particularly in presenting cases, is linked, since specialized vocabulary is acquired while students gain experience and improve their understanding of diseases.[32]

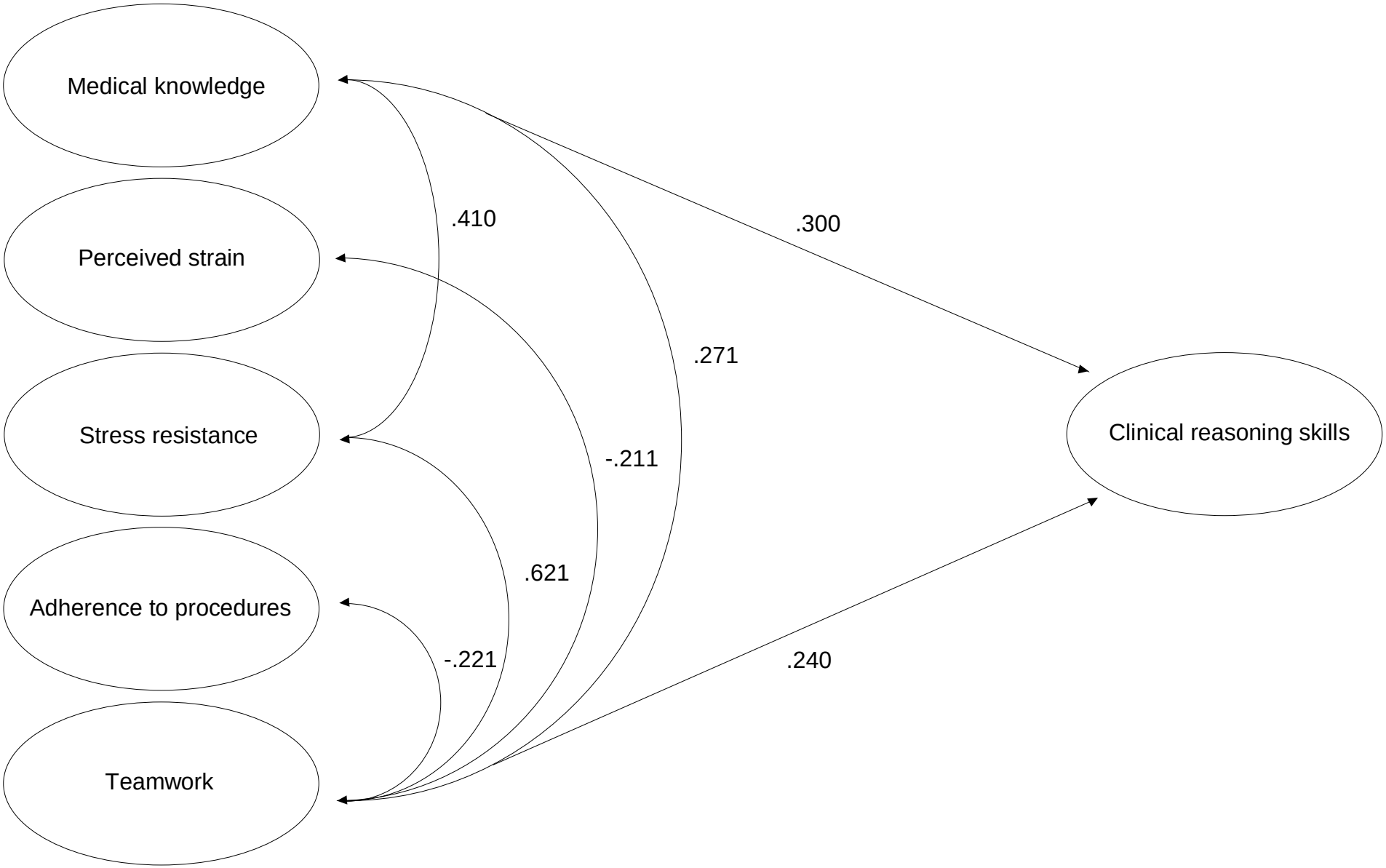
The factor teamwork explained around 10% of the variance of clinical reasoning skills in our study. In a human patient simulation for pharmaceutical students, clinical judgement and problem-solving skills, which are needed for clinical reasoning, were improved in combination with teamwork while solving the cases successfully.[33] Dental students who participated in a problem-based learning course also reported an increase in their teamwork and problem solving-skills.[34] Teamwork has also been shown to facilitate the development of creative solutions to challenging problems.[35] Simulation-based learning in teams during undergraduate medical education can also be fostered by using collaboration scripts.[36] Even though no explicit teamwork task for clinical reasoning was implemented in our 360-degree assessment, participants could discuss their thoughts on the management of the patients with

their supervisor or other health care personnel and could request laboratory and radiology tests.

Contextual factors like the emotional reaction of students (e.g. to patients' conditions or behavior) and the physician-patient relationship were found to have an impact on clinical reasoning skills.[10] In our study, students' perceived strain did not predict clinical reasoning skills, which could be due to the fact that the students perceived moderate strain, but not actual stress during the simulated work day. However, no differences with respect to diagnostic accuracy and clinical reasoning arguments between stressed and less stressed students were found elsewhere.[37]

During the GAP-test students showed the highest scores for adherence to procedures compared to the scores for the other competences.[26] However, adherence to procedures did not predict clinical reasoning skills. Apparently, the clinical reasoning process requires additional skills than just carefully following the rules. It refers to a thinking process, which includes medical problem solving and medical decision making-skills.[28] Furthermore, it requires the ability to switch from intuitive to analytic thing to make correct diagnoses when patient cases are complex.[38]

A strength of our study is the fact that students from medical schools with different undergraduate curricula and with different academic advancement participated. This enabled us to control for these factors in our analysis. A weakness of our study is that the summary statements were assessed by just one experienced physician. However, she has been teaching clinical reasoning for many years[2] and was involved in the design and operationalization of the 360-degree assessment.[18] Despite the low sample number, we were able to identify


Medical knowledge
Perceived strain
Stress resistance
Adherence to procedures
Teamwork
Clinical reasoning skills
.410
.271
-.211
.621
-.221
.300
.240

significant predictors of clinical reasoning skills measured with a validated scoring form.[20] With our simulation we created a realistic environment to investigate factors, which can influence clinical reasoning skills, supported by the validated GAP-test used for flight school applicants.[27]

Conclusion

Medical knowledge and teamwork skills predicted clinical reasoning skills of undergraduate medical students from medical schools with different curricula and with different academic advancement during a simulated first day of residency. Teamwork skills support good clinical reasoning, since teamwork involves social sensitivity and exchange of information. Thus, it might be useful to support medical students in developing the ability to work in teams as well as to acquire long-term knowledge to be used for clinical reasoning. Trainings for the improvement of teamwork also should be included in postgraduate education programs to help residents to enhance their clinical reasoning skills. It should also be considered to implement teamwork assessment in selection procedures for medical students.

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6 Summary in German and English

6.1 Zusammenfassung

Im Laufe des Studiums eignen sich Medizinstudierende eine große Menge Fachwissen und Fertigkeiten an, die sie mit dem Berufseinstieg beherrschen und im komplexen medizinischen Arbeitsumfeld anwenden sollen. Dabei müssen sie ständig klinische Entscheidungen treffen, um im diagnostischen und therapeutischen Prozess eine gute Versorgung der PatientInnen zu gewährleisten. Unter klinischer Entscheidungsfindung werden neben dem Abrufen von medizinischem Fachwissen ärztliche Denkvorgänge bei der kritischen Sichtung und Bewertung von diagnostischen Befunden verstanden, die zur Entscheidung für die Behandlung der PatientInnen beitragen. Der klinischen Entscheidungsfindung liegen verschiedene Kompetenzen zugrunde, welche jedoch bisher meistens weder im Rahmen des Medizinstudiums explizit vermittelt werden noch als Lernziele in der Ausbildung verankert sind. Weiterhin ist aus der arbeitspsychologischen Forschung bekannt, dass es durch zu lange und/oder intensive Beanspruchung zu Fehlleistungen kommt. Denkfehler treten ebenfalls in den Prozessen der klinischen Entscheidungsfindung auf.

Ziel dieser Arbeit war es, die Ausprägung relevanter Kompetenzen, die sich Fähigkeiten der klinischen Entscheidungsfindung zuordnen lassen, zu ermitteln. Dafür wurde die Relevanz verschiedener Kompetenzen für ärztliche BerufsanfängerInnen in der Bewertung durch erfahrene ÄrztInnen sowie durch StudienanfängerInnen und PJ-Studierende erfasst. Über die Bedeutsamkeit der Verantwortungsübernahme und Aspekte des PatientInnenmanagements und der PatientInnenkommunikation angehender ÄrztInnen waren sich alle Befragten einig. Medizinstudierende stellten zudem die Relevanz der PatientInnenversorgung sowie den Umgang mit Unsicherheit und den Umgang mit Fehlern in den Vordengrund.

Da sich Kompetenz in Performanz (Leistung) äußert, durchliefen 70 Medizinstudierende gegen Ende ihres Studiums eine auf diesen Kompetenzen basierende Prüfung, die einen ersten Arbeitstag im Krankenhaus simulierte. Im Rahmen der Prüfung wurden die Fähigkeiten der klinischen Entscheidungsfindung sowie das Beanspruchungsempfinden der Studierenden untersucht und es wurde geprüft, ob verschiedene Faktoren diese Fähigkeit beeinflussen. Während der Managementphase der Prüfung berichteten Medizinstudierende über ein stärkeres Beanspruchungsempfinden als während der Sprechstunde oder der PatientInnenübergabe. Zudem konnte die Fähigkeit ihrer klinischen Entscheidungsfindung sowohl durch ihr medizinisches Fachwissen als auch durch die Ausprägung ihrer Zusammenarbeitsfähigkeit vorhergesagt werden.

Die im Rahmen dieser Dissertation durchgeführten Studien deuten darauf hin, dass bei der Curriculumsplanung ein stärkerer Fokus auf Veranstaltungen, die Managementkompetenzen vermitteln und eine Verbesserung der Teamfähigkeit angehender MedizinerInnen unterstützen, gelegte werden sollte.

6.2 Summary

During undergraduate education, medical students acquire a large amount of medical knowledge and skills which they should memorize when starting their careers and apply in the complex medical work environment. Simultaneously, they constantly have to make clinical decisions in order to ensure good patient care during the diagnostic and therapeutic process. Clinical reasoning means, in addition to retrieving medical knowledge, the processes of clinical decision-making with critical review and evaluation of diagnostic findings that contribute to the decision process to treat a patient. Clinical reasoning is based on various competencies, which are to date most of the time not explicitly taught in medical curricula or anchored as learning objectives in medical education. Furthermore, it is known from work and

organizational psychology research that too long and/or intensive strain reduces performance. Cognitive errors also occur in the processes of clinical reasoning.

The aim of this dissertation was to determine the degree of relevant competencies that can be assigned to clinical reasoning skills. Therefore, the relevance of different competencies for first year residents was ranked by experienced physicians as well as undergraduate students. All participants agreed on the importance of assuming responsibility and aspects of patient management and patient communication for first year residents. Medical students also considered the relevance of patient care as well as coping with uncertainty and coping with mistakes.

Since competency is expressed in performance, 70 advanced medical students participated in an assessment that simulated a resident's first day in hospital based on these competencies. In this assessment, the clinical reasoning skills, including factors affecting this ability, and the perceived strain of the students were examined. During the management phase, medical students reported more perceived strain than during the consultation hour or the patient handover. In addition, their clinical reasoning skills could be predicted by their medical knowledge and by their teamwork.

The studies, which were part of this dissertation, suggest that it might be worthwhile in curriculum planning to focus on courses that support management skills and the improvement of teamwork for medical students close to graduation.

7 Explanation of the personal contribution to publications

All publications and manuscripts included in this cumulative dissertation were written by me, Sophie Fürstenberg, as individual first author. The basic ideas, the specific research questions, and analyses were developed by me in consultation with Prof. Dr. Sigrid Harendza.

Chapter 2: Competencies for first year residents – physicians' views from medical schools with different undergraduate curricula

The preparation of the online questionnaire based on 25 pre-selected competencies needed for entrustment decisions in first year residents was done me with technical support by Florian Wölfle. The selection of a suitable quantitative analysis method for not normally distributed data as well as non-homogeneity of variance data was made by me. I did the complete statistical analysis and interpretation of the results, and wrote the first draft of the manuscript, including tables. The linguistic adaptation suggestions of the text after revision by Prof. Dr. Sigrid Harendza was executed by me. The revision after the peer review was carried out by me in cooperation with Prof. Dr. Sigrid Harendza.

Chapter 3: Differences between medical student and faculty perceptions of the competencies needed for the first year of residency

The preparation of the online questionnaire based on 25 pre-selected competencies needed for entrustment decisions in first year residents were done me with technical support by Florian Wölfle. The selection of a suitable quantitative analysis method for normally distributed data as well as homogeneity of variance data was made by me. I did the complete statistical analysis and interpretation of the results, and wrote the first draft of the manuscript, including tables. The linguistic adaptation suggestions of the text after revision by Prof. Dr. Sigrid

Harendza was executed by me. The revision after the peer review was carried out by me in cooperation with Prof. Dr. Sigrid Harendza.

Chapter 4: Perceived strain of undergraduate medical students during a simulated first day of residency

The search for and selection of a suitable, valid questionnaire to record the perceived strain and to adjust the order and inversion of the items was done by me. The data was entered and prepared by me, adjusted and inverted. I did all statistical analyses, interpreted the results, and made a first draft of the manuscript, including tables and figures. The linguistic adaptation suggestions of the text after revision by Prof. Dr. Sigrid Harendza was implemented by me. The revision after the peer review was carried out by me in cooperation with Prof. Dr. Sigrid Harendza.

Chapter 5: Medical knowledge and teamwork predict clinical reasoning skills in undergraduate medical students

When selecting the rating scale, I followed a validated scoring form for evaluating clinical reasoning. The clinical reasoning skills were assessed by Prof. Dr. Sigrid Harendza. The data was entered and prepared by me. I calculated all statistical analyses, interpreted the results, and made a first draft of the manuscript. The linguistic adaptation suggestions of the text after revision by Prof. Dr. Sigrid Harendza was implemented by me. The revision after the peer review was carried out by me in cooperation with Prof. Dr. Sigrid Harendza.

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9 Curriculum vitae

Lebenslauf entfällt aus datenschutzrechtlichen Gründen

Lebenslauf entfällt aus datenschutzrechtlichen Gründen

10 Eidesstatliche Versicherung

Ich versichere ausdrücklich, dass ich die Arbeit selbständig und ohne fremde Hilfe verfasst, andere als die von mir angegebenen Quellen und Hilfsmitel nicht benutt und die aus den benutten Werken wörtlich oder inhaltlich entnommenen Stellen einzeln nach Ausgabe (Auflage und Jahr des Erscheinens), Band und Seite des benutten Werke kenntlich gemacht habe.

Ferner versichere ich, dass ich die Dissertation bisher nicht einem Fachvertreter an einer anderen Hochschule zur Überprüfung vorgelegt oder mich anderweitig um Zulassung zur Promotion beworben habe.

Ich erkläre mich einverstanden, dass meine Dissertation vom Dekanat der Medizinischen Fakultät mit einer gängigen Software zur Erkennung von Plagiaten überprüf werden kann.

Hamburg, den 08.01.2019 _____

Sophie Fürstenberg