The clinician-scientist pipeline: undergraduate and postgraduate supply, leaks and perspectives

Bakker, C.R. den

The clinician–scientist pipeline

undergraduate and postgraduate supply, leaks and perspectives

Charlotte R. den Bakker

The clinician–scientist pipeline

undergraduate and postgraduate supply,
leaks and perspectives

Charlotte R. den Bakker

Colophon
The studies described in this thesis were conducted at the Center for Innovation in Medical Education of Leiden University Medical Center, Leiden, the Netherlands.
Financial support for printing of this thesis was kindly provided by Leiden University, the Dutch Association for Medical Education (NVMO), BKV, ChipSoft and GeriCall.

Author	Charlotte den Bakker
Cover design	Mark den Bakker
Layout	Mark den Bakker
Print	Print.com

The clinician–scientist pipeline

undergraduate and postgraduate supply, leaks and perspectives

Proefschrift

ter verkrijging van
de graad van doctor aan de Universiteit Leiden,
op gezag van rector magnificus prof.dr.ir. H. Bijl,
volgens besluit van het college voor promoties
te verdedigen op donderdag 28 september 2023
klokke 11.15 uur

door

Charlotte Rosalie den Bakker
geboren te Seria, Brunei
in 1992

Promotor	Prof.dr. F.W. Dekker
Copromotores	Dr. A.J. de Beaufort Dr. B.W.C. Ommering
Promotiecommissie	Prof.dr. P.H.A. Quax Prof.dr. E.Y. Sarton Prof.dr. M. Wijnen-Meijer, Technical University of Munich Prof.dr. J. de Graaf, Radboud University Medical Center

"EDUCATION IS A LIFELONG JOURNEY
WHOSE DESTINATION EXPANDS
AS YOU TRAVEL."
– Jim Stovall, 2015.

Table of contents

Chapter 1 General introduction and outline of the thesis 9

Part I: Undergraduate research training

Chapter 2 Assessing publication rates from medical students' mandatory research projects in the Netherlands: a follow-up study of 10 cohorts of medical students 31
BMJ Open, 2022

Chapter 3 The role of mandatory research projects in medical students' research motivation 51
Submitted

Chapter 4 Exploring fairness in scholarly development: Are we creating knowledge storing zombies or curious, creative and critical healthcare professionals? 73
Advances in Medical Education and Practice, 2023

Chapter 5 Twelve tips for fostering the next generation of medical teachers 83
Medical Teacher, 2021

Part II: Postgraduate research training

Chapter 6 Comparing medical PhD programmes around the world: a matter of apples and oranges? 97
Submitted

Chapter 7 Inspecting the leaky clinician-scientist pipeline: a national study on medical PhD candidates' motivations in the Netherlands 111
Submitted

Chapter 8 The bumpy ride to a medical PhD degree: a qualitative study on factors influencing motivation 137
Submitted

Chapter 9 General discussion 155

Chapter 10 Summary 175
Nederlandse samenvatting 182

Appendices Supplemental material 191
PhD Portfolio 208
Dankwoord 212
Curriculum Vitae 214

Part I: Undergraduate research training

Chapter 1

General introduction and outline of the thesis

1. Introduction

The high quality of medical care provided today is built upon years of effort by clinicians, clinician-scientists, PhD candidates, and other healthcare professionals investigating healthcare including the causes of, and potential treatments for, disease. Tireless efforts of healthcare professionals have made many once life-threatening conditions and diseases history. Even so in the future, development of medical knowledge and, hence, improvement of patient care will highly rely on medical professionals who are involved in medical research. In the past few decades, concerns are being raised about the academic workforce in medicine, with academic career pathways being referred to as 'the leaky pipeline'.[1-3] This thesis focuses on the leaky pipeline and studies undergraduate and postgraduate supply, leaks and perspectives.

The purpose of this introductory chapter is to illustrate how the recent situation in medical education and academic medicine have inspired the rresearch projects described in this thesis. Therefore, this chapter starts with a solid description and overview of medical undergraduate and postgraduate research education, as well as pathways based on medical education literature. Next, challenges, knowledge gaps and barriers in academic medicine are identified. At the end of this chapter, the research questions of this thesis are formulated and the research projects that together form this thesis are outlined.

1.1 The value of clinician-scientists in the medical field

The Royal College of Physicians and Surgeons of Canada developed a medical education framework in the 1990s aiming to improve patient care: the Canadian Medical Education Directives for Specialists (*CanMEDS*).[4] Revised in 2005 and 2015, the CanMEDS is currently the most widely adopted and applied medical education framework worldwide, from medical school to continuing professional development. This competency framework identifies and describes required abilities for medical doctors to successfully meet the healthcare needs of those they serve. These abilities are grouped under seven professional roles that a medical doctor must embody. One of these roles is the role of 'scholar'. Scholarly ability is defined by four key competencies. Scholars are able to:

1. Engage in the continuous enhancement of their professional activities through ongoing learning (i.e. lifelong learner);
2. Teach students, residents, the public, and other healthcare professionals (i.e. medical teacher);
3. Integrate best available evidence into practice (i.e. evidence-based medicine);
4. Contribute to the creation and dissemination of knowledge and practices applicable to health (i.e. conducting research).

In short, the role of a scholar entails learning (i.e. being a lifelong learner as well as teaching others) and research (i.e. using and doing research) competencies.[4] This thesis will mainly focus on the latter.

According to the CanMEDS framework, all clinicians should be able to practice evidence-based medicine and conduct research. However, *being able* to is not inherently linked to *actually* doing something. Nevertheless, it is a common belief that every clinician should not only be limited to be able to practice evidence-based medicine only, but should actually implement evidence-based medicine in (part of) their daily clinical practice.[5,6] The practice of evidence-based medicine means integrating individual clinical expertise and patient values with the best available scientific evidence (*Figure 1*).[5,7] It is a process of life-long, self-directed learning in which evidence-based medicine creates the need for clinically relevant and up-to-date information about diagnosis, prognosis, therapy, and other clinical and healthcare issues.[7] Therefore, all clinicians are expected to be skilled and knowledgeable in the utilization of research and scientific methods of enquiry as applied to medical practice. Indeed, clinician literacy in research improves critical thinking in guiding clinical judgement – necessary ingredients for effective implementation of evidence-based medicine in daily practice.[8]

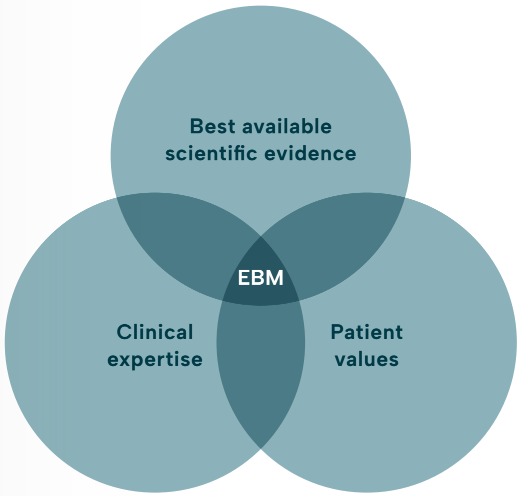

Figure 1. *Evidence-based medicine (EBM) in pursuit of the best possible health care outcomes*

To incorporate this information as best evidence in everyday practice, the following steps are required; (1) clinical care is translated into questions; (2) the best available evidence is tracked down; (3) this evidence is critically appraised for its validity (closeness to truth), impact (size of the effect), and usefulness (clinical applicability); (4) the appraisal is integrated with clinical expertise and applied within clinical practice; (5) the clinical practice is monitored and evaluated.[7,9] This should be an ongoing process in clinical practice and therefore it may also be illustrated as a circle (*Figure 2*).

Figure 2. *The cycle of practicing evidence-based medicine*

Furthermore, according to the CanMEDS framework, every clinician should be able to contribute to the creation, dissemination, application and translation of knowledge within healthcare. Thus, in addition to utilizing research, clinicians should be able to conduct research. However, as medical research is the driving force behind the practice of evidence-based medicine, it is important that a subset of clinicians actually conducts research. Clinicians who also devote a substantial amount of their time to conducting research next to their clinical care, i.e. clinician-scientist, are indispensable in medical research and, thus, the development of evidence-based medicine. Clinician-scientists, in current literature also referred to as clinical researchers, clinical investigators, physician investigators or physician-scientists, connect medical research with clinical care, and vice versa, as illustrated in *Figure 3*. This is a unique and valuable position in the translation of medical research, also referred to as translational research. The process of translational research comprises translating information or knowledge that

is created in one area to another and consists of two main translational stages.[10] One is the process of applying discoveries generated by basic research or preclinical studies to the development of clinical trials in healthy volunteers or patients. The second stage of translation involves clinical care and is applicable in two ways. In this stage, research findings find their way to clinical care, but also vice versa, with relevant clinical questions being converted to research questions.

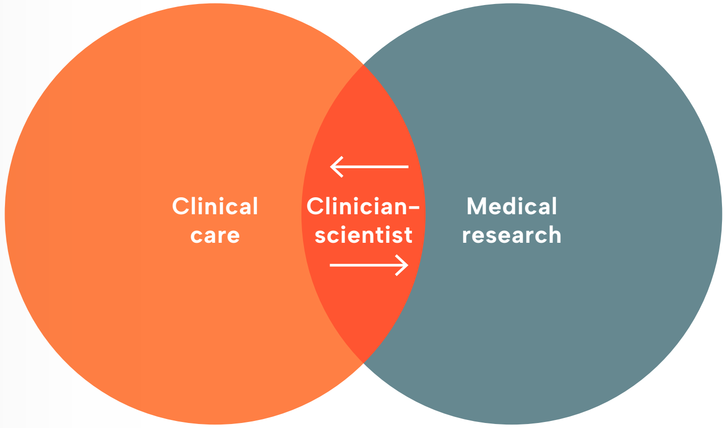

Figure 3. *Clinician-scientists linking clinical care with medical research and vice versa*

The value of clinician-scientists for translational research in medicine is more relevant than ever. Medical research has developed into a multidisciplinary field, as advances in the medical field are closely linked with scientific developments in other disciplines (e.g. biochemistry, pharmacology, health technology, etc.). These disciplines have one common goal: improving healthcare. This requires that scientific knowledge derived from these disciplines finds its way to clinical care, and vice versa. This need is enhanced by the rapid pace of developments in the multidisciplinary medical field. Clinician-scientists have the best position within both the research and clinical domain to connect clinical care and research.

To summarize, all medical doctors should utilize and be able to conduct research in order to provide evidence-based medicine. Additionally, some of them need to be engaged in research as clinician-scientist in order to develop and improve evidence-based medicine. However, there is a decrease in the number of clinician-scientists in many countries. This decrease has not diminished since over four decades when it first received attention.[11] Clinician-scientists are being referred to as 'endangered species' and clinician-scientist career pathways are described as 'the leaky pipeline'.[1-3] As a result, there is an urgent need to attract and support (future) medical graduates to become clinician-scientists and, subsequently, strengthen the connection that is needed between clinical care and medical research.

1.2 The clinician-scientist pipeline

The importance of evidence-based medicine together with concerns about the decreasing number of clinician-scientists emphasizes the need for promoting and encouraging research in medical education. Undergraduate medical education is the first step of each medical doctor's career and the only stepping stone in medicine that all medical doctors worldwide have in common. Hence, medical schools have a pivotal position in training scholarly doctors able to provide evidence-based medicine and conduct research. Consequently, undergraduate medical education is frequently recommended as part of the solution for the clinician-scientist shortage as it creates the opportunity for early cultivation, identification and recruitment of potential clinician-scientists.[8,12-15] In short, undergraduate research education is important in serving this dual purpose to (1) train all future medical doctors as scholars who practice evidence-based medicine and are able to conduct research, and (2) encourage a subset of future medical doctors to pursue a clinician-scientist career.

In order to train all medical doctors to reach the required level of a scholar and at the same time counteract the decline of the clinician-scientist workforce, medical curricula incorporate research courses. To this end, all medical students are theoretically educated in research e.g. research ethics, methodology and statistics, and, thus, are able to utilize research. In line with many others, I would like to argue that, as theory is different from practice, theoretical research courses might enable (future) medical doctors to utilize research, but are hardly sufficient to enable them to actually conduct research. This is captured in the famous quote attributed to Albert Einstein; "In theory, theory and practice are the same. In practice, they are not.". As example, knowing how to drive a car (theory) does not per definition equal being able to drive a car (practice). From an educational perspective, this is substituted by Healey and colleagues, who have developed a framework to illustrate the research-teaching nexus and explain four ways in which students can experience research in the curriculum.[16] This framework identifies students as audience or as active participants, while the emphasis can be on the research process or on the research content. Involving students as participants combined with an emphasis on the research content (i.e. research led learning: learning that occurs through engagement with research that goes beyond simply learning about research), is considered as a form of active learning.[17] Active learning, or 'learning by doing', is seen as the most optimal way to engage students in research training as it promotes deep rather than surface learning.[18] In this respect, research practising can help students to understand and utilize research, while at the same time they are trained as scholars being able to conduct research. In addition, it provides an opportunity to shed light on a possible research-oriented career. This highlights the potential of undergraduate practical hands-on research programmes in serving the dual purpose, as mentioned before, to (1) train all future medical doctors as scholars who practice evidence-based medicine and are able to conduct research, and (2) encourage a subset of future medical doctors to pursue a clinician-scientist career.

Although there is currently no consistent way in which medical students are engaged in research, globally, the perspectives medical students have on research in undergraduate medical education share many common themes. Most medical students acknowledge the necessity and importance of research training as part of their medical education and for their future career as reflected by many students reporting positive attitudes and interest in research endeavours.[8,13,19-21] In addition, there is a high-level of agreement in the literature on students' perceptions of research that, despite the importance of research, it is poorly represented in their medical curricula. An explanation for this perceived underrepresentation of research in medical curricula could be that research activities are time-consuming, require good organization and resourcing, and depend upon adequate supervision support. Additionally, curricula are often overloaded with basic and clinical subjects with little room for research instruction and learning.[22] As a consequence, research training is often placed beyond the core curriculum as an elective or extracurricular activity, and predominantly accessible to highly motivated students or students looking for an extra challenge.

Next to crowded curricula, other student and faculty related barriers for student participation in research are reported, e.g. lack of interest, self-efficacy, (protected) time, lack of or unaware of opportunities, research infrastructure, funding, or supervision.[20,21,23-26] As a result of these barriers, the number of students indicating research interest is larger than the number of students who are actually involved in research.[24] A scoping review by Murray and colleagues on research training during medical school described approximately half of undergraduate research training programmes being mandatory.[15] Barriers to participate in research combined with esearch, combined with research training not being a mandatory part of the formal curriculum, result in a subset of students graduating as doctor without any research experience, with reported rates between 30% to 70%.[21,24,27]

The question whether undergraduate medical research programmes should be made a mandatory part of undergraduate medical education has been discussed in the literature, and is a matter of debate.[15,24] Elective or extracurricular research programmes (e.g. summer courses or scholarly concentration programmes) attract students with prior research interest, talent, motivation and/or ambition, while mandatory research training reaches all medical students. Arguments against mandatory research incorporation revolve around the importance of focusing on clinical skills education, while arguments in favour of it revolve around the ever-increasing importance of evidence-based medicine needed to be practiced by all medical doctors.[24] In addition to this favour and mentioned earlier, learning by doing is considered the most optimal way to engage students in research activities. Indeed, successful research engagement (e.g. resulting in a publication) during medical school is widely reported to predict postgraduate research involvement.[15,20,24,28] Accordingly, it is not surprising that research-intensive medical schools are more successful in enhancing research-related learning outcomes compared to medical schools that integrate research less in their curricula.[29] In this way, besides developing scholarly doctors that practice evidence-based medicine, research engagement during medical school can serve as a breeding ground for clinician-scientists and, hence, might reverse the trend in declining numbers of clinician-scientists. In conclusion, mandatory research programmes seem to be perfectly in line with the dual purpose to train every doctor as a scholar and cultivate the next generation of clinician-scientists.

Once medical students obtain the medical doctor degree (MD), diverse and flexible career pathways can be chosen. Following graduation, many medical doctors further develop their professional identity, including perceptions on what career fits their talents and ambitions. Although there is a wide variation in postgraduate medical systems worldwide,[30] the number of graduates entering a medical PhD programme, considered the common pathway in training clinician-scientists, globally increases.[31-38] It is unknown whether and, if so, to what extent the increased investment in research training during medical schools contributes to this, or whether other causes declare this increase. However, contrary to the tremendous increase in graduates entering the clinician-scientist pipeline as medical PhD candidate, the number of MD-PhDs actually working as clinician-scientists still declines.[1,3,39]

At first glance, this seems to be a contradiction. How can an increased 'supply' of (future) clinician-scientists and a decrease in the clinician-scientist workforce coexist? There might be two possible explanations for this contradiction. First, during the PhD programme, PhD candidates could drop-out. Indeed, with the increase in medical PhD candidates, concerns about prolonged completion times and programme attrition rise as well with an average of six years for completing a PhD in the medical field and attrition rates of 30-50%.[40,41] This might be because, for example, the doctoral experience is not aligned with the PhD candidate's expectations, values and ambitions (anymore). Another reason for programme attrition could be that, although the supply of (future) clinician-scientists apparently seems to be sufficient when it comes to quantity of medical doctors that enrol in a PhD programme, the 'quality' of this supply (i.e. medical PhD candidates) is not meeting the required qualities needed to fulfil a PhD trajectory. The second explanation for the contradiction is that, once the PhD is completed, MD-PhDs are 'leaking out' the clinician-scientist pipeline. This is in line with several studies showing that shortly after obtaining the PhD-degree scientific production appears to decline and MD-PhDs often become scientifically inactive.[32,40,42,43] It could be that career ambitions change during the PhD or, perhaps, that they never aspired a clinician-scientist career, but obtained a PhD as a mean to achieve other goals. In addition, barriers to stay engaged in research after a PhD could deter MD-PhDs from continuing their career in academic medicine. Previous research identified obstacles to continue research oriented careers after obtaining a PhD degree, such as rising clinical responsibilities (e.g. postgraduate training), work-life balance, lack of funding, and insufficient supervision.[44-46]

To summarize, a shortage of clinician-scientists has been attributed to a lack of supply (e.g. lack of interest in research careers) or too many obstacles to stay actively engaged in research (e.g. drop-out during or soon after PhD trajectory), at both the undergraduate and postgraduate level, also considered as leaks in the clinician-scientist pipeline. As motivation is widely reported to be related to persistence, academic success, future research involvement and other desirable outcomes, also within the context of medical education, perhaps this could also contribute to the leaky clinician-scientist pipeline. Therefore, the following section will discuss the possible role of motivation in the pathway of (future) clinician-scientists.

1.3 The role of motivation in the (leaky) pipeline

In general, motivation can be defined as a force that drives a person to engage in certain behaviour. The development of theories of motivation is a fairly recent phenomenon emerging in the 20th century. These theories tend to conceptualise motivation as a unitary entity, focusing on the amount of motivation a person has.[47] An example is the Expectancy-Value Theory (EVT), including its further developed models, which basically focuses on the quantity of motivation as a sequel of expectancies to be successful in the task and the incentive value of (fulfilment of) the task. If both – expectancies and values – are lined up well, it is expected that the quantity of motivation to initiate and accomplish a task is higher.[48]

Different from EVT and many other theories of motivation emphasizing quantity of motivation, Ryan and Deci proposed Self-Determination Theory (SDT), nowadays one of the leading theories in human motivation.[49] According to this theory, it is not only quantity of motivation that is important, but also, or perhaps even more, quality of motivation that determines behaviour. Basically, the theory drives the idea that motivation is an interplay between the extrinsic forces acting on persons and the intrinsic motive and needs of human beings. SDT divides motivation into six categories of regulatory styles that sit upon a continuum from amotivation to intrinsic motivation. Based on different cut-offs of these regulatory styles, different divisions in quality of motivation can be made. First, motivation, next to amotivation, can be divided in two types of motivation; intrinsic and extrinsic motivation. Intrinsic motivation (IM), consisting of intrinsic regulation only, is defined as showing behaviour or being involved in a specific activity out of genuine interest or pure enjoyment (e.g. enjoy doing research). In contrast, extrinsic motivation (EM) represents behaviour or involvement in a specific activity for obtaining a certain reward or avoiding a certain loss or punishment, gaining social approval or achieving a valued outcome. Extrinsic motivation can be further subdivided into four types of regulations, depending on the level of self-determination:

- External regulation (i.e. behaviour is directly controlled by external forces like rewards or punishment), for example participating in research because it is mandatory within the curriculum and without participation a (desired) medical degree is not rewarded.
- Introjected regulation (i.e. external controls are taken in, but not fully accepted, there is a focus on approval from self and others), for example participating in research because of the belief that programme directors value this activity.
- Identified regulation (i.e. identification with and conscious valuing of an activity), for example participating in research for improving skills.
- Integrated regulation (i.e. identifications are integrated with a person's other values and beliefs), for example participating in research because this is consistent with own values (e.g. curiosity, ambition, success).

As SDT has been further developed over years, a second widely used distinction in motivation has been made in the literature: autonomous and controlled motivation.[50] *Autonomous motivation* (AM) consists of intrinsic, integrated and identified regulation (the latter two being the most internalized forms of extrinsic motivation). Thus, autonomous motivation is not only fuelled by intrinsic motivation (i.e. genuine interest or enjoyment in the activity or goal), but also driven by the value given to an activity or goal. *Controlled motivation* (CM) includes the least internalized forms of extrinsic motivation and consists of introjected and external regulation.

Controlled motivation is purely driven by external forces and controls. In short, controlled motivation is controlled by external factors, while autonomous motivation originates from within the individual itself.

SDT posits that higher levels of self-determination leads to better quality of motivation. Thus, intrinsic motivation is of better quality compared to extrinsic motivation, and, in the same way, autonomous motivation is of better quality then controlled motivation. Different quantities of motivational qualities can coexist within an individual and can change over time. An overview of the motivation continuum according to SDT is displayed in *Figure 4*.

<table>
<tr><th rowspan="2">Amotivation</th><th colspan="2">Controlled Motivation</th><th colspan="3">Autonomous Motivation</th></tr>
<tr><th colspan="4">Extrinsic motivation</th><th>Intrinsic Motivation</th></tr>
<tr><th>Non-Regulation</th><th>External Regulation</th><th>Introjected Regulation</th><th>Identified Regulation</th><th>Integrated Regulation</th><th>Intrinsic Regulation</th></tr>
<tr><td>→ Lack of apathy
→ Lack of intention
→ Lack of value</td><td>→ External rewards (e.g. career opportunities
→ Avoiding external punishments</td><td>→ Internal rewards (e.g. pride, self-esteem)
→ Avoiding internal punishments (e.g. guilt, disapproval)
→ Focus on approval from self and others</td><td>→ Personal importance
→ Conscious valuing of activity
→ Self-endorsement of goals</td><td>→ Congruence
→ Values fully assimilated into self
→ Synthesis and consistency of identification</td><td>→ Pure interest
→ Enjoyment
→ Curiosity
→ Inherent satisfaction</td></tr>
</table>

Low quality → *High quality*

Figure 4. *The motivation continuum according to Self-Determination Theory*

According to SDT, three basic psychological needs must be satisfied in order to enhance intrinsic motivation, the highest quality of motivation. First, the need for autonomy, which is defined as the need to self-regulate your actions and feel in control of your own behaviour and goals. Feelings of autonomy are enhanced when students are given choice and are able to govern their own behaviour, rather than feeling controlled or threatened, or have to operate according to deadlines. Second, the need for competence, which is the need to feel capable in effectively dealing with your important life context and trust in having the skills needed for success to ensure that desired goals are achieved.

This can be satisfied when the demands of a task are optimally matched to a student's skills, or positive feedback is received. If tasks are too challenging or a student receives negative feedback, feelings of competence decrease. Third, the need for relatedness, which includes the need to feel a sense of belonging and socially connected to significant others. Feelings of relatedness are fostered when students feel respected and cared for by others, e.g. teacher or peers, and are part of an inclusive environment. Alternatively, these feelings can be undermined by competition, closed groups, and criticism from others. Personal well-being is a direct function of the satisfaction of these three basic psychological needs.[50,51]

Regardless of the education level, motivation has become a central concept in the understanding of academic persistence and achievement. Following the SDT, both quantity and quality of motivation could be particularly important in stimulating (future) medical doctors to pursue a clinician-scientist career. Although many students express interest towards research, the quality of motivation behind this interest varies. For example, some medical students or doctors view research as mean for personal development (according to SDT considered as high quality motivation), whilst others are interested in research to improve chances for a competitive residency spot (according to SDT considered as low quality motivation).[20,21,24,52–54] Previous studies showed the importance of high quality motivation in well-being, academic success, persistence, and many other favourable outcomes.[37,51,55,56] More specific, on the medical undergraduate level, it is known that intrinsic motivation for research fosters extracurricular research participation in bachelor students.[57] In turn, it is shown that undergraduate research participation results in research engagement after graduation.[24,26] However, there is a knowledge gap regarding the effect of mandatory research, in which all medical students are involved, on the quality and quantity of motivation for research and postgraduate ambitions and involvement. This is important as motivation for participating in a PhD are already formed during medical school.[53]

On the postgraduate level, motivation has often not been conceptualized as a multidimensional construct, neglecting the well-known importance of quality of motivation. In addition, previous studies on motivation for research amongst PhD candidates focusses on PhD candidates in other domains. A PhD in the medical field is more common than in any other domain.[41] Medical PhD candidates are medical doctors early in their clinical career, who commonly combine clinical tasks with their PhD trajectory, are mainly supervised by PhD-holding clinicians, and often (partly) return to clinical care after their PhD trajectory.[58] Thus, the medical doctoral context is different from many other domains and, therefore, different motivations might play a role. Despite many stating that medical PhD candidates are mainly driven by external regulations

as CV building, no previous study have touched upon this in the medical domain. To gain better insight in attraction, training and retention of clinician-scientists, this thesis partly focuses on quantity and quality of motivation for research during undergraduate mandatory research and postgraduate PhD programmes.

1.4 Research context

All Dutch medical schools developed and implemented their educational programme in line with the Dutch National Blueprint for Medical Education, based on the CanMEDS competency framework.[59] Hence, undergraduate medical education curricula are more or less comparable regarding learning goals and structure of their educational programme, with six years of undergraduate education, divided in a three-year bachelor's programme, and a subsequent three-year master's programme. This is based on the three-cycle system within European higher education consisting of three levels; undergraduate (i.e. bachelor's programme), graduate (i.e. master's programme) and doctoral (i.e. PhD programme) studies. In the Netherlands, there are two major research training programmes within undergraduate and postgraduate medical education. The first one regards a research training during the master's phase in medical school. The second major training programme is a medical PhD programme, which is (mostly) postgraduate and on a voluntary basis.

As in the Netherlands the educational programmes are aligned with the Dutch National Blueprint for Medical Education, similarities between institutes exist. For instance, within the bachelor's phase research theory and practice are introduced to develop research knowledge, skills, and attitude. Students are theoretically educated in research ethics, methodology and statistics. Although similarities in learning goals and procedures exist, medical schools are free to design their own curriculum. Studies in this thesis focussing on the undergraduate phase of the clinician-scientist pipeline are conducted among medical students at Leiden University Medical Center (LUMC), one of the eight medical schools in the Netherlands. In LUMC, students make their first steps in research practice during a first-year course, where students are provided with the opportunity to individually conduct research, and a critically appraised topic (CAT) project in the third year of the bachelor phase challenging students on utilization and critically appreciation of existing literature.

The master's phase includes an authentic fulltime mandatory research project of at least four months, next to clinical clerkships, and is the main context of the studies conducted on undergraduate research training. Different from many other countries, this research project is mandatory and, consequently, reaches all future medical doctors.

Students have much autonomy as they arrange their internship at a health institute and department of preference, choose a research domain, are able to extent their research with five or ten weeks and are free to choose the timing to conduct their research before or after clerkships. The programme starts with a two week course on research theory and practice in terms of designing, conducting, analysing, interpreting and reporting research. During the research project, students fulfil the role of primary investigator and are guided by one or few research supervisors, mostly (clinician-)scientists or PhD candidates. This research programme has a dual purpose and aims to (1) train all future medical doctors as scholars, who practice evidence-based medicine and are able to conduct research, and (2) cultivate the next generation of clinician-scientists.

After graduation, it is common in the Netherlands to gain working experience before applying for a specialty training position, mostly in a clinical setting as doctor not in training. Once the choice has been made to pursue a PhD degree, there are three pathways towards a PhD. First and foremost, medical doctors apply for a position as PhD candidate after graduation and before applying for a specialty training position. This can be before as well as after gaining clinical working experience as a doctor not in training. Second, a smaller part applies already during medical school and combines a PhD programme with the undergraduate medical education programme, also known as MD-PhD programmes. Lastly, a minority starts a PhD programme as residents already in training or as medical specialists. To summarize, a PhD trajectory can be initiated from any job position in the medical career pathway, simultaneously with other educational programmes or clinical activities, or as a fulltime paid job. Next to a medical school, all Dutch academic hospitals incorporate a graduate school as well. Medical PhD candidates have to be admitted to a graduate school until completion of their dissertation. Studies in this thesis focussing on the postgraduate academic pipeline are conducted nationwide and included all eight Graduate Schools.

The research in this thesis was conducted within the pragmatic research paradigm, meaning that different approaches of philosophy and reality were implemented using the research question as main guiding principle. Depending on what method fitted the research question best, constructivist or post-positivist stances were adopted, leading to quantitative and qualitative research designs. Within this thesis, Self-Determination Theory is used as theoretical lenses to conceptualise motivation. SDT was adopted as theory to investigate both quantity and quality of motivation during the task (i.e. conducting research), as medical student or PhD candidate. EVT was used to focus on the expectancies and values prior to a PhD, assuming that this leaded to a certain amount of motivation needed to actually initiate a PhD.

1.5 Outline of this thesis

In this thesis we explore outcomes and challenges of undergraduate (*part I*) and postgraduate (*part II*) research training, and the role of motivation in the supply, leaks and perspectives of the clinician-scientist pipeline, aiming to optimize the pipeline, and, eventually, contribute to a sustainable clinician-scientist workforce. Insight in the role of motivation for research during such research training programmes, and vice versa, the impact of research training programmes on motivation, can lead to practical implications to attract, train and retain the right person, at the right time and position within the clinician-scientist pipeline. To fulfil this aim, we conducted different studies which are described below and will be discussed in detail in the upcoming chapters.

Previous studies have shown that it is important to catch clinician-scientists young.[15,20,24,28] More specifically, motivation for research could and should be cultivated as early as possible; during medical school. Hence, when focusing on the clinician-scientist pipeline, undergraduate research training should be considered as the first step of a clinician-scientist career and possible stepping stone towards postgraduation research activities. Therefore, in **chapter 2**, we examine the scientific yield of undergraduate mandatory research training, including postgraduate research engagement. We use outcomes such as publication as a proxy for success, a well-known predictor for postgraduate research engagement. In understanding how best to foster high quality motivation for research, an essential step in the process of choosing a research-oriented career we study motivation for research during mandatory research training in **chapter 3**. We aim to unravel the effect of this undergraduate mandatory research on students' motivation for research, including students' research perspectives, psycho-cognitive needs (i.e. research self-efficacy, autonomy, relatedness) and research ambitions. Next, research skills, knowledge and attitudes as an essential part of a medical doctor are assessed to demonstrate scholarly competency. This can be done in several ways such as formative assessment (e.g. portfolios) or summative assessment (e.g. research reports). As students tend to focus on what is assessed, some scholarly learning goals are at risk to be considered as optional extra to the curriculum when not assessed. Therefore, in **chapter 4**, we will explore challenges in developing and assessing scholarly competencies, for example during mandatory research training. The role of scholar not only entails research competencies, but teaching competencies as well. Teaching is frequently judged inferior to research by academic leaders, resulting in a decline in medical teachers.[60] **Chapter 5** provides twelve tips to foster the next generation of medical teachers.

After graduation, medical doctors can enrol in a PhD programme on a voluntary basis. These programmes, also considered as the third cycle after a bachelor's and master's degree, globally aim to train clinician-scientists.[61] **Chapter 6** describes differences and similarities of medical PhD programmes in the top ten leading countries in life sciences research around the world. In **chapter 7**, we survey the quantity and quality of motivation for research, research self-efficacy, work engagement, drop-out intentions and ambitions for research among Dutch medical PhD candidates. In **chapter 8**, we investigate what factors affect motivation for research during a PhD trajectory.

An overview of all chapters including the specific research questions with corresponding research method and analyses is given in *Table 1*. A brief overview and in-depth discussion of the main research findings, practical implications for educational practice and directions for future research is discussed in **chapter 9**.

Table 1. *Studied research aim/questions with corresponding research methods and analyses*

	Chapter	Research aim or question(s)	Design	Research method	Analyses
Part I	**2**	**1.** What is the scientific output (i.e. publication rate, impact of publication, author position) of undergraduate mandatory esearch projects? **2.** Which student and project related factors are associated with this scientific output? **3.** Is this scientific output associated with postgraduate research activity?	Single centre retrospective cohort study (quantitative)	Bibliometric search strategies combined with cross-sectional alumni surveys	Descriptive statistics, T-tests, multivariate logistic and multivariate linear regression analyses
	3	**1.** How does motivation for research, its determinants (i.e. research perceptions, research self-efficacy, autonomy, relatedness) and research career ambitions develop during undergraduate mandatory research? **2.** What is the effect of development of motivational deteraminants on development of motivation for research during mandatory research? **3.** What is the effect of (development of) motivation for research on (development of) research career ambitions during mandatory research?	Single centre prospective study (quantitative	Student surveysa	Descriptive statistics, T-tests, multivariate logistic and multivariate linear regression analyses
	4	Challenges in developing and assessing scholarly competenciesa	Monograph	Perspective based on literature and own experiences	n.a.
	5	Twelve tips for fostering the next generation of medical teachers	Twelve tips article	Practical tips based on theory, previous research, and own experiences	n.a.
Part II	**6**	What are differences of and similarities in medical PhD programmes around the world?	Survey study (qualitative)	Stakeholder surveys combined with literature review	Content analyses
	7	**1.** What is the effect of expectancies and values for success on motivation for research in medical PhD candidates? **2.** What is the effect of motivation for research on (perceived) doctoral outcomes (i.e. work engagement, delay, expected delay, drop-out intentions, research career ambitions) in medical PhD candidates? **3.** Does motivation differ in PhD candidates who are in different positions in their career, in different doctoral phases, and in less versus highly competitive specialties? **4.** What motivational profiles can be identified among medical PhD candidates and how do these profiles relate to motivational determinants and (perceived) doctoral outcomes?	National multicentre survey study (quantitative)	PhD candidate surveys	Descriptive statistics, T-tests, multivariate logistic regression analyses
	8	What factors affect motivation for research during a medical PhD programme?	National multicentre interview study (qualitative)	Interviews with timeline mapping	Thematic analysis

References

1. Yeravdekar, R.C. and A. Singh, Physician-Scientists: Fixing the Leaking Pipeline - A Scoping Review. Medical Science Educator, 2022. 32(6): p. 1413-1424.
2. Linnenbrink-Garcia, L., et al., Repairing the leaky pipeline: A motivationally supportive intervention to enhance persistence in undergraduate science pathways. Contemporary Educational Psychology, 2018. 53: p. 181-195.
3. Lin, A.Y., Fixing the Leaky Pipeline: Redefining Physician-Scientist Efforts to Fit the Needs of the New Normal. Acad Med, 2021. 96(12): p. 1628-1629.
4. Frank, J.R. Snell, L. Sherbino J. editors. CanMEDS 2015 Physician Competency Framework. Ottawa: Royal College of Physicians and Surgeons of Canada; 2015.
5. Sackett, D.L., et al., Evidence based medicine: what it is and what it isn't. BMJ, 1996. 312(7023): p. 71-72.
6. Martini, C., What "Evidence" in Evidence-Based Medicine? Topoi, 2021. 40(2): p. 299-305.
7. Sackett, D.L., Evidence-based medicine. Seminars in Perinatology, 1997. 21(1): p. 3-5.
8. Stone, C., et al., Contemporary global perspectives of medical students on research during undergraduate medical education: a systematic literature review. Med Educ Online, 2018. 23(1): p. 1537430.
9. Strauss, S.E., Evidence-based medicine: how to practice and teach EBM. 2005, Edinburgh, New York: Elsevier/Churchill Livingstone.
10. Fudge, N., et al., Optimising Translational Research Opportunities: A Systematic Review and Narrative Synthesis of Basic and Clinician Scientists' Perspectives of Factors Which Enable or Hinder Translational Research. PLoS One, 2016. 11(8): p. e0160475.
11. Wyngaarden, J.B., The clinical investigator as an endangered species. Bull N Y Acad Med, 1981. 57(6): p. 415-26.
12. Ommering, B.W.C., et al., Future physician-scientists: could we catch them young? Factors influencing intrinsic and extrinsic motivation for research among first-year medical students. Perspectives on Medical Education, 2018. 7(4): p. 248-255.
13. Chang, Y. and C.J. Ramnanan, A Review of Literature on Medical Students and Scholarly Research: Experiences, Attitudes, and Outcomes. Academic Medicine, 2015. 90(8): p. 1162-1173.
14. Weaver, A.N., et al., Impact of elective versus required medical school research experiences on career outcomes. J Investig Med, 2017. 65(5): p. 942-948.
15. Murray, H., J. Payandeh, and M. Walker, Scoping Review: Research Training During Medical School. Med Sci Educ, 2022. 32(6): p. 1553-1561.
16. Healey, M. Linking research and teaching: exploring disciplinary spaces and the role of inquiry-based learning. 2005.
17. Healey, M., et al., The research-teaching nexus: a case study of students' awareness, experiences and perceptions of research. Innovations in Education and Teaching International, 2010. 47(2): p. 235-246.
18. Gogus, A., Active Learning, in Encyclopedia of the Sciences of Learning, N.M. Seel, Editor. 2012, Springer US: Boston, MA. p. 77-80.
19. Ommering, B.W.C., et al., Promoting positive perceptions of and motivation for research among undergraduate medical students to stimulate future research involvement: a grounded theory study. BMC Med Educ, 2020. 20(1): p. 204.
20. Griffin, M.F. and S. Hindocha, Publication practices of medical students at British medical schools: experience, attitudes and barriers to publish. Med Teach, 2011. 33(1): p. e1-8.
21. Siemens, D.R., et al., A survey on the attitudes towards research in medical school. BMC Med Educ, 2010. 10.
22. The crowded medical curriculum. JAMA, 2009. 302(12): p. 1373-1373.
23. Cuschieri, S., Are Medical Students Interested in Conducting Research? A Case Study on the Recruitment Outcome of an Elective Research Summer Opportunity. Med Sci Educ, 2022. 32(6): p. 1279-1283.
24. Amgad, M., et al., Medical Student Research: An Integrated Mixed-Methods Systematic Review and Meta-Analysis. PLoS One, 2015. 10(6): p. e0127470.
25. El Achi, D., et al., Perception, attitude, practice and barriers towards medical research among undergraduate students. BMC Medical Education, 2020. 20(1): p. 195.
26. Burgoyne, L.N., S. O'Flynn, and G.B. Boylan, Undergraduate medical research: the student perspective. Med Educ Online, 2010. 10.
27. Young, B.K., et al., Promoting medical student research productivity: the student perspective. R I Med J (2013), 2014. 97(6): p. 50-2.
28. Waaijer, C.J.F., et al., Scientific activity by medical students: the relationship between academic publishing during medical school and publication careers after graduation. Perspectives on Medical Education, 2019.
29. Vereijken, M.W.C., et al., Student learning outcomes, perceptions and beliefs in the context of strengthening research integration into the first year of medical school. Adv Health Sci Educ Theory Pract, 2018. 23(2): p. 371-385.
30. Weggemans, M.M., et al., The postgraduate medical education pathway: an international comparison. GMS J Med Educ, 2017. 34(5): p. Doc63.
31. Reinink, M. PhD Explosie. Retrieved August 28, 2022, from www.artsenauto.nl/phd-explosie/. 2019.
32. Traill, C.L., et al., Time to research Australian physician-researchers. Internal Medicine Journal, 2016. 46(5): p. 550-558.
33. Eley, D.S., The clinician-scientist track: an approach addressing Australia's need for a pathway to train its future clinical academic workforce. BMC medical education, 2018. 18(1): p. 227-227.
34. Andreassen, P. and M.K. Christensen, Science in the clinic: a qualitative study of the positioning of MD-PhDs in the everyday clinical setting. BMC Med Educ, 2018. 18(1): p. 115.
35. Andreassen, P., L. Wogensen, and M.K. Christensen, The employers' perspective on how PhD training affects physicians' performance in the clinic. Dan Med J, 2017. 64(2).
36. Castelló, M., et al., Why do students consider dropping out of doctoral degrees? Institutional and personal factors. Higher Education, 2017. 74(6): p. 1053-1068.
37. Litalien, D. and F. Guay, Dropout intentions in PhD Studies : a comprehensive model based on interpersonal relationships and motivational resources. Contemporary Educational Psychology, 2015. 41: p. 218-231.
38. Shin, M., A. Goodboy, and S. Bolkan, Profiles of doctoral students' self-determination: susceptibilities to burnout and dissent. Communication Education, 2021.
39. Milewicz, D.M., et al., Rescuing the physician-scientist workforce: the time for action is now. The Journal of Clinical Investigation, 2015. 125(10): p. 3742-3747.
40. Wolters, F., Academische carrièreperspectieven van gepromoveerde dokters: Een landelijk cohortonderzoek in de periode 1992-2018. Nederlands Tijdschrift voor Geneeskunde, 2020. 164.
41. Anttila, H., et al., The Added Value of a PhD in Medicine - PhD Students' Perceptions of Acquired Competences. The International Journal of Higher Education, 2015. 4:p. 172-180.
42. Wildgaard, L. and K. Wildgaard, Continued publications by health science PhDs, 5 years post PhD-Defence. Research Evaluation, 2018. 27(4): p. 347-357.
43. Fosbol, E.L., et al., Low immediate scientific yield of the PhD among medical doctors. BMC Med Educ, 2016. 16: p. 189.
44. Mills, J.M.Z., et al., Attractions and barriers to Australian physician-researcher careers. Intern Med J, 2019. 49(2): p. 171-181.
45. Ortega, G., et al. Preparing for an Academic Career: The Significance of Mentoring. MedEdPORTAL : the journal of teaching and learning resources, 2018. 14, 10690.
46. Chakraverty, D., D.B. Jeffe, and R.H. Tai, Transition Experiences in MD-PhD Programmes. CBE Life Sciences Education, 2018. 17.
47. Cook, D.A. and A.R. Artino Jr, Motivation to learn: an overview of contemporary theories. Medical Education, 2016. 50(10): p. 997-1014.
48. Wigfield, A. and J.S. Eccles, Expectancy-Value Theory of Achievement Motivation. Contemp Educ Psychol, 2000. 25(1): p. 68-81.
49. Ryan, R.M. and E.L. Deci, An overview of self-determination theory, in Handbook of self-determination research, E.L. Deci and R.M. Ryan, Editors. 2002, University of Rochester Press: Rochester, NY.

50. Ryan, R.M. and E.L. Deci, Self-determination theory: Basic psychological needs in motivation, development, and wellness. Self-determination theory: Basic psychological needs in motivation, development, and wellness. 2017, New York, NY, US: The Guilford Press. xii, 756-xii, 756.
51. Ryan, R.M. and E.L. Deci, Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. Am Psychol, 2000. 55.
52. Ommering, B.W.C. and F.W. Dekker, Medical students' intrinsic versus extrinsic motivation to engage in research as preparation for residency. Perspect Med Educ, 2017. 6(6): p. 366-368.
53. Ghedri, A., Bontje, W., Abdelmoumen, A. Promoveren of profileren? De Geneeskundestudent, 2018.
54. Pathipati A S, T.N., Research in Medical School: A Survey Evaluating Why Medical Students Take Research Years. Cureus 8(8): e741. DOI 10.7759/cureus.741.
55. Litalien, D., F. Guay, and A.J.S. Morin, Motivation for PhD studies: Scale development and validation. Learning and Individual Differences, 2015. 41: p. 1-13.
56. Kusurkar, R.A., et al., Motivational profiles of medical students: association with study effort, academic performance and exhaustion. BMC Med Educ, 2013. 13: p. 87.
57. Ommering, B.W.C., et al., Fostering the physician-scientist workforce: a prospective cohort study to investigate the effect of undergraduate medical students' motivation for research on actual research involvement. BMJ Open, 2019. 9(7): p. e028034.
58. Kusurkar, R.A., et al., What stressors and energizers do PhD students in medicine identify for their work: A qualitative inquiry. Med Teach, 2022. 44(5): p. 559-563.
59. Raamplan Artsopleiding 2020. Retrieved January 31, 2023, from www.nfu.nl/sites/default/files/2020-08/20.1577_Raamplan_Artsenopleiding_-_maart_2020.pdf.
60. Allsop, S., et al., Every doctor an educator? Medical Teacher, 2023: p. 1-6.
61. Marz, R., et al., Tuning research competences for Bologna three cycles in medicine: report of a MEDINE2 European consensus survey. Perspectives on Medical Education, 2013. 2(4): p. 181-195.

Chapter 2

Assessing publication rates from medical students' mandatory research projects in the Netherlands: a follow-up study of 10 cohorts of medical students

Charlotte R. den Bakker
Belinda W.C. Ommering
Thed N. van Leeuwen
Friedo W. Dekker
Arnout Jan de Beaufort

BMJ Open, 2022

Abstract

Objectives The medical field is facing a clinician-scientist shortage. Medical schools could foster the clinician-scientist workforce by offering students research opportunities. Most medical schools offer elective research programmes. Subsequently, a subset of doctors graduates without any research experience. Mandatory research projects may be more sufficient to develop clinician-scientist, but take more supervision and curricular time. There is limited insight in the scientific outcomes of mandatory research experiences. This study aims to examine publication rates of a mandatory research experience, identify factors associated with publication, and includes postgraduate research engagement.

Design and setting Prospective follow-up study involving 10 cohorts of medical students' mandatory research projects from Leiden University Medical Center.

Participants All medical students who conducted their research project between 2008 and 2018 (n=2329) were included.

Main outcome measure Publication rates were defined as peer-reviewed scientific publications, including research papers, reviews, and published meeting abstracts. Postgraduate research engagement was defined as research participation and dissemination of research at scientific conferences or in journals.

Results In total, 644 (27.7%) of all mandatory research experiences resulted in publication, with students mainly as first (n=984, 42.5%) or second author (n=587, 25.3%) and above-world-average citation impact (mean normalised journal score 1.29, mean normalised citation score 1.23). Students who conducted their research in an academic centre (adjusted OR 2.82; 95% CI 2.10 to 3.77), extended their research (adjusted OR 1.73; 95% CI 1.35 to 2.20), were involved in an excellency track (adjusted OR 2.08; 95% CI 1.44 to 3.01), or conducted clinical (adjusted OR 2.08; 95% CI 1.15 to 3.74) or laboratory (adjusted OR 2.16; 95% CI 1.16 to 4.01) research published their research more often. Later as junior doctors, this group significantly more often disseminate their research results at scientific conferences (adjusted OR 1.89; 95% CI 1.11 to 3.23) or in journals (adjusted OR 1.98; 95% CI 1.14 to 3.43).

Conclusions Our findings suggest that a significant subset of hands-on mandatory research projects with flexible learning pathways result in tangible research output with proper impact and that such successful experiences can be considered as diving board towards a research-oriented career.

Introduction

All doctors should be able to critically appraise and use research in clinical practice to keep up to date and apply evidence-based medicine within their field of expertise.[1,2] Additionally, society needs doctors to conduct research and contribute to new developments and knowledge.[3] Clinician-scientists, that is, doctors with research expertise and engagement, do not only conduct research, but also play significant roles in directly translating clinical observations to the bench and in moving research findings into everyday practice. Thereby they contribute importantly to the development of tomorrow's healthcare as newly invented medical solutions and developments will reach patients sooner.[4,5] The adoption of this scholarly competency in frameworks as the US Accreditation Council for Graduate Medical Education and the Canadian Medical Education Directives for Specialists reflects the importance of doctors who conduct research.[6,7] Despite this recognition, the number of clinician-scientists globally declined over the past few decades resulting in a shortage.[8–12]

A solution to overcome the clinician-scientist shortage is to engage medical students in research endeavours during medical school. Efforts concentrated on the research engagement of medical students and consisted of extracurricular or intracurricular research activities, the latter either mandatory or elective research programmes.[9,13–17] To date, most medical schools only offer elective or extracurricular research programmes, such as summer schools and scholarly concentration programmes, mostly aimed at excellent or highly motivated students.[9,18–20]

Several studies demonstrated that these undergraduate research experiences (voluntary as well as mandatory) enhance research skills such as searching and critically appraising evolving medical literature, designing research, data analysis, academic writing and presenting.[9,16,17,19,21–23] Furthermore, they foster research self-efficacy, positive research perceptions, motivation for research,[24–27] and, on the long term, the ambition to pursue an academic career.[9,11,14,17,19,28–30] Even more, some research experiences result in peer-reviewed publications, often assumed as an objective measure and a proxy for the ultimate learning experience of research programmes, and suggested to be one of the factors related to persistence within academic medicine. Considering these positive effects, one may argue that every medical student should engage in hands-on research. However, as current research experiences are mostly voluntarily, about 30%-70% medical students graduate without any hands-on research experience.[17,20,34] Some of these students initially may lacked interest and motivation, while others did not participate in research due to time pressure, a lack of supervision, and/or opportunities.[35–37]

It may well be that elective programmes involve above average motivated and committed students.[37] As such, previously described beneficial outcomes of elective research experience may differ from mandatory research experiences. Furthermore, given the limited curricular time, the benefits of mandatory research projects must outweigh the efforts of compressing an already tight learning schedule. In addition, proper supervision of mandatory research projects may demand substantial efforts from scientists and faculty, which might be justified if these research projects result in at least some publications. To the best of our knowledge, however, a large cohort analysis of medical students' mandatory research output has not yet been conducted. This may prove useful to medical schools with established mandatory research programmes or others considering the introduction of a mandatory research experience. It can provide insight into the effects of mandatory research and help to influence policy around the introduction of mandatory research experiences and the enhancement of research-oriented careers among medical students. Therefore, this 10-year cohort study aims to investigate the scientific output based on number of publications resulting from mandatory research projects and identify key factors associated with these publications. In addition, we explore scientific engagement after medical school including the residency period and early clinical careers.

Methods

Setting

In the Netherlands, all eight medical schools' educational programmes are based on the Dutch National Blueprint for Medical Education. The programme consists of a 3-year bachelor's programme and a 3-year master's programme. Individual mandatory research projects are longstanding part of each Master of Medicine and were already incorporated in all Dutch medical curricula even before 1970. Students have 4 to 6 months for a full-time, authentic, and hands-on research experience. They go through the phases of the empirical cycle by conducting their own research and develop research skills such as searching and critically appraising literature, designing research, analysing and interpreting data, academic writing and presenting. During this project students have much autonomy, for example in arranging their internship at a health institute and department of preference, and in choosing a research domain (e.g. laboratory research, clinical research, public health research). In addition, students are free to choose the timing to conduct their research (i.e. before or after clerkships) and to extend their research project with 5 or 10 weeks. During the research project, students fulfil the role of the primary investigator and receive input from one or few supervisors. Supervision is carried out by faculty staff members, that is, (clinician-)scientists or PhD candidates. As final products, students write a research report and orally present their findings at the department.

Materials and definitions

Publication rates and factors associated with publication This follow-up study included all medical students from Leiden University Medical Centre, who started their mandatory research internship between 1 January 2008 and 1 January 2018. The latter cut-off was to allow for lag time between project completion and peer-reviewed publication. We extracted names and initials of all students together with the name of the supervisor(s) from course registration systems, together with other student factors (e.g. participation in an excellency track) and project factors (e.g. planned duration of the research project). Scientific output is operationalised as peer-reviewed publication rates of research projects. We included the following publications: research articles, meeting abstracts, and reviews, as these are described as most common measures for research success.[9] Letters to the editor, editorial materials, corrections and news items were excluded. Within the publications, we looked at author position of the student, year of publication, and impact. For the latter, we used the mean normalised citation score (MNCS) as impact ratio of research articles, compared with the world citations average in the subfields in which the research unit is active, as well as the mean normalised journal score (MNJS) as impact ratio of the journal in which a research unit has published (the research unit's journal selection), compared with the world citations average in the subfields covered by these journals.[38,39]

Postgraduate research engagement For postgraduate scientific engagement, we developed a questionnaire (*Appendix A*) regarding research activity after graduation (other than accomplishing publication(s) of the research project). We defined conducting research as postgraduate participation in research, whether or not in the form of a PhD programme, next to disseminating research results, that is, publishing articles in journals or provide oral presentations at scientific conferences. This questionnaire was part of an institutional questionnaire about different postgraduate career pathways. Those who graduated before May 2019 were sent a questionnaire for postgraduate (i.e. after medical school) follow-up.

Procedure

Publication rates and factors associated with publication To identify mandatory research projects that resulted in a peer-reviewed publication, we searched full names of the students and supervisor(s) together with filters based on department and year of research project using validated bibliometric methods. Bibliometric methods enables to track scientific output of individuals strengthened by mapping individual hits to larger sets of publications (i.e. author clustering), with more robust bibliometric scores of citation impact as a result. Author clustering algorithms are more accurate when more information is available, as publications can be clustered even when the initials do not match exactly.[40,41] Consequently, students are more susceptible for false positive results due to a minimal oeuvre compared with their prolific supervisor(s). Therefore, as a first step, between December 2019 and January 2020, we searched names of all supervisor(s) in the in-house database in of one of the most comprehensive and widely used publisher-independent global citation database, Web of Science (WoS), at the Centre for Science and Technology Studies using a validated algorithm. This bibliometric search resulted in a list of clustered oeuvres of the supervisors. Second, we searched publications that also included the students' name they supervised and considered these papers as publication that resulted from the research project. Common problems in such searches are false positive or negative assignments of papers, due to common Dutch names, forgotten initials or spelling errors.[42] This problem is applicable for the bibliometric search to identify the oeuvre of the supervisor, as well as searching students' names within this oeuvre. Therefore, we checked all included publications to distinct if the published paper matched the topic of the research project, department, and institute. Some false negatives are inevitable as a subset of students published in journals that are not indexed in the WoS-database (e.g. a Dutch-language journal or English-language journals not processed for WoS), or because of spelling errors, missing initials, changed names, or changed initials. Complementary to bibliometric analysis, we performed a sensitivity analysis by manual assignment on a random sample of 150 research projects. By searching key words based on research title, next to students' together with supervisors' names on Google Scholar, PubMed, LinkedIn, and ResearchGate, 12% (n=18) false negatives and no false positives were identified. We critically studied these publications to identify explanations for being false negative in order to improve our search and added the publications to our dataset.

Postgraduate research engagement After graduation, the Alumni Office registers medical graduates of whom 80% agreed to receive questionnaires. To identify long-term scientific engagement, we invited medical graduates from 2008 up until May 2019 by email with a link to the online questionnaire. Participants received information on the study and an informed consent form.

Analysis

Publication rates and factors associated with publication We used descriptive statistics to describe demographic variables. We grouped the population into a publisher and non-publisher group to analyse factors associated with publication. An unpaired t-test was used to compare group differences (e.g. age and gender) between the publishers and non-publishers. To identify what student and project factors are associated with publication, we used logistic regressions, both crude and adjusted for possible confounding variables. Additionally, regarding publications, impact score, author position and mean publication delay were analysed.

Postgraduate research engagement For sensitivity analysis to identify possible (non-) response bias, we performed unpaired t-tests to disclose any differences between features (e.g. age, publication) of responders and non-responders of the alumni questionnaire. To identify postgraduate outcomes associated with publication of the research project as student, we used multiple logistic and linear regressions. We adjusted for age, gender, and previous participation in an excellency track (i.e. Honours programme) as possible confounders.[43] We used a 95% confidence interval (CI) to determine statistical significance. We analysed our data using IBM SPSS Statistics V26.0.

Patient and public involvement

No patients involved.

Ethical approval

This study involves human participants and was approved by the Educational Institutional Review Board of Leiden University Medical Center (reference number OEC/ERRB/20191112/1). Participants gave informed consent to participate in the study before taking part.

Results

Publication rates and factors associated with publication Between 2008 and 2018, 2329 medical students had started their research internship. These students were 20 to 39 years (M=24.3, SD=2.0). Of all 2329 students, 1561 (67.0%) were female. In total, 644 students (27.7%) had one or more publication(s) as a result of their research project. Within the group that had published their research project, 57% has published one article, 15% has published two articles, 8% has published three articles, and 20% has published four or more articles related to their research project. Publishers and non-publishers did not differ in gender. However, they did differ in age with a mean difference of 0.46 years (95% CI 0.29 to 0.63). Further demographics are shown in *Table 1*.

Table 1. *Demographics of student and project factors of mandatory research projects (n=2329)*

Variable	Mean (SD) or number (%) of students
Student factors	
Age at start of project (years)	24.3 (SD 2.0)
Female	1561 (67.0%)
Participated in a bachelor's excellency track	125 (5.4%)
Project factors	
Timing before clerkship	1167 (40.9%)
Extended duration using elective weeks *5 weeks* *10 weeks*	 636 (27.3%) 523 (22.5%)
Research type *Clinical research* *Laboratory research* *Public health research* *Other*	 1547 (66.4%) 422 (18.1%) 259 (11.1%) 101 (4.3%)
Academic Medical Centre	1731 (75.5%)
Location abroad total, whereof *Low-income country* *Middle-income country* *High-income country*	216 (9.3%) 24 (11.1%) 25 (11.6%) 167 (77.3%)

Students who (1) were involved in an excellency track, (2) voluntarily extended their research project with 10 weeks, (3) conducted their research in an academic medical centre, or (4) conducted clinical or laboratory research published their research project more often (*Table 2*). After adjustment for potential confounding variables, effects of timing of the research project and doing research abroad lost significance. When looking at research abroad more closely, 24 projects were conducted in a low-income country, whereof one was published (4.2%) and 25 projects conducted in middle-income countries had no associated publications. Projects conducted abroad in high-income countries (n=136) resulted in 31 publications (18.6%).

Sensitivity analysis showed comparable results during the study period, publication rates excepted. The latter declined in the last 3 years (*Figure 1*). Of all 2182 publications, 1451 (66.5%) were research papers, followed by 609 (27.9%) meeting abstracts and 122 (5.6%) reviews. Of all students who published their research project, almost half of them (46.0%) had at least two types of publications (e.g. research paper and meeting abstract). When distinguishing research papers and reviews from meeting abstracts, over two-thirds (69.7%) of students with a meeting abstract had a research paper and/

or review as well. Students were first author of 984 publications (42.5%), followed by second author of 587 publications (25.3%), third author of 349 publications (15.1%), and fourth author of 398 publications (17.2%). Publications were cited with an average of 17.8 citations per publication. The MNJS in which students published was 1.29, with an MNCS of 1.23. The average lag time between the research project and first publication of this project was 2.4 years.

Table 2. *Student and project factors associated with published research projects*

Factors associated with publication	Crude OR	95% CI	Possible confounders adjusted for	Adjusted OR	95% CI
Participated in an excellency track *No* *Yes*	 1.00 2.31*	 1.60–3.32	Age, gender	 1.00 2.08*	 1.44–3.01
Timing of research project *Before clerkships* *After clerkships*	 1.00 .89	 .74–1.07	Age, gender, participation in an excellency track, type of institute, project duration, research type	 1.00 1.16	 .92–1.46
Project duration *Not extended* *Extended with 5 weeks* *Extended with 10 weeks*	 1.00 1.20 1.47*	 .96–1.49 1.17–1.84	Age, gender, participation in an excellency track, type of institute, project duration, research type, timing of the research project	 1.00 1.20 1.73*	 .95–1.51 1.35–2.20
Research type *Other* *Public health* *Clinical research* *Laboratory research*	 1.00 1.34 2.10* 2.24*	 .72–2.47 1.21–3.61 1.26–3.97	Age, gender, participation in an excellency track, project duration, type of institute, timing of research project	 1.00 1.35 2.08* 2.16*	 .69–2.61 1.15–3.74 1.16–4.01
Type of institute *Non-academic centre* *Academic centre*	 1.00 2.60*	 1.97–3.45	Participation in an excellency track, project duration, research type, timing of the research project	 1.00 2.82*	 2.10–3.77
Country *The Netherlands* *Abroad*	 1.00 .41*	 .27–.61	Age, gender, participation in an excellency track, type of institute, project duration, research type, timing of the research project	 1.00 .47	 .47–1.40

* *Indicating statistical significance p < 0.05*

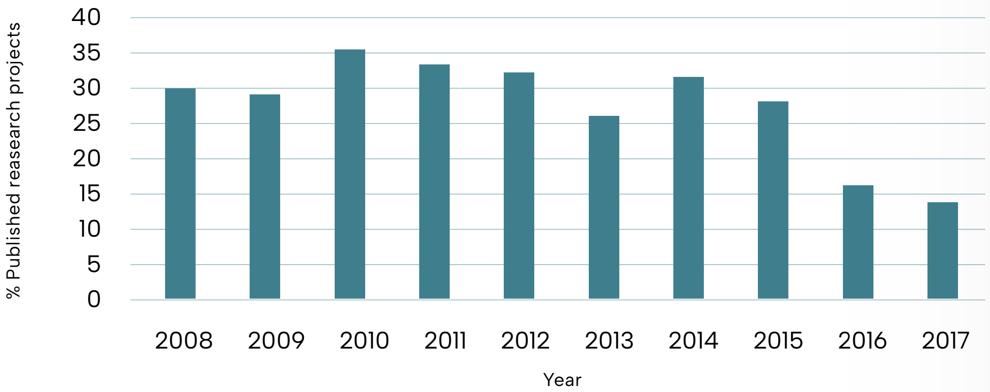

Figure 1. *Published research projects per year*

Postgraduate research engagement In total, 250 alumni (11% of all included students) participated in the survey. *Table 3* shows main findings. The mean time between graduation and participation was 5.1 years (SD 2.7, median 4.5 years). We found no significant differences between the responder and non-responder group in gender, Honours programme participation, timing of research project or year in which the research project was started. The groups significantly differed in publication rates, with more publications of the mandatory research project in the responder group (mean difference -0.18, 95% CI -0.25 to 0.12).

Students who had published their undergraduate research project were more likely to publish (adjusted OR 1.98, 95% CI 1.14 to 3.43) after medical school or to share their research at a scientific conference (adjusted OR 1.89, 95% CI 1.11 to 3.23). Logistic regression showed a crude association between publication of the student research project and later enrolment in a PhD programme as medical doctor (OR 1.95, 95% CI 1.16 to 3.29). After adjusting for participation in an excellency track as possible confounder, this effect became marginally smaller (OR 1.74, 95% CI 1.01 to 3.00), as shown in *Table 3.*

Table 3: *Postgraduate research engagement after publication of the undergraduate research project*

Association between publication and postgraduate research engagement	Crude OR	Crude 95% CI	Adjusted OR[a]	Adjusted 95% CI
Postgraduate research participation	1.26	.76-2.09	1.12	.66-1.90
Postgraduate research publication(s)	2.11*	1.25-3.54	1.98*	1.14-3.43
Participation in a PhD programme	1.84*	1.10-3.08	1.69	.98-2.90
Postgraduation research conference contribution	1.99*	1.19-3.34	1.89*	1.11-3.23

[a] *Adjusted for the following confounders: age, gender, participation in an excellency track*
** Indicating statistical significance p < 0.05*

Disscusion

The integration of scientific research projects into medical school programmes to develop scholarly doctors or even clinician-scientists is a widely discussed topic. Our study revealed that more than one out of four medical students publishes findings of their mandatory research project in a peer-reviewed paper, mainly as first or second author. These papers are apparently of good quality as they passed peer review procedures as well with impact scores above world citation average, even though these students can be considered as relatively young researchers. Students who were younger, participated in an excellency track, conducted their research in an academic medical centre, and voluntarily extended their project with 10 weeks by using elective weeks for the research project were more likely to publish their undergraduate research project. Timing or type of research did not impact publication rates.

Only few other studies have focused on the scientific output (publications) of mandatory research experiences. Three of these studies were conducted in private schools, with small amounts of graduates every year, which limits the generalisability, usability and applicability for education systems of public.[44-46] Two other studies conducted in public schools reported publication rates of 11% and 17%, however, these were outdated or included less than 230 research projects.[47,48] One other study conducted at a Dutch single institute included 551 research projects and describes a publication rate of 27%, in line with our results.[49] Studies on elective or extracurricular research experiences reported publication rates between 14% and 75%, with limited numbers of students included usually selected on excellence or prior research interest.[9,31,44,50] Although publication rates vary, at best 75%, this concerns a subset of an already pre-selected group representing the minority of all students. From this perspective, the scientific output based on number of publications of mandatory research experiences found in this study is relatively high and indicates actual scholarly development of medical students when research is imposed on them. It is important to note that comparisons of measured output reported in other studies should be done carefully, as variability in publication rates in the literature is likely attributable to differences in objective output, for example when including meeting abstracts or oral presentations (the number of confirmed published papers is, as expected, lower). Moreover, our study shows that student and project factors (e.g. duration) are associated with publication rates of mandatory research experiences and might vary between institutes.

Student and project factors associated with publication provide insight in how faculties can optimise research experiences to foster the future clinician-scientist workforce. In line with Möller and Shoshan, we have found no gender difference regarding publication rates.[51] Other studies are inconclusive and reasons behind a potential gender difference regarding publication rates remain unclear.[26,50,52,53] While timing of the research projects apparently does not affect publication rates, extended duration results in higher publication rates. Half of all students are motivated to spend their elective weeks on extension of their research project. More time for research evidently leads to more mature research products with increased publication rates, which is also described by Dyrbye et al.[44] Lastly, this study showed that projects conducted in an academic medical centre more often resulted in a publication. This might be attributed to the supervisor. Perhaps, projects conducted in an academic medical centre are more 'publishable' than others, as they are supervised by (clinician-)scientists working in an academic environment. This academic environment is highly research oriented as it includes research departments (i.e. department of statistics and department of epidemiology) and facilitates, for example, journal clubs and research courses. Another explanation could be that these supervisors are more experienced in publishing research, as most clinicians in academic hospitals are involved in academic activities next to clinical care. Indeed, Alamri et al found that students with academic supervisors publish more often than those with non-academic clinicians as supervisor.[50]

Previous research has not demonstrated that mandatory research in medical school leads to a more productive academic career.[9,22] This study provides a first insight in scientific engagement in the first years as medical doctor. It seems that graduates after publication of their research project tend to be more often involved in research and doctoral programmes, but this was not significant. However, when they did, they had significantly more scientific impact as they were two times as likely to disseminate their knowledge via peer-reviewed publications or presentations at scientific conferences. Perhaps, as (pre-)resident, these doctors are more scientifically literate and conduct high(er) quality research, which in turn might lead to more accepted published papers

and orals at conferences. Another explanation is the power of success experiences for self-efficacy levels.[26] Published student research projects might comfort students about publication issues and the dissemination of scientific knowledge and fosters future publications.[31] This is an interesting outcome, as dissemination of research findings is essential for translating scientific outcomes to clinical practice and enhance evidence-based patient care, considered as the most important aspect of clinician-scientists.

Furthermore, there is also the aforementioned selection effect for research opportunities to preferably hiring medical graduates who have published before.[54] As a result, we cannot firmly state that the association with postgraduate research engagement is regardless or if because they had a greater interest in research, and whether the publication of their scientific work had directly benefitted postgraduate research opportunities. At the same time, unknown makes unloved; one may argue that there is a subset of students who on beforehand do not have the ability to take on extracurricular activities next to the overcrowded formal curriculum, hold inaccurate perceptions, or, perhaps, even do not have initial interest in research at all.[35,36] This seems undesirable, as other studies showed that a significant subset of students (30%-70%) graduates without any research experiences, next to the clinician-scientist shortage.[17,20,34]

A mandatory research experience can provide them with an opportunity to explore how much fun it is, and an experience of success when they successfully fulfil their own research project, or even publish their first paper. As this is assumable, but cannot be drawn from our data, it would be worthwhile to explore if undergraduate mandatory research experiences positively affect research motivation, perceptions, and self-efficacy, and, thus, can foster future clinician-scientists who perhaps would have missed out on future research engagement when a first research experience would not have been imposed on them.

Our study has several limitations. First, although bibliometric methods are widely accepted and used for large-scale analysis of scientific output, false positive and negative results might occur. Sensitivity analysis resulted in 12% suspected false negatives and 0% false positives, suggesting that the observed 27.7% publication rate may underestimate the actual rate. Further adaption of our bibliometric search strategy risks the inclusion of false positives. Additionally, it is likely that conference proceedings were under-recognised in our study, as we included conference presentations as evidenced by publication of the associated abstract; however, many conferences do not publish abstracts. Therefore, we have to accept that our result is subjected to an underestimation of the number of actual publications. This is further strengthened by publication delay. Most publications appeared in the literature 2.4 years after research completion, a lag-period that is in line with findings from other studies and is especially applicable to research projects that have started at the final phase of our inclusion period.[47,50,55] This might explain the decrease observed in *Figure 1*, when looking at the last years of the analysis, as papers might still be in the process of getting published.

As a second limitation, we conducted this study at a single institution. However, van Eyk et al. showed very small differences between Dutch medical schools' scientific training regarding timing, duration and European Credits, as well as students' publication rates during medical school.[56] Therefore, we assume that our results are representative for other medical schools with similar mandatory research training.

A third limitation is that postgraduate responses were voluntary and despite the exact response rate is not known, 11% of all students were included for long-term follow-up. Although this is low, it does not substantially deviate from response rates of medical education surveys elsewhere in the literature. As a result, response bias might occur, as perhaps 'publishers' are more motivated to participate in our survey.

Conclusions

To our best knowledge, this is the first study investigating objectively verified publications rates as a result of undergraduate mandatory research experiences, together with associated factors and postgraduate outcomes in over 2000 medical students. Besides all students having experienced an authentic hands-on research project before becoming clinicians, a significant proportion of authentic undergraduate mandatory research experiences have great scientific value, judged by an overall publication rate of at least 27.7% of all medical students, with mainly first or second author positions and an above-world-average citation impact. This is particularly true when medical schools provide the opportunity to conduct research in an academic environment and facilitate flexible pathways regarding the duration and curricular position with respect to clerkships, for those who are willing to invest more. After experiencing such high levels of scholarly achievement during medical school, as young doctor, this group also more often disseminates their scientific findings with the field, enhancing the translation of research to clinical care, considered as one of the unique and distinctive aspects of clinician-scientists. As such, mandatory research experiences not only equip all future doctors with basic research knowledge and skills, but can also serve as breeding ground for potential clinician-scientists and can be perceived as worth it when countering the current decline in clinician-scientists.

Strengths and limitations of this study

- → This is the first prospective cohort study that bibliometrically reports scientific outcomes (publications) of a hands-on mandatory research experience including postgraduate research engagement in 10 cohorts with over 2000 medical students in total.
- → Insight in scientific outcomes (publications) of mandatory research programmes fills a gap in the literature since previous studies mainly focus on elective research outcomes with a subset of students graduating without any research experience.
- → Our study identified student and project factors associated with publication of a mandatory research project, thereby providing insight how to reach high academic levels among medical students.
- → Insight in postgraduate research engagement is limited due to loss to follow-up and non-response.
- → Publication rate is subjected to an underestimation of actual published papers due to publication delay and false negative cases.

References

1. de Beaufort AJ, de Goeij AFPM, AFPM de G. Academic and scientific education in medical curricula in the Netherlands: a programme director's view. Perspect Med Educ 2013;2:225-9.
2. Frank J, Snell L, Sherbino J. CanMEDS 2015 physician competency framework, 2015.
3. Laidlaw A, Aiton J, Struthers J, et al. Developing research skills in medical students: AMEE guide No. 69. Med Teach 2012;34:754-71.
4. Stewart PM. Academic medicine: a faltering engine. action is needed to respond to growing need and opportunities. Europe PMC 2002;324:437-8.
5. Woolf SH. The meaning of translational research and why it matters. JAMA 2008;299:211-3.
6. Frank JR, Snell L, Sherbino J, editors. CanMEDS 2015 Physician Competency Framework. Ottawa: Royal College of Physicians and Surgeons of Canada, 2015.
7. ACGME. Accreditation Council for graduate medical education common programme requirements (residency), 2018. Available from: www.acgme.org/Portal/o/PFAssets/ProgramRequirements/CPRResidency2019.pdf [Accessed 13 Aug 2020].
8. Milewicz DM, Lorenz RG, Dermody TS, et al. Rescuing the physician-scientist workforce: the time for action is now. J Clin Invest 2015;125:3742-7.
9. Chang Y, Ramnanan CJ. A review of literature on medical students and scholarly research: experiences, attitudes, and outcomes. Acad Med 2015;90:1162-73.
10. Sklar DP. We must not let clinician-scientists become an endangered species. Acad Med 2017;92:1359-61.
11. Lopes J, Ranieri V, Lambert T, et al. The clinical academic workforce of the future: a cross-sectional study of factors influencing career decision-making among clinical PhD students at two research-intensive UK universities. BMJ Open 2017;7:e016823.
12. Sheridan DJ. Reversing the decline of academic medicine in Europe. The Lancet 2006;367:1698-701.
13. Rosenkranz SK, Wang S, Hu W. Motivating medical students to do research: a mixed methods study using Self-Determination theory. BMC Med Educ 2015;15:95.
14. Ley TJ, Rosenberg LE. The physician-scientist career pipeline in 2005: build it, and they will come. JAMA 2005;294:1343-51.
15. Weaver AN, McCaw TR, Fifolt M, et al. Impact of elective versus required medical school research experiences on career outcomes. J Investig Med 2017;65:942-8.
16. Conroy MB, Shaffiey S, Jones S, et al. Scholarly research projects benefit medical students' research productivity and residency choice:outcomes from the University of Pittsburgh school of medicine. Acad Med 2018;93:1727-31.
17. Amgad M, Man Kin Tsui M, Liptrott SJ, et al. Medical student research: an integrated mixed-methods systematic review and meta-analysis. PLoS One 2015;10:e0127470.
18. George P, Green EP, Park YS, et al. A 5-year experience with an elective scholarly concentrations program. Med Educ Online 2015;20:29278.
19. Havnaer AG, Chen AJ, Greenberg PB. Scholarly concentration programmes and medical student research productivity: a systematic review. Perspect Med Educ 2017;6:216-26.
20. Wolfson RK, Arora VM. More on promoting medical student scholarly research. Acad Med 2016;91:159.
21. Griffin MF, Hindocha S. Publication practices of medical students at British medical schools: experience, attitudes and barriers to publish. Med Teach 2011;33:e1-8.
22. Parsonnet J, Gruppuso PA, Kanter SL, et al. Required vs. elective research and in-depth scholarship programmes in the medical student curriculum. Acad Med 2010;85:405-8.
23. Healey M, Jordan F, Pell B, et al. The research-teaching nexus: a case study of students' awareness, experiences and perceptions of research. Innovations in Education and Teaching International 2010;47:235-46.
24. O'Sullivan PS, Niehaus B, Lockspeiser TM, et al. Becoming an academic doctor: perceptions of scholarly careers. Med Educ 2009;43:335-41.
25. Brancati FL, et al. Early predictors of career achievement in academic medicine. JAMA 1992;267:1372.
26. Ommering BWC, van Blankenstein FM, van Diepen M, et al. Academic success experiences: promoting research motivation and Self-Efficacy beliefs among medical students. Teach Learn Med 2021;33:423-33.
27. Boyle SE, Cotton SC, Myint PK, et al. The influence of early research experience in medical school on the decision to intercalate and future career in clinical academia: a questionnaire study. BMC Med Educ 2017;17:245.
28. Siemens DR, Punnen S, Wong J, et al. A survey on the attitudes towards research in medical school. BMC Med Educ 2010;10:4.
29. Frenk J, Chen L, Bhutta ZA, et al. Health professionals for a new century: transforming education to strengthen health systems in an interdependent world. The Lancet 2010;376:1923-58.
30. Jain MK, Cheung VG, Utz PJ, et al. Saving the Endangered Physician-Scientist – A Plan for Accelerating Medical Breakthroughs. N Engl J Med 2019;381:399-402.
31. Waaijer CJF, Ommering BWC, van der Wurff LJ, et al. Scientific activity by medical students: the relationship between academic publishing during medical school and publication careers after graduation. Perspect Med Educ 2019;8:223-9.
32. Reinders JJ, Kropmans TJB, Cohen-Schotanus J. Extracurricular research experience of medical students and their scientific output after graduation. Med Educ 2005;39:237.
33. Wootton R. A simple, generalizable method for measuring individual research productivity and its use in the long-term analysis of departmental performance, including between-country comparisons. Health Res Policy Syst 2013;11:2.
34. Young BK, Cai F, Tandon VJ, et al. Promoting medical student research productivity: the student perspective. R I Med J 2014;97:50-2.
35. Almasry M, Kayali Z, Alsaad R, et al. Perceptions of preclinical medical students towards extracurricular activities. Int J Med Educ 2017;8:285-9.
36. Stockfelt M, Karlsson L, Finizia C. Research interest and activity among medical students in Gothenburg, Sweden, a cross-sectional study. BMC Med Educ 2016;16:226.
37. Ommering BWC, van Blankenstein FM, Wijnen-Meijer M, et al. Fostering the physician-scientist workforce: a prospective cohort study to investigate the effect of undergraduate medical students' motivation for research on actual research involvement. BMJ Open 2019;9:e028034.
38. Waltman L, van Eck NJ, van Leeuwen TN, et al. Towards a new crown indicator: some theoretical considerations. J Informetr 2011;5:37-47.
39. Waltman L, van Eck NJ, van Leeuwen TN, et al. Towards a new crown indicator: an empirical analysis. Scientometrics 2011;87:467-81.
40. Moed HF, De Bruin RE, Van Leeuwen TN. New bibliometric tools for the assessment of national research performance: database description, overview of indicators and first applications. Scientometrics 1995; 33:381-422.
41. Moed HF, Visser MS. Developing bibliometric indicators of research performance in computer science: An exploratory study. CWTS report. 1, 2007.
42. van Leeuwen TN. Modelling of bibliometric approaches and importance of output verification in research performance assessment. Res Eval 2007;16:93-105.
43. Ommering BWC, van den Elsen PJ, van der Zee J, et al. Using an extracurricular Honors programme to engage future physicians into scientific research in early stages of medical training. Med Sci Educ 2018;28:451-5.
44. Dyrbye LN, Davidson LW, Cook DA. Publications and presentations resulting from required research by students at Mayo medical school, 1976-2003. Acad Med 2008;83:604-10.
45. McPherson JR, Mitchell MM. Experience with providing research opportunities for medical students. Academic Medicine 1984;59:865-8.
46. Laskowitz DT, Drucker RP, Parsonnet J, et al. Engaging students in dedicated research and scholarship during medical school: the long-term experiences at Duke and Stanford. Academic Medicine 2010;85:419-28.
47. Al-Busaidi IS, Alamri Y. Publication rates and characteristics of undergraduate medical theses in New Zealand. N Z Med J 2016;129:46-51.
48. Salmi LR, Gana S, Mouillet E. Publication pattern of medical theses, France, 1993-98. Med Educ 2001;35:18-21.

49. van Wijk IJ, Daelmans HEM, Wouters A, et al. Exploring the timing of medical student research internships: before or after clerkships? BMC Med Educ 2018;18:259.
50. Alamri Y, Currie W, Magner K, et al. Publication rates of, and attitudes toward, summer research projects: 10-year experience from a single institution in New Zealand. Adv Med Educ Pract 2019;10:263-71.
51. Möller R, Shoshan M. Medical students' research productivity and career preferences; a 2-year prospective follow-up study. BMC Med Educ 2017;17:51.
52. Funston G, Piper RJ, Connell C, et al. Medical student perceptions of research and research-orientated careers: an international questionnaire study. Med Teach 2016;38:1041-8.
53. Salgueira A, Costa P, Gonçalves M, et al. Individual characteristics and student's engagement in scientific research: a cross-sectional study. BMC Med Educ 2012;12:95.
54. Husnoo N, Goonoo MS. How to boost your specialty training application. BMJ 2016;352:i1392.
55. Wells CI, Wallace HB, McLaughlin SJP. Rate and predictors of publication by medical and health science summer research students: a 14-year analysis from Auckland, New Zealand. MedEdPublish 2016;3:43.
56. van Eyk HJ, Hooiveld MHW, Van Leeuwen TN, et al. Scientific output of Dutch medical students. Med Teach 2010;32:231-5

Chapter 3

The role of mandatory research projects in medical students' research motivation

Charlotte R. den Bakker
Belinda W.C. Ommering
Arnout Jan de Beaufort
Friedo W. Dekker

Submitted

Abstract

Introduction Research experiences within medical school are mainly offered as elective or extracurricular initiative. Consequently, some students become doctors without hands-on research experience while every clinician is expected to be a scholar able to both use and contribute to research. Additionally, research experiences are needed to cultivate the next generation clinician-scientists as medicine is facing a clinician-scientist shortage. Research motivation is believed to play an important role in both using and actually participating in research as clinician(-scientist). However, development of motivation during a mandatory research project has not been investigated yet. Therefore, this study, investigates the role of mandatory research in medical students' research motivation and ambition. Using Theory of Planned Behaviour and Self-Determination Theory, we included motivational determinants to further unravel motivational development, also in students that would not have participated in research if not mandatory.

Methods 304 medical students (response rate 94.4%) completed a questionnaire prior to, during, and after their mandatory research about research motivation, motivational determinants and research ambitions. Regression analyses were used to explore development of motivation, its determinants and research ambition during mandatory research.

Results Research perceptions, self-efficacy, autonomy, and relatedness increased in most students and strengthened intrinsic motivation (adjusted β=.38, .31, .15, .14, respectively). Both perceptions and self-efficacy strengthened extrinsic motivation (adjusted β=.37, .15, respectively). Intrinsic and extrinsic motivation fostered research ambitions (adjusted β=.82, .16, respectively). One out of four students stated that they would not participate if it had not been mandatory. Most of this subgroup increased in research motivation and ambitions, but did not reach levels equal to peers.

Conclusions Mandatory research projects foster both intrinsic and extrinsic research motivation in most students and, in turn, foster research career ambitions. The beneficial effects of mandatory research experiences were more pronounced in students who initially were not intending to participate in research. Furthermore, this study established the applicability of Theory of Planned Behaviour and Self-Determination Theory within a mandatory context. Our results suggests that substantial educational investments in and allocation of resources for mandatory research projects could be regarded as a meaningful step toward providing all future doctors with hands-on research experience. This experiences enables them to use and conduct research, thereby cultivating the next generation of clinician-scientists.

Introduction

'The conscientious, explicit and judicious use of the best evidence in making decisions about the care of patients' is at heart of *evidence-based medicine* (EBM).[1] This requires curious and capable doctors able to use, critically appraise, and appropriately apply the best available scientific evidence to individual clinical patient care. Furthermore, the development of EBM highly depends on doctors (i.e. clinician-scientists) actively engaged in research as they bring two worlds (i.e. clinical care and research) together. In line with this, a common belief is that every clinician should be a scholar able to both use and contribute to research and is incorporated in widely used frameworks like CanMEDS.[2]

Hands-on research projects are suitable opportunities for future doctors to serve these scholarly aims. During research participation, medical students are challenged to be curious and critically appraise and value research, relevant when using research in future clinical care. Furthermore, research participation during medical school is an important determinant in future research participation, e.g. choosing to pursue a research career,[3–6] and thereby, additionally, may help to counteract the concerning decline and shortage in clinician-scientists.[7,8] These projects can contribute to fostering and identifying research talent, useful in cultivating the next generation of clinician-scientists. However, research projects are time-consuming and require a lot of educational resources (e.g. supervision) as they are on individual or small group level. Consequently, they are mainly offered as elective or extracurricular initiative for students looking for extra challenges or those highly motivated for research. As a result of predominantly voluntary research opportunities, a significant number of students around the world graduates without any hands-on research experience.[4] Some initially lack research interest or have time pressure, while most did not participate in research due to a lack of opportunities.[9]

Motivation is an important factor for research engagement. Previous studies showed that research motivation strengthens research participation during and after medical school.[4,6,10] Therefore research motivation is believed to play an important role in using and actually participating in research as clinician(-scientist). As it is challenging to incorporate mandatory research projects in the curriculum, critically evaluating the role of mandatory research in motivation for research is important. Previous studies on mandatory research experiences have focused on perceived learning outcomes, research attitudes and publication rates.[4,9,11] However, no studies so far have focused on motivation of students doing mandatory research projects.

Two well-established theoretical frameworks to comprehend motivational dynamics are the Theory of Planned Behaviour (TPB) and the Self-Determination Theory (SDT).[12,13]

In the context of our study, these two theoretical constructs intersect, culminating in a comprehensive understanding of the determinants of motivation. According to TPB, attitudes serves as a prerequisite to motivation, which, in turn, correlates with specific behaviours. Attitudes reflect individual's perceptions of a certain behaviour including the evaluation of the behaviour. Subjective norms, encompassing societal influences and expectations, along with perceived behavioural control, somewhat similar to SDT's need for competence representing an individual's self-assessment of their capability to perform a behaviour, further contributes to shaping these intentions. Moreover, SDT advances a nuanced perspective on motivation, categorizing it into various forms. Of particular relevance to our study are *intrinsic motivation* (IM), characterized by an inherent interest in an activity (e.g. doing research out of interest), and *extrinsic motivation* (EM), propelled by external rewards or avoidance of penalties (e.g. doing research for a grade or to increase the chance of getting into a specific residency position). IM is believed to be of better quality as it promotes deep learning, academic achievement and feelings of well-being.[14-16] Furthermore, IM results in actual research participation later on.[4,6,10] According to SDT, feelings of autonomy (i.e. the need to feel ownership of one's behaviour), competence (i.e. the need to produce desired outcomes and to experience mastery, also referred to as self-efficacy) and relatedness (i.e. the need to feel connected to others) must be satisfied to be intrinsically motivated.

In sum, in our study, we integrated research perceptions, feelings of autonomy, research self-efficacy and relatedness as determinants of motivation in alignment with the theoretical frameworks. As these motivation determinants involve dynamic processes and can develop over time, we assume that students' type (i.e. IM and EM) and quantity of motivation develops as well. This study investigates the development of motivation, its determinants, as well as research career intentions during mandatory research (*Figure 1*), also in students who stated that they would not have participated in research if it had not been mandatory. It was hypothesized that, although research takes place in a mandatory setting, research perceptions, self-efficacy, autonomy and relatedness strengthen intrinsic motivation, also in students who initially did not intend to participate in research. Furthermore, we hypothesized that intrinsic motivation, in turn, fosters research ambitions. Insights in the effect of mandatory research on research motivation can contribute to the discussion if and how research should be integrated into medical curricula to further improve mandatory research experiences and enhance research motivation.

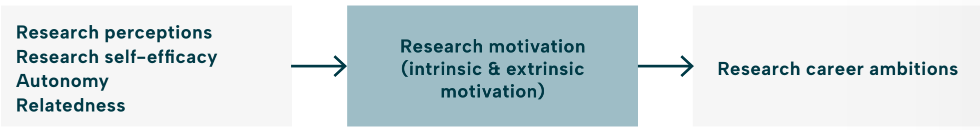

Figure 1. *Overview of tested study constructs according to the theoretical framework*

Methods

Setting

Leiden University Medical Center (LUMC) is one of eight Dutch medical schools which all use the same blueprint for learning outcomes,[17] and have mandatory individual research projects for master students. First, students need to arrange their internship at a health institute and department of preference, and choose a research domain e.g. clinical research, laboratory research, or public health research. Students are free to choose the timing to conduct their research before or after clerkships. During the research project, students work full-time on their authentic, hands-on research for four to six months. While students fulfil the role of primary investigator, they are mentored by one or few research supervisors, mostly (clinician-)scientists or PhD candidates. Students conduct their own research and develop research skills, such as searching and critically appraising literature, designing research, and analysing and interpreting data. As final products, students write a research report and present their findings orally at the department. Assessment consists of two parts: the research product and students' learning process. More than one out of four students voluntarily invest extra time and publish their report as a scientific paper in a peer-reviewed journal.[11]

Materials and definitions

This prospective cohort study included all medical students at LUMC who started and completed their research project between October 2020 and August 2022 (partly during the COVID-19 pandemic). We used a 7-point Likert type questionnaire with five scales ranging from 1 to 7 with multiple data collection moments (*Figure 2 and Appendix B*). Scales on intrinsic and extrinsic motivation for research, research perceptions, and research self-efficacy were used in previous studies in first-year medical students at the LUMC.[18,19] These studies confirmed the internal consistency (Cronbach's alpha between .77-.88) and construct validity within the SDT context. Additionally, the autonomy scale of the validated Work-related Basic Need Satisfaction Scale (WBNS) was used.[20] The relatedness scale was based on the relatedness scale of the WBNS combined with the 'integration of the research community' scale of the Dutch Student Perception of Research Integration Questionnaire.[20,21] We translated items of the autonomy and relatedness scales to Dutch using forward-backward translation procedure. Slight adjustments were made in order to fit the context of medical master students (e.g. replaced 'job' for 'research internship'). Lastly, we added items to the questionnaire to measure students' current (i.e. if students would or would not have participated in research if it had not been mandatory) and further research career ambitions as publication, research involvement, research career ambitions. Finally, we tested the refined pilot questionnaire among medical master students using a think-aloud procedure to ensure items were clearly formulated and understood correctly. Subsequently, the questionnaire was reviewed by experts in the field before being distributed.

Procedure

Students filled in a questionnaire prior to starting their project (T0), around four weeks (T1), and after finishing their research project (T2) (*Figure 2*). Beforehand, they received information about the study and informed consent was asked to also use their data for scientific purposes. The T0-survey served as baseline measurement for research motivation, self-efficacy and perceptions. As feelings of relatedness and autonomy were not measurable prior to the research project, these constructs were measured early in the research project (T1, after around 4 weeks). Finally, all constructs were measured after the research project when students uploaded their research report (T2). As COVID-19 not only impacted healthcare but medical education including research internships as well, we included to what extent students worked from home.

T0 (start of research project)	**T1** (early-stage evaluation around 4 weeks)	**T2** (submission of research report)
Demographics		Demographics
Motivation for research	Autonomy	Motivation for research
Research self-efficacy	Relatedness	Research self-efficacy
Research perceptions		Research perceptions
Research career ambitions		Autonomy
		Relatedness
		Research career ambitions

Figure 2. *Overview of data points*

Analysis

Cronbach's alpha was checked for all scales. Development of motivation and its determinants was measured by means at T2, adjusted for baseline or early stage measurement at T0 or T1. We used linear regression analyses, both crude and adjusted for possible confounders, to study the relation between development of motivational determinants and actual motivational development, as well as between motivation and research career ambitions. A 95% confidence interval (CI) was used to determine statistical significance.

Ethical approval

Ethical approval was obtained from the Institutional Review Boards of Leiden University Medical Center (OEC/ERRB/20200414/1).

Results

In total, 304 out of 322 medical students (94%) consented to participate and completed questionnaires at T0, T1 and T2. Two thirds of the respondents were female, reflecting the male/female ratio in medical schools in The Netherlands. The mean age was 23.7 years (SD 2.07, 19-31 years). Most students conducted clinical research (74%, n=224) and chose a formal research period of 18 weeks (82%, n=250). *Table 1* shows the demographics of the participants. Approximately 35% of all students worked more than 80% at home during their research project. Cronbach's alpha of all constructs were between .74-.89. See *Table 2*.

Table 1. *Demographics of medical students*

Demographic variable	Categories	N	%
Sex	Female	209	68.7
	Male	95	31.3
Formal duration research project	18 weeks	250	82.2
	23 weeks	37	12.2
	28 weeks	17	4.6
Curricular timing	Before clerkships	174	57.2
	After clerkships	130	42.8
Type of research	Clinical research	224	73.7
	Public and primary healthcare	39	12.8
	Laboratory research	7	2.3
	Other	34	11.2
Extra-curricular research experience	Yes	84	27.6
	No	220	72.4
Worked at home due to COVID-19	0% of the research project	9	3.0
	10-40% of the research project	66	21.7
	50-80 % of the research project	116	38.1
	90% of the research project	61	20.1
	100% of the research project	52	17.1

Table 2. *Scales with corresponding Cronbach's alpha*

Construct	Cronbach's alpha[a]	Items (n)	Item example
IM T0	.86	5	*I enjoy doing research.*
EM T0	.86	4	*I believe that doing research benefits my CV.*
Research perceptions T0	.86	5	*Each clinician should be able to independently conduct research.*
Research self-efficacy T0	.89	6	*I believe that I am good in doing research.*
Relatedness T1	.89	3	*During my internship, I felt part of a group.*
Autonomy T1	.74	8	*I feel free to do my internship the way I think it could best be done.*
Research career ambitions T0	.87	2	*I would like to conduct research as part of my work once I am a medical doctor.*

[a] *Cronbach's alpha was not materially different at T1 and/or T2*

Development of motivation, its determinants and research career ambitions

Mean IM at baseline (T0) was 5.31 (SD .86) and 5.58 (SD .94) after the research project (T2). IM increased in almost three out of four students with a mean increase of .66 on a 7-point Likert scale. About a quarter of all students decreased in IM with a mean of .67. Mean EM at baseline (T0) was 5.26 (SD 1.03) and 5.32 (SD 1.11) after the research project (T2). EM increased in 60% of all students with a mean increase of .69 on a 7-point Likert scale, in other students EM decreases on average .88. Mean IM and EM at baseline (T0) were significantly lower (mean difference .24, $p<0.001$ and mean difference .52, $p<0.001$) in students who increased in IM or EM during their research project.

The majority of the students (68%, n=207) increased in positive research perceptions during the research project, with a mean of .63 point. One out of three students' research perceptions decreased with a mean of .80 point. Regarding research self-efficacy, approximately one out of four students had lower research self-efficacy scores after the research project. Within the group with growth of research self-efficacy during the research project, the mean increase was .90 point. Both relatedness and autonomy declined in almost half of students with on average .67 point. Students that increased in relatedness and autonomy increased with on average .63 and .44 point, respectively. Lastly, research career intentions increased in more than two out of three students with on average .78 point. Baseline scores of motivation, its determinants and research career ambitions were significantly lower in those who experienced an increase in these

constructs during the research project (all p-values<0.001). An overview of mean scores and development of the constructs is shown in *Table 3*.

Table 3. *Development of motivation, its determinants and research career ambitions based on a 7-point Likert scale*

Construct	All students who conducted and completed their research project	Students whose construct score increased during the research project (T0/T1-T2)	Students whose construct score decreased during the research project (T0/T1-T2)
IM			
N (%)	304 (100%)	216 (71.1%)	88 (28.9%)
Mean score T0 (SD; min-max)	5.31 (.86; 2.60-7.00)	5.24 (.85; 2.60-7.00)	5.48 (.88; 3.00-7.00)
Mean score T2 (SD; min-max)	5.58 (.94; 2.40-7.00)	5.90 (.73; 3.40-7.00)	4.81 (.96; 2.40-6.40)
Mean development[a] (SD; min-max)	+ .27 (.83; -2.20-3.00)	+ .66 (.62; .00-3.00)	- .67 (.39; -2.20- - .20)
EM			
N (%)	304 (100%)	183 (60.2%)	121 (39.8%)
Mean score T0 (SD; min-max)	5.26 (1.03; 2.00-7.00)	5.05 (1.07; 2.00-7.00)	5.57 (.89; 2.00-7.00)
Mean score T2 (SD; min-max)	5.32 (1.11; 1.50-7.00)	5.74 (.89; 3.25-7.00)	4.69 (1.10; 1.50-6.50)
Mean development[a] (SD; min-max)	+ .06 (1.01; -3.25-3.00)	+ .69 (.66; .00-3.00)	- .88 (.64; -3.25- - .25)
Perceptions			
N (%)	304 (100%)	207 (68.1%)	97 (31.9%)
Mean score T0 (SD; min-max)	5.12 (.97; 2.00-7.00)	5.02 (.97; 2.00-7.00)	5.34 (.94; 2.20-7.00)
Mean score T2 (SD; min-max)	5.29 (1.05; 2.00-7.00)	5.65 (.86; 2.20-7.00)	4.54 (1.03; 2.00-6.60)
Mean development[a] (SD; min-max)	+ .17 (.87; -2.40-3.80)	+ .63 (.59; .00-3.80)	- .79 (.53; -2.40- - .20)

Research self-efficacy			
N (%)	304 (100%)	234 (77.0%)	70 (23.0%)
Mean score T0 (SD; min-max)	4.66 (1.00; 1.00-7.00)	4.59 (1.04; 1.00-7.00)	4.91 (.82; 2.67-7.00)
Mean score T2 (SD; min-max)	5.16 (.95; 1.33-7.00)	5.44 (.75; 3.33-7.00)	4.21 (.95; 1.33-6.00)
Mean development[a] (SD; min-max)	+ .50 (1.00; -2.67-4.33)	+ .85 (.82; .00-4.33)	- .70 (.44; -2.67- - .33)
Relatedness			
N (%)	304 (100%)	166 (54.6%)	138 (45.4%)
Mean score T1 (SD; min-max)	4.18 (1.22; 1.00-7.00)	4.05 (1.24; 1.00-6.88)	4.34 (1.18; 1.13-7.00)
Mean score T2 (SD; min-max)	4.22 (1.27; 1.00-7.00)	4.68 (1.19; 1.19;1.50-7.00)	3.67 (1.16; 1.00-6.75)
Mean development[a] (SD; min-max)	+ .04 (.85; -2.63-3.00)	+ .63 (.59; .00-3.00)	- .67 (.52; -2.63- - .13)
Autonomy			
N (%)	304 (100%)	169 (55.6%)	135 (44.4%)
Mean score T1 (SD; min-max)	5.20 (.86; 2.80-7.00)	5.02 (.81; 2.80-7.00)	5.43 (.87; 3.20-7.00)
Mean score T2 (SD; min-max)	5.15 (.91; 1.80-7.00)	5.46 (.75; 3.40-7.00)	4.76 (.95; 1.80-6.60)
Mean development[a] (SD; min-max)	- .05 (.73; -2.40-2.80)	+ .44 (.47; .00-2.80)	- .67 (.49; -2.40- - .20)
Research career ambitions			
N (%)	304 (100%)	210 (69.1%)	94 (30.9%)
Mean score T0 (SD; min-max)	4.26 (1.54; 1.00-7.00)	4.10 (1.59; 1.00-7.00)	4.62 (1.36; 2.00-7.00)
Mean score T2 (SD; min-max)	4.46 (1.64; 1.00-7.00)	4.88 (1.55; 1.00-7.00)	3.53 (1.45; 1.00-6.50)
Mean development[a] (SD; min-max)	+ .20 (1.17; -4.00-4.00)	+ .78 (.47; .00-2.80)	- .50 (.69; -4.00- - .50)

[a] *Mean development (T0 to T2 or T1 to T2) reflect the development of the construct during the research project*

Development of determinants of motivation in relation to development of motivation

Development of students' research perceptions and self-efficacy were significantly positively related to development of both IM (adjusted β=.38; .31, respectively) and EM (adjusted β=.37; .15, respectively). Furthermore, development of both relatedness and autonomy were significantly positively related to development of IM after adjustment for other variables (adjusted β=.15; .14, respectively), but no significant association with development of students' EM was found (adjusted β=.06; .06, respectively). An overview of the development of motivation and its determinant and possible confounders adjusted for is depicted in *Table 4*.

Table 4. *Development of different types of motivation (i.e. IM and EM) in relation to development of determinants of motivation (N=304)*

Theoretical determinant of motivation	Outcome	β (95% CI)	Adjusted R^2	Possible confounders adjusted for†
Development of perceptions (T0-T2)	Development of IM (T0-T2)	.39 (.30-.48)* .42 (.33-.51)* .38 (.30-.47)*	.10 .50 .55	 Age, sex, before/after clerkship, previous research experience, duration, working from home due to covid, EM T0, research self-efficacy T0 + Autonomy T1, relatedness T1
Development of perceptions (T0-T2)	Development of EM (T0-T2)	.35 (.24-.47)* .38 (.27-.50)* .37 (.26-.49)*	.04 .43 .43	 Age, sex, before/after clerkship, previous research experience, duration, working from home due to covid, EM T0, research self-efficacy T0 + Autonomy T1, relatedness T1
Development of research self-efficacy (T0-T2)	Development of IM (T0-T2)	.30 (.22-.39)* .31 (.23-.39)* .31 (.23-.39)*	.03 .49 .54	 Age, sex, before/after clerkship, previous research experience, duration, working from due to covid, EM T0, research perceptions T0 + Autonomy T1, relatedness T1
Development of research self-efficacy (T0-T2)	Development of EM (T0-T2)	.10 (-.01-.20) .16 (.05-.27)* .15 (.04-.25)*	.00 .35 .36	 Age, sex, before/after clerkship, previous research experience, duration, working from due to covid, IM T0, research perceptions T0 + Autonomy T1, relatedness T1

Theoretical determinant of motivation	Outcome	β (95% CI)	Adjusted R^2	Possible confounders adjusted for†
Development of relatedness (T1-T2)	Development of IM (T0-T2)	.12 (.02-.22)* .11 (.01-.21)* .15 (.05-.24)*	.01 .38 .45	Age, sex, before/after clerkship, previous research experience, duration, working from due to covid, EM T0, research perceptions T0, research self-efficacy T0 + Autonomy T1
Development of relatedness (T1-T2)	Development of EM (T0-T2)	.06 (-.07-.18) .04 (-.08-.16) .06 (-.06-.18)	.00 .34 .35	Age, sex, before/after clerkship, previous research experience, duration, working from due to covid, IM T0, research perceptions T0, research self-efficacy T0 + Autonomy T1
Development of autonomy (T1-T2)	Development of IM (T0-T2)	.11 (-.01-.23) .12 (-.00-.24) .14 (.02-.26)*	.02 .38 .40	Age, sex, before/after Alerkship, previous research experience, duration, working from due to covid, EM T0, research perceptions T0, research self-efficacy T0 + Relatedness T1
Development of autonomy (T1-T2)	Development of EM (T0-T2)	.07 (-.07-.21) .05 (-.09-.19) .06 (-.08-.21)	.00 .34 .35	Age, sex, before/after clerkship, previous research experience, duration, working from due to covid, IM T0, research perceptions T0, research self-efficacy T0 + Relatedness T1

† Motivational development was approached as motivation T2 scores adjusted for T0 scores as first step. Hereafter, we adjusted for possible confounders at T0. As relatedness and autonomy were not measurable at T0 (prior to the research project) and measured at T1 (early stage of research) we separately adjusted for these constructs in a final step.
** Indicating statistical significance $p < 0.05$*

Working from home (measured on 0-100 scale as percentage) due to COVID-19 significantly reduced intrinsic and extrinsic motivation after the research project (crude β=-.005; -.005, respectively). Furthermore, working from home significantly and negatively impacted development in relatedness (crude β=-.004), as well as both relatedness and positive research perceptions after the research project (crude β=-.021; -.005, respectively). Other relations between working from home and motivational determinants were not significant. An overview of the association between motivational determinants including working from home and the development of motivation is depicted in *Table 5*.

Table 5. *Overview of the impact of working from home due to COVID-19 on motivation and its determinants using regression analyses*

Determinant	Outcome	β (95% CI)
Working from home due to COVID-19	Intrinsic motivation T2*	-.005 (-.009 – -.001)
Working from home due to COVID-19	Development of IM (T0-T2)	-.003 (-.006 – .001)
Working from home due to COVID-19	Extrinsic motivation T2*	-.005 (-.009 – -.001)
Working from home due to COVID-19	Development of EM (T0-T2)	-.002 (-.005 – .002)
Working from home due to COVID-19	Research perceptions T2	-.005 (-.009 – -.001)
Working from home due to COVID-19	Development of research perceptions (T0-T2)	-.003 (-.007 – .000)
Working from home due to COVID-19	Autonomy T2	-.002 (-.005 – .001)
Working from home due to COVID-19	Development of autonomy (T0-T2)	-.003 (-.007 – .000)
Working from home due to COVID-19	Relatedness T2*	-.021 (-.026 – -.017)
Working from home due to COVID-19	Development of relatedness (T0-T2)*	-.004 (-.007 – -.001)
Working from home due to COVID-19	Research self-efficacy T2	-.004 (-.007 – .000)
Working from home due to COVID-19	Development of research self-efficacy (T0-T2)	-.001 (-.005 – .003)

** Indicating statistical significance $p < 0.05$*

Motivation and scientific outcomes

Students with higher IM and to a lesser extent EM after their research project had significantly more research career ambitions (adjusted β=.82, β .16, respectively). In addition, development of IM and to a lesser extent EM were significantly positively correlated with development of research career ambitions (adjusted β=-.74; .30, respectively). Almost 40% of all students reported that they will publish an article as a result of their research project, and 20% reported a probably publication. Approximately

40% did not intend to publish. In addition, one out of three students reported that they were planning on further participation in research at the department where they conducted their research internship. The association between motivation and research career ambitions is depicted in *Table 6*.

Table 6. *Motivation and research career ambitions*

Determinant	Outcome	Adjusted β (95% CI)	Adjusted R^2	Possible confounders adjusted for[a]
IM after research project (T2)	Research career ambitions after the research project (T2)	1.35 (1.23-1.48)* .82 (.63-1.02)*	.60 .66	Age, sex, before/after clerkship, previous research experience, duration, working from home due to covid, EM T2, perceptions T2, research self-efficacy T2, relatedness T2, autonomy T2
EM after research project (T2)	Research career ambitions after the research project (T2)	.78 (.63-.92)* .16 (.05-.28)*	.27 .66	Age, sex, before/after clerkship, previous research experience, duration, working from home due to covid, IM T2, perceptions T2, research self-efficacy T2, relatedness T2, autonomy T2,
Development IM (T0-T2)	Development in research career ambitions (T0-T2)	.75 (.62-.88)* .77 (.64-.90)* .74 (.61-.88)*	.67 .68 .68	Age, sex, before/after clerkship, previous research experience, duration, working from home due to covid, EM T0, perceptions T0, research self-efficacy T0 + Relatedness T1, autonomy T1
Development EM (T0-T2)	Development in research career ambitions (T0-T2)	.31 (.19-.43)* .33 (.21-.45)* .30 (.17-.42)*	.57 .57 .58	Age, sex, before/after clerkship, previous research experience, duration, working from home due to covid, IM T0, perceptions T0, research self-efficacy T0 + Relatedness T1, autonomy T1

[a] *Motivational development and development of research career ambitions were approached as T2 scores adjusted for T0 scores as first step. Hereafter, we adjusted for possible confounders at T0. As relatedness and autonomy were not measurable at T0 (prior to the research project) and measured at T1 (early stage of research) we separately adjusted for these constructs in a final step.*
* *Indicating statistical significance $p < 0.05$*

Outcomes if research would not have been mandatory

Approximately one out of four students (n=87, 29%) stated beforehand that they would not have participated in research if it had not been mandatory. This group (*group 2*) had significantly lower mean IM and EM prior to their research project (mean difference IM 1.07; mean difference EM .88), as well as less research career ambitions (mean difference 2.10) compared to students who wanted to participate in research without it being imposed on them or were neutral (*group 1)* (*Table 7*). Throughout the research experience, mean IM increased .47 and mean EM .08 point in group 2. Furthermore, their research career ambitions increased with on average .38 point. Mean IM, EM, and ambitions within group 1 increased as well throughout the research internship, but to a lesser extent. The majority in group 2 increased in IM (74%, n=64), EM (60%, n=52), research perceptions (67%, n=58), self-efficacy (74%, n=64), and research career ambitions (72%, n=63). Half of this group increased in relatedness (51%, n=44) and autonomy (52%, n=45), which is almost equal to group 1 and comparable to the average of all students. Of group 2, 35 students (40%) stated after the research project that they would participate in research if it had not been mandatory. Within group 1, 23 students (11%) changed their mind and stated after their research project that they would not have participated in research if it had not been mandatory. Of all students, after the research, 25% (n=75) stated that they would not have participated in research not mandatory, whereof 69% (n=52) stated the same prior to their research.

Table 7. *Group differences between students that prior to their research project stated that they would have (group 1) or have not (group 2) participated in research if research would not have been mandatory*

Mean construct	Group 1† (N=217)	Group 2†† (N=87)	Mean difference	95% CI
IM baseline	5.61	4.54	1.07*	.90 – 1.26
IM after research project	5.81	5.01	.80*	.56 – 1.05
IM development	.20	.47	.27*	-.50 – -.05
EM baseline	5.51	4.63	.88*	.64 – 1.12
EM after research project	5.57	4.70	.87*	.57 – 1.15
EM development	.06	.08	.02	-.31 – .27
Research perceptions baseline	5.41	4.39	1.02*	-1.23 – -.80
Research perceptions after research project	5.55	4.64	.91*	-1.18 – -.64
Research perceptions development	.15	.25	.10	-.14 – .35
Research self-efficacy baseline	4.93	4.00	.93*	-1.16 – -.70
Research self-efficacy after research project	5.33	4.74	.59*	-.84 – -.33
Research self-efficacy development	.40	.75	.35*	.05 – .64
Research relatedness baseline	4.35	3.75	.60*	-.90 – -.31
Research relatedness after research project	4.39	4.24	.59*	-.90 – -28
Research relatedness development	.04	.05	.01	-.20 – .23
Research autonomy baseline	5.27	5.02	.26*	-.47 – -.05
Research autonomy after research project	5.25	4.89	.36*	-.59 – -.14
Research autonomy development	-.02	-.13	.10	-.29 – .08
Research career ambitions baseline	4.86	2.76	2.10*	1.80 – 2.40
Research career ambitions after research project	4.99	3.14	1.85*	1.50 – 2.21
Research career ambitions development	.13	.38	.25	-.54 – .04

† *Students who initially wanted to participate in research if research would not have been mandatory in the curriculum or students who were neutral (T0)*
†† *Students who initially not wanted to participate in research if research would not have been mandatory in the curriculum (T0)*
* *Indicating statistical significance p < 0.05*

Discussion

This is the first longitudinal, theory based study on medical students' motivation for research students in a mandatory setting. Our study shows that mandatory research not

only offers every future doctor a hands-on research experience, but also fosters both intrinsic and extrinsic research motivation, secondary to improvement of its determinants, first and foremost research perceptions and self-efficacy, in a majority of students. The development in both type and quantity of research motivation matters, as both students' intrinsic motivation and to a lesser extent extrinsic motivation after the research experience strengthen research career ambitions. Previous studies showed theory based determinants tested in our study contributed to motivation and that medical students are more likely to pursue research careers in students that voluntarily participated in research.[3-6,22] Our study adds that this is also true in a mandatory setting, when those who would otherwise become doctors without any hands-on research experience are included as well. Consequently, this also provides evidence for the idea that if these motivational determinants are fostered in a mandatory setting, motivation can be influenced as well. In turn, this offers opportunities to develop (mandatory) interventions and implement evidence-based strategies aiming to target students' motivation for research in early stages of medical school.

Although most students benefit from a mandatory research experience, a minority declines in research motivation (IM 29%, EM 40%), perceptions (32%), self-efficacy (23%), relatedness (45%), autonomy (44%), and/or research career ambitions (31%). Baseline scores of these constructs are lower in students who increase in these constructs compared to students who decrease during the research experience. The decrease in motivation, its determinants and research career ambitions might (partially) be due to regression to the mean, a principle that, over repeated sampling periods, random outliers tend to revert to the mean.[23] Explanations for a motivational decline may be the impact of COVID-19 (e.g. poor homeworking conditions) or supervision insufficiently tailored to students' needs and expectations. Another explanation could be that students beforehand overvalue research and along the way get a more realistic perspective of research e.g. due to the practical side of research not meeting their expectations. In this way, a hands-on research experience provides students an authentic opportunity to find out if research is their path forward. Next to research career orientation, mandatory research experiences could conceivably also give substance to other benefits, as it could provide better insight and relevant contacts in a desired specialty, (future) job opportunities and/or chances of publication within the desired specialty.[11,22] Thus, although a decrease in motivation and research career ambitions may be unfortunate, by doing so, a mandatory research experience may still be valuable for medical students' future careers.

In line with SDT, our study shows that an increase in intrinsic motivation is related to fulfilling the three basic psychological needs: research self-efficacy, autonomy and relatedness. While demonstrating statistical significance, the observed increase in both relatedness and autonomy yields only marginal advancements in intrinsic motivation. Plausibly, the attenuated correlation between autonomy and relatedness with intrinsic motivation might be ascribed to their assessment taking place at a subsequent time point (T1), distinct from that of the other constructs (T0). Additionally, it is conceivable that the need for autonomy is less prominent when students engage in research for the first time, a notion supported by precedent studies in alternative contexts.[24,25] Furthermore, the need for autonomy could have been influenced by the obligatory nature of the requirement. Although we adjusted the relation between determinants and motivation for working from home due to COVID-19, it remains plausible that the pandemic affected the sense of relatedness while working at the department e.g. due to workplace restrictions, and thus, potentially impeding the cultivation of motivation. This potentially resulted in an underestimation of the observed mean increase in motivation.

Research in a mandatory setting mostly affects students who do not have interest beforehand and therefore would not have (voluntarily) participated in research. Barriers to participate in research are a lack of interest, time, supervision, and opportunities.[9,26] Mandatory research projects require substantial educational investments and resources, but can overcome students' barriers to participate in research. Prior to the mandatory research project, more than one in four students (29%) stated that they would not participate in research if not mandatory. Yet, after the mandatory research experience, the majority of this group has on average increased in motivation (IM 74%, EM 60%) and research career ambitions (72%). Despite not reaching equal final levels of motivation and research career ambitions compared to students who wanted to participate in research otherwise, their intrinsic motivation increased substantially more.

Only one in ten students did not have research interest beforehand together with a decline in intrinsic research motivation during the research project. While future research is useful to provide further insight in the complex process of motivational decline during research and the actual impact on both the use of research and participation in research as clinician, it can be considered undesirable that some students would otherwise not have participated in research and even become less motivated for research during their mandatory research experience. On the other hand, this raises the question if it would be more harmful when they become doctors aiming to practice evidence-based medicine without any hands-on research experience. Hence, high educational investments in and allocation of resources for mandatory research projects can be considered as a valuable investment in developing scholarly doctors able to both apply and develop EBM in their clinical care.

Strengths, limitations and future research

Our study with a large sample size and high response rate prospectively measured theory

based constructs and thereby provides a first insight in the applicability of TPB and SDT in new and relevant context including a mandatory setting. This study was partly conducted in an exceptional and unanticipated setting due to the COVID-19 pandemic, potentially limiting its generalizability to workplace learning. Our data showed, indeed, a negative impact of COVID-19 on relatedness, perceptions, and in line with TPB and SDT, eventually, motivation. Besides adjusting for working from home due to COVID-19, the pandemic might still have impacted the research experience in other ways. When students were allowed to (partly) do their research at the hospital, the workplace setting might was subjected to restrictions, e.g. less availability of supervisors or peers. Consequently, as the research project is a workplace learning experience by design, the described average increase in motivation as well as its determinants (e.g. relatedness) and outcomes, could be an underestimation compared to a non-pandemic setting without in-hospital workplace restrictions.

For future research it would be interesting to qualitatively explore students' research experiences within a mandatory setting to study how these theory based constructs can be fostered to further strengthen motivation for research. In addition, mandatory research experiences can be implemented in multiple ways. As insight in mandatory research is still limited and our study only studied one educational design of undergraduate research experiences, more research on various designs with e.g. differences in durations and group sizes would benefit insight in motivational development and can optimize resource allocation.would benefit insight in motivational development and can optimize resource allocation.

Conclusion

This study shows that substantial educational investments in and allocation of resources for mandatory research projects can be considered as a valuable investment, especially in students who did not intent to voluntarily participate in research. Many medical schools offer hands-on research experiences to medical students, though in many different forms (e.g. voluntarily and mandatory). If the pre-eminent goal of undergraduate research is to deliver scholarly medical doctors able to practice, develop and contribute to evidence-based medicine, it seems valuable to implement mandatory research experiences. It provides all future doctors with a hands-on research experience and enables them to use and conduct research within clinical practice, as well as cultivates the next generation of clinician-scientists. Furthermore, this study established the applicability of Theory of Planned Behaviour and Self-Determination Theory within the context of mandatory research within the medical domain.

References

1. Sackett DL. Evidence-based medicine. Seminars in Perinatology. 1997/02/01/ 1997;21(1):3-5.
2. Frank JR SL, Sherbino J, editors. . CanMEDS 2015 Physician Competency Framework. Ottawa: Royal College of Physicians and Surgeons of Canada; 2015.
3. Greenberg RB, Ziegler CH, Borges NJ, Elam CL, Stratton TD, Woods S. Medical student interest in academic medical careers: a multi-institutional study. journal article. Perspectives on Medical Education. November 01 2013;2(5):298-316.
4. Amgad M, Man Kin Tsui M, Liptrott SJ, Shash E. Medical Student Research: An Integrated Mixed-Methods Systematic Review and Meta-Analysis. PLoS One. 2015;10(6):e0127470.
5. Lopes J, Ranieri V, Lambert T, et al. The clinical academic workforce of the future: a cross-sectional study of factors influencing career decision-making among clinical PhD students at two research-intensive UK universities. BMJ Open. 2017;7(8):e016823.
6. Ommering BW, van Blankenstein FM, Wijnen-Meijer M, van Diepen M, Dekker FW. Fostering the physician–scientist workforce: a prospective cohort study to investigate the effect of undergraduate medical students' motivation for research on actual research involvement. BMJ Open. 2019;9(7):e028034.
7. Milewicz DM, Lorenz RG, Dermody TS, Brass LF. Rescuing the physician-scientist workforce: the time for action is now. The Journal of Clinical Investigation. 10/01/ 2015;125(10):3742-3747.
8. Eshel N, Chivukula RR. Rethinking the Physician-Scientist Pathway. Academic Medicine. 2022:10.1097/ACM.0000000000004788.
9. Griffin MF, Hindocha S. Publication practices of medical students at British medical schools: experience, attitudes and barriers to publish. Med Teach. 2011;33(1):e1-8.
10. Ranieri V, Barratt H, Fulop N, Rees G. Factors that influence career progression among postdoctoral clinical academics: a scoping review of the literature. BMJ Open. 2016;6(10):e013523.
11. den Bakker CR, Ommering BW, van Leeuwen TN, Dekker FW, De Beaufort AJ. Assessing publication rates from medical students' mandatory research projects in the Netherlands: a follow-up study of 10 cohorts of medical students. BMJ Open. 2022;12(4):e056053.
12. Ryan R, Deci E. Self-determination theory. Basic psychological needs in motivation, development and wellness. New York, NY : Guilford Press. 2017:231.
13. Bandura A. Self-efficacy: toward a unifying theory of behavioral change. Psychol Rev. Mar 1977;84(2):191-215.
14. Ryan R, Deci E. An overview of self-determination theory. In: Deci EL, Ryan RM, eds. Handbook of self-determination research. University of Rochester Press; 2002.
15. Ryan R, Deci E. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. Am Psychol. 2000;55
16. Vallerand R. Deci and Ryan's self-determination theory: A view from the hierarchical model of intrinsic and extrinsic motivation. Psychological Inquiry 01/01 2000;11:312-318.
17. ten Cate O. Medical Education in the Netherlands. Medical teacher. 11/01 2007;29:752-7.
18. Ommering BWC, van Blankenstein FM, Waaijer CJF, Dekker FW. Future physician-scientists: could we catch them young? Factors influencing intrinsic and extrinsic motivation for research among first-year medical students. Perspectives on Medical Education. 2018/08/01 2018;7(4):248-255.
19. Ommering BWC, van Blankenstein FM, Dekker FW. First steps in the physician-scientist pipeline: a longitudinal study to examine the effects of an undergraduate extracurricular research programme. BMJ Open. Sep 13 2021;11(9):e048550.
20. Van den Broeck A, Vansteenkiste M, De Witte H, Soenens B, Lens W. Capturing autonomy, competence, and relatedness at work: Construction and initial validation of the Work-Related Basic Need Satisfaction Scale. Journal of Occupational and Organizational Psychology. 2010; 83(4), 981–1002.
21. Visser-Wijnveen GJ, van der Rijst RM, van Driel JH. A questionnaire to capture students' perceptions of research integration in their courses. Higher Education. 2016/04/01 2016;71(4):473-488.
22. Ommering BWC, Wijnen-Meijer M, Dolmans D, Dekker FW, van Blankenstein FM. Promoting positive perceptions of and motivation for research among undergraduate medical students to stimulate future research involvement: a grounded theory study. BMC Med Educ. Jun 26 2020;20(1):204.
23. Barnett AG, van der Pols JC, Dobson AJ. Regression to the mean: what it is and how to deal with it. Int J Epidemiol. Feb 2005;34(1):215-20.
24. Ryan R, Lynch M, Vansteenkiste M, Deci E. Motivation and autonomy in counseling, psychotherapy, and behavior change: A look at theory and practice. The Counseling Psychologist. 2011;39:193-260.
25. Deci E, Ryan R. The support of autonomy and the control of behavior. Journal of Personality and Social Psychology. 1987;53:1024-1037.
26. El Achi D, Al Hakim L, Makki M, et al. Perception, attitude, practice and barriers towards medical research among undergraduate students. BMC Medical Education. 2020/06/17 2020;20(1):195.

Chapter 4

Exploring fairness in scholarly development: Are we creating knowledge storing zombies or curious, creative and critical healthcare professionals?

Charlotte R. den Bakker
Arnout Jan de Beaufort
Friedo W. Dekker
Belinda W.C. Ommering

Advances in Medical Education and Practice, 2023

Abstract

Scholarly doctors require research knowledge and skills (*Ausbildung*), as well as an academic mindset, which includes curiosity, creativity, and critical thinking (*Bildung*). However, in contrast to knowledge and skills, summative assessment of development of an academic mindset is not so easy in an objective and so-called fair way. As a result, in practice, assessing knowledge and skills tends to dominate in scholarly development. In this perspective we explore the issues that arise when we give priority to objective assessment of knowledge and skills in scholarly development to safeguard fairness and, consequently, standardize educational procedures and learning pathways. We argue that eventually this approach may even result in hampered development of a true academic mindset and can be considered *un*fair rather than fair. To solve this, perhaps we should go back to the core business of the university and, in the tradition of founder of the modern university Von Humboldt focus on shaping an academic mindset (*Bildung*). To rebalance *Ausbildung* and *Bildung* in academic education, we should go beyond the assumption that objectivity is a prerequisite for achieving fairness in assessment. Shifting the focus from pure objectivity to both objectivity *and* subjectivity in assessment as well as learning pathways, can assist in protecting fairness and, as a result, bring back *Bildung* to medical education to ensure future doctors to be true scholars.

"Education is not the learning of facts, but the training of the mind to think."
– Albert Einstein (1879-1955).

Developing scholars is an essential part of the medical doctor's training. The scholar is, rightfully so, one of the roles outlined in the CanMEDS competency framework.[1] Scholarly doctors require the retention of research knowledge and skills, as well as an academic mindset, which includes curiosity, creativity, and critical thinking. Research projects are widely used to develop future doctors into scholars. However, in contrast to knowledge and skills, assessment of development of an academic mindset in these projects is not so easy in a fair way. We explore and illustrate the issues that arise when focusing on objective, i.e. equal and unbiased, summative assessment of knowledge and skills in scholarly projects in order to safeguard fairness.

In the Netherlands, all medical schools provide a mandatory individual research project to develop scholarly abilities of future doctors.[2-4] During this project, students work individually full-time for 16 up to 26 weeks on their own research. They go through all phases of the empirical cycle in an authentic setting and develop practical research skills such as searching and critically appraising literature, designing research, analyzing and interpreting data, and academic writing. Moreover, to shape an academic mindset, they receive training-on-the-job in research integrity, ethics, and philosophy and get challenged on their curiosity, creativity, and critical thinking. A staff member, PhD candidate or doctor-scientist supervises the students individually. To complete their project, students write a report formatted as a scientific paper and present the results at the department where they conducted their research.

We facilitated a few roundtable sessions for medical educators from all eight Dutch medical schools. The participants were course coordinators, supervisors and independent assessors in the mandatory research projects. During these sessions participants shared their opinions, experiences, and challenges regarding supervision and assessment of the research projects. Participants deemed, or even convicted, that training scholarly skills, knowledge, and attitude were the main aims of the course. Regarding assessment of the learning goals, the vast majority considered fairness a fundamental quality of assessment and hence a main guiding principle, also well-known as a general principle in (medical) education.[5-8] It is difficult to provide a precise definition of fairness as there is no all-encompassing consensus definition described in the literature. The Cambridge Academic Content Dictionary describes fairness as 'the quality of treating people equally or in a way that is right or reasonable'. Participants perceived objective approaches as imperative for fairness in assessment, perhaps even the only way to achieve fairness, which is in line with common beliefs in higher education.[5]

4

To pursue fairness in assessment through objectivity, participants deemed standardized, equal, and unbiased educational procedures pivotal: all students should be treated similarly regarding, among others, supervision and assessment. This was perceived particularly important since all students carry out their research project individually at different departments. To guide supervisors and teachers in supervising and assessing students equally, all institutes use standardized procedures, quality measures, protocols, and rubrics. While we fully acknowledge the value of fairness in assessment, some dilemmas in shaping scholars arise when objectivity is assumed to be a prerequisite for fairness. We illustrate this with three practical examples that were discussed during the roundtable sessions.

The first example of objective assessment regards the standardized amount of provided study time. Some faculties set deadlines for submission of research reports to ensure that all students receive the same amount of study time. Exceeding the deadline influences their grades adversely. The second example concerns supervision: to further safeguard objectivity in assessment some schools standardize and regulate the frequency and amount of feedback the supervisor provides on drafts of the written report. The more feedback is given, the more the research report may well be effectively (co-)authored by the supervisor, which likely improves the quality of the research report and could result in higher grades. Most roundtable participants considered this unfair and argued that frequency and amount of feedback should be standardized for every student, and even restricted to e.g. two times max. 1 hour of feedback. Therefore, medical schools provide guidelines, for instance for deadlines and feedback. Finally, to objectively assess scholarly learning outcomes, schools commonly use summative testing with rubrics. As summative assessment of the research report can be subjected to the favor of the supervisor, a four-eyes principle is used to strengthen objective assessment. Therefore, a second, independent assessor appraises the research paper as well. In this way the chance of subjective assessment by supervisors favoring their own students is believed to decrease, as objective assessment of the research product is paramount. This is reinforced by visitation committees, who often evaluate students' written reports as part of national quality assurance. These committees commonly note that grades given by supervisors are higher than committee's own grades, and this way of assessing emphasizes the importance of objective assessment in medical education.

These examples illustrate that all participants considered standardized educational procedures essential for objective and, thus, fair assessment of scholarly abilities. To us, at first, this seemed reassuring – who could oppose an objective assessment of scholarly learning outcomes? On second thought, however, some dilemmas emerge. For instance, if the research report is assessed by an independent reviewer after a structured process with strict timelines and a standardized (often limited) amount of feedback, does this educational format properly reflect the learning objectives of a scholarly project? Even so, what are the consequences for growth and development of future scholars when objectivity is the main guiding principle to safeguard fairness?

First, we will elaborate on the consequences of the examples of objective assessment. We, as project supervisors ourselves, experience that some students are willing to maximize their learning potential; the discovery of the fun nature of conducting research during the project is intrinsically motivating and makes them eager to invest even more time and effort in their project.[9] Providing extra time in such cases may boost their learning curve and could take them to a next level.[4] This additional time even enables a significant subset of students to reach such academic levels that they publish their research in a peer-reviewed journal.[2,10,11] Moreover, these experiences increase the likelihood of postgraduate research activities.[12] Regarding frequency and amount of feedback, some students continuously improve upon every feedback session, i.e. their academic growth will benefit from more feedback.[13] From this perspective, the process of students' academic growth and degree of feedback provided during their research project is beneficial for shaping their academic mindset, as they are willing to make the most of this academic opportunity. Although this dedication and eagerness could be considered as the highest achievable scholarly development, when safeguarding fair assessment objectively, this seems to be undesired learning behaviour. Some faculties might even consider to give a lower grade in such situations, which, by emphasizing the objective measurable research product, complicates the learning process.

Within the context of individual research projects, standardized procedures to achieve objective assessment irrevocably imply fixed and regulated study time, standardized quantity of feedback, same curricular timing, and, at the end, assessment of learning only by an independent assessor. One could even argue that, in order to provide students with maximum standardized opportunities, they should all work alone on an identical research topic. Consequently, a research project that aims to shape curious, creative, and critical doctors with research skills and knowledge devaluates into an almost fully standardized writing assignment. In this way, in fact, standardized procedures for objective as mean for fair assessment are placed above the scholarly learning objectives. While standardization and procedural approaches concerning feedback and limited study time seem appropriate for the development of research knowledge and skills, there is friction when applying these in the context of shaping true scholars with academic mindsets.

Two complementary concepts, *Ausbildung* and *Bildung*, illustrate the friction of scholarly learning objectives eminently. *Ausbildung*, achieved through vocational training, provides students mainly with theoretical knowledge and practical skills. Within this context, modules are measurable units of learning and assessment of this learning leads to the awarding of credit. In addition, students learn along a fixed, regulated timely pathway defined by national standards. *Bildung*, on the other hand, involves the process of continuous individual development, shaping, and growth of an academic mindset. This cannot be easily measured, let alone objectively assessed, and its goal is different from provision of knowledge and skills. *Bildung* focusses on the journey (i.e. learning process) rather than the destination (i.e. research product). It is a lifelong process without regulated and fixed learning pathways or measurable and known attainment levels. Pace, tendency, and final attainment levels depend solely on the individual, and flexible learning pathways can support students in their journey. Treating students fairly based on their needs facilitates, supports, and stimulates this growth.

Wilhelm von Humboldt, founder of the modern university, linked the concept of *Bildung* to academic education in the early 1800s. He envisaged university education as a student-centred activity of research. Up until today, medicine is considered to be an academic discipline, taught at university. The word 'university' is derived from the Latin 'universitas magistrorum et scholarium', which roughly means 'community of teachers and scholars'. Von Humboldt believed that universities should enable students to become individuals with an academic mindset by developing their own reasoning powers and choosing their own way in an environment of academic freedom, as he captures in his 'Theorie der Bildung'.[14]

Applying *Ausbildung* and *Bildung* to our national academic research project, *Ausbildung* reflects vocational research knowledge and skills, with standardized educational learning pathways, using objective assessment instruments. Equally important, however, is our aim to shape academic mindsets, in line with Von Humboldt's *Bildung*. As we aim to fairly assess the scholarly development of medical students, learning objectives that can be measured (e.g. research papers), as well as standardized learning pathways are useful. From an *Ausbildung* perspective, objective assessment of knowledge and skills is aligned. *Bildung*, however, hardly seems compatible with standardized educational procedures and objective assessments. *Bildung* implies academic freedom and is supposed to shape students with academic mindsets. It requires a merely formative approach based on academic freedom, flexible learning pathways without fixed study time or limited amount of feedback, and thus, ultimately, assessment *for* learning.

As our examples illustrate, the combined *Bildung* and *Ausbildung* approach in academic courses is reduced to *Ausbildung* only, especially when academic education is strictly regulated and objectively assessed to safeguard so-called fairness. Even more, only educating and assessing *Ausbildung* inevitably spoils and harms *Bildung*. When doing so, we risk to equip future doctors with theoretical knowledge and practical skills only, rather than training doctors with truly academic mindsets. Consequently, harsh tongues talk about marketized regimes of massification, evaluation, accreditation, and quality assurance that limits academic freedom and growth in medical education. In addition, medical students are referred to as malleable and manageable zombies, trained to store knowledge rather than shaping a curious, creative, and critical mindset.[15-17] In line with this, the competency of scholar is being referred to as 'the neglected competency' and medical schools are considered to be 'degree mills' and 'uniformity factories without leaving any room for creative, independent, critical, and confident individuals'.[15-17]

In short, over the past few decades a contradiction has emerged within the field of scholarly competencies, as attempts to standardize the unstandardizable in the name of so-called fair assessment have inadvertently created a disconnect between education and practice. While objectivity is frequently viewed as a prerequisite for fairness and commonly used when designing educational guidelines, protocols and rubrics, our examples illustrate that excessive reliance on objectivity *can* actually undermine fairness as it only measures what can be measured quantitatively.[5,17] We demonstrated that the development of a true academic mindset requires individually tailored discussion and feedback, which cannot be adequately achieved through standardized approaches. Returning to the principle of fairness, objective assessment with standardized learning pathways is considered fair, but in practice learning activities are directed to passing writing assessments rather than training real scholars. Consequently, an objective approach may even result in hampered development of a genuine academic mindset. In this way, objectivity can be considered *un*fair rather than fair.

To rebalance *Ausbildung* and *Bildung* in academic education we should go beyond the assumption that objectivity is a prerequisite for achieving fairness in assessment. We mainly focused on the contradiction and consequences of striving for fairness and objectivity within assessment in the light of developing scholarly competencies, but it is likely to be applicable to the development of other competencies within medical education – or maybe even all educational domains – as well. There has already been an increasing push in the literature to re-set the traditional objective approach and to be more open to an equal role of subjectivity in assessment.[5,17,18] We would like to go one step further and besides changing the focus on fairness in assessment, apply this focus to learning pathways as well.

Scholarly doctors with an academic mindset in the realm of patient care are crucial to ensure, critically appraise, and advance the quality of patient care. To develop genuine academic mindsets within academia, all students deserve to have their unique abilities recognized and be intellectually stimulated at their own level. Therefore, we encourage medical teachers, curriculum coordinators, and faculty members to support diverse, flexible, and individual learning paths, including procedural variation with a more subjective, programmatic approach with feedback and feedforward conversations between a scholarly supervisor and his/her pupil. In practice, this suggests a minimum rather than a maximum of, among others, study time and feedback and less standardized educational procedures in scholarly courses to allow academic freedom to flourish. Shifting the focus from pure objectivity to both objectivity *and* subjectivity in assessment as well as learning pathways can assist in protecting fairness and, as a result, bring back *Bildung* to medical education to ensure future doctors to be true scholars.

References

1. Frank JR SL, Sherbino J. CanMEDS 2015 Physician Competency Framework. Ottawa: Royal College of Physicians and Surgeons of Canada; 2015.
2. Havnaer AG, Chen AJ, Greenberg PB. Scholarly concentration programmes and medical student research productivity: a systematic review. Perspect Med Educ 2017, 6(4):216-226.
3. de Beaufort AJ, de Goeij AFPM. Academic and scientific education in medical curricula in the Netherlands: a programme director's view. Perspectives on medical education 2013, 2(4):225-229.
4. Dekker FW. Achieving research competences through medical education. Perspect Med Educ 2013, 2(4):178-180.
5. Valentine N, Durning SJ, Shanahan EM, van der Vleuten C, Schuwirth L. The pursuit of fairness in assessment: Looking beyond the objective. Med Teach 2022, 44(4):353-359.
6. Green SK, Johnson RL, Kim D-H, Pope NS: Ethics in classroom assessment practices: Issues and attitudes. Teaching and Teacher Education 2007, 23(7):999-1011.
7. Tierney RD. Fairness in classroom assessment. SAGE handbook of research on classroom assessment 2013:125-144.
8. General Medical Council-UK. GMC Tomorrow's Doctors. 2009. Available from: www.gmc-uk.org/Tomorrow_s_Doctors_0414.pdf_48905759.pdf. Accessed 18 July, 2014.
9. Ommering BWC, Wijnen-Meijer M, Dolmans D, Dekker FW, van Blankenstein FM. Promoting positive perceptions of and motivation for research among undergraduate medical students to stimulate future research involvement: a grounded theory study. BMC Med Educ 2020, 20(1):204.
10. den Bakker CR, Ommering BWC, van Leeuwen TN, Dekker FW, de Beaufort AJ. Assessing publication rates from medical students' mandatory research projects in the Netherlands: a follow-up study of 10 cohorts of medical students. BMJ Open 2022, 12(4):e056053.
11. Chang Y, Ramnanan CJ. A Review of Literature on Medical Students and Scholarly Research: Experiences, Attitudes, and Outcomes. Academic Medicine 2015, 90(8):1162-1173.
12. Waaijer CJF, Ommering BWC, van der Wurff LJ, van Leeuwen TN, Dekker FW. Education NSIGoS: Scientific activity by medical students: the relationship between academic publishing during medical school and publication careers after graduation. Perspectives on Medical Education 2019.
13. Bing-You R, Hayes V, Varaklis K, Trowbridge R, Kemp H, McKelvy D. Feedback for Learners in Medical Education: What Is Known? A Scoping Review. Academic Medicine 2017, 92(9):1346-1354.
14. Von Humboldt WHA. Theory of *Bildung*. 2000:57-61.
15. Ologunde R, Di Salvo I, Khajuria A. The CanMEDS scholar: the neglected competency in tomorrow's doctors. Advances in medical education and practice 2014, 5:383-384.
16. Van Engelen B. Wat is er met de dokter gebeurd? Ervaringen en bespiegelingen vanuit de medische arena. Bohn Stafleu van Loghum 2018 (1st edition).
17. Veen M, Skelton J, de la Croix A. Knowledge, skills and beetles: respecting the privacy of private experiences in medical education. Perspect Med Educ 2020, 9(2):111-116.
18. Ten Cate O, Regehr G. The Power of Subjectivity in the Assessment of Medical Trainees. Acad Med 2019, 94(3):333-337.

Chapter 5

Twelve tips for fostering the next generation of medical teachers

Charlotte R. den Bakker
Renée A. Hendriks
Mirjam Houtlosser
Friedo W. Dekker
Adriaan F. Norbart

Medical Teacher, 2021

Abstract

Medical professionals with a special interest in and focus on education are essential to provide good quality education. Despite high numbers of students expressing an interest in teaching, concerns are rising regarding the supply of medical teachers, with few junior educators on the career ladder. To date, only some medical schools offer in-depth courses to students wanting to explore or aspire a career as a specialised medical teacher. We propose twelve tips for an elective course to foster the next generation of medical teachers. This course aims to enhance theoretical foundations and educational practices to cultivate the next generation of medical teachers.

Background

Teaching, patient care and research are the key responsibilities of medical doctors. In addition to teaching as part of good medical practice, doctors with a special interest in and focus on delivering education are needed: they have a pivotal role both as specialised medical teachers as well as educators of future medical professionals.[1] Despite high numbers of students interested in teaching, the shortage of medical teachers combined with few junior educators on the career ladder, is of growing concern.[1,2] The lack of defined career pathways in teaching together with the emphasis on research at the expense of teaching are barriers in the medical teachers' workforce.[1,2] Moreover, expanding student numbers and high expectations of educational quality and outcomes necessitate increasing numbers of scholarly medical teachers.[1]

During medical school, the foundation for the different roles of a medical doctor is being laid. Most curricula have integrated electives to enable students explore medical fields of interest (e.g. research or public health) in-depth.[3] However, similar courses on medical education are scarce.[4] To cater to this need and to fulfil students' requests, we introduced an elective course on medical education for (bio)medical students. Two educational specialists defined essential key concepts for future medical teachers and created an elective to combine the theory and practice of teaching for 15 students yearly. During the years, the course was further developed, expanded, and a module regarding research into medical education was integrated. The latter was refined and coordinated by two medical education PhD candidates. In addition, the medical teaching community of our faculty is key in creating teaching opportunities within their courses, together with sharing their educational expertise as teaching specialists. This course resonates the three pillars of the faculty: clinic, education and research. Key concepts are educational theories, designing education, teaching, and medical education research. This course dives beyond the surface of teaching and includes didactics, pedagogy, psychology, philosophy, and research. Drawing on our experiences, literature, and theories, we propose twelve tips to build your own medical education elective for fostering the next generation of medical teachers.

Tip 1

Catch them young: Motivate students for teaching early in your program

Not everyone is a born teacher. To become a competent medical teacher one needs to develop relevant teaching skills over time. Therefore, we recommend exposing students to teaching principles, theory, and techniques before taking on actual clinical teaching responsibilities. This means the provision of special (i.e. extracurricular or elective) courses in undergraduate programmes, followed by professionalisation through postgraduate education and into practice. Amorosa et al. describe that early teaching opportunities in medical students create awareness of the medical teacher role as part of their medical doctor identity, and thus moves this role from the hidden to the formal curriculum.[5] Early identification with the teacher role might affect career orientation. Literature on enhancement of clinician-scientist career shows that early engagement of students in research triggers enthusiasm, helps to recognize talent, and stimulates future research engagement.[6,7] Although no studies address early engagement in teaching as a means to enhance medical teacher careers, it seems fair to assume that catching potential medical teachers' young has similar effects on future engagement in education.

Tip 2

Put students in the driver's seat

Learner agency and autonomy positively correlate with motivation for learning and student well-being.[8,9] In addition, how teachers interpret and foster autonomy is closely connected to their own learning experiences.[10] To promote autonomy and agency in future medical teachers, it is logical to put students in the driver's seat: make them responsible for their own learning as soon as possible. For example, based on Davidson et al., let students create a 'manifesto'.[11] This manifesto is a set of agreements participants consider to be important throughout the course, e.g. 'be on time or let the group know you are going to be late.' Another way to substantiate a student-centred approach is to grant students instructor rights in the Electronic Learning Environment (grading excepted). Make students responsible for their division into teams for groupwork and time frames for presentations. Additionally, let students design and execute part of the course assessment, and have them add a personal learning goal to the rubric used to assess the course research product.

Tip 3

Discuss epistemology and paradigms of teaching as starting point for students to explore their views on teaching

For aspiring teachers, it is extremely valuable to be familiar with established views and paradigms of knowledge and learning, and how one's own vision relates to those.[12] This can be a tool to explore the teacher they want to be, underpin educational designs, and place feedback on teaching from peers and students in a meaningful framework.[13,14] Ask future medical teachers: 'What is knowledge?', 'How do we gain knowledge?', and 'What is the purpose of education?.' Next, offer insight into differences in assumptions between epistemologies, e.g. objectivism versus constructivism and paradigms of teaching, e.g. behaviourism, cognitivism, and constructivism, and eventually, challenge students to explore what paradigm(s) fits their own thoughts.[12,15] This exploration can be facilitated by dividing a space into several zones that each represent a paradigm, asking students to literally take position where they feel most comfortable, and plenary discussing why. Students discover that peers may find themselves in other paradigms and how this increases mutual comprehension. In our experience medical students are mostly familiar with objectivist assumptions about knowledge and many feel enlightened, after some confusion, when their horizon broadens.

Tip 4

Be an implicit and explicit role model: Practice what you preach and let students in on your own reflection

Role models are people we can identify with, who have qualities we would like to have, and are in positions we would like to reach.[16] Students see teaching role models as being able to provide a constructive learning environment, a good understanding of the curriculum, and an ability to cater to the learning needs.[17] Furthermore, role models influence students' decisions on their future career.[18] Medical teachers can enhance their status as role models by developing a conscious awareness of role modelling.[18,19] This requires teachers to explicitly articulate what aspects they are modelling. They have to practice what they preach, consciously show passion and enthusiasm towards teaching, and explain why they do the things they do. In addition, Benbassat et al. advocates that role models should share their doubts and uncertainties.[20] Especially, when teaching about teaching, instructors should reflect on their personal role as teacher, what it is like to be a teacher, which uncertainties they have, how they deal with complex situations, and how they combine a teaching career with clinical practice. Teachers should emphasize that any question about teaching is welcome. Eventually, this strengthens students' identification with and relatedness to teaching, and possibly a career as medical teacher.

Tip 5

Zoom out and show students the bigger educational picture

Curricular design and complex organizational infrastructures underlying lectures, working groups and timetables are often unknown to students.[21] Geraghty et al. showed that students with curricular organizational involvement appreciate the complexity of medical education and had more favourable views on it.[22] They gain a new perspective:

Although teaching itself is often a one-person job, it is always designed, facilitated and integrated by a team and part of a wider programme in which many people are involved. As a teacher, it is important to realize you are part of this bigger picture and to have a good understanding of curriculum development, other stakeholders and influencing factors. With their knowledge, experiences and competencies, teachers are central to curricular development and the classroom delivery of the curriculum.[23] To make prospective medical teachers appreciate their role in the organization,[22] challenge students to critically evaluate their curriculum. Let students zoom out from their classroom and provide meet and greets with different stake holders, e.g. curriculum coordinators, managers, etc, and discuss history and future of medical schools. In our experience, students learn to see education from different perspectives, and eventually, the bigger educational picture.

Tip 6

Introduce the basics of educational design, learning principles and theories

When constructing courses, alignment of desired learning outcomes, activities and assessment to optimize the effectiveness of learning is pivotal- the principle of constructive alignment.[24] Teachers must have the ability to design learning activities safeguarding this alignment. Therefore, equip students with basic knowledge about educational design, make them familiar with constructive alignment and with different teaching methods, e.g. flipped classroom principles or team based learning, and proper testing (i.e. formative and summative). In addition, introduce 'the first principles of instruction' for learning activities such as: *problem-centeredness, activation, demonstration, application*, and *integration*.[25] Since teachers' conceptions of learning and teaching affect their teaching behaviour[26] and probably their instructional designs, discuss and reflect on important learning theories, e.g. Leary's interaction rose to reflect on teaching experiences, Cognitive Load Theory to reflect on curricular overload, or Self Determination theory to reflect on student's wishes for electives.

Tip 7

Integrate designing for learning: Let students bring learning principles and theories into practice

In line with the previous tip together with the assumption that knowing and doing are inseparable students should design a learning activity based on theories and principles, e.g. sessions for each other with a self-chosen learning outcome.[27] Some may find it difficult where to start as most students are used to a rather tightly structured teacher and content centred curriculum. Provide structure by giving learning goals for this design assignment, examples, suggestions, expert feedback, and continuously express trust in their capabilities. Another relevant hands-on designing element derived from Cathy Davidson includes contributing to the community by sharing what you have learned.[11] We playfully challenge the idea of sharing, and invite students to leave a legacy for their fellow teachers, in which they are completely free to choose what they want the teaching community to have. One group created a printed set of 'icebreaker' cards with concepts they had found in the literature to stimulate discussion about learning and teaching. Another group designed a mini booklet that teachers could put in their pocket, containing useful tips to stimulate interaction in classes, again based upon literature we used in class.

Tip 8

Provide (near-)peer education opportunities

Prospective medical teachers benefit from teaching (near-) peers as this enables them to actually apply their newly mastered knowledge, theories and teaching tools *(tips 3, 4, 6, 7)*. Organizing near-peer education however can be challenging. Convince senior teachers of the added value to let students participate in teaching activities in the core curriculum. Students teaching (near-)peers brings new dynamics to small group teaching sessions. Less experienced, closer to their peers, they offer the learners other learning experiences than the sage on the stage, the expert clinician who knows everything but not necessarily is a good teacher.[28] As a guide on the side, (near-)peer teachers are approachable and have a greater understanding of the learner's perspective on the content at hand.[29] Learning outcomes when taught by (near)peers and faculty are similar.[29] Also, the student-teacher and senior teacher benefit from near-peer teaching constructions, as student teachers are assisted during their first teacher adventures, and senior teachers can step aside as they only need to provide a safety net to ensure students learn what they need to learn. Furthermore, senior teachers are challenged to reflect on the way they teach and contribute to their future workforce.

Tip 9

Provide students with knowledge about technology enhanced learning to prepare them for tomorrow's education

Technology Enhanced Learning (TEL) will definitely stay in the (medical) educational landscape. Enhanced by the COVID-19 pandemic online teaching has become much more standard, but it requires specific knowledge and skills. As such, students need to learn how to develop engaging online teaching activities and have opportunities to practice. Mishra and Koehler explained in their T-pack model that technical, pedagogical, and content knowledge need to be combined to offer proper education.[30] To know what expertise is required for TEL, introduce to students' concepts of blended learning, flipped, synchronous and asynchronous classrooms, and the T-pack model.

An advanced project combining *tips 6, 7 and 8* is to let students choose a TEL tool, for example virtual reality, serious games, or open educational resources. After exploring the possibilities and limitations, they teach a blended or online flipped class about the tool to each other. Finally, students should reflect on their knowledge and skills gain when designing and teaching. They can relate these knowledge and skills to the T-pack model to reach higher levels of learning according to Bloom's taxonomy.

Tip 10

Focus on reflection and involve peers in this process

Reflection is important as it helps teachers to collect, record, and analyse what happened during lessons.[31,32] It allows teachers to move from just experiencing towards understanding, and it is an important source for personal and professional development.[31] Be mindful that students might see their 'self' as teacher, but also still as student. We use microteaching techniques during class to prepare the students for real teaching, e.g. by recording their teaching and reflect on it together with an educational expert and peers.[33] This enables students' opportunities for discovering and reflecting on both their own and other's teaching styles and techniques. We suggest four reflection activities: invite students to reflect on their teacher role at least twice with a tried and trusted model.[34] Ask students to link their reflections to concepts and theories discussed in class to deepen their understanding of these concepts and theories by applying them to their own teaching behaviours and strategies. Encourage students to be creative in both reflection method and medium to stimulate the personal nature of reflection and avoid a 'ticking the box' approach.[35] We received reflective drawings, podcasts as well as written reports. Lastly, let students observe each other while teaching: both the teacher being observed and the observer to improve a teacher's professional practice and development will benefit.[36] This observation provides students with feedback from another perspective, creates opportunities to discuss challenges and successes with trusted colleagues, supports the sharing of ideas and expertise, and builds a community of trust.

Tip 11

Introduce the world of medical education research and let students participate

For medical education practice, teachers that understand and perform educational research are key.[37] In addition to being the foundation of evidence-based educational designs, research offers the tools to innovate and evaluate medical education practice. Most medical schools offer courses on (bio)medical research, but, as educational research lies in the social sciences domain, the toolkit of educational research questions, paradigms, and methodologies needs expansion to fit in and do justice to medical educational contexts.[38] To gain insight into the complexity and value of educational

research, let students create and present an authentic research product, e.g. a written research proposal, or a literature review. To support students in this project offer them journal clubs, workshops about paradigms, quantitative and qualitative methods, and literature search strategies. To guide students during their first steps in the world of medical education research, link them to a supervisor with medical education research experience.[39] Pay special attention to creating a relevant research question that students are interested in, and fitting an appropriate methodology, as students often struggle with this.

Tip 12

Build steppingstones for future educational steps

Once students have successfully completed their first in-depth course in medical education and have gained experience in teaching, they form a dedicated group of teaching assistants, and a talented pool for future medical teachers. As the lack of defined career pathways is one of the barriers in becoming a dedicated medical teacher, it is important to offer not only an elective in medical education but also consider it as a starting point for a medical teachers' career. Thus, offer students possibilities to move forward[40] and invite students to participate in a broad range of teaching activities and faculty activities such as faculty management, quality assurance, module and curriculum design or research in medical education, as a win-win situation for both students and faculty.[41] During four years of running this course in the current format a new community with inspired junior teachers was born, eager and easily approachable to e.g. supervise (bio)medical working groups as side-job, or chair sessions during national medical education conferences. Others are involved in the development of an educational anatomy app funded by the faculty, or work together with educational experts to support course coordinators in blending their education. When feasible, they carry out their research proposal as a credit bearing research experience under supervision of a medical education researcher. Availability of grants and other incentives enabling participation in medical education (research) conferences will further engage students as members of the professional teachers' community. In addition, stimulate students to record teaching experiences and development in a teaching portfolio, and provide intervision opportunities for reflection and to foster coping strategies.[42] The knowledge, skillset, and attitude students have acquired can be formally acknowledged by installing a Student Teaching Qualification, as a steppingstone towards a University Teaching Qualification and a career in medical education.

Conclusion

A targeted elective course in medical education enables students to get inspired before they need to take on their clinical role and consider future specialisation. Moreover, this course helps to recognize promising future colleagues and guide them further into the complex and exciting world of medical education. We are willing to share the education pack we have created, e.g. lesson plans and materials, with the medical teaching community for integration elsewhere.

We consider our undergraduate course on medical education a steppingstone in the career of a medical teacher. Moreover, these twelve tips can be valuable for all involved in developing medical teachers beyond the life of such undergraduate courses, including leaders of intercalated and postgraduate medical education degrees. We believe these tips can help both in designing smaller educational activities as well as extended courses to foster development of medical teachers.

References

1. Kandiah, D.A., Where is the next generation of medical educators? The Medical journal of Australia, 2013. 198(10): p. 534-535.
2. Bartle, E. and J. Thistlethwaite, Becoming a medical educator: motivation, socialisation and navigation. BMC Med Educ, 2014. 14: p. 110.
3. Sobral, D.T., Student-selected courses in a medical school: scope and relationships. Med Teach, 2008. 30(2): p. 199-205.
4. Dandavino, M., L. Snell, and J. Wiseman, Why medical students should learn how to teach. Med Teach, 2007. 29(6): p. 558-65.
5. Amorosa, J.M., Mellman, L.A., and Graham, M.J., Medical students as teachers: how preclinical teaching opportunities can create an early awareness of the role of physician as teacher. Med Teach, 2011. 33(2): p. 137-44.
6. Wolfson, R.K., et al., The Impact of a Scholarly Concentration programme on Student Interest in Career-Long Research: A Longitudinal Study. Acad Med, 2017. 92(8): p. 1196-1203.
7. Ommering, B.W.C., et al., Fostering the physician-scientist workforce: a prospective cohort study to investigate the effect of undergraduate medical students' motivation for research on actual research involvement. BMJ Open, 2019. 9(7): p. e028034.
8. Neufeld, A. and G. Malin, Exploring the relationship between medical student basic psychological need satisfaction, resilience, and well-being: a quantitative study. BMC Med Educ, 2019. 19(1): p. 405.
9. Ryan, R.M. and E.L. Deci, Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. Am Psychol, 2000. 55.
10. Reinders, H. and C. Balçıkanlı, Learning to Foster Autonomy: The Role of Teacher Education Materials. Studies in Self-Access Learning Journal, 2011. 2.
11. Davidson, C.N., The New Education: How to Revolutionize the University to Prepare Students for a World In Flux. 2017: Basic Books.
12. Baker, L., et al., Aligning and Applying the Paradigms and Practices of Education. Academic Medicine, 2019. 94(7): p. 1060.
13. McManus, D.A., The Two Paradigms of Education and the Peer Review of Teaching. Journal of Geoscience Education, 2001. 49(5): p. 423-434.
14. Hendriks, R.A., et al., Teaching modes and social-epistemological dimensions in medical Massive Open Online Courses: Lessons for integration in campus education. Med Teach, 2019. 41(8): p. 917-926.
15. Arbaugh, J.B. and R. Benbunan-Finch, An Investigation of Epistemological and Social Dimensions of Teaching in Online Learning Environments. Academy of Management Learning & Education, 2006. 5(4): p. 435-447.
16. Paice, E., S. Heard, and F. Moss, How important are role models in making good doctors? BMJ, 2002. 325(7366): p. 707-10.
17. Burgess, A., K. Goulston, and K. Oates, Role modelling of clinical tutors: a focus group study among medical students. BMC Med Educ, 2015. 15: p. 17.
18. Mohammadi, E., et al., Enhancement of role modelling in clinical educators: A randomized controlled trial. Medical Teacher, 2019. 42: p. 436 - 443.
19. Passi, V., et al., Doctor role modelling in medical education: BEME Guide No. 27. Med Teach, 2013. 35(9): p. e1422-36.
20. Benbassat, J., Role modeling in medical education: the importance of a reflective imitation. Acad Med, 2014. 89(4): p. 550-4.
21. Gold J, H.H., Hun D. , Understanding medical school leadership: medical teachers as agents of change. In: Dent J, Harden R, Hunt D, editors. Practical Guide for Medical Teachers. . 2017.
22. Geraghty, J.R., et al., Empowering medical students as agents of curricular change: a value-added approach to student engagement in medical education. Perspectives on Medical Education, 2019. 9: p. 60 - 65.
23. Alsubaie, M., Curriculum Development: Teacher Involvement in Curriculum Development. Journal of Education and Practice, 2022.
24. Biggs, J., Constructive alignment in university teaching. HERDSA, 2014. 1:5-22.
25. Merrill, M.D., First principles of instruction. Educational Technology Research and Development, 2002. 50(3): p. 43-59.
26. Jacobs, J.C.G., et al., An international study on teachers' conceptions of learning and teaching and corresponding teacher profiles. Medical Teacher, 2020. 42: p. 1000 - 1004.
27. Rencic, J., et al., Clinical reasoning performance assessment: using situated cognition theory as a conceptual framework. Diagnosis (Berl), 2020. 7(3): p. 241-249.
28. King, A., From Sage on the Stage to Guide on the Side. College Teaching, 1993. 41(1): p. 30-35.
29. Rees, E.L., et al., How does peer teaching compare to faculty teaching? A systematic review and meta-analysis. Med Teach, 2016. 38(8): p. 829-37.
30. Mishra, P. and M.J. Koehler, Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. Teachers College Record: The Voice of Scholarship in Education, 2006. 108: p. 1017 - 1054.
31. Sandars, J., The use of reflection in medical education: AMEE Guide No. 44. Med Teach, 2009. 31(8): p. 685-95.
32. Aronson, L., Twelve tips for teaching reflection at all levels of medical education. Med Teach, 2011. 33(3): p. 200-5.
33. Remesh, A., Microteaching, an efficient technique for learning effective teaching. J Res Med Sci, 2013. 18(2): p. 158-63.
34. Korthagen, F. and A. Vasalos, Levels in reflection: core reflection as a means to enhance professional growth. Teachers and Teaching, 2005. 11(1): p. 47-71.
35. de la Croix, A. and M. Veen, The reflective zombie: Problematizing the conceptual framework of reflection in medical education. Perspect Med Educ, 2018. 7(6): p. 394-400.
36. Sullivan, P.B., et al., Peer observation of teaching as a faculty development tool. BMC Med Educ, 2012. 12: p. 26.
37. Dolmans, D.H. and C.P. van der Vleuten, Research in medical education: pratical impact on medical training and future challenges. GMS Z Med Ausbild, 2010. 27(2): p. Doc34.
38. Blanchard, R.D., A.R. Artino, Jr., and P.F. Visintainer, Applying Clinical Research Skills to Conduct Education Research: Important Recommendations for Success. J Grad Med Educ, 2014. 6(4): p. 619-22.
39. Blanchard, R.D., P.F. Visintainer, and J. La Rochelle, Cultivating Medical Education Research Mentorship as a Pathway Towards High Quality Medical Education Research. J Gen Intern Med, 2015. 30(9): p. 1359-62.
40. Yu, T.C., et al., Medical students-as-teachers: a systematic review of peer-assisted teaching during medical school. Adv Med Educ Pract, 2011. 2: p. 157-72.
41. Dhaese, S., et al., Student participation: To the benefit of both the student and the faculty. Education for Health, 2015. 28(1): p. 79-82.
42. Franzenburg, G., Educational Intervision: Theory and practice. Problems of education in the 21st century. PEC, 2009. p.37-43

Part II: Postgraduate research training

Chapter 6

Comparing medical PhD training programmes around the world: a matter of apples and oranges?

Charlotte R. den Bakker
Marjo Wijnen-Meijer
Jacqueline Bustraan
Friedo W. Dekker
Arnout Jan de Beaufort

Manuscript submitted

Abstract

In this article article we explore and describe medical PhD programmes aiming to train medical doctors as clinician-scientists in ten leading countries in life sciences research (United States of America, United Kingdom, China, Germany, Japan, France, Canada, Australia, Switzerland, and The Netherlands). Although the number of agreements regarding mutual recognition of the medical doctoral degree increase, the structure, requirements and characteristics of these programmes highly differ between and even within countries. As such, transparency of the different medical PhD pathways is crucial, especially with the increasing pace of globalization and exchange in healthcare. Exchanging information about PhD programmes can improve international recognition and quality of medical PhD programmes and degrees and serves (future) PhD candidates, clinician-scientists, supervisors, graduate schools and others involved in medical PhD programmes. Lastly, this could help researchers as well as a global readership to be aware of the importance of context when sharing and interpreting research on medical PhD programmes. To improve interpretation and generalizability of research on this topic, the great diversity in PhD programmes requires authors to comprehensively describe the doctoral setting in future research.

Introduction

A medical PhD programme is a common educational track for medical doctors pursuing a clinician-scientist (MD-PhD) career. A PhD degree (Doctor of Philosophy) is an internationally recognized and highly valued qualification. PhD programmes enable graduates to develop and demonstrate academic leadership, independence, creativity and innovation in research. These programmes are also referred to as the third cycle in the Bologna Process, as a follow up to the first (bachelor) and second (master) cycle, in an attempt to standardize and harmonize higher education systems across Europe.[1] Although all medical PhD programmes around the world aim to train medical doctors as clinician-scientists and the relevance of transparency of medical training increases, insight in similarities and diversity of pathways towards a PhD is currently lacking.[1,2] In this article, we explore various pathways for medical doctoral training, aiming to contribute to transparency by describing generic characteristics and differences, of medical PhD programmes around the world. First, we will further clarify three main reasons why an international comparison of medical PhD programmes is useful.

The first reason is related to the increasing pace of globalization in healthcare, resulting in raising numbers of exchange and migration of medical students, graduates, and specialists.[3-5] This international academic mobility is also one of the main goals of the Bologna Process.[1,6] While many countries around the world have agreements regarding mutual recognition of medical degrees, it is not always clear whether educatitoral contexts can imonal programmes and graduation levels are equal among countries with different higher education systems and career trajectories.[7-11] Furthermore, when countries do not mutually recognize medical degrees, confusion arises when PhD candidates or clinician-scientists experience substantial differences in academic level and must adapt to different medical academic systems.

Another reason to compare medical PhD programmes is the ever evolving medical field as response to the changes in society, healthcare, and challenges of a global workforce, which requires medical education systems to adapt as well.[12,13] In addition, the number of (future) medical doctors that globally enrol in PhD programmes highly increased over the last few decades.[14-22] These developments have various implications for PhD programmes, e.g. regarding funding and academic outcomes.

Lastly, differences in doctoral contexts can impact the interpretation, relevance and transferability of studies on medical PhD candidates and PhD programmes. Hence, insight in medical PhD programmes around the globe can benefit researchers and readers of educational journals in interpreting research outcomes within the context in which they were obtained, and in determining whether the outcomes can be compared and translated to their own context.

Materials and Methods

We compared PhD programmes of the ten leading countries in life sciences research based on the Nature index, an indicator of institutional research performance.[23] The metrics of 'Count and Share' used to order Nature Index listings are based on an institution's or country's publication output (primary research articles) in 82 natural-science journals, selected on reputation by an independent panel of leading scientists. The top ten countries are the United States of America, United Kingdom, China, Germany, Japan, France, Canada, Australia, Switzerland, and The Netherlands. We involved medical experts from our network and used snowballing methods to reach well-informed informants. These key-informants were experienced and practicing medical doctors with almost all having a PhD degree, involved in and/or knowledgeable about medical PhD programmes in their country. In total, 17 medical education key informants (i.e. at least one expert per country) were invited by email between September 2021 and April 2022 to fill in an online survey with open-ended questions (*Appendix C*) on medical doctoral PhD programmes in their respective country.

The three questionnaire topics were:

1. Demographics and career positions of a medical PhD, including positions in the careers of (future) clinician-scientists, motivations and ambitions of doctoral students for research, and the value of a PhD degree within the medical field;
2. Medical PhD programme structures and content, including admission requirements, guidelines, duration, type of programme and employment, and required activities as part of the program;
3. Graduation requirements, including thesis and defense criteria, and degree obtained.

Content analysis was applied to the survey outcomes. All responses were screened independently by two reviewers (CRdB and AJdB) and any discrepancies were resolved by consensus. When answers were insufficient or unclear, participants were again consulted for further clarification.

To strengthen validity and credibility of the results, we additionally searched the literature for country-specific information, particularly context sections of research on medical PhD programmes. However, almost all included studies on medical PhD programmes and PhD candidates within our ten included countries were conducted in a single institute and often lacked a comprehensive description of the doctoral setting.[22, 24-34] In the final stage, key informants were consulted to fact check the results on the situation in their respective country and in some cases for some additional questions for further clarification.

Results

1. Demographics and career position of a medical PhD

1.1 Timing in the clinician-scientist pathway and admission requirements Multiple entry points of a PhD programme within the medical career are described, but generally a PhD takes place during medical school (i.e. MD-PhD program) or early in the clinical career. Unlike in the USA, in most included European countries obtaining a master's degree was not necessarily part of the PhD program, but mostly an entrance requirement. The North American Medical-scientist training programmes (MSTPs) were the first combined MD-PhD programmes launched in 1964 to enhance recruitment to academic medicine. MSTPs are the most common and deemed successful pathway to become a clinician-scientist in North America.[2,32] Hereafter, the combined MD-PhD track (in the UK known as UCL MBPhD track) was incorporated in many medical curricula worldwide and most included countries nowadays offer PhD tracks for medical students as well (Japan, China, Switzerland, The Netherlands, France, the UK). However, in some countries (e.g. the Netherlands and Australia) the majority of doctors usually enter a PhD programme after obtaining a medical master's degree, which is a prerequisite before entering a PhD program. In the Netherlands and Australia a minority of doctors start a PhD programme later in their career, as resident (possible as combined residency-PhD track) or specialist. In France most medical doctors enter a PhD after residency and fellowship, as in the UK where a PhD will usually be undertaken during higher specialist training as final step of medical specialization.[33]

1.2 Ratio of clinicians with or without a PhD degree Key-informants estimate a minority (5% to 30%) of MDs holding a PhD degree. Mostly, the PhD/no-PhD degree ratio differs between specialties (USA, China, Australia, Netherlands, UK). In some countries, for example Australia and the Netherlands, a PhD degree was valued as a selection criterion to get into specialty training. In addition, big differences in PhD degree rates between specialties are described, with highly competitive specialties having more MD-PhDs. Key-informants state that in these countries a subset of medical PhD candidates not pursues a career as clinician-scientist. In Switzerland, up to 20-30 years ago a PhD degree was mandatory to obtain a medical specialty position. Nowadays many Swiss hospitals still expect a PhD for a senior clinical position. Also in the UK many postgraduate medical specialties require a PhD degree for consultant applications. Simultaneously, in some other countries (e.g. Japan) no differences in PhD ratio between specialties exist. In China, the ratio of PhD degrees not only depends on specialty but also highly relies on the degree of urban development, and tiers and types of hospitals. For example up to 90% specialists with PhD degrees are in first-tier city hospitals and none in community hospitals. Also in Canada, many doctors have to do a PhD besides their specialty training to get a job in an urban teaching hospital.

1.3 Motivation for, value of a PhD, and ambition of PhD candidates In all countries a medical PhD for MDs is considered a first step in a clinician-scientist career. Furthermore, also for clinical careers it is highly valued to improve career prospects e.g. salary, job positions, and learning opportunities. Most respondents indicate that they believe a subset of PhD candidates have a strong interest in research, for example in the USA PhD candidates mainly aspire a career as clinician-scientist. However, in other countries (e.g. the Netherlands, Australia, Switzerland, and Germany) it is assumed that a substantial number of PhD candidates is motivated to obtain a PhD as adds to their CV and improve job opportunities (e.g. residency positions) without clinician-scientist career ambitions.[34]

2. Medical PhD programme structures and content

2.1 National guidelines None of the included countries has national guidelines for medical PhD programmes. However, some, e.g. France and UK have a framework for PhD programmes in general. Medical PhD programmes are usually regulated locally, which means that universities have a certain degree of freedom. Almost all institutes incorporate graduate schools that provide guidelines for PhD programmes. Consequently, available guidelines not only varied between countries but also within countries.

2.2 Duration, employment, and (core) activities The duration of medical PhD programmes has no fixed duration and varies by country, with a median time-to-degree of three to five years (full-time) or seven to nine years when combined with an MD degree.[2] For example in Germany, France, and China, the minimum of a PhD programme is three years. China as only country has a maximum duration of five to six years. In the Netherlands, duration of a PhD programme can vary without a fixed duration and depending on multiple variables as funding, type of employment (e.g. full time versus part time or in spare time next to residency), and research type (e.g. laboratory research and clinical research, as well as using an already existing database or set up research studies from scratch). PhD candidates typically receive a monthly income coming from grants, scholarship or salary from the government, graduate school or hospital. Only in Japan a PhD is usually unpaid. In Australia, the Netherlands, and Switzerland a PhD programme can be paid and unpaid, and are often paid less compared to clinical jobs. However, in the Netherlands, a PhD programme in medicine is a higher paying job compared to PhD programmes in other domains. Research is the core activity of PhD programmes. Compulsory educational courses or activities (e.g. teaching) are mostly part of the doctoral requirements. PhD candidates sometimes must complete courses totalling 30 credits during the PhD program. Some PhD candidates are also expected to be involved in clinical tasks, varying between countries, as well as institutes and even departments. In Switzerland, the typical medical PhD is done alongside a clinical training (residency). In the Netherlands a minority of PhD candidates obtains their PhD in their 'spare time' alongside a clinical job as junior doctor, resident, or specialist. In Canada and the USA, the first two years of MD-PhD tracks involve coursework and comprehensive examinations. Hereafter, the PhD students becomes a PhD candidate and most of the remaining time will be devoted to their own research.

2.3 Supervision PhD candidates are always supervised by at least one, but mostly two thesis supervisor(s) and a thesis committee. Most supervisors are professors and/or clinical doctors. The supervisor(s) is/are responsible for mentoring, progress, quality of output, equipment sources, and often funding. Irrespective of availability of supervision criteria, in practice, supervision varies between supervisors.

3. Dissertation & defense

3.1 Requirements for completion In most included countries the dissertation or thesis, as final product of the PhD program, consists of an introduction, multiple published peer-review research articles, and a concluding chapter. However, there are no national dissertation requirements in any of the included countries. Consequently, requirements are determined by institutes and sometimes even depend on the supervisor and, thus, vary in the extent to which requirements with respect to dissertation content are documented.[33] Some countries (e.g. Japan and France) require a minimum of peer-reviewed publications, while other countries have no publication requirements. In addition, most, but not all, institutes have format rules. Sometimes there is a word requirement (e.g. Australia) for the dissertation. In some countries usually one (e.g. China) or three (e.g. the UK) research papers are included as chapter, while other countries require a minimum of four research papers for the thesis. Furthermore, in addition to the freedom institutes have in defining thesis requirements, some supervisors demand more (published papers) (e.g. China and the Netherlands) than required by institutional guidelines. As these are implicit norms and values, it is hard to capture to what extent requirements are determined by the supervisor.

3.2 Dissertation and defense process Dissertation and defense processes of medical PhD trajectories vary from a summative assessment to a formality without failure options. Yet, all defences aim at evaluating the thesis and the candidate's competencies, require the candidate to answer questions, test academic skills, and form the final (ceremonial) test of the PhD. In most countries, a panel of experts questions the candidate during a traditional oral defense ceremony, in some countries (e.g. the UK) called 'viva voce' (Latin for 'living voice'). The performance during the defence is part of the overall assessment of the thesis. Mostly, e.g. in China, France, and the Netherlands, an (sometimes blinded) examination prior to the oral defense is done to assess if all requirements have been met, with the decision whether the dissertation meets the institutional standard. This assessment of the dissertation is done by a reading committee of experts in the field of interest and critically study and approve the thesis. Hereafter, it is unusual to fail during the oral defense, as the thesis supervisor, research team and reading committee usually warrant the quality of the research. The oral dissertation is open to the public in some but not all universities and lasts one or more hours. Other countries (e.g. the UK) consider the dissertation and defense as an assessment of learning (summative assessment) with dissertation outcomes as pass or fail possibly with minor or major revisions and resubmission of the thesis.

3.3 Names of degree obtained Medical PhD programmes award different degrees in different countries, with some countries awarding a Doctor of Philosophy (PhD) degree, which is similar to the PhD degree (e.g. USA, the Netherlands, and China). In Australia and the UK, an alternative degree (Master of Philosophy) can be awarded depending on the quality of the thesis and dissertation. The Master of Philosophy (MPhil) is also a research degree, but its scope is more limited. In Japan a successful dissertation leads to a teaching assistant degree. Even so, in Germany and German speaking universities in Switzerland different degrees exist. Thus, medical PhD programmes include different pathways with different degrees in some countries while being considered as synonyms in other countries. Unlike in the Anglo-Saxon model, German medical doctors do not receive a default MD degree with graduation. The Doctor degree (Dr. Med.) is in Germany awarded after a medical PhD programme and most medical doctors obtain this degree. However, this is not comparable to a Doctor degree in other countries, as it is obtained during medicine school consisting of mostly one research paper which generally takes 6-12 months. Therefore, usually, this degree is not recognized in the USA or elsewhere as a PhD degree. After the Dr. Med. degree, medical doctors can obtain a PhD (Dr. Phil.), which requires multiple years of research and publications. As we aimed to compare medical PhD programmes we included information regarding the German PhD programme that is rewarded with a Dr.Phil. degree only and excluded information on the doctoral training programme leading to a Dr.Med. degree.

Discussion

The purpose of this paper was to explore and describe pathways of doctoral training in medicine. Medical PhD programmes around the world intend to train clinician-scientists and several agreements on mutual recognition of a PhD degree exist. Nevertheless, our results show a rich variety in the structure, content, length of and timing in the medical career, and in thesis criteria. Institutions have a high degree of freedom in designing their PhD programmes and by that each programme can be unique and may have its own specific requirements and focus. Consequently, different pathways may lead to different qualities and outcomes, but are rewarded with a similar degree (i.e. PhD). Accordingly, not *all roads may lead to Rome* and the definition and value of 'the medical PhD' is challenging to capture on national level, let alone on an international level.

It is important to realize that the variety of medical PhD programmes mirrors the diversity of MD training programmes and specialty training programmes around the globe. Wijnen-Meijer et al. provided an overview of medical training formats across over 100 different countries to address issues regarding increasing globalization in healthcare and mutual recognition of medical professional diploma.[9,10] The authors conclude that, even when countries mutually recognize diplomas, names of stages and degrees do not fully explain the education received and final level of training at graduation. This is in line with our results showing a great variety in medical PhD pathways. Thus, a PhD degree does not necessarily imply equivalency of learning outcomes of all qualifications at the same medical education level.

Within the European Union, there is a push towards developing a uniform format for the doctoral defence.[35] After the Brexit, these discussions are resumed. A study by Lantsoght on differences and similarities of general doctoral defence formats included 26 countries and, in line with our study based on 10 countries, found a great variety in defence formats, also between EU countries participating in the Bologna Process.[36] The large difference between the 'viva voca' format in the UK and the continental public defence is considered a barrier in developing a uniform format. Lantsoght revealed four main building blocks of doctoral defences as explanation for differences observed between defence formats. In addition the authors conclude that these blocks may contribute to the discussion on a (more) uniform defence format with the EU, including defences within the medical field. These building blocks include (1) publication of the thesis before or after the defence, (2) number of steps in the defence (e.g. private defence followed by a public defence), (3) public defence or behind closed doors, and (4) fixed time schedule for the defence or examination until satisfaction of the committee.

Despite attempts to harmonize medical education interesting one could question whether it is desirable and possible to increase the uniformity of medical doctoral training and if uniformity is a prerequisite for international mobility.[1,7,8,37,38] März and colleagues studied intended learning outcomes for all three Bologna cycles and found a high degree of consensus, especially for the third Bologna cycle (PhD).[39] Yet, we observed a large diversity in PhD programmes around the globe which underlines the relevancy to explicitly communicate differences. We believe the observed diversity in PhD programmes around the globe underlines the relevancy to explicitly communicate differences. Furthermore, this transparency should be the foundation for migration and globalization. In this way, quality of PhD programmes, mutual recognition, exchange of (future) clinician-scientists, and generalizability of research on medical PhD candidates and PhD programmes can be improved.

This study has some limitations. Our study was a first attempt to make an overview and comparison between training pathways of clinician-scientists in ten leading countries in life sciences research. However, the wealth and variety in conceptual, practical, and structural aspects of PhD programmes, including the (apparent) large variety, cannot be done fully justice within the space limitations of a descriptive article like ours. Our article describes medical PhD pathways at this moment, while medical education keeps changing. Furthermore, a limited number of key-informants, with some countries only including one key-informant, may lead to a certain level of subjectivity. However, we believe that the conclusion of our paper will hardly change after including more informants. We suggest future research providing an in-depth overview of differences and similarities including more countries and other aspects of PhD programmes (e.g. achieved competencies) in medical education.

To summarize, despite medical PhD programmes share a common goal (i.e. training clinician-scientists), the pathway to a PhD degree highly varies among countries. Even between institutes of countries, between departments within institutes, and between research teams within departments, PhD pathways differ. This also applies in countries that mutually recognize each other's degrees, for example those participating in the Bologna Process. This great diversity in pathways towards a PhD degree require improved transparency of PhD programmes to benefit mutual recognition of PhD degrees, quality of PhD programmes, and mobility of the medical academic workforce as a response to globalization. Furthermore, it requires awareness of both the global readership and researchers regarding the importance of context when sharing and interpreting previous and future research on medical PhD programmes.

References

1. Patricio, M. and R. Harden, The Bologna Process – A global vision for the future of medical education. Medical teacher, 2010. 32: p. 305-15.
2. Alamri, Y., The combined medical/PhD degree: a global survey of physician-scientist training programmes. Clinical medicine (London, England), 2016. 16(3): p. 215-218.
3. Hallock, J.A., D.W. McKinley, and J.R. Boulet, Migration of doctors for undergraduate medical education. Med Teach, 2007. 29(2-3): p. 98-105.
4. OECD, Recent Trends in International Migration of Doctors, Nurses and Medical Students, OECD Publishing, Paris, https://doi.org/10.1787/5571ef48-en. 2019.
5. Garba, D.L., et al., How Do We Decolonize Global Health in Medical Education? Ann Glob Health, 2021. 87(1): p. 29.
6. Christensen, L., The Bologna process and medical education. Medical Teacher, 2004. 26(7): p. 625-629.
7. ASEAN. ASEAN (Association of South East Asian). 2020. ASEAN Qualifications Reference Framework (AQRF) – Referencing Guideline. Retrieved October 19, 2022, from

   www.asean.org/wp-content/uploads/2017/03/AQRF-Referencing-Guidelines-2020-Final.pdf. 2020.
8. UNESCO, Director-General, 2017- (Azoulay, A.). Global Convention on the Recognition of Qualifications concerning Higher Education. Retrieved October 19, 2022, from www.unesdoc.unesco.org/ark:/48223/pf0000373602.locale=en. 2020.
9. Wijnen-Meijer, M., et al., Stages and transitions in medical education around the world: Clarifying structures and terminology. Medical Teacher, 2013. 35(4): p. 301-307.
10. Wijnen-Meijer, M., M. van den Broek, and O. ten Cate, Six Routes to Unsupervised Clinical Practice. Academic Medicine, 2021. 96(3): p. 475.
11. Byrne, M.H.V., et al., All medical degrees are equal, but some are more equal than others: An analysis of medical degree classifications. Med Educ, 2023.
12. Philibert, I. and D. Blouin, Responsiveness to societal needs in postgraduate medical education: the role of accreditation. BMC Medical Education, 2020. 20(1): p. 309.
13. Emanuel, E.J., The Inevitable Reimagining of Medical Education. JAMA, 2020. 323(12): p. 1127-1128.
14. Reinink, M. PhD Explosie. Retrieved August 28, 2022, from www.artsenauto.nl/phd-explosie/. 2019.
15. Andreassen, P. and M.K. Christensen, Science in the clinic: a qualitative study of the positioning of MD-PhDs in the everyday clinical setting. BMC Med Educ, 2018. 18(1): p. 115.
16. Andreassen, P., L. Wogensen, and M.K. Christensen, The employers' perspective on how PhD training affects physicians' performance in the clinic. Dan Med J, 2017. 64(2).
17. Eley, D.S., The clinician-scientist track: an approach addressing Australia's need for a pathway to train its future clinical academic workforce. BMC medical education, 2018. 18(1): p. 227-227.
18. Traill, C.L., et al., Time to research Australian physician-researchers. Internal Medicine Journal, 2016. 46(5): p. 550-558.
19. Castelló, M., et al., Why do students consider dropping out of doctoral degrees? Institutional and personal factors. Higher Education, 2017. 74(6): p. 1053-1068.
20. Litalien, D. and F. Guay, Dropout intentions in PhD Studies : a comprehensive model based on interpersonal relationships and motivational resources. Contemporary Educational Psychology, 2015. 41: p. 218-231.
21. Shin, M., A. Goodboy, and S. Bolkan, Profiles of doctoral students' self-determination: susceptibilities to burnout and dissent. Communication Education, 2021.
22. de Guzman Strong, C. and L.A. Cornelius, Preparing the next generation in academic medicine: recruiting and retaining the best. J Invest Dermatol, 2012. 132(3 Pt 2): p. 1018-25.
23. Nature Index www.nature.com/nature-index/annual-tables/2021/country/life-sciences/all Accessed 5 December, 2021.
24. Chakraverty, D., J.E. Cavazos, and D.B. Jeffe, Exploring reasons for MD-PhD trainees' experiences of impostor phenomenon. BMC Medical Education, 2022. 22(1): p. 333.
25. Ahn, J., et al., MD-PhD Students in a Major Training programme Show Strong Interest in Becoming Surgeon-Scientists. Clinical Orthopaedics and Related Research®, 2004. 425: p. 258-263.
26. Andriole, D.A., A.J. Whelan, and D.B. Jeffe, Characteristics and career intentions of the emerging MD/PhD workforce. Jama, 2008. 300(10): p. 1165-73.
27. Kuehnle, K., D.T. Winkler, and P.J. Meier-Abt, Swiss national MD-PhD-program: an outcome analysis. Swiss Med Wkly, 2009. 139(37-38): p. 540-6.
28. Kusurkar, R., et al., What stressors and energizers do PhD students in medicine identify for their work: A qualitative inquiry. Med Teach, 2022. 44(5): p. 559-563.
29. Kusurkar, R., et al., Burnout and engagement among PhD students in medicine: the BEeP study. Perspect Med Educ, 2021. 10(2): p. 110-117.
30. Kwan, J.M., et al., Exploring intentions of physician-scientist trainees: factors influencing MD and MD/PhD interest in research careers. BMC Med Educ, 2017. 17(1): p. 115.
31. Skinnider, M.A., et al., Predictors of sustained research involvement among MD/PhD programme graduates. Med Educ, 2018. 52(5): p. 536-545.
32. Stewart, G.W., An MBPhD programme in the UK: the UCL experience. Clinical Medicine, 2012. 12(6): p. 526-529.
33. van Galen, L. and J. Wachelder, Cruising through the journey without getting drowned: The saga of a PhD student in the Netherlands. Acute Med., 2017. 16: p. 43-45.
34. Pathipati A S, T.N., Research in Medical School: A Survey Evaluating Why Medical Students Take Research Years. Cureus 8(8): e741. DOI 10.7759/cureus.741.
35. Goulding, N. and A. Geraghty, Standards for PhD Education in Pharmacology in the UK. Turkish Journal of Biochemistry, 2011. 36: p. S19-S25.
36. Lantsoght, E.O.L., Doctoral defence formats. Studies in Higher Education, 2022: p. 1-13.
37. WFME. Basic Medical Education WFME Global Standards for Quality Improvement – The 2020 Revision. (PDF) Public availability of information from WFME-recognized accreditation agencies. Available from: https://wfme.org/wp-content/uploads/2020/12/WFME-BME-Standards-2020.pdf Accessed 6 October 2022 2020.
38. Weisz, G. and B. Nannestad, The World Health Organization and the global standardization of medical training, a history. Global Health, 2021. 17(1): p. 96.
39. Marz, R., et al., Tuning research competences for Bologna three cycles in medicine: report of a MEDINE2 European consensus survey. Perspectives on Medical Education, 2013. 2(4): p. 181-19

6

Chapter 7

Inspecting the leaky clinician-scientist pipeline: a national study on medical PhD candidates' motivations in the Netherlands

Charlotte R. den Bakker
Belinda W.C. Ommering
Arnout Jan de Beaufort
Friedo W. Dekker
Jacqueline Bustraan

Manuscript submitted

Abstract

Introduction The number of medical doctors embarking on a PhD trajectory, considered to be the most common educational track for clinician-scientists training, has tremendously increased. Meanwhile, the clinician-scientist pathway is often referred to as 'the leaky pipeline' as a subset drops out during a PhD or becomes scientifically inactive soon after obtaining a PhD, contributing to the clinician-scientist shortage. This study investigates PhD candidates' quantity and type of motivation and the relation to its determinants and perceived doctoral outcomes, aiming to gain better insight in the leaky clinician-scientist pipeline.

Methods In total, 1509 medical PhD candidates participated in this nationwide cross-sectional questionnaire study based on well-established motivational theories. They were questioned about their motivations for a PhD, expectancies of success, values, work engagement, (expected) delay, drop-out intentions, and clinician-scientist career ambitions.

Results One out of seven (14%) PhD candidates has very low to low autonomous motivation for a PhD and of all PhD candidates with high to very high autonomous motivation almost a quarter had high to very high controlled motivation for a PhD as well. Autonomous motivation was related to higher work engagement, lower drop-out intentions, and more clinician-scientist career ambitions, while controlled motivation was inversely related to these perceived doctoral outcomes.

Conclusions Both quantity and type of motivation are relevant factors in the leaky clinician-scientist pipeline. To train and retain clinician-scientists it is crucial to focus on fostering autonomous motivation and mitigating controlled motivation in (potential future) PhD candidates. This could be achieved by (1) (potential future) PhD candidates carefully reflecting on their expectancies, values, motivational profile and corresponding perceived doctoral outcomes, (2) PhD candidates and their supervisors investing in well-known drivers for autonomous motivation during the PhD programme, such as research self-efficacy, autonomy and relatedness, (3) challenging programme directors on their perceived value according to (potential future) PhD candidates, more specifically inviting programme directors to explicitly and critically appraise the value of a doctoral profile within their specialty, and (4) flexibility in research career pathways including entering a PhD later on during a clinical career or engagement in research on other levels than a full PhD.

Introduction

Clinician-scientists play a vital role in advancing healthcare. They are key in bringing research from bedside to bench and vice versa. A continuous inflow of newly educated clinician-scientists is essential to ensure scientific developments. However, a decline in clinician-scientists is of growing global concern. This decline is often referred to as the result of 'the leaky pipeline' in the pathway of becoming a clinician-scientist.[1-3]

Development of potential clinician-scientists is a continuum that starts early: in medical curricula, students are introduced in academic and scientific training often right from the beginning of their study. In the following years, students and graduated junior doctors dive in the medical domain and start developing their professional identity, including perceptions on whether doing research fits their talents and ambitions and the value of research within the field and community they aspire to become part of.

Previous studies have focused on the early stage of this continuing pathway by looking at interventions to foster research interest in initial phases of medical training, aiming to inspire medical students for a clinician-scientist career.[4-6] This approach may be deemed successful, as the number of graduates entering a medical PhD programme, which is considered a common pathway in training clinician-scientists, has increased worldwide. For example, in the Netherlands, the number of medical dissertations has increased by 263% over the past 20 years.[7] Danish universities enrol approximately 60% more MD-PhD students compared to 2006,[8,9] and similar trends in doctoral admissions are also seen outside the European Union e.g. in Australia, Canada and the USA.[10-14] However, despite this tremendous increase in graduates entering the clinician-scientist pipeline, the number of MD-PhDs actually working as clinician-scientists has declined in the past few decades.[1-3]

A PhD can be a long, bumpy, and challenging journey.[15-17] Some candidates drop out during this journey,[13,18] for example due to lack of time, support, and supervision, questionable research practice, and poor well-being.[16,19,20] The average completion rate of Dutch PhDs in healthcare is around 75%,[21] which is relatively high compared to PhD completion rates in other countries.[13-15,22] Furthermore, many of those completing their PhD do not aspire academic positions and become scientifically inactive shortly after obtaining a PhD.[11,23-28] Perhaps, motivations for a PhD may not match the actual experience or intended outcomes and, hence, contribute to the leaky pipeline. Moreover, medical doctors with a PhD degree possibly are at an advantage in future career steps, as programme directors frequently use a PhD degree in the selection for postgraduate training programmes[29-31] or subspecialty and consultant positions.[26] Some studies state that a PhD degree is nowadays simply an instrument to get into (sub)specialty training and that doctors, especially in highly competitive specialties[27,32,33] enter a PhD programme to 'tick the box', without really having the ambition for a clinician-scientist career. At the same time, one may argue that a PhD can still be considered valuable for clinicians even if they are not active as clinician-scientists. However, a systematic review by Zuckerman described that previous research experience or output predicts future research performance, but does not predict other areas of residency success.[34]

To date, little is known what motivates the growing group of junior doctors that pursue a PhD degree. Motivation is defined as the process whereby activities are *initiated* and *sustained*.[35] Within (doctoral) education, motivation has been proposed as a determinant of degree completion and (further) academic performance.[13,36,37] Some studies have qualitatively investigated motivation of PhD candidates focussing on exploring motivations for obtaining a PhD.[38-43] However, in line with the qualitative approach, these studies did not provide insights into the extent to which these motivations exist on a larger scale. Few quantitative studies on PhD candidates' motivation exist. Most of these studies are conducted over 15 years ago, in non-medical settings, or conceptualized motivation as a single dimension lacking a valid theoretical framework and, consequently, are barely transferable to current medical PhD candidates.[27,44-49] Therefore, our study aims to contribute to the dialogue on the leaky clinician-scientist pipeline by inspecting both the quantity and type of motivation, how motivation is formed and what outcomes are related to motivation among those who are currently in the PhD pipeline.

We use Self-Determination Theory (SDT) and Expectancy-Value Theory (EVT) as theoretical lenses.[35,50,51,52] SDT and EVT are well-established theories of motivation and can be complementary.[53,54] Combining both theories can unravel different qualities of motivations of those who actually started and currently are in the PhD pipeline (using SDT), whereas EVT supports additional exploration of what expectations and values 'came and counted' *before* these participants actually entered the PhD pipeline and how these theoretical determinants might relate to different qualities and quantities of motivation.

The SDT is commonly used as framework to investigate the complex nature of motivation.[48,50] According to this theory, motivation is a multidimensional concept which consists of various qualities that regulate behaviour and can coexist within an individual. Moreover, SDT distinguishes two broader categories: (1) *autonomous motivation* (AM) consisting of intrinsic, integrated and identified regulation, and (2) *controlled motivation* (CM) consisting of introjected and external regulation. Intrinsic regulation is the most autonomous type of motivation and is an incentive to engage in a PhD that derives from pleasure and genuine interest in the research itself. In contrast, external regulation is the most controlled type of motivation and refers to engaging in a PhD as a means to an end that is separate from the activity itself, for example to obtain a reward (e.g. a desired job position). AM has been

reported to be associated with positive outcomes in education, such as intention to persist and subjective well-being, whereas CM is associated with negative outcomes, such as anxiety and lower positive affect.[55-57]

To gain insight into the process before embarking on a PhD, we applied EVT, which offers a framework for better understanding the motivation behind *initiating* a specific task. In our study, we focused on the motivation to initiate a PhD trajectory.[35,51,52] According to this theory, motivation to initiate and sustain in activities is a sequel of expectancies of success and perceived task values. Expectancy of success is the degree to which individuals believe they will be successful if they try, also referred to as self-efficacy.[58] Perceived task values include intrinsic value (i.e. enjoyment gained from doing the task itself) and utility value (i.e. perceived usefulness of the task for realizing one's long-term goals), attainment value (i.e. personal importance of doing well on the task), and costs (i.e. competition with other goals). In some versions of EVT, costs are considered as separate components rather than sub-components, or are not considered at all.[59] If both – expectancies and values – are lined up well, it is expected that a person initiates the task.

It is important to understand both how and to what extent PhD candidates are motivated (from the perspective of SDT), as well as how motivational types (i.e. AM and CM) and quantity relate to its determinants (based on EVT) and factors potentially influencing staying or leaving the clinician-scientist pipeline (i.e. doctoral outcomes) (*Figure 1*). Doctoral outcomes include *(expected) delay, work engagement, drop-out intentions,* and *clinician-scientist career ambitions*. Work engagement and burn-out have typically been found to be negatively related to each other.[60,61] This means that PhD candidates experiencing high levels of work engagement are likely to experience low levels of burn-out and vice versa. In addition, burn-out during doctoral studies is related to doctoral study delay and drop-out intentions[15,62], while engagement in doctoral studies has been shown to be positively related to study progress and negatively related to drop-out intentions.[12]

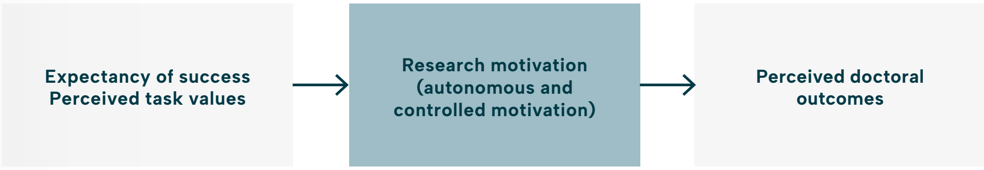

Figure 1. *Overview of tested study constructs according to the theoretical framework*

In this study, we aim to answer the following research questions:
1. Do expectancy of success and values affect types and quantities of motivation of medical PhD candidates?
2. What is the effect of types and quantities of motivation on perceived doctoral outcomes?
3. What are the differences in types and quantities of motivation of PhD candidates in different positions in their careers (e.g. doctors not in training and medical specialists), in different doctoral phases, and in less competitive versus highly competitive specialties?
4. What motivational profiles can be identified and quantified among medical PhD candidates, and how do they relate to determinants of motivation and perceived doctoral outcomes?

Inspecting the leaky pipeline with a focus on types and quantities of PhD candidates' motivation could optimize attracting academically aspired candidates to enter and stay in the clinician-scientist pipeline. In addition, graduate schools and PhD supervisors can benefit from a better understanding of why the pathways of PhDs differ based on different motivations and how these motivations are related to pre-PhD expectancy of success and values, as well as perceived doctoral outcomes.

Methods

Design and setting

We performed a cross-sectional nationwide questionnaire study among Dutch medical PhD candidates. Once the choice is made to pursue a PhD degree there are three main ways to get into a PhD programme: (1) most common in the Netherlands, and similar to for example Australia and the UK, is after graduation and before applying for a specialty training position. Most junior doctors start to gain work experience as a doctor not in training (DNIT) or apply for a position as PhD candidate before or after their clinical work experience; (2) a smaller part applies already as medical student to start a parallel MD-PhD track and graduate as MD and PhD; (3) residents already in training or medical specialists can participate in a PhD programme, but this includes a minority. Some doctors combine their clinical job as a DNIT, resident or medical specialist with obtaining a PhD degree in their spare time, while others take a break from their clinical job to obtain a PhD degree. Most PhD candidates are paid as regular employees, except those obtaining a PhD in their spare time next to a clinical job.

Recruitment and data collection

In the Netherlands, academic medical centres have Graduate Schools (n=8) that facilitate all medical PhD programmes. PhD candidates are admitted to a Graduate School until

completion of their dissertation. We obtained informed consent from all eight medical schools for contacting all medical PhD candidates. All eight Graduate Schools sent an online survey that included two reminders to their medical PhD candidates. To reach Dutch medical (future) doctors who are obtaining their PhD degree, Graduate Schools only invited medical PhD candidates with a Dutch nationality and a (future) medical degree. PhD candidates consented to participate by clicking on the link after reading study information. They were informed that their response data would not be linked to any other personal data. Participation was voluntary, anonymous, and without incentive. Data were collected from April 2021 to June 2021.

Development of questionnaire

The first part of the online questionnaire (*Appendix D*) consisted of demographics. This included age, gender, personal characteristics (e.g. position before starting a PhD, specialty (preference)), and doctoral characteristics (e.g. progression, (expected) delay). The second part consisted of the following constructs (1) determinants of motivation (i.e. expectancy of success and values), (2) motivation (i.e. autonomous and controlled motivation), (3) perceived doctoral outcomes (work engagement, (expected) delay, drop-out intention, clinician-scientist career ambition). We used a stepwise approach for survey scale design in medical educational research.[63] Scales were mostly based on existing validated scales with adjustments to fit the context of Dutch medical PhD candidates (e.g. replacing study or work for PhD).

Expectancy of success & perceived task value The expectancy of success scale consisted of three items about the belief in one's ability to successfully conduct research (perceptions of competence), previously validated and used in studies on medical students' motivation for research in the Netherlands, with a reported Cronbach's alpha of .86.[64] As a validated perceived task value scale is lacking in the current literature, this scale was self-constructed to identify how PhD candidates perceived the value of a PhD in the medical field. Bryan et al. qualitatively identified four domains of doctoral value: personal, social, skills, and career.[38] Career values were twofold, as they could relate to medical *or* research careers. Interviews with stakeholders revealed societal (i.e. doctoral studies benefit society) and external values (i.e. the perceived value of colleagues in the same specialty). We converted these perceived task values into items and validation resulted in three factors, labelled according to the EVT: (1) skills, personal, and societal value were labelled as *intrinsic and attainment value*, (2) clinical career values and external values were labelled as *medical utility value*, and (3) social and clinician-scientist career value were labelled as *research utility value*.

Motivation The Motivation for PhD Studies Scale (MPhD), developed and validated by Litalien et al., was used to measure motivation for a PhD, consisting of different qualities of motivation according to SDT.[48] Adjustments and additions were made based on the suggestions of Litalien, literature, and interviews to fit the Dutch medical doctoral context. This scale included the following subscales: intrinsic motivation (five items), integrated regulation (four items), identified regulation (five items), introjected regulation (three items), and external regulation (10 items), which were further merged as autonomous and controlled motivation. Factor analysis did not materially differ between the MPhD scales and modified MPhD scales. To approach motivation as a multidimensional construct and explore the association between expectations, values, and perceived doctoral outcomes, we created motivational profiles. To the best of our knowledge, no previous studies have described MPhD cut-off values. Therefore, we arbitrarily classified very low to very high motivation based on a 7-point Likert scale.

Perceived doctoral outcomes It has been suggested that work engagement is indicative of an optimal PhD experience characterized by vigor, dedication, and absorption.[60,65] To measure work engagement, we included a short version (9 items) of one of the most internationally used instruments to assess work engagement: the Utrecht Work Engagement Scale (UWES-9).[66] Again, slight adjustments were made to fit the medical doctoral context (e.g. replace 'job' for 'PhD trajectory'). The drop-out intention scale consisted of four items inspired by the Turnover Intention Scale 6 (TIS-6) and interviews.[67] Delay and (further) expected delay were both measured as a single item. Lastly, the clinician-scientist career ambition scale was constructed based on the literature and interviews, as the literature lacks a validated scale. All items were translated into Dutch using a forward-backward procedure. PhD candidates had to indicate their answers on a 7-point scale (1=strongly disagree, 7=strongly agree). Exploratory factor analysis showed sufficient validation of these constructs.

Data analysis

All statistical analyses were performed using IBM SPSS Statistics 25. First, Cronbach's alpha and mean scores for every scale were calculated. Descriptive statistics were used for demographics. Hereafter, we performed linear regression analyses to investigate both crude and adjusted relations between motivation and its determinants and perceived doctoral outcomes (*RQ 1 and 2*). We performed complete case analysis and adjusted for potential common causes. Unpaired t-tests were used to explore motivational differences between PhD candidates in different positions (e.g. DNIT and medical specialist), in different doctoral phases, and in less competitive versus highly competitive specialties (*RQ 3*). To differentiate between less and highly competitive specialties a Dutch report 'De keuzemonitor Geneeskunde' was used, including specialty preferences of Dutch medical students during the year of graduation compared to the corresponding capacity of specialty training positions advised by the Advisory Committee on Medical Manpower Planning (ACMMP).[64,69] Finally, we quantified motivation as a multidimensional construct (AM combined with CM)

as it occurs in practice within medical PhD candidates and investigated how these profiles relate to both determinants and perceived doctoral outcomes (*RQ 4*).

Ethical Approval

The Educational Institutional Review Board of Leiden University Medical Center approved this study (reference number OEC/ERRB/20210112/1).

Results

Demographic results

In total, 1509 PhD candidates filled in our survey (response rate ≈ 42%), 1398 participants completed the survey. *Table 1* presents the demographics of the participants. Of all respondents, 70% were female and 29.7% were male, reflecting the female/male ratio of Dutch medical students. The average age was 29.8 years (SD 4.4, ranging from 22-64 years). More than 80% of the PhD candidates were MD-PhD student or DNIT with/without clinical experience (i.e. not resident or medical specialist yet) and at the time of questioning 76% of them had not obtained a specialty training position (yet). MD-PhD students and DNITs were mostly (84%) aspiring a highly competitive specialty prior to their PhD and 1 out of 5 (20%) had changed their specialty preference at the time of the survey. Most PhD candidates (84%) were employed as PhD candidate, with one out of ten candidates doing a PhD parallel to their clinical job. The formal length of their PhD programmes was on average 46 months (SD 19.9). Almost one out of five participants (18.6%) participated while their formal end date was passed without defending their thesis yet. Participants completed 33 months of their PhD trajectory (SD 24.6) and 2.2 articles (SD 2.4) were accepted.

Table 1. *Demographics of participating Dutch medical PhD candidates*

Demographic variable	Categories	N	%
Gender	Female	1061	70.3
	Male	448	29.7
Job position before PhD	Medical student	170	11.3
	Doctor not in training with clinical work experience	621	41.1
	Doctor not in training without clinical work experience	454	30.1
	Resident (hospital based specialty)	161	10.7
	Resident (non-hospital based specialty)	20	1.3
	Medical specialist	83	5.5
Employed (paid) or unemployed (unpaid) PhD trajectory	Employed as a PhD candidate as MD-PhD student / doctor (not) in training / medical specialist	1260	83.5
	Unemployed as a PhD candidate as doctor (not) in training / medical specialist	173	11.5
	Other	76	5.0
Specialty preference prior to PhD	Less competitive	136	11.2
	Highly competitive	1021	84.2
	Don't know yet	56	4.6
Changed specialty preference during PhD	Yes	910	75.0
	No	303	25.0
PhD progression related to formal end date	0-25%	269	17.8
	25-50%	285	18.9
	50-75%	263	17.4
	75-100%	323	21.4
	>100%	281	18.6
	No clear/fixed start and/or end date or missing	88	5.8
Accepted papers	0	471	32.4
	1	263	18.1
	2	206	14.2
	3	170	11.7
	4	111	7.6
	≥5	231	15.9
	Unknown	57	3.8

Motivations with related determinants and perceived doctoral outcomes

Table 2 shows the descriptive values of the variables including means and Cronbach's alpha ranging from .67 to .93. As expected, Cronbach's alpha of the Motivation for PhD Studies Scale increased when self-constructed items were added.

Table 2. *Variable descriptives based on a 7-point Likert scale*

Theoretical predictor or doctoral outcome	Cronbach's alpha	Items (n)	Mean score (SD)	Item example
Expectancy of success	.91	3	5.00 (0.97)	*I feel competent enough to do research as a PhD candidate.*
Research utility value	.67	4	5.63 (0.76)	*A PhD is an important step towards a career as clinician-scientist.*
Medical utility value	.75	5	5.16 (0.97)	*A PhD increases the chance of future jobs (e.g. residency position, fellowship, job as medical specialist).*
Intrinsic & attainment value	.80	7	5.45 (0.78)	*Obtaining a PhD makes you more resilient as a person.*
Autonomous motivation	.86	14	4.92 (0.85)	*I am doing a PhD for the satisfaction I feel when I surpass myself in my PhD activities.*
Controlled motivation	.84	15	3.34 (1.01)	*I am doing a PhD for the prestige associated with a PhD.*
Work engagement	.93	9	4.56 (1.15)	*I am proud of the activities I do in my PhD project.*
Delay	N/A	1	3.80 (1.74)	*So far, I am on schedule with my PhD trajectory (compared to the current official end date). [reflected item]*
Expected delay	N/A	1	3.84 (1.64)	*I expect that I will be (further) delayed during my PhD trajectory.*
Drop-out intention	.68	4	2.59 (1.00)	*I am considering to quit my PhD trajectory.*
Clinician-scientist career ambitions	.83	6	4.04 (1.16)	*As a doctor, I want to combine scientific research and clinical tasks after my PhD.*

Higher expectancy of success resulted in significantly more autonomous motivation and less controlled motivation (adjusted β=.15; adjusted β=-.23) (*Table 3*). Furthermore, PhD candidates with more research utility and intrinsic and attainment values were significantly more autonomously motivated (adjusted β=.28; adjusted β=.45). PhD candidates with higher medical utility values were significantly less autonomously motivated (adjusted β=-.07) and more controlled motivated (adjusted β=.33).

Table 3. *Effect of expectancies and values on motivation according to the Expectancy-Value Theory*

Determinant	Outcome	Crude β (95% CI)	Adjusted β (95% CI)[a]
Expectancy of success	AM	.269 (.230 – .307)*	.145 (.112 – .177)*
Medical utility value	AM	.031 (-.015 – .077)	-.065 (-.101 – -.029)*
Intrinsic & attainment value	AM	.626 (.579 – .672)*	.446 (.395 – .497)*
Research utility value	AM	.545 (.494 – .597)*	.278 (.224 – .331)*
Expectancy of success	CM	-.212 (-.259 – -.165)*	-.226 (-.272 – -.180)*
Medical utility value	CM	.300 (.249 – .352)*	.327 (.276 – .378)*
Intrinsic & attainment value	CM	.090 (-.157 – .023)*	-.045 (-.117 – .028)
Research utility value	CM	-.024 (-.093 – .045)	-.011(-.087 – .066)

[a] *Adjusted for the other determinants listed in this table. With additional adjustment for age and gender results were not materially different (results not shown).*
** Indicating statistical significance p < 0.005*

Table 4 shows that, when looking at motivation for a PhD and its perceived doctoral outcomes, PhD candidates with higher AM were significantly more engaged in their PhD (adjusted β=.42) and were more intending to pursue a clinician-scientist career after obtaining a PhD degree (adjusted β=.25). Both crude effects became stronger after adjusting for CM. In addition, they were more likely to expect (further) delay (adjusted β=.05) and had less drop-out intentions (adjusted β=-.04). In contrast, PhD candidates with higher CM were significantly less engaged in their PhD (adjusted β=-.22), were less delayed (adjusted β=-.04), had higher drop-out inentions (adjusted β=.36), and were less intending to pursue a clinician-scientist career (adjusted β=-.18). All crude effects besides (expected) delay became stronger after adjusting for AM.

Table 4. *Effect of motivation on perceived doctoral outcomes*

Type of motivation	Outcome	Crude and adjusted β (95% CI)	Adjusted for[a]
AM	Work engagement	.506 (.475 – .538)* .540 (.475 – .538)* .416 (.377 – .454)*	- CM + Delay, expected delay, drop-out intention, clinician-scientist career ambition
AM	Delay	-.140 (-.168 – -.112)* -.133 (-.162 – -.105)* -.016 (-.039 – .008)	- CM + Work engagement, expected delay, drop-out intention, clinician-scientist career ambition
AM	Expected delay	-.040 (-.071 – -.010)* -.030 (-.061 – .001) .048 (.025 – .071)*	- CM + Work engagement, delay, drop-out intention, clinician-scientist career ambition
AM	Drop-out intention	-.377 (.422 – -.331)* -.413 (-.464 – -.362)* -.038 (.085 – -.030)*	CM + Work engagement, delay, expected delay, clinician-scientist career ambition
AM	Clinician-scientist career ambition	.425 (.390 – .461)* .438 (.400 – .475)* .248 (.214 – .282)*	- CM + Work engagement, delay, expected delay, drop-out intention
CM	Work engagement	-.296 (-.343 – -.250)* -.421 (-.484 – -.357)* -.221 (-.288 – -.153)*	- AM + Delay, expected delay, drop-out intention, clinician-scientist career ambition
CM	Delay	.090 (.057 – .123)* .076 (.042 – .110)* -.040 (-.075 – -.005)*	- AM + Work engagement, expected delay, drop-out intention, clinician-scientist career ambition
CM	Expected delay	.102 (.067 – .137)* .097 (.062 – .131)* .011 (-.024 – .046)	- AM + Work engagement, delay, drop-out intention, clinician-scientist career ambition
CM	Drop-out intention	.449 (.397 – .500)* .488 (.431 – .545)* .358 (.291 – .425)*	- AM + Work engagement, delay, expected delay, clinician-scientist career ambition
CM	Clinician-scientist career ambition	-.258 (-.306 – -.211)* -.294 (-.352 – -.236)* -.177 (-.231 – -.122)*	- AM + Work engagement, delay, expected delay, drop-out intention

[a] *With additional adjustment for age and gender results were not materially different (results not shown).*
** Indicating statistical significance p < 0.005*

7

Motivation in different career positions, PhD phases and specialties

We found a significant difference in AM (mean difference = 0.17, 95% CI .06-.29) in (future) doctors without specialty training positions (MD-PhD students and DNITs) as compared to doctors with a specialty training position (residents) and/or medical specialists, with slightly higher AM in the first group. Also CM was significantly higher within the first group (mean difference = 0.47, 95% CI .35-.56). Furthermore, AM and to a lesser extent CM significantly decreased with more PhD progression in years (β=-.06, 95% CI -.09 – -.04; β=-.03, 95% CI -.06 – -.00, respectively) with a mean formal PhD duration of almost four years. PhD candidates with less competitive specialty preferences prior to the start of their PhD were slightly higher autonomously motivated (mean difference = .07, 95% CI -.10-.25) and slightly less controlled motivated (mean difference CM = -.18, 95% CI -.39-.02) compared to PhD candidates with preferences for a highly competitive specialty prior to their PhD. However, these differences were not statistically significant.

Motivation profiles

For further analysis PhD candidates were grouped based on their motivation on a two dimensional axis; AM and CM. Subgroups were divided based on quartiles on both axis with very high = 5.50-7.00, high = 4.00-5.50, low = 2.50-4.00, very low = 1.00-2.50 (*Figure 2*).

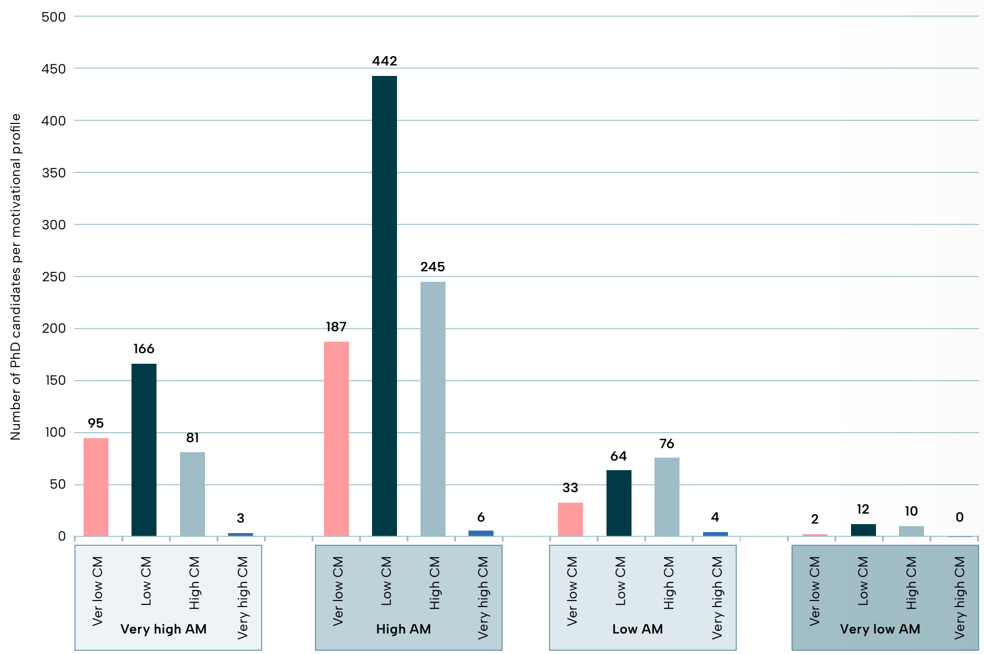

Figure 2. *Number of PhD candidates per motivation profile*

Figures 3-5 show two-dimensional motivation profiles with (1) expectancy of success and perceived task values scores, (2) unfavourable perceived doctoral outcomes (i.e. (expected) delay and drop-out intentions), and (3) favourable doctoral (potential) outcomes (i.e. work engagement and clinician-scientist career ambitions). Within AM profiles with the same classification (very high/high/low/very low), increasement in CM results in generally lower expectancy of success, research utility value, intrinsic and attainment value, work engagement, and clinician-scientist career ambition, as well as higher medical utility value, (further expected) delay, and drop-out inentions.

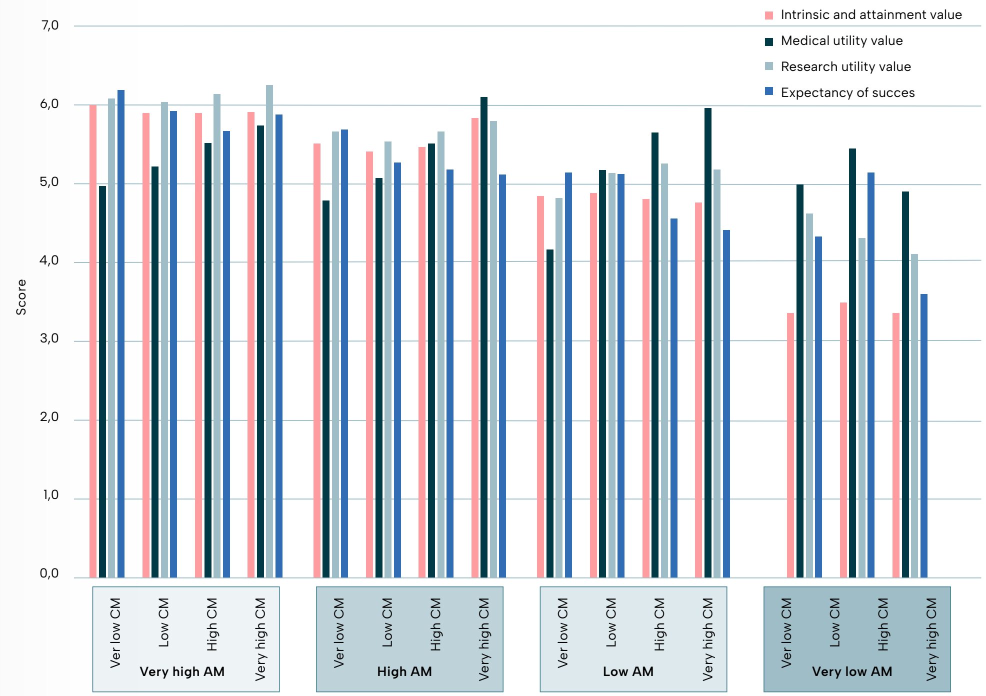

Figure 3. *Expectancy of success scores and values scores (Y-axis) per motivation profile (x-axis)*

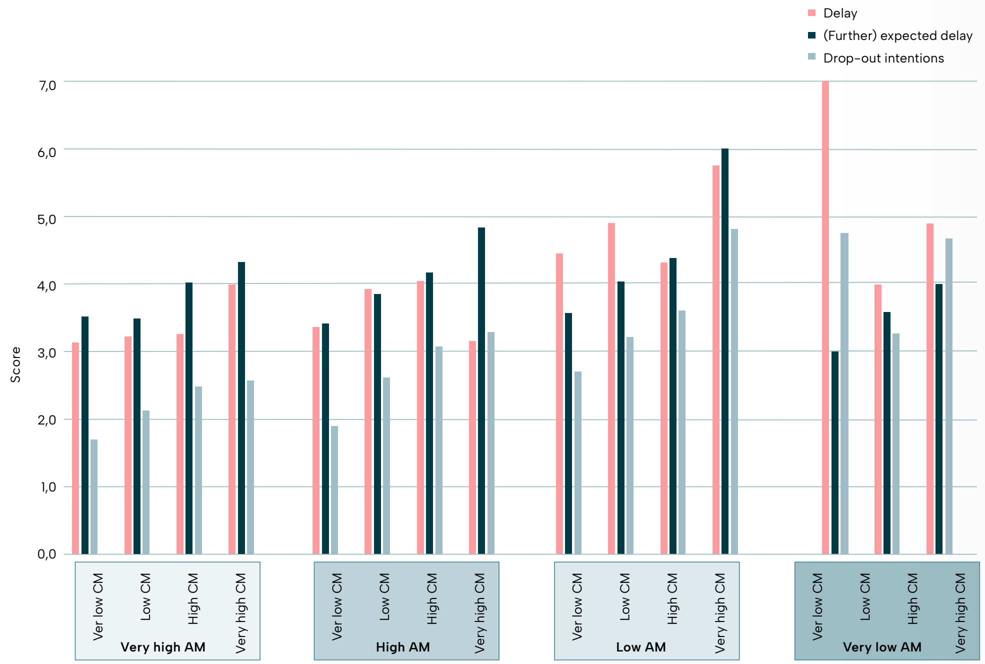

Figure 4. *Unfavourable perceived doctoral outcomes scores (Y-axis) per motivation profile (X-axis)*

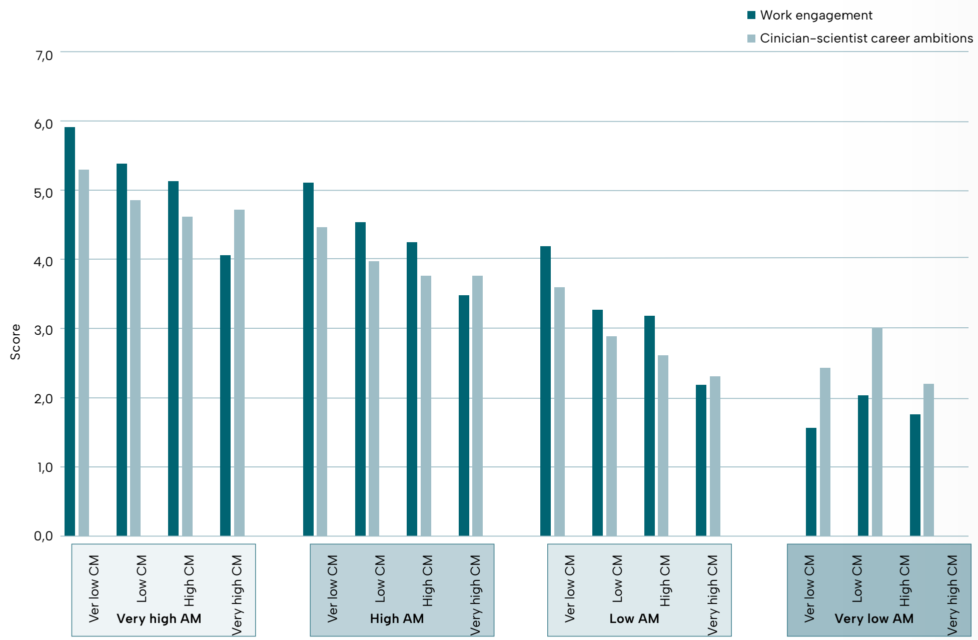

Figure 5. *Favourable perceived doctoral outcomes scores (Y-axis) per motivation profile (X-axis)*

Discussion

Our study showed that the majority of medical PhD candidates is highly autonomously motivated for their PhD. However, of those with (very) high autonomous motivation almost a quarter had (very) high controlled motivation for their PhD as well. Furthermore, one out of seven PhD candidates showed a poor motivation profile with (very) low autonomous motivation. In those with low autonomous motivation and/or high controlled motivation, we found higher expected delay and drop-out intention scores, while they are also less engaged in their work and have less ambitions for a clinician-scientist career. This suggests that type and quantity of motivation both contribute to the leaky pipeline of clinician-scientists.

This study has several strengths and limitations. It is a nationwide study including all Dutch University medical centres and based on well-established motivational theories with mostly validated scales. To our best knowledge, this is the first study that provides insight in the role of motivation of medical PhD candidates for getting into and staying in the clinician-scientist pipeline. Furthermore, this study approaches motivation as a multidimensional construct including determinants of motivation and perceived doctoral outcomes with relatively high response rate, resulting in a large sample size. However, due to the cross-sectional design and despite CM negatively affects drop-out intentions and clinician-scientist career ambitions, we have no follow-up on changes in motivation and on actual academic drop out during or after the PhD programme. Comprehensive research on doctoral attrition is challenging and one of the foremost reasons is that there is no proper registry of attrition in many countries, including the Netherlands.[70] Finally, there might be some circular or mutually influencing effects between different scores based on the questionnaire we used. However, the existing literature and motivational theories substantiate the directions of the effects tested in this study.

Our results are in line with Ghedri et al., who showed that almost 80% of the medical students valued a PhD as means to get into a highly competitive specialty training programme.[32] An equal number of these medical students was motivated to pursue a PhD, of whom almost 40% (out of 80%) indicated that they would not aspire to a PhD if it would not benefit the chance of obtaining a specialty training position, which can be labelled as CM. Apparently, motivation and perceptions of the value of pursuing a PhD degree have already settled before graduation. As no follow-up was performed by Ghedri et al., it is unknown to what extent these values acted upon after graduation.

In our study, 22% of the PhD candidates stated that they would not have participated in their PhD programme if it would not impact their chance of obtaining a future job position (e.g. specialty training position). In addition, our study included mostly postgraduate doctors who acted upon their expectancy of success and values, and showed that different values are related to AM and CM. More specifically, building on Ghedri et al., medical utility value (e.g. the value of a PhD for programme directors and future job positions) fosters CM for a PhD.

While values and corresponding qualities of motivation for obtaining a PhD degree are apparently already formed before entering a PhD programme, they are likely to further develop throughout the PhD journey. We found somewhat lower AM and CM in PhD candidates who were further along with their PhD programme. According to the SDT, AM can be strengthened by enhancing feelings of competence, relatedness and autonomy. We therefore deem it relevant to further investigate development of motivation during a PhD and to foster feelings of research competence, relatedness, and autonomy.

Almost all PhD candidates in our study were (future) doctors without specialty training (yet) (83%) aspiring a career in a highly competitive specialty (84%). A highly competitive setting can be a strong incentive for CV building, even more so when programme directors highly value a PhD degree as selection criterium,[29–31] which in the Netherlands is more common in hospital based specialties (mostly highly competitive) in comparison with non-hospital based specialties (mostly less competitive).[32] This is called credential inflation (i.e. increase in the education credentials required for a job) and can result in less career opportunities for MDs without a PhD degree and thereby possibly underappreciation of profiles other than research, as well as devaluation of PhD degrees. Surprisingly, we found no motivational differences between PhD candidates with less competitive specialty preferences compared to PhD candidates with highly competitive specialty preferences. Although PhD candidates with less or highly competitive specialty preferences have similar AM and CM, the abundance of PhD candidates and, consequently, clinicians with a PhD degree within highly competitive specialties compared to less competitive specialties, may fragment scientific development of the medical field.

When inspecting the leaky pipeline, it is a matter of concern that a subset of PhD candidates demonstrates lower autonomous drive and/or a high degree of controlled motivation. Additionally, it is noteworthy that some might not have participated in a PhD programme if it did not impact future job prospects. Our study revealed that this particular group was less engaged in their work, expressed stronger intentions to drop-out, and showed lesser ambition towards a clinician-scientist career. Encouragingly, PhD candidates

could be empowered to select paths in harmony with their inherent values and passions, rather than solely driven by external pressures such as competitive job positions. Those whose interests do not lie in research engagement or a clinician-scientist career might find greater fulfillment specializing in other profiles valuable to the medical workforce and society, rather than embarking on the time-intensive PhD trajectory. Beyond the investment of time already spent in the pipeline, the timing within the medical career to enter the clinician-scientist pipeline matters as well. Residents or medical specialists had approximately similar autonomous motivation but lower controlled motivation scores compared to doctors not in training and MD-PhD students. In line with this, Eshel and colleagues are making a plea for more flexible entry points into the clinician-scientist pipeline with protected time for research training and not necessarily as a full PhD, for example, during residency and fellowships.[71]

Although some PhD candidates may have compelling reasons to leave academia during or soon after their PhD, this 'leak' has impact on several levels. At the individual level, PhD candidates who drop out may have lower self-esteem and fewer employment opportunities.[13] When another road than a full PhD would be an option, a part of this group might be motivated to be involved in research to another extent (e.g. publish one or a few articles). Others might prefer developing themselves in other domains than research, such as medical education, leadership, management, or technology and innovation.[72–74] These are, next to research, crucial demands of future healthcare as well. At the academic institutional level, maintaining the current high-level PhD programmes for a growing number of PhD candidates requires substantial investments in time, education, supervision, support, and funding. A more targeted approach could optimize the return on investment by nourishing those who clearly aspire a strong research profile as part of their future career, while allowing others to choose differently. This also might benefit quality of doctoral supervision in practice, which is squeezed by increasing research supervision demands.[75] Last, at the societal level, society might profit from some clinicians entering medical practice years earlier as they do not feel obliged or have to include a PhD trajectory in their already yearlong training period.

We found that autonomous motivation positively relates to clinician-scientist career ambitions *after* a PhD, however, our data do not provide insight into actual academic involvement after a PhD. A recent study found that 10 years after obtaining a PhD degree, 43% of MD-PhDs had an academic oriented career.[23] Furthermore, a postdoctoral academic career was more likely in medical specialties (48%) compared to surgical related (33%) and non-hospital based specialties (23%), and men were twice as likely to publish compared to women in academic careers. Irrespective of motivation and corresponding (lack of) academic ambition resulting in potentially leaking out the pipeline after a PhD, other well-known barriers to stay academically involved are rising clinical responsibilities in residency, work-life balance, lack of funding, and insufficient supervision.[76-78] On the other hand, if all MD-PhDs would have academic ambitions the demand will probably exceed the number of available academic positions in the medical field.

Even for those who are no longer academically involved after obtaining a PhD, their doctoral degree can still be considered valuable. MD-PhDs develop scientific and generic competences, thereby enhancing academic standards and the quality of healthcare in non-academic hospitals.[15] Moreover, large-scale PhD research significantly contributes to scientific advancement and consequently, enhances clinical care. Furthermore, a quarter of PhD candidates alter their specialty preferences during their doctoral studies, a factor that might have been underestimated due to the inclusion of candidates from all phases of the doctoral programme. This aspect underlines the potential of a PhD journey to facilitate career orientation, as candidates closely engage with a specialty for multiple years. Ultimately, this has the potential to mitigate attrition among medical trainees, which is a global concern.[79,80]

Conclusion

To train and retain aspired clinician-scientists it is crucial to focus on fostering autonomous motivation and mitigating controlled motivation prior to and during PhD programmes, as our findings implicate that both type and quantity of motivation contribute to the leaky pipeline of clinician-scientists. This could be achieved by (1) (potential future) PhD candidates carefully reflecting on their expectancies, values, motivational profile and corresponding perceived doctoral outcomes; (2) PhD candidates and their supervisors investing in well-known drivers for autonomous motivation during the PhD programme in line with SDT, such as research self-efficacy, autonomy, and relatedness; (3) challenging programme directors on their perceived value according to (potential future) PhD candidates, more specifically inviting programme directors to explicitly and critically appraise the value of a doctoral profile within their specialty; and (4) flexibility in research career pathways including entering a PhD later on during a clinical career or engagement in research on other levels than a full PhD.

References

1. Eley DS, Jensen C, Thomas R, Benham H: What will it take? Pathways, time and funding: Australian medical students' perspective on clinician-scientist training. BMC medical education 2017, 17(1):242-242.
2. Milewicz DM, Lorenz RG, Dermody TS, Brass LF: Rescuing the physician-scientist workforce: the time for action is now. The Journal of Clinical Investigation 2015, 125(10):3742-3747.
3. Ley TJ, Rosenberg LE: The physician-scientist career pipeline in 2005: build it, and they will come. JAMA 2005, 294.
4. den Bakker CR, Ommering BW, van Leeuwen TN, Dekker FW, De Beaufort AJ: Assessing publication rates from medical students' mandatory research projects in the Netherlands: a follow-up study of 10 cohorts of medical students. BMJ Open 2022, 12(4):e056053.
5. Möller R, Shoshan M: Medical students' research productivity and career preferences; a 2-year prospective follow-up study. BMC Medical Education 2017, 17(1):51.
6. Conroy MB, Shaffiey S, Jones S, Hackam DJ, Sowa G, Winger DG, Wang L, Boninger ML, Wagner AK, Levine AS: Scholarly Research Projects Benefit Medical Students' Research Productivity and Residency Choice: Outcomes From the University of Pittsburgh School of Medicine. Acad Med 2018, 93(11):1727-1731.
7. PhD Explosie. Retrieved August 28, 2022, from https://www.artsenauto.nl/phd-explosie/
8. Andreassen P, Christensen MK: Science in the clinic: a qualitative study of the positioning of MD-PhDs in the everyday clinical setting. BMC Med Educ 2018, 18(1):115.
9. Andreassen P, Wogensen L, Christensen MK: The employers' perspective on how PhD training affects physicians' performance in the clinic. Dan Med J 2017, 64(2).
10. Eley DS: The clinician-scientist track: an approach addressing Australia's need for a pathway to train its future clinical academic workforce. BMC medical education 2018, 18(1):227-227.
11. Traill CL, Januszewski AS, Larkins R, Keech AC, Jenkins AJ: Time to research Australian physician-researchers. Internal Medicine Journal 2016, 46(5):550-558.
12. Castelló M, Pardo M, Sala-Bubaré A, Suñe-Soler N: Why do students consider dropping out of doctoral degrees? Institutional and personal factors. Higher Education 2017, 74(6):1053-1068.
13. Litalien D, Guay F: Dropout intentions in PhD Studies : a comprehensive model based on interpersonal relationships and motivational resources. Contemporary Educational Psychology 2015, 41:218-231.
14. Shin M, Goodboy A, Bolkan S: Profiles of doctoral students' self-determination: susceptibilities to burnout and dissent. Communication Education 2021.
15. Anttila H, Lindblom-Ylänne S, Lonka K, Pyhältö K: The Added Value of a PhD in Medicine - PhD Students' Perceptions of Acquired Competences. The International Journal of Higher Education 2015, 4:172-180.
16. Woolston C: Graduate survey: A love–hurt relationship. Nature 2017, 550(7677):549-552.
17. Kusurkar R, van der Burgt S, Isik U, Mak-van der Vossen M, Wilschut J, Wouters A, Koster A: Burnout and engagement among PhD students in medicine: the BEeP study. Perspect Med Educ 2021, 10(2):110-117.
18. Wollast R, Boudrenghien G, Linden N, Galand B, Roland N, Devos C, Clercq M, Klein O, Azzi A, Frenay M: Who Are the Doctoral Students Who Drop Out? Factors Associated with the Rate of Doctoral Degree Completion in Universities. International Journal of Higher Education 2018, 7:143.
19. Kis A, Tur E, Lakens D, Vaesen K, Houkes W: Leaving academia: PhD attrition and unhealthy research environments. PloS one 2022, 17(10).
20. Nagy GA, Fang CM, Hish AJ, Kelly L, Nicchitta CV, Dzirasa K, Rosenthal MZ: Burnout and Mental Health Problems in Biomedical Doctoral Students. CBE Life Sci Educ 2019, 18(2):ar27.
21. VSNU Overzichten Promovendi 2018. Retrieved August 28, 2022 from: www.vsnu.nl/files/documenten/Feiten_en_Cijfers/Overzichten_Promovendi_2018.xlsx.
22. Jeffe DB, Andriole DA, Wathington HD, Tai RH: Educational Outcomes for Students Enrolled in MD–PhD Programs at Medical School Matriculation, 1995–2000: A National Cohort Study. Academic Medicine 2014, 89(1):84-93.
23. Wolters F: Academische carrièreperspectieven van gepromoveerde dokters: Een landelijk cohortonderzoek in de periode 1992-2018. Nederlands Tijdschrift voor Geneeskunde 2020, 164.

24. Kwan JM, Daye D, Schmidt ML, Conlon CM, Kim H, Gaonkar B, Payne AS, Riddle M, Madera S, Adami AJ et al: Exploring intentions of physician-scientist trainees: factors influencing MD and MD/PhD interest in research careers. BMC Med Educ 2017, 17(1):115.
25. Lopes J, Ranieri V, Lambert T, Pugh C, Barratt H, Fulop NJ, Rees G, Best D: The clinical academic workforce of the future: a cross-sectional study of factors influencing career decision-making among clinical PhD students at two research-intensive UK universities. BMJ Open 2017, 7(8):e016823.
26. Ranieri VF, Barratt H, Rees G, Fulop NJ: A Qualitative Study of the Influences on Clinical Academic Physicians' Postdoctoral Career Decision Making. Academic Medicine 2018, 93(11):1686-1693.
27. Giesler M, Boeker M, Fabry G, Biller S: Importance and benefits of the doctoral thesis for medical graduates. GMS J Med Educ 2016, 33(1):Doc8.
28. Wildgaard L, Wildgaard K: Continued publications by health science PhDs, 5 years post PhD-Defence. Research Evaluation 2018, 27(4):347-357.
29. ten Cate O: Medical Education in the Netherlands. Medical teacher 2007, 29:752-757.
30. Dijkhuizen K, Bustraan J, van den Bogaard MED, Velthuis SI, van Lith JMM, Driessen EW, de Beaufort AJ: Values and beliefs on trainee selection: What counts in the eye of the selector? A qualitative study exploring the program director's perspective. Med Teach 2020, 42(10):1179-1186.
31. Mattijsen JC, Ghedri, A., Reinhard, M.: Promoveren Opleiders. De Geneeskundestudent 2019.
32. Ghedri A, Bontje, W., Abdelmoumen, A. : Promoveren of profileren? . De Geneeskundestudent 2018.
33. Bisshop A: Een goede arts hoeft echt niet te promoveren. . Trouw 4:9 2019.
34. Zuckerman SL, Kelly PD, Dewan MC, Morone PJ, Yengo-Kahn AM, Magarik JA, Baticulon RE, Zusman EE, Solomon GS, Wellons JC, 3rd: Predicting Resident Performance from Preresidency Factors: A Systematic Review and Applicability to Neurosurgical Training. World Neurosurg 2018, 110:475-484.e410.
35. Cook DA, Artino Jr AR: Motivation to learn: an overview of contemporary theories. Medical Education 2016, 50(10):997-1014.
36. Determined to Succeed: Motivation Towards Doctoral Degree Completion. 2013.
37. Kusurkar R, ten Cate O, Vos C, Westers P, Croiset G: How motivation affects academic performance: A structural equation modelling analysis. Advances in health sciences education : theory and practice 2012, 18.
38. Bryan B, Guccione K: Was it worth it? A qualitative exploration into graduate perceptions of doctoral value. Higher Education Research & Development 2018, 37(6):1124-1140.
39. Brailsford I: Motives and Aspirations for Doctoral Study: Career, Personal, and Inter-personal Factors in the Decision to Embark on a History PhD. International Journal of Doctoral Studies 2010, 5.
40. Kemp MW, Molloy TJ, Pajic M, Chapman E: An analysis of reported motivational orientation in students undertaking doctoral studies in the biomedical sciences. BMC Med Educ 2014, 14:38.
41. Skakni I: Reasons, motives and motivations for completing a PhD: a typology of doctoral studies as a quest. 2018.
42. Terentev E, Rybakov N, Bednyi B: Why Embark on a PhD Today? A Typology of Motives for Doctoral Study in Russia. Voprosy obrazovaniya / Educational Studies Moscow 2020:40-69.
43. McCulloch A, Guerin C, Jayatilaka A, Calder P, Ranasinghe D: Choosing to study for a PhD: A framework for examining decisions to become a research student. Higher Education Review 2017, 49:85-106.
44. Clercq M, Frenay M, Azzi A, Klein O, Galand B: All You Need is Self-Determination: Investigation of PhD Students' Motivation Profiles and Their Impact on the Doctoral Completion Process. International Journal of Doctoral Studies 2021, 16:189-209.
45. Guerin C, Jayatilaka A, Ranasinghe D: Why start a higher degree by research? An exploratory factor analysis of motivations to undertake doctoral studies. Higher Education Research and Development 2015, 34.
46. Hands A: What's your type? An examination of first-year doctoral student motivation. Education for Information 2020, 36:371-387.
47. Lynch M, Salikhova N, Salikhova A: Internal Motivation among Doctoral Students: Contributions from the Student and from the Student's Environment. International Journal of Doctoral Studies 2018, 13:255-272.
48. Litalien D, Guay F, Morin AJS: Motivation for PhD studies: Scale development and validation. Learning and Individual Differences 2015, 41:1-13.

49. Anderson MS, Swazey JP: Reflections on the graduate student experience: An overview: An Exploration. In: 1998; 1998.
50. Ryan R, Deci E: Self-determination theory. Basic psychological needs in motivation, development and wellness. New York, NY : Guilford Press. 2017:231.
51. Wigfield A, Eccles JS: Expectancy-Value Theory of Achievement Motivation. Contemp Educ Psychol 2000, 25(1):68-81.
52. Eccles J, Dweck C: Handbook of competence and motivation. In.: New York, NY: Guidford Press; 2005.
53. Savolainen R: Self-determination and expectancy-value: Comparison of cognitive psychological approaches to motivators for information seeking about job opportunities. Aslib J Inf Manag 2018, 70:123-140.
54. Yue Y, Lu J: International Students' Motivation to Study Abroad: An Empirical Study Based on Expectancy-Value Theory and Self-Determination Theory. Front Psychol 2022, 13:841122.
55. Koestner R, Otis N, Powers TA, Pelletier L, Gagnon H: Autonomous Motivation, Controlled Motivation, and Goal Progress. Journal of Personality 2008, 76(5):1201-1230.
56. Deci E, Ryan R: The importance of autonomy for development and well-being. Self-Regulation and Autonomy: Social and Developmental Dimensions of Human Conduct 2005:19-46.
57. Wang CKJ, Liu WC, Kee YH, Chian LK: Competence, autonomy, and relatedness in the classroom: understanding students' motivational processes using the self-determination theory. Heliyon 2019, 5(7):e01983.
58. Bandura A: Self-efficacy: toward a unifying theory of behavioral change. Psychol Rev 1977, 84(2):191-215.
59. Barron K, Hulleman C: Expectancy-Value-Cost Model of Motivation. In., edn.; 2014: pp. 503-509 (Vol. 508).
60. Schaufeli WB, Salanova M, González-romá V, Bakker AB: The Measurement of Engagement and Burnout: A Two Sample Confirmatory Factor Analytic Approach. Journal of Happiness Studies 2002, 3(1):71-92.
61. Schaufeli W, Salanova M: (2006). Work engagement: An emerging psychological concept and its implications for organizations. DSSW Gilliland, Research in social issues in Management: Vol Managing social and ethical issues in organization Green, CT: InformationAgePublishers, 2007.
62. Pyhältö K, Toom A, Stubb J, Lonka K: Challenges of Becoming a Scholar: A Study of Doctoral Students' Problems and Well-Being. ISRN Education 2012, 2012:934941.
63. Artino AR, Jr., La Rochelle JS, Dezee KJ, Gehlbach H: Developing questionnaires for educational research: AMEE Guide No. 87. Med Teach 2014, 36(6):463-474.
64. Ommering BWC, van Blankenstein FM, van Diepen M, Dekker FW: Academic Success Experiences: Promoting Research Motivation andSelf-Efficacy Beliefs among Medical Students. Teach Learn Med 2021, 33(4):423-433.
65. Upadyaya K, Salmela-Aro K: Development of early vocational behavior: Parallel associations between career engagement and satisfaction. Journal of Vocational Behavior 2015, 90:66-74.
66. Balducci C, Fraccaroli F, Schaufeli WB: Psychometric Properties of the Italian Version of the Utrecht Work Engagement Scale (UWES-9) A Cross-Cultural Analysis. European Journal of Psychological Assessment 2010, 26:143-149.
67. Bothma CFC, Roodt G: The validation of the turnover intention scale. Sa Journal of Human Resource Management 2013, 11:1-12.
68. De Keuzemonitor Geneeskunde. Retrieved from https://www.nivel.nl/sites/default/files/bestanden/keuzemonitor_geneekunde_2015.pdf July, 2021.
69. Butterman O, Slenter V, Velden LVd, Batenburg R: Gender differences in attrition rates of hospital-based medical specialty programs: attributable to gender composition of the clinical specialty? In.: Research Square; 2020.
70. Bair CR, Haworth JG: Doctoral Student Attrition and Persistence: A Meta-Synthesis of Research. ASHE Annual Meeting Paper. In: 1999; 1999.
71. Eshel N, Chivukula RR: Rethinking the Physician-Scientist Pathway. Academic Medicine 2022:10.1097/ACM.0000000000004788.
72. Ireri SK, Walshe K, Benson L, Mwanthi MA: A qualitative and quantitative study of medical leadership and management: experiences, competencies, and development needs of doctor managers in the United Kingdom. Journal of Management & Marketing in Healthcare 2011, 4:16 - 29.
73. Sherbino J, Frank JR, Snell L: Defining the Key Roles and Competencies of the Clinician–Educator of the 21st Century: A National Mixed-Methods Study. Academic Medicine 2014, 89(5):783-789.
74. Vogel L: Doctors need retraining to keep up with technological change. CMAJ 2018, 190(30):E920.
75. Carter S, Kensington-Miller B, Courtney M: Doctoral Supervision Practice: What's the Problem and How Can We Help Academics? Journal of Perspectives in Applied Academic Practice 2016, 5.
76. Chakraverty D, Jeffe DB, Tai RH: Transition Experiences in MD–PhD Programs. CBE Life Sciences Education 2018, 17.
77. Mills JMZ, Januszewski AS, Robinson BG, Traill CL, Jenkins AJ, Keech AC: Attractions and barriers to Australian physician-researcher careers. Intern Med J 2019, 49(2):171-181.
78. Ortega G, Smith C, Pichardo MS, Ramirez A, Soto-Greene M, Sánchez JP: Preparing for an Academic Career: The Significance of Mentoring. In: MedEdPORTAL. vol. 14; 2018: 10690.
79. Bustraan J, Dijkhuizen K, Velthuis SI, van der Post RS, Driessen EW, van Lith JMM, De Beaufort AJ: Why do trainees leave hospital-based specialty training? A nationwide survey study investigating factors involved in attrition and subsequent career choices in the Netherlands. BMJ Open 2019, 9.
80. Bongiovanni T, Yeo H, Sosa JA, Yoo PS, Long T, Rosenthal M, Berg D, Curry L, Nunez-Smith M: Attrition from surgical residency training: perspectives from those who left. Am J Surg 2015, 210(4):648-654.

Chapter 8

The bumpy ride to a medical PhD degree: A qualitative study on factors influencing motivation

Charlotte R. den Bakker
Belinda W.C. Ommering
Arnout Jan de Beaufort
Friedo W. Dekker
Jacqueline Bustraan

Manuscript submitted

Abstract

Introduction In parallel with a tremendous increase in medical PhD enrolments, concerns have risen about PhD candidates' well-being and increasing attrition rates. According to Self-Determination Theory, autonomous motivation is strongly linked to positive aspects of well-being and positive outcomes such as study completion and success, and thus plays a key role in successful completion of medical doctoral programmes. In this study we explored factors affecting motivation during the PhD journey and aimed to contribute to engaging doctoral education environments, and, eventually, a sustainable clinician-scientist workforce.

Methods This constructivist qualitative interview study was conducted among medical PhD candidates in the final phase of their PhD. We used timeline assisted interviews to identify meaningful experiences throughout their PhD journey. Thematic analyses as iterative process resulted in overarching themes.

Results We identified six themes, meaningful for motivation along the bumpy ride to a PhD degree; (1) Initial motivation to start a PhD matters; (2) Autonomy as a matter of the right dose at the right time; (3) PhD as proof of competency and/or learning trajectory?; (4) It takes two to tango; (5) Peers can make or break your PhD; (6) Strategies to stay or get back on track.

Discussion This study revealed factors that contribute positively and/or negatively to motivation. Some factors impacted motivation differently depending on the PhD phase and individual strategies. Additionally, some factors could coincide and change from positive to negative and vice versa, showing that a successful journey cannot simply be reduced to an absence of negative experiences.

Introduction

Medical PhD programmes aim to train future generations of clinician-scientists i.e., medical doctors who combine patient care with research. Enrolment in medical PhD programmes has increased tremendously in the past decades.[1-5] Simultaneously, there are concerns about PhD candidates' well-being[6-10], a complex combination of positive (e.g. satisfaction, self-efficacy, work engagement) and/or absence of negative (e.g. anxiety, stress, burn-out) mental states.[11] Several studies found that 30-50% of PhD candidates self-report significant levels of stress, burn-out and other mental health problems.[12-16] Negative aspects are related to delaying doctoral study and intentions to quit.[17-23] Subsequently, programme attrition, with rates between 25-60%, is a major concern in the medical domain, as well as in other doctoral domains.[10,19,24]

Motivation is strongly linked to well-being and, hence, persistence and study completion and success.[6,25-30] Therefore, insight into factors affecting motivation of medical doctors (MDs) pursuing a PhD could provide guidance on how to optimize medical doctoral programmes as learning environments and subsequent support PhD candidates in both maintaining and fostering motivation during their programme. In this study, motivation is regarded as a multidimensional construct consisting of different types of motivation based on Self-Determination Theory (SDT).[25-28] SDT distinguishes autonomous and controlled motivation. *Autonomous motivation* (AM) derives from a PhD candidate attributing personal value to learning, due to genuine interest and pleasure in the research itself. *Controlled motivation* (CM) includes persuasion of learning or work as a means to an end that is separate from the activity itself, for example to obtain a reward such as a future training or job position. Autonomous motivation is associated with positive outcomes in education, such as intention to persist and subjective well-being, whereas controlled motivation is reported to be associated with negative outcomes, such as anxiety and lower positive affect.[6,26,29-32]

A PhD in the medical field is more common than in any other domain.[19] Furthermore, the research environment of medical PhDs differs substantially from environments in other fields. Medical PhD candidates are (future) medical doctors, who commonly combine patient care with their PhD trajectory, mainly supervised by PhD-holding clinicians, and often return to clinical care after their PhD trajectory.[33] Furthermore, as they are employed at a clinical department, the healthcare culture and hierarchy will affect the research environment. In addition, some programme directors consider a PhD highly important or necessary to get a specialty training position.[34] To this end, a subset of medical PhD candidates obtains a PhD degree to gain admission to their desired specialty.[35] This admission-related aspect of pursuing a PhD might be more prevalent in medicine in contrast to other domains and, by definition, is controlled motivation.

Recently, we quantitively explored autonomous and controlled motivation and its relation to work engagement, (expected) delay, drop-out intentions, and clinician-scientist career ambitions in over 1300 Dutch medical PhD candidates.[30] Our national survey study showed that autonomous motivation was positively related to PhD candidates' work engagement and clinician-scientists career ambitions. In addition, higher autonomous motivation resulted in less drop-out intentions, contrary to controlled motivation which was related to lower work engagement and research ambitions, and higher drop-out intentions. However, insight into factors affecting motivation during the PhD journey was lacking and deeper understanding called for a qualitative approach. In this follow-up study we aim to answer the question which factors affect motivation during the PhD journey. By that, we aim to contribute to the conscious use of strategies to increase autonomous motivation and, hence, well-being, successful completion of the PhD programme, and, eventually, a sustainable clinician-scientist workforce.

Methods

Study design

For our interview study, we used a constructivist approach. A constructivist paradigm asserts that knowledge and reality are socially constructed by people through experiences and reflections on those experiences, and that researchers should attempt to relate to subjective experiences of study participants.[36] Interviews are a commonly used method within the constructivist paradigm and, in our view, match well with our aim to understand how, when and why PhD candidates' motivation develops during their PhD trajectory. We designed a guide (*Appendix E*) for semi-structured, timeline-assisted interviews that were held between April and July 2021. Timelining adds a chronological visual representation related to the experience, anchors the interview and helps the participant to identify and focus on meaningful events and experiences. It can provide participants a way to reflect deeply on their stories and even help to create new understandings[37,38]. Interviews started with open questions about the interviewee's pathway prior to their start as PhD candidate. When participants reached the start of their PhD trajectory in their story they were asked to write meaningful experiences of their PhD trajectory (e.g. persons or events) down on post-its. Hereafter, they were asked to put these experiences on their PhD trajectory timeline as tool for reflection. To gain more insights into the impact of these experiences on their motivation during their PhD, participants were asked to position post-its that had greater positive impact on their motivation higher on the y-axis. During the rest of the interview, experiences were chronologically discussed in-depth and the PhD timeline was reflected on.

Study setting

In the Netherlands, there are different pathways to embark on a PhD trajectory. After graduation and before applying for a specialty training position, junior doctors mostly choose to either work as a doctor-not-in-training to gain more work experience, or to apply for a PhD position before or after gaining clinical work experience. Less common pathways are obtaining a PhD as medical student (MD-PhD track), as resident already in training, or later as medical specialist. PhD candidates are (mostly paid) employees facilitated at a University Medical Center (UMC).[30,39]

Sampling and data collection

PhD candidates with a master's degree in medicine and in the final phase of their PhD trajectory at various departments of all Dutch medical graduate schools were selected using purposive sampling to include a variety of participants with different motivational profiles. Selection was based on relatively low and high AM and CM scores as found in our previous national survey study.[30] Participants were invited by email and all agreed to participate. The first author (CdB) conducted ten interviews of 60-90 minutes until inductive thematic saturation (i.e. the point when additional data leads to no new emergent codes or themes) was achieved.[40] All interviewees verbally consented to the audio-recording before the interview started. They were informed that pseudonymized data would only be accessible for co-authors and that published results would be strictly anonymous. Sampling and data collection occurred concurrently with thematic analysis and informed future data collection.

Data analysis

Interviews were audiotaped, transcribed verbatim and pseudonymized. The interviews were analysed using thematic analysis.[41] Two researchers (CdB and JB) independently conducted open coding using Atlas.ti. Similar codes were grouped under coding categories and then moved from the categorical level (open codes and categories) to the conceptual level (relationships between codes and construction of important themes), an iterative process using an inductive approach.[42] Through ongoing discussions, consensus on the coding scheme was reached. There were several meetings (CdB, JB, BO) to discuss overarching themes and to ensure that the research question was addressed adequately. Methodologic rigor was ensured through triangulation in data analysis (i.e. independent data analysis by two investigators followed by team discussions and consensus) and member checking to ensure that interpretations were accurate.[43]

Research team & reflexivity

Our multidisciplinary research team included members with a variety of backgrounds and perspectives. CdB is an MD and PhD candidate in medical education. For interviewees she was considered as a peer without conflict of interest as she was not employed within a medical specialty, which resulted in a safe environment to talk openly about PhD experiences. JB has a background in educational sciences, and is a senior consultant and researcher in postgraduate medical education. The other authors are experienced educational researchers and PhD supervisors with backgrounds in pedagogical and educational sciences (BO), paediatrics (AJdB), and epidemiology (FD). The diversity within the team enhances the trustworthiness of our results and mitigates bias as insider researchers. All researchers were familiar with SDT prior to this study as it formed the framework for our earlier studies. In line with the constructivist approach to reality, we were well aware of the role of this theory including the general concepts of AM and CM. Yet, to take into account the in-depth, exploratory character of this interview study, we explicitly chose not to deliberately start looking how relatedness, autonomy and competence played a role in the development of our interviewees' motivation, which is why we choose a timeline approach where participants were free to share what came to mind. In this way, we consciously aimed to be as open as possible to all themes coming up during the interviews or (open) coding process.

We used the COREQ-32 checklist to report important aspects of the research team, study methods, context of the study, findings, analysis and interpretations.[44]

Ethics approval and consent to participate

The study was conducted in accordance with Helsinki Declaration. Verbal (audio-recorded) informed consent was obtained from all individual participants included in the study. The study including verbal consent was approved by the Educational Institutional Research Review Board of Leiden University Medical Center (reference number OEC/ERRB/20210112/1A).

Results

Motivation throughout a PhD journey developed simultaneously with meaningful events. Our analysis revealed six themes. Within these themes, sub-themes provide further insight into factors affecting motivation during a PhD trajectory. Because of the rich data, not all subthemes are discussed in detail. An overview of all themes and subthemes can be seen in *Appendix F*. The following higher-order themes emerged:

1. Initial motivation to start a PhD matters

Motives to start a PhD already formed prior to enrolment influenced motivational development throughout the PhD journey. Most candidates stated that the option to start a PhD trajectory happened to 'came their way', e.g. while working as doctor not in training, without actively looking for a PhD programme. We identified three main reasons to embark on a PhD trajectory, which can be categorised from high to low autonomous motivation:

1.1 **As stepping stone towards a clinician-scientist career.** A PhD trajectory was started with a genuine interest in research. Participants described the desire to (1) immerse themselves into a topic that they were passionate about, (2) become an expert on a specific topic, and/or (3) have an opportunity to be challenged in critical and creative thinking as this was perceived as insufficient in their clinical job, with many protocols and standardized procedures.

1.2 **As stopover for career orientation purposes.** This motivation often was stated with a short term future perspective. Research was perceived as (potentially) interesting and fun, but a PhD trajectory was used to buy time for future career steps, mature further, have a break from the clinics and/or as career orientation for the long term in both the clinical and scientific world.

1.3 **As vehicle to gain admission to future clinical job positions.** A PhD trajectory was used to gain admission to the preferred specialty. It was considered useful for network contact and perceived as a prerequisite to get a training position within the specialty. Genuine interest in research and/or the research topic were less relevant.

In most cases, multiple reasons coexisted. Additionally, motives to start a PhD were often supplemented with the 'why not?' argument, in which a PhD trajectory was valued as something that can only benefit and won't harm you. While motivation can change over time, the motives for initiating a PhD were indicative and mattered for coping strategies during meaningful events throughout the PhD, especially in the first phase.

> *"You learn little about research in medical school. It is just an education that really makes you primarily become a doctor, but not so much a scientist. So I really wanted to learn that. Actually getting a kind of driver's license for doing scientific research, that's how you might put it."*
> – Interviewee #7

"And a lot of people also strategically opt for a PhD programme in which as little effort as possible is needed and which is completed as soon as possible."
– Interviewee #5

"Firstly, because it seemed good just for my CV and by that, I also thought it would be a better way to obtain a specialty training position. Furthermore, I also wanted to give myself some time to do something totally different."
– Interviewee #9

2. Autonomy, a matter of the right dose at the right time

Candidates perceived autonomy in research activities as a need during the programme. This need appeared to vary throughout different phases during the PhD trajectory. PhD candidates stated that, in the first phase, they often felt consciously incompetent, resulting in a stronger need for guidance than autonomy, whereas at a later stage the need for autonomy became enhanced. If the 'autonomy dose' needed at a certain stage was insufficiently met, frustration ensued and negatively impacted AM. In contrast, the importance of autonomy in working hours and not working shifts did not vary throughout the PhD trajectory and resulted in improved work-life balance and enhanced motivation.

"I think it's very important that people know where to go to when having questions. Not like you're swimming in the deep, forever, because no one tells you what the plan is. You really don't know anything at the beginning of your PhD."
– Interviewee #6

"So when it (i.e. the research projects) started to take off and I got more and more of an idea what my PhD entailed and where it should go, my motivation also went up sharply."
– Interviewee #8

3. PhD as proof of competence and/or as learning trajectory?

Most PhD candidates considered their PhD period as a learning trajectory. However, some believed that supervisors perceived the trajectory as proof of competence. PhD candidates then assumed that they were expected to already master and show sufficient skills to succeed in the research tasks assigned to them right from the start. This 'fear of failure' was fostered in a dependency relationship and mainly resulted in imposter syndrome; an internal experience of believing that you are not as competent as others (i.e. supervisors) perceive you to be and not willing to fail in the eyes of the supervisor. This leads to feelings of self-doubt, feeling lost, and loneliness.[45] These feelings often led to a decrease in both AM and CM and could result from and/or be further strengthened by expected supervisor's beliefs. Vice versa, supervisors were able to foster confidence and self-efficacy and, accordingly, counteract the imposter syndrome.

"There is a lot of competition around you, so you also have to work very hard to keep up with that and show that you are worth it and you can surely show that within a PhD programme, because you can show that you are able to achieve things."
– Interviewee #6

"And she (i.e. supervisor) literally thought that I should be able to do it all on my own and I disagreed and that made it difficult."
– Interviewee #1

4. It takes (at least) two to tango

Supervision is a process that aims to support and assure the development of knowledge, skills and values of PhD candidates. According to PhD candidates, this requires a supervisor who is approachable, makes time, provides constructive and timely feedback, gives trust and autonomy, and sees the person behind the research projects. Supervision can be provided by the thesis-promotor and/or by other research team members. PhD candidates perceived supervision as one of the most crucial factors for their motivation. A good fit with at least one supervisor was key to their autonomous motivation as it directly affected their autonomy and self-efficacy. An additional good fit with other supervisors was beneficial, but not as crucial as a good fit with at least one supervisor 'to tango with'.

"We also have conversations, more on a kind of meta level about the professional development of a young doctor or clinician-scientist. That goes beyond just discussing research content. That's great, because it just works well and is very good and important, I think, for a successful and pleasant PhD trajectory."
– Interviewee #7

"My co-supervisor was really - that's what I'm trying to emulate now – on how to guide someone - and we also guide students together. Just very positive, always available to spar with, always responding to me within a week with good suggestions and good feedback. And just encouraging, so giving positive feedback, says 'well done', always being positive in emails, and so on, so he's really a great supervisor."
– Interviewee #8

"There was little input or guidance from them. I expected a bit more involvement in the process I'm going through or the research I'm doing, but it was quite disappointing. I quickly got the feeling of, do you really care about the work I'm doing? But well, maybe that's not what they wanted to convey, but that's the feeling I got anyway."
– Interviewee #3

"So there was more pressure on me to publish and show results, and I actually had to do it all on my own without any guidance. So that wasn't communicated well by the supervisors, that I had to do it all on my own and that I actually had to be able to do it all before starting the PhD. (...) In retrospect, I think that the supervisor and I just didn't click and that it didn't work from the beginning."
– Interviewee #1

5. Peers can make or break your PhD

Peer support was important on different levels for enhancing AM. Peers, mostly PhD candidates from the same department or research group, could share their experiences. Professionally, this was useful in sharing resources and effective strategies. On a personal level, peers countered feelings of loneliness or social isolation and provided support in personal doubts, e.g. career orientation. Peer activities in non-formal settings, for example during an international conference trip or Friday drinks, facilitated peer support.

The lack of peer support, e.g. within a competitive context or due to drop-out of peers, resulted in an unsafe learning environment and negatively impacted AM.

"The most important thing about a PhD trajectory is that you get a really special bond with your peers who you work with day by day. (...) because of your colleagues, I think you are able to hold on, they are a great support. They make it (i.e. PhD trajectory) the most fun."
– Interviewee #1

"In any case, negative things are rarely discussed because you do not want to give the impression that you- that things are not going well or...- status is just so important. You just have to be in control and you have to do things with great pleasure."
– Interviewee #3

6. Strategies to stay or get back on track

PhD candidates experienced the trajectory as a bumpy and challenging ride with highs and lows. These 'bumps' were often assumed to be part of the PhD journey, for example slow progress, dealing with 'politics' (e.g. conflicting interests with supervisors, or authorship issues), disappointing research outcomes, and no good fit with the research team. In case of frustration in needs, or conflicting values or interests, PhD candidates used targeted strategies to keep going and stay or get back on track:

6.1 **Active solution-seeking approach.** PhD candidates actively sought workarounds to overcome struggles and keep going. They used solution-seeking strategies such as 'speaking up' and 'making some changes', for example by continuing their work at another work place or department, by finding peers for personal support, or actively seeking for collaborations or supervision elsewhere, to change the team into 'a winning team'. When PhD candidates successfully conquered the 'bumps', feelings of achievement, personal growth, and eventually, AM was fostered. Most PhD candidates who aspired to a future research role explicitly mentioned they definitely wanted to use and translate their own learning experiences (varying from good to bad) in how they would fill in their future role as research supervisor. Lastly, dependency was considered a risk factor for conflicts with personal values to avoid professional conflicts. An often mentioned barrier to protect personal values and/or speak up was the vulnerable position in which most PhD are in, for instance when they admire to obtain a desired job position while supervisor(s) or other colleagues had powerful roles (e.g. programme director) in this procedure.

6.2 Accept that lows are part of a PhD journey. PhD candidates accepted that lows were part of their PhD and used (passive) 'take it or leave it' coping strategies to stay motivated. This 'tendency to accept' was stronger when PhD candidates were dependent on their supervisor(s) to get a desired future career position. This was a sustainable strategy when, for example, a highly desired specialty training position was obtained; it was all worth it in the end. However, when the 'wheels fell off' and the desired job position was not obtained, frustration replaced genuine interest and joy and mainly CM was a source to keep going. In addition, PhD candidates also used this strategy as they did not want to give up because they have come this far and already invested a lot of time and energy ('sunk cost effect'; i.e. the tendency to persist in a decision, even when it is unfavourable, because it involved significant costs as time, money and/or effort) and/or they do not want to disappoint themselves and others.

"I had never realized before, but in research it all has to do with who has the most power? Who is in charge? There will be authors on papers who have actually done nothing, but purely as favour. You have to work with people just to satisfy people and it's usually not the best for the research, we don't get the best results from that. But unfortunately that's how it goes..."
– Interviewee #5

"I was able to accept pretty soon that those are external factors that you just have to resign yourself to, because you simply can't do anything about it."
– Interviewee #9

"But I took that for granted, because I also thought , well; I just have to persevere, as soon as I'm a resident things will get better again. So you go on and you accept it. (...) But yes, I have invested so many hours that I just really want to finish it now."
– Interviewee #10

"Once I start something, I want to finish it. And that feeling was much stronger than, well, you know; I don't want to get into that desired specialty anymore, so I'm not going to get my PhD anymore either."
– Interviewee #1

When candidates mainly mentioned negative experiences (e.g. conflicts with personal values) when reflecting on their timeline, while at the same time over years a great effort was spent to achieve the PhD degree, they often added that, in hindsight, it was worth the effort. They described it to be valuable for other important aspects such as personal development, friendships that emerged, or career progress and orientation (in both specialty and academia).

"Well, it obviously moulds you into the person you are now. It's hard to then...That six months abroad gave me so much, also on a personal level, so many insights and that was such a cool period that – even though it was a hard time afterwards – it was worth it."
– Interviewee #3

"But it (i.e. PhD trajectory)– even though I may sound a little negative overall – has also brought me good things. So I did really enjoy doing it as well. (...) Well, maybe I want to emphasize that I don't want to say...It hasn't been a very negative experience, but it's how I look back on it now and it hasn't been like that over all these years."
– Interviewee #10

Discussion

Insights into factors affecting PhD candidates' motivation during their PhD journey are useful for both PhD candidates and their supervisors. We identified six themes influencing motivation along the challenging PhD journey: motives to start a PhD, autonomy at the right dose and time, a PhD trajectory to be a proof of competency and/or learning trajectory, support from supervisors and peers, and strategies to stay or get back on track.

The results of this study can be useful for graduate schools, PhD supervisors, PhD candidates or those considering a PhD. However, this study also comes with limitations. A first limitation of this study is that we only focussed on the experiences of PhD candidates. As our implications also affect and include supervisors, it would be useful to further explore the perceptions and experiences of PhD supervisors. A second limitation is the focus on motivation of PhD candidates who, in the end, were sufficiently motivated to get to the final phase of their PhD. Perhaps, PhD candidates who dropped out during their PhD encountered other barriers and/or used different strategies. Future study including dropped-out PhDcandidates can further strengthen insight into the complex nature of motivational development during a PhD and contribute to a sustainable doctoral environment.

Most studies on PhD candidates' experiences focused on negative attributes such as stress, anxiety, depression, and burn-out, while positive aspects of a PhD experience have been studied to a lesser extent.[6,8–11,16,23,45] This study reveals that positive and negative motivational factors for pursuing a PhD coincide as some factors were experienced positively, while the opposite was being experienced negatively, and vice versa (e.g. a good supervisor and the lack of a good supervisor). Some factors impacted motivation differently over time, changing from positive to negative and vice versa (e.g. dose of autonomy). In addition, there are individual differences in how a factor is perceived, showing that a successful journey cannot be simply reduced to just an absence of negative experiences. A recent single-centre study on both energizers and stressors of medical PhD candidates provided a first insight into factors affecting a PhD journey in medicine.[33] Our national multi-centre interview study adds, in addition to in-depth insight into factors affecting motivation during a PhD, that factors such as the dose of autonomy can contrary affect motivation depending on both the phase of the PhD and, in the end, individual strategies. Hence, one size fits nobody when it comes to supporting and maintaining an individual PhD's motivation. This underlines the relevance of reflecting on these themes before and during the PhD programme and to adjust support based on the outcomes of this reflection. Making the implicit explicit could contribute to autonomous motivation and hence, well-being, successful PhD completion, and, eventually aspired (future) clinician-scientists.

PhD candidates are usually high achievers, especially in the medical field when next to a research pathway a clinical career is aspired to.[46] Coping strategies like 'finish what you start' or 'keep your eyes on the price' were mentioned frequently. In addition, the concept of cognitive dissonance might be at stake in cases where some PhD candidates clearly described downsides of their PhD trajectory, yet had a tendency to quickly downside these as well. Cognitive dissonance refers to a situation involving conflicting attitudes, beliefs or behaviours resulting in feelings of discomfort leading to an alteration in one of the attitudes, beliefs or behaviours to reduce the discomfort and restore balance. Furthermore, distressing feelings arise when a PhD is perceived as a proof of competency. Particularly in the first phase of the PhD, when self-efficacy levels are

often low, these feelings are linked to the imposter syndrome. Stelling et al. found that the imposter syndrome among early career clinicians is associated with burn-out as a result of 'striving to fit in and stand out'.[47] Sverdlik et al. studied the imposter syndrome among doctoral students and found that feelings of belonging were a negative predictor of imposter syndrome which, in turn, predicted higher levels of depression, stress, and illness symptoms.[45] In line with these studies, our study highlights the importance of fostering a supportive environment. Our results show that this support is important at different levels (i.e. academic, autonomous, and personal level), which is also described by Overall and colleagues.[48] Support on the academic and autonomous level is mainly fulfilled by the research team and highly dependent on feeling supported by at least one supervisor. Lastly, personal support, is ideally fulfilled by the supervisory team, but can also be (further) provided by peers.

Conclusion

This study revealed factors that contribute positively and/or negatively to motivation during a PhD trajectory and result in the following practical implications: (1) PhD candidates and their supervisors should explicitly discuss learning goals and expectations of the PhD trajectory to contribute to a safe learning climate; (2) PhD candidates value to have at least one supervisor who is approachable, makes time, provides constructive and timely feedback, gives trust and autonomy, and sees the person behind the studies; (3) To strengthen peer support, it is important to facilitate peer activities in both formal (e.g. intervision, conferences) and non-formal (e.g. drinks) settings; (4) Autonomy is important during a PhD trajectory and it is necessary to find the right balance in guidance. It is essential to regularly evaluate how much autonomy is needed and it is important to align the amount of guidance accordingly, as the need for autonomy often changes as the PhD candidates gains more experience and expertise; (5) When difficulties are overcome, this is experienced as a personal achievement and success experience. It is important as research team to openly discuss the 'bumps during the ride' and stimulate solution seeking approaches. Some factors could coincide and change from positive to negative and vice versa, showing that a successful PhD journey cannot simply be reduced to an absence of negative experiences.

References

1. Kemp MW, Molloy TJ, Pajic M, Chapman E. An analysis of reported motivational orientation in students undertaking doctoral studies in the biomedical sciences. BMC Med Educ. Feb 27 2014;14:38.
2. Reinink M. PhD Explosie. Retrieved August 28, 2022, from https://www.artsenauto.nl/phd-explosie/.
3. Eley DS. The clinician-scientist track: an approach addressing Australia's need for a pathway to train its future clinical academic workforce. BMC medical education. 2018;18(1):227-227.
4. Andreassen P, Christensen MK. Science in the clinic: a qualitative study of the positioning of MD-PhDs in the everyday clinical setting. BMC Med Educ. May 25 2018;18(1):115.
5. Andreassen P, Wogensen L, Christensen MK. The employers' perspective on how PhD training affects physicians' performance in the clinic. Dan Med J. Feb 2017;64(2)
6. Kusurkar R, van der Burgt S, Isik U, et al. Burnout and engagement among PhD students in medicine: the BEeP study. Perspect Med Educ. Mar 2021;10(2):110-117.
7. Schad A, Layton RL, Ragland D, Cook JG. Mental health in medical and biomedical doctoral students during the 2020 COVID-19 pandemic and racial protests. Elife. Sep 6 2022;11
8. Zhang F, Litson K, Feldon DF. Social predictors of doctoral student mental health and well-being. PLoS One. 2022;17(9):e0274273.
9. Mattijssen L, Bergmans J, van der Weijden I, Teelken J. In the eye of the storm: the mental health situation of PhD candidates. Perspectives on Medical Education. 2020;10:71 - 72.
10. Sverdlik A, Hall NC, McAlpine L, Hubbard K. The PhD Experience: A Review of the Factors Influencing Doctoral Students' Completion, Achievement, and Well-Being. International Journal of Doctoral Studies. 2018;13:361-388.
11. Schmidt M, Hansson E. Doctoral students' well-being: a literature review. International Journal of Qualitative Studies on Health and Well-being. 2018/01/01 2018;13(1):1508171.
12. Ven I, Beukman J-J, Ali F, Weijden I, Meijer I. Policy report: The mental well-being of Leiden University PhD candidates. 2017.
13. Panger G. Graduate Student Happiness & Well-Being Report. 2015.
14. Levecque K, Anseel F, De Beuckelaer A, Van der Heyden J, Gisle L. Work organization and mental health problems in PhD students. Research Policy. 2017/05/01/ 2017;46(4):868-879.
15. Mattijssen L, van Vliet N, van Doorn T, Kanbier N, Teelken C. PNN PhD Survey: Asking the relevant questions. Mental wellbeing, Workload, Burnout, Research environment, Progress of the PhD project, Considering to quit. Online publication or Website https://hetpnn.nl/wp-content/uploads/2020/08/PNN-PhD-Survey-report-Wellbeing.pdf. 2020;
16. Woolston C. PhDs: the tortuous truth. Nature. 2019;575:403-406.
17. Korhonen J, Linnanmäki K, Aunio P. Learning difficulties, academic well-being and educational dropout: A person-centred approach. Learning and Individual Differences. 2014/04/01/ 2014;31:1-10.
18. Pyhältö K, Toom A, Stubb J, Lonka K. Challenges of Becoming a Scholar: A Study of Doctoral Students' Problems and Well-Being. ISRN Education. 2012/10/16 2012;2012:934941.
19. Anttila H, Lindblom-Ylänne S, Lonka K, Pyhältö K. The Added Value of a PhD in Medicine - PhD Students' Perceptions of Acquired Competences. The International Journal of Higher Education. 2015;4:172-180.
20. Devine K, Hunter KH. PhD student emotional exhaustion: the role of supportive supervision and self-presentation behaviours. Innovations in Education and Teaching International. 2017/07/04 2017;54(4):335-344.
21. Cornér S, Löfström E, Pyhältö K. The Relationships between Doctoral Students' Perceptions of Supervision and Burnout. International Journal of Doctoral Studies. 01/01 2017;12:091-106.
22. Barry K, Woods M, Warnecke E, Stirling C, Martin A. Psychological health of doctoral candidates, study-related challenges and perceived performance. Higher Education Research & Development. 01/19 2018:1-16.
23. Tikkanen L, Pyhältö K, Bujacz A, Nieminen J. Study Engagement and Burnout of the PhD Candidates in Medicine: A Person-Centered Approach. Front Psychol. 2021;12:727746.
24. Castelló M, Pardo M, Sala-Bubaré A, Suñe-Soler N. Why do students consider dropping out of doctoral degrees? Institutional and personal factors. Higher Education. 2017/12/01 2017;74(6):1053-1068.

25. Ryan R, Deci E. Self-determination theory. Basic psychological needs in motivation, development and wellness. New York, NY : Guilford Press. 2017:231.
26. Deci E, Ryan R. The importance of autonomy for development and well-being. Self-Regulation and Autonomy: Social and Developmental Dimensions of Human Conduct. 01/01 2005:19-46.
27. Ryan R, Deci E. An overview of self-determination theory. In: Deci EL, Ryan RM, eds. Handbook of self-determination research. University of Rochester Press; 2002.
28. Ryan R, Deci E. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. Am Psychol. 2000;55
29. Kusurkar R, ten Cate O, Vos C, Westers P, Croiset G. How motivation affects academic performance: A structural equation modelling analysis. Advances in health sciences education: theory and practice. 02/22 2012;18
30. den Bakker CR, de Beaufort AJ, Ommering BWC, Dekker FW, Bustraan J. Inspecting the leaky clinician-scientist pipeline: a national study on medical PhD candidates' motivations in the Netherlands. Manuscript submitted for publication. 2023.
31. Koestner R, Otis N, Powers TA, Pelletier L, Gagnon H. Autonomous Motivation, Controlled Motivation, and Goal Progress. Journal of Personality. 2008;76(5):1201-1230.
32. Wang CKJ, Liu WC, Kee YH, Chian LK. Competence, autonomy, and relatedness in the classroom: understanding students' motivational processes using the self-determination theory. Heliyon. 2019/07/01/ 2019;5(7):e01983.
33. Kusurkar R, Isik U, van der Burgt S, Wouters A, Mak-van der Vossen M. What stressors and energizers do PhD students in medicine identify for their work: A qualitative inquiry. Med Teach. May 2022;44(5):559-563.
34. Mattijsen JC, Ghedri, A., Reinhard, M. Promoveren Opleiders. De Geneeskundestudent. 2019;
35. Ghedri A, Bontje, W., Abdelmoumen, A. . Promoveren of profileren? . De Geneeskundestudent. 2018;
36. Adom D, com A, Ankrah K. Constructivism philosophical paradigm; implication for research, teaching and learning Global Journal of Arts Humanities and Social Sciences. 10/01 2016;4:1-9.
37. Basnet N, Wouters A, Kusurkar R. Timeline Mapping as a Methodological Approach to Study Transitions in Health Professions Education. International Journal of Qualitative Methods. 2023;22:16094069221148868.
38. Adriansen HK. Timeline interviews: A tool for conducting life history research. 2012:
39. den Bakker C, Wijnen-Meijer M, Bustraan J, Dekker F, de Beaufort A. Comparing medical PhD training programmes around the world: a matter of apples and oranges? Manuscript submitted for publication. 2023;
40. Varpio L, Ajjawi R, Monrouxe LV, O'Brien BC, Rees CE. Shedding the cobra effect: problematising thematic emergence, triangulation, saturation and member checking. Med Educ. Jan 2017;51(1):40-50.
41. Braun V, Clarke V. Using thematic analysis in psychology. Qualitative Research in Psychology. 2006/01/01 2006;3(2):77-101.
42. Kiger ME, Varpio L. Thematic analysis of qualitative data: AMEE Guide No. 131. Med Teach. Aug 2020;42(8):846-854.
43. Birt L, Scott S, Cavers D, Campbell C, Walter F. Member Checking: A Tool to Enhance Trustworthiness or Merely a Nod to Validation? Qualitative health research. 06/22 2016;26
44. Tong A, Sainsbury P, Craig JC. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. International journal for quality in health care : journal of the International Society for Quality in Health Care. 2007;19 6:349-57.
45. Sverdlik A, Hall N, McAlpine L. PhD Imposter Syndrome: Exploring Antecedents, Consequences, and Implications for Doctoral Well-Being. International Journal of Doctoral Studies. 01/01 2020;15:737-758.
46. Rosenthal S, Schlussel Y, Yaden MB, et al. Persistent Impostor Phenomenon Is Associated With Distress in Medical Students. Fam Med. Feb 2021;53(2):118-122.
47. Stelling BEV, Andersen CA, Suarez DA, et al. Fitting In While Standing Out: Professional Identity Formation, Imposter Syndrome, and Burnout in Early Career Faculty Physicians. Academic Medicine. 2022:10.1097/
48. Overall NC, Deane KL, Peterson ER. Promoting doctoral students' research self-efficacy: combining academic guidance with autonomy support. Higher Education Research & Development. 2011/12/01 2011;30(6):791-805.

Chapter 9

General discussion

1. General aim

Clinician-scientists connect clinical care to medical research, and vice versa, which is crucial for advancements in evidence-based medicine. The pathway of clinician-scientist careers is often referred to as 'the leaky pipeline', as many (potential future) clinician-scientists along their career are leaking out of this pipeline, resulting in a current clinician-scientist shortage worldwide. This shortage of clinician-scientists has been attributed to a lack of supply and too many obstacles to stay actively engaged in research, considered as leaks. In line with this, counteracting the clinician-scientist decline is approached in two ways: (1) Boosting the supply of the clinician-scientist pipeline, i.e. stimulating medical students and doctors to enter this pipeline, and (2) Preventing (future) clinician-scientists leaking out the pipeline.[1]

Research training programmes play an important role in attracting, training and retaining (future) clinician-scientists.[1-4] In this thesis, we focussed on challenges and outcomes of undergraduate and postgraduate research training programmes. In addition, we studied the potential role of motivation in the supply and leaks of the clinician-scientist pipeline, aiming to optimize the pipeline, and, eventually, contribute to a sustainable clinician-scientist workforce.

This general discussion chapter elaborates on how this aim has been fulfilled. First, a brief overview of the main findings of each study will be provided (an extended summary can be found in the next chapter). Thereafter, the main findings of the studies will be combined to draw general conclusions on supply and leaks of the clinician-scientist pipeline, particularly regarding the role of motivation for research in undergraduate and postgraduate research training. To conclude, both implications for practice and future perspectives will be discussed.

2. Brief overview of main findings

2.1 Part I: Undergraduate research training

In our first study (**chapter 2**), we bibliometrically investigated scientific outcomes of undergraduate mandatory research programmes in over 2000 medical students. At least one out of four medical students publish a peer-reviewed paper as a result of this mandatory research project. They were mainly first (42.5%) or second (25.3%) author and their papers showed an above-world-average citation impact. Students who conducted their research in an academic centre, conducted a clinical or laboratory study, extended their research, or were involved in an excellency track were more likely to publish. After

publishing as a result of the mandatory research project, students were twice as likely to publish or present research after graduation.

To further study the outcomes of undergraduate mandatory research, we used Self-Determination Theory to investigate the development of motivation, its determinants (i.e. research perceptions, research self-efficacy, autonomy, relatedness) and research ambitions during mandatory research projects (**chapter 3**). All motivational determinants increased during the research project, and, subsequently, fostered intrinsic motivation. Some of these (i.e. research perceptions and self-efficacy) also affected extrinsic motivation, though to a lesser extent. In turn, both intrinsic motivation and to a lesser extent extrinsic motivation were related to enhanced research ambitions. The increase in motivational determinants, motivation and research ambitions were more pronounced in students who initially stated that they would not have participated in research if it had not been a mandatory part of their curriculum. Only one out of ten students did not have research interest beforehand together with a decline in their intrinsic motivation for research during the research project. In sum, our results illustrated that undergraduate mandatory research programmes not only equip all future doctors with basic research knowledge, skills and attitude to practice evidence-based medicine, but also cultivates potential future clinician-scientists and, subsequently, might be part of the solution for the current decline in clinician-scientists.

In the next chapter (**chapter 4**) we address challenges in fair assessment of both research knowledge and skills (*Ausbildung*), and a scholarly attitude (*Bildung*), for example during mandatory research training. We illustrate how objectivity in learning procedures and assessment, often received as the only way to achieve fairness, can hamper developing a true academic mindset. Objectivity often results in standardized educational procedures to treat students equally. We demonstrate that not treating students in a same way can foster scholarly development by considering fairness as meeting students' (different) needs. This requires a certain amount of subjectivity and flexible learning pathways to train doctors as true scholars. As the role of scholar is mainly comprised of research competencies, but also entails teaching competencies, **chapter 5** focuses on educating teaching competencies in future scholarly doctors and provides twelve tips for an educational programme to foster the next generation of medical teachers.

2.2 Part II: Postgraduate research training

In **chapter 6** we compared medical PhD training programmes of the top ten leading countries in life sciences research around the world (the United States of America, the United Kingdom, China, Germany, Japan, France, Canada, Australia, Switzerland,

and the Netherlands). Medical PhD training programmes around the world have a common goal (i.e. training clinician-scientists). In addition, the number of agreements regarding mutual recognition of a PhD degree increases. Nevertheless, we learned that the structure, requirements and characteristics of these programmes highly differ between and even within countries. PhD pathways even differ between institutes of the same country, between departments within institutes, and between research teams within departments. We conclude that transparency of the differences and similarities between medical PhD training programmes can improve international recognition, mobility, and quality of medical PhD candidates and MD-PhDs. In addition, this is relevant for sharing, interpreting and generalising outcomes of research on medical PhD candidates and doctoral education.

Thereafter, we focused on medical PhD programmes in the Netherlands and investigated quantity and quality of motivation of over 1300 Dutch medical PhD candidates (**chapter 7**). We found that the majority is highly autonomously motivated for research (i.e. high quality motivation), but within this group a quarter is highly controlled motivated for research as well (i.e. low quality motivation). Autonomous motivation was fostered by expectancy of success beliefs and when a PhD was valued for personal interest or development and a clinician-scientist career. Controlled motivation was fostered when a PhD was perceived as valuable for clinical career development. In turn, autonomous motivation was related to higher levels of work engagement, lower levels of drop-out intentions, and increased clinician-scientist career ambitions, whilst controlled motivation was contrary related to these constructs. In addition, we explored the combined effect of autonomous and controlled motivation and learned that controlled motivation was detrimental for the positive effects related to autonomous motivation.

Following on this study, in **chapter 8** we qualitatively identified factors influencing PhD candidates' motivation for obtaining a PhD during their PhD trajectory. This study revealed the following six factors that contributed positively and/or negatively to high quality motivation: (1) Initial motivation to start a PhD matters; (2) Autonomy, a matter of the right dose at the right time; (3) PhD as proof of competence and/or as learning trajectory?; (4) It takes (at least) two to tango; (5) Peers can make or break your PhD; (6) Strategies to stay or get back on track. In addition, we found that some factors could be experienced positively, while a lack of it can be experienced negatively, and vice versa. Additionally, some factors had different effects on motivation as they could change over time and often depended on the phase of the PhD. This study also highlighted the impact of vulnerable positions that most PhD candidates were in. This fostered feelings of the imposter syndrome, the pressure to fit in while standing out, and challenged individual coping strategies when conflicts with personal values were

encountered. A supportive environment, including both peers and a good fit with at least one supervisor, appeared to be crucial in fostering high quality motivation, and hence, a successful PhD trajectory.

3. General conclusions

3.1 Supply

When focussing on the supply, previous research showed that it is important to catch future clinician-scientists young, which is why we choose undergraduate research training as potential starting point of the clinician-scientist pipeline.[3-6] There is no clear description of what an optimal undergraduate research training programme, let alone curriculum, looks like. The question of whether undergraduate medical research should be made mandatory is still a matter of debate. Mandatory research programmes have a dual purpose aiming to train every future doctor as a scholar who practices evidence-based medicine and is able to conduct research, as well as cultivate future clinician-scientists (**chapter 4**). To evaluate research programmes, scientific output in terms of peer-reviewed published papers are often perceived as a proxy for quality and success of undergraduate research programmes.[6-10] Indeed, medical students who reach high levels during their research experiences resulting in a peer-reviewed paper are more likely to be involved in research after graduation.[3-6]

This is in line with our results showing that students who published were twice as likely to publish or present their research after graduation (**chapter 2**). Our retrospective follow-up study showed that at least one out of four students published findings of their mandatory research in a peer-reviewed paper, mainly as first or second author. This might be an underestimation due to limitations of the bibliometric methods used. Indeed, within our prospective follow-up study, 40% of the medical students indicate that they will publish their project and an additional 20% state they would probably publish their research outcomes (**chapter 3**). This scientific output is (almost) equal to publication rates of voluntary research projects.[4,11] This may not seem surprising at first. Perhaps, students that feel the need for research participation are facilitated by mandatory research opportunities, but would otherwise have participated in elective research opportunities. However, one needs to bear in mind that in mandatory research programmes not only pre-selected excellent students, but all students were involved. Consequently, similar publication rates in mandatory research concern a higher number of students who published their research. Placing these publication rates in a broader and more general perspective, it is noteworthy that medical students in the Netherlands start medical training right after graduating from high school mostly without prior research experience.[12,13] Thus, contrary to the majority of medical students involved in elective undergraduate research programmes with similar outcomes, students included in our studies were relatively new in conducting research.[11]

In the perspective of stimulating the clinician-scientist pipeline supply, these results may be considered encouraging. However, a compelling main reason for medical students to participate in research and/or publish is the common belief that this will improve their chances for a competitive residency position and enhances their curriculum vitae (CV), rather than for the value it has in and of itself.[4,5,14–17] Research is an important factor in residency selection, particularly in competitive specialties.[16–18] Even 20-60% of the students stated that they would not participate in research activities when it was not affecting their chances for a residency spot.[16–18] This demonstrates that medical students are already taking postgraduate challenges into consideration whilst at medical school. This incentive to conduct and publish research for future clinical career aspects can be categorized as a low quality of motivation (i.e. external regulation, being part of extrinsic and controlled motivation, see *Figure 2* in 'General introduction'). Although measurable scientific outcomes as publication rates are often used to indicate success of research programmes and, indeed, are reported to be associated with postgraduate research involvement, we felt the need to adopt an extra perspective in studying the supply and leaks of the clinician-scientist pipeline by looking at motivation for research in our subsequent studies (**chapter 3, 7 and 8**).

When aiming to create a sustainable clinician-scientists workforce, following Self-Determination Theory, it seems desirable to foster high quality motivation (i.e. intrinsic or autonomous motivation, see *Figure 2* in 'General introduction'). Similar to undergraduate publication, intrinsic motivation for research enhances future research involvement.[19] In our longitudinal study we learned that next to relatively high intrinsic motivation (i.e. high quality motivation), students also had relatively high extrinsic motivation (i.e. low quality motivation). In line with students being highly motivated for research to improve their CV, the questions arises whether low quality of motivation only seem less favourable than high quality motivation or should be labelled as 'bad' in the perspective of a sustainable clinician-scientist workforce. Our study showed that low and high quality of motivation further increased during mandatory research (**chapter 3**), especially in students who initially stated that they were not willing to participate in research when it was not a mandatory part of their medical curriculum. In turn, intrinsic motivation and to a lesser extent extrinsic motivation improved students' research career ambitions and, hence, can both be perceived as relevant in cultivating the next generation clinician-scientists. Taken these results together, we hope that this thesis convincingly showed that undergraduate mandatory research programmes are valuable for both the quantity and quality of the clinician-scientist pipeline supply.

3.2 Leaks

After obtaining a medical degree, junior doctors are in control of shaping their own future career steps. This allows some clinicians to specialise in research and enter the clinician-scientist pathway, while others opt to invest in other ventures. A PhD trajectory is the most common pathway to become a clinician-scientist.[20] More and more medical doctors decide to enrol in a medical PhD programme in the past two decades,[21–28] with reported rates between 25-33% of junior doctors starting a PhD programme, an encouraging trend in the perspective of the clinician-scientist shortage.[29] Remarkably, this intensified enrolment exists alongside the continuing clinician-scientist decline leading to the hypothesis that next to quantity (i.e. number of doctors entering the pipeline by initiating a PhD), quality (i.e. motivations) of supply might play an important role in the leaky clinician-scientist pipeline.

Motivation has become a key concept in the understanding of academic persistence, achievement, well-being, academic success, research involvement and many other favourable outcomes.[19,30,31] Motivations for participating in a PhD are already formed during medical school (**chapter 3 and 8**),[16] but follow-up on those who actually decided to enrol in a PhD programme lacks. In a nationwide study we identified motivational profiles among Dutch medical PhD candidates (**chapter 7**). We showed that most medical PhD candidates incorporate high quality motivation as they are highly autonomously motivated for their PhD. However, next to high autonomous motivation, almost a quarter had high controlled motivation (i.e. low quality motivation) for their PhD as well. In addition, one out of seven medical PhD candidates showed a lack in high quality of motivation for a PhD. In conclusion, 36% of Dutch medical PhD candidates lack high quality motivation and/or have a high amount of low quality motivation. In the same study we demonstrated that high quality motivation is associated with work engagement, programme persistence intentions and the ambition to work as a clinician-scientist after obtaining a PhD degree. Contrary, low quality of motivation (i.e. controlled motivation) was associated with less work engagement, intentions to drop out of the PhD programme and the ambition to work as a clinician without research involvement. Although we did not provide follow-up including actual drop-out or persistence during or after the PhD trajectory, the literature confirms the direct effect of work engagement and the intention to persist in completing the PhD.[32,33] This opposing effect of types of motivation (i.e. autonomous and controlled motivation) is corroborated by other studies showing high quality motivation is positively related to numerous desirable outcomes such as well-being and persistence, whilst low quality motivation is not or negatively related to them.[34–37]

It is remarkable that low quality of motivation among medical students is positively related to research career ambitions, whilst, when continuing in the clinician-scientist pipeline, low quality of motivation among medical PhD candidates is negatively related to research career ambitions (**chapter 3 and 7**). This can be explained by addressing high quality motivation in students as intrinsic motivation (consisting of intrinsic regulation only), while we broadened high quality motivation to autonomous motivation (consisting of intrinsic, integrated and identified regulation) in PhD candidates. Another explanation for this can be that medical students aspire to take further steps towards a research career in the short term to improve their CV, indicating that they intent to participate in a PhD programme, without aspiring a research career in the long term. In this way, low quality motivation (e.g. CV building) is related to (short term) research career ambitions amongst medical students. After starting a PhD programme and perhaps obtaining a residency position as PhD candidate, this aim vanishes and, thereby, potentially, the ambition to further pursue research activities in the future. This might also explain that medical doctors who obtain a PhD degree later on in their clinical career, e.g. as medical specialist, show lower levels of controlled motivation compared to doctors not in training (**chapter 7**). In line with low quality motivation resulting in decreased ambitions for research amongst PhD candidates, a study by Wolters showed that less than half of Dutch medical PhDs work in an academic centre ten years after obtaining their PhD degree. In addition, almost half of them have not published any paper within these ten years. Accordingly, a Danish study showed one out of three MD-PhDs to be a zero publisher nine years after their PhD.[38]

3.3 Perspectives

In sum, more than one out of three Dutch medical PhD candidates lack high quality motivation and/or have a high amount of low quality motivation (**chapter 7**). As high quality motivation improves work engagement, programme persistence and research ambitions, whilst low quality motivation increases burn-out and drop-out intentions (**chapter 3, 7, 8**),[27,31,39-41] a substantial amount of PhD candidates are at risk of dropping out the clinician-scientist pipeline during or soon after their PhD based on their motivation. Our outcomes may contribute to understanding the widely reported increasing concerns regarding well-being and, subsequently, attrition rates in doctoral education.[39,42-44] In this way, quality of motivation seem particularly important when aiming to improve the clinician-scientist pipeline and to reverse the trend towards a declining clinician-scientist workforce. According to our findings, next to improving quantity of the supply (i.e. stimulating students and doctors to enter the pipeline), we should aim to foster to the quality of this supply (i.e. motivation of students and PhD candidates). More specific, we should address threats to and improve quality of motivation for research while attracting, training and retaining (future) clinician-scientists to prevent them leaking out the pipeline.

This thesis offers some insight in stimulating high quality motivation and/or limiting low quality motivation for research among (future) clinician-scientists. Within our studies, multiple constructs emerged and were examined on their relationship with high quality of motivation for research. Our studies highlighted the importance of values, positive research perceptions, relatedness, autonomy, and research self-efficacy beliefs in enhancing high quality motivation (**chapter 3, 7 and 8**). This is substantiated by different motivational theories; Theory of Planned Behaviour (TPB), Expectancy Value Theory (EVT), and Self-Determination Theory (SDT). The first theory proposes that, among others, attitudes and perceived behavioural control are prerequisites for motivation, which in turn is related to a certain behaviour.[45] Attitudes are a reflection of one's values.[46] Attitudes as mentioned within TPB are defined as favourable or unfavourable perceptions of a certain behaviour of interest. Perceived behavioural control refers to a person's perception of the ease or difficulty of performing the behaviour of interest. This is in line with the second theory (EVT), stating that values (touching upon TPB's attitudes as reflection of one's values) together with expectancies for success (touching upon TPB's behavioural control) result in a certain behaviour.[47] However, both theories do not distinguish type of motivations and focuses on quantity of motivation rather than quality of motivation. As our studies, and multiple other studies within other domains and target populations, did corroborate SDT's vision that quality of motivation matters in order to reach desired outcomes, we believed that it is valuable to make this distinction. When testing both theories in our specific context, we therefore investigated the effect of these motivational prerequisites on different qualities of motivation using SDT. Previous studies showed that students perceptions of research are open to change, which offers opportunities to target and adjust unrealistic research perceptions, as well as promote positive perceptions of research, and in turn influence motivation for research.[48,49]

In line with SDT, the importance of self-efficacy, i.e. one's belief in his or her own ability to accomplish a task, was next to relatedness and autonomy emphasized in fostering high quality motivation. Self-efficacy is believed to be somewhat similar to SDT's need for competence and EVT's expectancy for success (**chapter 3 and 7**). In line with SDT, during a PhD programme, self-efficacy beliefs emerged as theme in our qualitative study as well, together with the need for the right dose of autonomy and the need for relatedness (**chapter 3 and 8**). A lack of self-efficacy beliefs is associated with the imposter syndrome. This syndrome refers to the inner speech of self-doubt, excessive self-criticism and the belief that you are not as competent as others perceive you to be, which eventually can become an obstacle to the completion of a PhD.[50] Also in other scientific disciplines, many PhD candidates doubt their abilities and experience severe performance pressure. Uncertainty and pressure are exacerbated by the increasing emphasis on competition and excellence. Within the medical context, this is emphasized by specific personality traits such as perfectionism and doctors being high achievers. Next to this, medical PhD candidates are often in a vulnerable position, as they not only aim to obtain their PhD degree, but also a competitive residency position (**chapter 8**). Stelling and colleagues (2022) described the dual desire to 'fit in while standing out' among early career clinicians and its relation to imposter syndrome and burn-out risks.[51] Fitting in is defined as feeling a sense of belonging at work, which touches upon SDTs need for relatedness. In our interview study we found that this relatedness during a PhD was approached in two ways. First, relatedness with peers was important for feelings of belonging and personal support. Aspects of the work environment, including feeling safe to share insecurities (e.g. intervision meetings), having informal meetings (e.g. drinks), and a culture of teamwork (e.g. proper supervision) were important for PhD candidates to feel like they fit in. Second, a PhD often influenced career orientation as the fit with the specialty was explored. The desire to stand out can be described as the need to demonstrate expertise. Our study adds that although some PhD candidates perceive their PhD as a learning trajectory, they often believe that others (e.g. supervisors) perceive it as a proof of competence, which in turn fostered feelings of imposter syndrome.

Supervisors can play an important role in targeting self-efficacy beliefs as a way to stimulate good quality of motivation for research. Self-efficacy beliefs are reported as cornerstone of doctoral studies persistence, as it shows to be a strong predictor of drop-out intentions and an important distinguisher between completers and non-completers amongst PhD candidates.[27] The role of mentorship in attracting, training and retaining the existing clinician-scientist have been widely reported to improve self-efficacy of young clinician-scientists and increases their retention in the profession of clinician-scientist.[20,27,52] According to PhD candidates, effective supervision is defined as having a supervisor who is approachable, makes time, provides constructive and timely feedback, gives trust, provides choices, and has an eye for the person behind the research projects (**chapter 8**). This is in line with Overall et al. (2011) describing that greater supervisor availability and feedback, as well as feeling valued and accepted is associated with more positive evaluations of supervision quality.[41] Experienced lack of satisfaction with supervision and low frequency of supervision are widely reported to negatively impact well-being, which in turn is related to attrition.[53-57] PhD candidates who did not complete their trajectory report random and infrequent meetings, a lack of active guidance, and poor quality supervisor relationships. Contrary, PhD candidates who completed their trajectory reported more regular meetings and fewer delays in obtaining feedback.[41]

In addition, Overall and colleagues describe that effective doctoral supervision includes autonomy support, academic support, and personal support.[41] Autonomy support entails acknowledging the PhD candidate's perspective, encouraging to be open with their ideas and providing them with opportunities to make their own decisions. Academic support refers to being available to help with academic activities and providing timely feedback. Personal support includes being emotionally supportive and boosting confidence when students encounter difficulties. Their results indicate that a combination of high levels of autonomy and academic support is associated with high levels of research self-efficacy and found no association between personal support for supervisors and research self-efficacy. They conclude that in turn, greater research self-efficacy resulting in high quality motivation predicts greater engagement, enhanced persistence, academic success, less drop-out intentions, more effective coping with setbacks and failures, and better academic performance. Our study reveals similar findings on the need for autonomy and academic support in medical PhD candidates and adds that the need for personal support not necessarily needs to be fulfilled by the supervisor, but also can be tailored by others, for example peers (**chapter 8**). Thus, personal support provision might be effectively achieved by other collegial relationships (e.g. peers) or participation in the wider research culture. In addition, we found that these needs for support differ within PhD candidates and phases of their trajectory. For example, most PhD candidates experienced less need for autonomy support (e.g. having choices) and a higher need for academic support (e.g. guidance on how to complete research tasks) in the beginning of their PhD trajectory. As their trajectory progressed and self-efficacy levels raised, the need for autonomy support was often more pronounced while the need for academic support became less.

To conclude, the quality of the PhD candidate-supervisor relationship is essential in fostering high quality motivation. However, the quality and availability of supervision is threatened by the increasing number of medical PhD candidates, resulting in higher numbers of PhD candidates per supervisor and, subsequently, dissatisfaction among PhD candidates.[42,58,59] Our qualitative research showed that a good fit with at least one supervisor is crucial for PhD candidates to stay on track. Devos and colleagues (2016) described that a misfit in supervision is likely to have a negative impact on high quality motivation and, subsequently, work engagement, and challenges conflict management.[60] In line with our results, different coping strategies are identified, varying from learn to live with it (accepting approach) to turning to alternate resources (solution seeking approach). Exploring the match between PhD candidate and supervisor before embarking on a PhD trajectory, may prevent PhD candidate's and supervisor's frustrations that come with a misfit. Moreover, supervisors could be trained and informed on PhD candidates' psychological needs, and encouraged to support them, a role that goes beyond traditional classroom teaching and research project supervision. In addition, group supervision and other collective forms of supervision are opted to contribute to better quality of supervision of PhD candidates, but its effectiveness in terms of supervision satisfaction is not yet known.[55]

With this thesis, we aimed to get insight in the challenges, outcomes, and role of motivation in the clinician-scientist pipeline. We learned that the amount and type of motivation are relevant for the supply and leaks of the pipeline. Within this general discussion, as a result of theoretical insights, quantitative and qualitative research findings, I focused on and emphasized the importance of high quality motivation for research. I hope to have shed light on challenges in training and retaining clinician-scientists and possibilities to improve the clinician-scientists pathways. I do feel the need, however, to explicitly mention that leaking out the clinician-scientist pipeline per definition not always should be labelled as 'bad'. A PhD can be valuable for the medical field even when it does not result in a clinician-scientist career. For example, as showed in this thesis, a PhD provides a unique insight in both the academic world and a preferred specialty and, in this way, improves a well-informed future career choice. Eventually, this could prevent attrition of residents, which is a worldwide concern.[61,62] In addition, MD-PhDs develop scholarly competences which serve them during the rest of their career and can improve quality of healthcare, also in non-academic hospitals. This is corroborated by a mixed-methods study by Andreassen and colleagues (2017) on PhD training affecting clinicians' performance in the clinic.[25] This study showed that employers seem satisfied with the skills and knowledge MD-PhDs brought to the clinic, particularly in terms of their ability to appraise and involve new and relevant information, instigate a more scientific approach in the clinic and, thereby, improving evidence-based medicine in practice. They recognized that a PhD also positively influences other CanMEDS roles, especially of collaborator, communicator and manager. In addition, they mentioned that MD-PhDs acted as 'role models' for the rest of the ward in terms of being curious, critical, reflective and educational. This demonstrates that the value of MD-PhDs contribute to clinical care in ways that are not directly measurable. Furthermore, PhD candidates are conducting research on a large scale and, subsequently, significantly contribute to advancements in the medical field. In the Netherlands, universities benefit financially from this, as PhD candidates are relatively cheap labor and each dissertation is rewarded with a financial fee.

At the same time, concerns have been raised about MD-PhDs who used their PhD as shortcut to a residency position and stop doing medical research in the clinic soon after completing their PhD.[25] In addition, drop-out during the PhD programme can lead to individual stress and loss of valuable time and resources invested in the PhD candidate

with no return on investment. Other concerns regarded too much emphasize being attached to a PhD degree.[25,38] It is opted that, while a PhD prompted certain relevant skills, these skills could also be achieved in other less expensive and intensive ways. When another road than a full PhD would be an option, a part of the medical doctors might be motivated to be involved in research to another extent, e.g. a research project or seminar.[63] In line with this, some argue that clinical diversity is threatened by the increasing number of MD-PhDs.[25,64] This need for diversity is emphasized by the rapidly evolving medical landscape. When medical doctors purely use a PhD as mean to get into a competitive specialty, they might prefer developing themselves in other domains than research, such as medical education (**chapter 5**), leadership, management, planetary health, or technology and innovation, which are crucial demands of the (future) medical landscape as well.[65-68] In the end, doing what you love significantly enhances the chances of success and, in this way, contributes to a sustainable medical working force, including the clinician-scientist working force.

3.4 Practical implications

Practical implications regarding attracting, training and retaining (future) clinician-scientist can be derived from this thesis and are showed in *Box 1*. This can be useful for all who are involved in the clinician-scientist pipeline e.g. students, PhD candidates, supervisors and policy makers.

Box 1. *Overview of practical implications derived from this thesis and combined with literature.*

Increasing entry into the clinician-scientist pipeline (supply)

- Provide every student with a fulltime authentic hands-on research experience. This fosters high quality motivation, especially in students who were initially not interested in research participation. In turn, high quality motivation enhances their research career ambitions. – ***chapter 2 & 3***
- Create flexible learning pathways in research training including a more subjective, formative approach, for example by more freedom in assessment and feedback. – ***chapter 2 & 4***
- Stimulate students to invest in a successful research experience by supporting them in publishing a paper as a result of their research project. – ***chapter 2***
- Focus on relatedness, autonomy and self-efficacy during undergraduate research experiences, for example by involving students in a research group during their research project, offering choice in duration and subject, and providing trust through supervision when facing difficulties. – ***chapter 3***
- Assure protected time in undergraduate and postgraduate research opportunities. – ***chapter 3 and 8***

Reducing attrition from the clinician-scientist workforce (leaks)

- Reflect on quality of motivation with corresponding potential outcomes before initiating a PhD trajectory. – ***chapter 7***
- Provide flexibility in research career pathways, for example by offering postgraduate research opportunities to conduct research on other levels than a full PhD or later on in the clinical career. – ***chapter 7 and 8***
- Pay attention to and support autonomy, relatedness and self-efficacy to foster and sustain high quality motivation for research. For example, by providing choices depending on the need and level of self-efficacy, by facilitating informal activities and intervision meetings with peers, and providing trust, timely feedback and guidance during academic progress. – ***chapter 7 and 8***
- Explore the match between supervisor and PhD candidate before the start of the PhD programme. – ***chapter 8***
- Emphasize the learning character of PhD programmes. – ***chapter 8***
- Explicitly promote the value and relevancy of other ventures for the medical field to challenge medical doctors who consider to participate in a PhD programme solely with the purpose of 'ticking the box' for a residency application and without genuine research interest. – ***chapter 5 and 8***

3.5 Future research avenues

This thesis provides directions for future research. First, in this thesis we focused on the role of motivation in the master's and doctoral phase within the clinician-scientist pipeline without (long term) follow up. The clinician-scientist pipeline, including its leaks, continues after the PhD journey. Previous studies have identified various barriers to stay actively engaged in research after obtaining a PhD, such as a lack of funding and difficulties combining research, clinical care, and family and personal life.[1,69] This thesis showed that quality of motivation can be added to this list. We found that quality of motivation impacts drop-out intentions during or after the PhD trajectory, but, despite that this can be used as a proxy for drop out, we were not able to provide insight in to what extent these intentions are acted upon and acknowledge the importance of follow-up during and after the PhD trajectory. Future research should be conducted over longer periods, for example following PhD candidates from the beginning of their PhD programme to ten years after their PhD, combining self-report measures with objective measures.

Second, within this thesis we included the perspective of medical students and PhD candidates. Medical students' and PhD candidates' motivation for research showed to be affected by their beliefs about how others perceive and value a PhD. It would be relevant to challenge these beliefs to further unravel the value of PhD in the medical domain. As many other stakeholders are involved in the leaky pipeline, including their perspective in improving the clinician-scientist pipeline could be of interest too. For example, unravelling the value of a PhD to provide insight in what counts in the eye of programme directors might result in leads to give meaning to this.

Third, all of the research was conducted within a single country. An important finding of this thesis was that medical PhD programmes highly differ between countries (**chapter 6**), which can limit generalisability of research on medical PhD programmes and candidates, and highlights the importance of transparency of these programmes. For example, in the Netherlands, as in some other European countries like Belgium and the Scandinavian countries, PhD candidates have a formal employment agreement with the university including a monthly salary.[42] This is only one of many differences between PhD programmes around the world. Although this study focused on the Netherlands, we believe that the results also have wider relevance to other countries. The international academic environments is increasingly typically described as a competitive field and shares other similarities. To improve generalisability, we comprehensively described the Dutch context within our studies and consciously interpret international literature regarding medical doctoral education. However, it is unclear to what extent the role of motivation is depending on the context of the medical PhD and deserves future attention.

References

1. Salata, R.A., et al., U.S. Physician–Scientist Workforce in the 21st Century: Recommendations to Attract and Sustain the Pipeline. Academic Medicine, 2018. 93(4): p. 565-573.
2. Stone, C., et al., Contemporary global perspectives of medical students on research during undergraduate medical education: a systematic literature review. Med Educ Online, 2018. 23(1): p. 1537430.
3. Murray, H., J. Payandeh, and M. Walker, Scoping Review: Research Training During Medical School. Med Sci Educ, 2022. 32(6): p. 1553-1561.
4. Amgad, M., et al., Medical Student Research: An Integrated Mixed-Methods Systematic Review and Meta-Analysis. PLoS One, 2015. 10(6): p. e0127470.
5. Griffin, M.F. and S. Hindocha, Publication practices of medical students at British medical schools: experience, attitudes and barriers to publish. Med Teach, 2011. 33(1): p. e1-8.
6. Waaijer, C.J.F., et al., Scientific activity by medical students: the relationship between academic publishing during medical school and publication careers after graduation. Perspectives on Medical Education, 2019.
7. Reinders, J.J., T.J. Kropmans, and J. Cohen-Schotanus, Extracurricular research experience of medical students and their scientific output after graduation. Med Educ, 2005. 39(2): p. 237.
8. Wootton, R., A simple, generalizable method for measuring individual research productivity and its use in the long-term analysis of departmental performance, including between-country comparisons. Health research policy and systems, 2013. 11: p. 2-2.
9. Al-Busaidi, I.S. and G.P. Tarr, Dissemination of results from medical student public health research training and factors associated with publication. 2018. 94(1112): p. 330-334.
10. Yassar Alamri, W.C., Kate Magner, Ibrahim Saleh Al-Busaidi, Tim J Wilkinson, Lutz Beckert, Publication rates of, and attitudes toward, summer research projects: 10-year experience from a single institution in New Zealand. Advances in Medical Education and Practice, 2019.
11. Chang, Y. and C.J. Ramnanan, A Review of Literature on Medical Students and Scholarly Research: Experiences, Attitudes, and Outcomes. Academic Medicine, 2015. 90(8): p. 1162-1173.
12. ten Cate, O., Medical Education in the Netherlands. Medical teacher, 2007. 29: p. 752-7.
13. Wijnen-Meijer, M., et al., Stages and transitions in medical education around the world: Clarifying structures and terminology. Medical Teacher, 2013. 35(4): p. 301-307.
14. Siemens, D.R., et al., A survey on the attitudes towards research in medical school. BMC Med Educ, 2010. 10.
15. Ommering, B.W.C. and F.W. Dekker, Medical students' intrinsic versus extrinsic motivation to engage in research as preparation for residency. Perspect Med Educ, 2017. 6(6): p. 366-368.
16. Ghedri, A., Bontje, W., Abdelmoumen, A. , Promoveren of profileren? . De Geneeskundestudent., 2018.
17. Pathipati A S, T.N., Research in Medical School: A Survey Evaluating Why Medical Students Take Research Years. . Cureus 8(8): e741. DOI 10.7759/cureus.741.
18. Mattijsen, J.C., Ghedri, A., Reinhard, M., Promoveren Opleiders. De Geneeskundestudent., 2019.
19. Ommering, B.W.C., et al., Fostering the physician–scientist workforce: a prospective cohort study to investigate the effect of undergraduate medical students' motivation for research on actual research involvement. BMJ Open, 2019. 9(7): p. e028034.
20. Yeravdekar, R.C. and A. Singh, Physician-Scientists: Fixing the Leaking Pipeline — A Scoping Review. Medical Science Educator, 2022. 32(6): p. 1413-1424.
21. Reinink, M. PhD Explosie. Retrieved August 28, 2022, from www.artsenauto.nl/phd-explosie/. 2019.
22. Traill, C.L., et al., Time to research Australian physician-researchers. Internal Medicine Journal, 2016. 46(5): p. 550-558.
23. Eley, D.S., The clinician-scientist track: an approach addressing Australia's need for a pathway to train its future clinical academic workforce. BMC medical education, 2018. 18(1): p. 227-227.
24. Andreassen, P. and M.K. Christensen, Science in the clinic: a qualitative study of the positioning of MD-PhDs in the everyday clinical setting. BMC Med Educ, 2018. 18(1): p. 115.

25. Andreassen, P., L. Wogensen, and M.K. Christensen, The employers' perspective on how PhD training affects physicians' performance in the clinic. Dan Med J, 2017. 64(2).
26. Castelló, M., et al., Why do students consider dropping out of doctoral degrees? Institutional and personal factors. Higher Education, 2017. 74(6): p. 1053-1068.
27. Litalien, D. and F. Guay, Dropout intentions in PhD Studies : a comprehensive model based on interpersonal relationships and motivational resources. Contemporary Educational Psychology, 2015. 41: p. 218-231.
28. Shin, M., A. Goodboy, and S. Bolkan, Profiles of doctoral students' self-determination: susceptibilities to burnout and dissent. Communication Education, 2021.
29. Andersen, S.B., et al., Extracurricular scientific production among medical students has increased in the past decade. Dan Med J, 2015. 62(9).
30. Ryan, R.M. and E.L. Deci, Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. Am Psychol, 2000. 55.
31. Litalien, D., F. Guay, and A.J.S. Morin, Motivation for PhD studies: Scale development and validation. Learning and Individual Differences, 2015. 41: p. 1-13.
32. Collini, S.A., A.M. Guidroz, L.M. Perez, Turnover in healthcare: the mediating effects of employee engagement. Journal of Nursing Management, 2015. 23(2): p. 169-178.
33. Clercq, M., et al., All You Need is Self-Determination: Investigation of PhD Students' Motivation Profiles and Their Impact on the Doctoral Completion Process. International Journal of Doctoral Studies, 2021. 16: p. 189-209.
34. Wang, C.K.J., et al., Competence, autonomy, and relatedness in the classroom: understanding students' motivational processes using the self-determination theory. Heliyon, 2019. 5(7): p. e01983.
35. Sheldon, K.M., et al., The independent effects of goal contents and motives on well-being: it's both what you pursue and why you pursue it. Pers Soc Psychol Bull, 2004. 30(4): p. 475-86.
36. Pedersen, L.B., et al., Burnout of intrinsically motivated GPs when exposed to external regulation: A combined panel data survey and cluster randomized field experiment. Health Policy, 2021. 125(4): p. 459-466.
37. Koestner, R., et al., Autonomous Motivation, Controlled Motivation, and Goal Progress. Journal of Personality, 2008. 76(5): p. 1201-1230.
38. Wildgaard, L. and K. Wildgaard, Continued publications by health science PhDs, 5 years post PhD-Defence. Research Evaluation, 2018. 27(4): p. 347-357.
39. Kusurkar, R.A., et al., Burnout and engagement among PhD students in medicine: the BEeP study. Perspect Med Educ, 2021. 10(2): p. 110-117.
40. Jeno, L.M., A.G. Danielsen, and A. Raaheim, A prospective investigation of students' academic achievement and dropout in higher education: a Self-Determination Theory approach. Educational Psychology, 2018. 38(9): p. 1163-1184.
41. Overall, N.C., K.L. Deane, and E.R. Peterson, Promoting doctoral students' research self-efficacy: combining academic guidance with autonomy support. Higher Education Research & Development, 2011. 30(6): p. 791-805.
42. van Rooij, E., M. Fokkens-Bruinsma, and E. Jansen, Factors that influence PhD candidates' success: the importance of PhD project characteristics. Studies in Continuing Education, 2021. 43(1): p. 48-67.
43. Tikkanen, L., et al., Study Engagement and Burnout of the PhD Candidates in Medicine: A Person-Centered Approach. Front Psychol, 2021. 12: p. 727746.
44. Skinnider, M.A., et al., Predictors of sustained research involvement among MD/PhD programme graduates. Med Educ, 2018. 52(5): p. 536-545.
45. Ajzen, I. From Intentions to Actions: A Theory of Planned Behavior. 1985.
46. Maio, G. and J. Olson, Value-Attitude-Behavior Relations: The Moderating Role of Attitude Functions. British Journal of Social Psychology, 2011. 33: p. 301-312.
47. Wigfield, A. and J.S. Eccles, Expectancy-Value Theory of Achievement Motivation. Contemp Educ Psychol, 2000. 25(1): p. 68-81.
48. Imafuku, R., et al., How do students' perceptions of research and approaches to learning change in undergraduate research? Int J Med Educ, 2015. 6: p. 47-55.

49. Vereijken, M.W.C., et al., Fostering first-year student learning through research integration into teaching: Student perceptions, beliefs about the value of research and student achievement. Innovations in Education and Teaching International, 2018. 55(4): p. 425-432.

50. Nori, H. and M. Vanttaja, Too stupid for PhD? Doctoral impostor syndrome among Finnish PhD students. Higher Education, 2022.

51. Stelling, B.E.V., et al., Fitting In While Standing Out: Professional Identity Formation, Imposter Syndrome, and Burnout in Early Career Faculty Physicians. Academic Medicine, 9900: p. 10.1097/ACM.0000000000005049.

52. Prazeres, F., PhD supervisor-student relationship. Journal of Advances in Medical Education & Professionalism, 2017. 5(4): p. 213-214.

53. Kusurkar, R.A., et al., What stressors and energizers do PhD students in medicine identify for their work: A qualitative inquiry. Med Teach, 2022. 44(5): p. 559-563.

54. Levecque, K., et al., Work organization and mental health problems in PhD students. Research Policy, 2017. 46(4): p. 868-879.

55. Cornér, S., E. Löfström, and K. Pyhältö, The Relationships between Doctoral Students' Perceptions of Supervision and Burnout. International Journal of Doctoral Studies, 2017. 12: p. 091-106.

56. Pyhältö, K., et al., Challenges of Becoming a Scholar: A Study of Doctoral Students' Problems and Well-Being. ISRN Education, 2012. 2012: p. 934941.

57. Mattijssen, L.v.V., N. van Doorn, T. Kanbier, N. Teelken, C., PNN PhD Survey: Asking the relevant questions. Mental wellbeing, Workload, Burnout, Research environment, Progress of the PhD project, Considering to quit. Online publication or Website https://hetpnn.nl/wp-content/uploads/2020/08/PNN-PhD-Survey-report-Wellbeing.pdf. 2020.

58. Wolters, F., Academische carrièreperspectieven van gepromoveerde dokters: Een landelijk cohortonderzoek in de periode 1992-2018. Nederlands Tijdschrift voor Geneeskunde, 2020. 164.

59. Carter, S., B. Kensington-Miller, and M. Courtney, Doctoral Supervision Practice: What's the Problem and How Can We Help Academics? Journal of Perspectives in Applied Academic Practice, 2016. 5.

60. Devos, C., et al., Misfits Between Doctoral Students and Their Supervisors: (How) Are They Regulated? International Journal of Doctoral Studies, 2016. 11: p. 467-486.

61. Bustraan, J., et al., Why do trainees leave hospital-based specialty training? A nationwide survey study investigating factors involved in attrition and subsequent career choices in the Netherlands. BMJ Open, 2019. 9.

62. Bongiovanni, T., et al., Attrition from surgical residency training: perspectives from those who left. Am J Surg, 2015. 210(4): p. 648-54.

63. Eshel, N. and R.R. Chivukula, Rethinking the Physician-Scientist Pathway. Academic Medicine, 2022: p. 10.1097/ACM.0000000000004788.

64. Cruz, V., Pleidooi van Winnifred van Lankeren, radioloog en opleider: 'Promoveren; geen must maar mogelijkheid' Magazine Medisch Specialist, 2021. 6.

65. Leenstra, B. De zorg heeft de creativiteit van ondernemers nu juist hard nodig. 2022; Available from: www.trouw.nl/opinie/de-zorg-heeft-de-creativiteit-van-ondernemers-nu-juist-hard-nodig~bd4e1206/?referrer=https%3A%2F%2Fwww

66. Venkatesh, V., X. Zhang, and T.A. Sykes, 'Doctors Do Too Little Technology': A Longitudinal Field Study of an Electronic Healthcare System Implementation. Information Systems Research, 2011. 22(3): p. 523-546.

67. Posnick, J.C., The Future of Artificial Intelligence in the Medical Field. Journal of Oral and Maxillofacial Surgery, 2022. 80(6): p. 978-979.

68. Veidis, E.M., et al., A call for clinicians to act on planetary health. The Lancet, 2019. 393(10185): p. 2021.

69. Cox, A.L., Balancing Research, Teaching, Clinical Care, and Family: Can Physician-Scientists Have it All? The Journal of Infectious Diseases, 2018. 218(suppl_1): p. S32-S35.

Chapter 10

Summary
Nederlandse samenvatting

Summary

In **chapter 1**, a general introduction on the rationale of this thesis is provided. Clinician-scientists are the driving force behind advancements in the medical field by connecting clinical care with medical research. The pathway of clinician-scientist careers is often referred to as 'the leaky pipeline', as many (potential future) clinician-scientists during their career are leaking out of this pipeline, resulting in a current clinician-scientist shortage worldwide. This shortage of clinician-scientists has been attributed to a lack of supply and/or (too many) obstacles to stay actively engaged in research, considered as leaks. Research training interventions in medical education are often opted as part of the solution. In this thesis we investigated undergraduate and postgraduate research programmes including its challenges, outcomes and the role of motivation for research during these programmes; thereby aiming to contribute to a sustainable clinician-scientist workforce.

Part I: Undergraduate research training

Examining research training programmes and their outcomes in undergraduate medical education is the first step in understanding how best to foster high quality motivation for research, an essential step in the process of enhancing clinician-scientists careers. In our first retrospective cohort study (**chapter 2**) we examined the scientific yield of over 2000 medical students' mandatory research training during the master's phase, including undergraduate and postgraduate scientific outcomes. Scientific outcomes such as publications were considered as a measurable proxy for success, a well-known predictor for postgraduate research engagement. We found that at least one out of four research projects resulted in a peer-reviewed published paper, with students mainly as first (42.5%) or second (25.3%) author. Even though these students can be considered as relatively young researchers mostly having their first hands-on research experience, their papers seemed of good quality as they passed peer-review procedures and had an above-world-average citation impact. To provide further insight in how to reach high academic levels among medical students, this study identified the following four student and project related factors positively associated with publication: conducting research in an academic centre, extension of the research project, a clinical or laboratory study, and involvement in an excellency track. Timing of the research project (i.e. before or after clerkships) and conducting research in the Netherlands compared to abroad did not impact publication rates. After graduation, junior doctors with a published paper resulting from the undergraduate mandatory research project were almost twice as likely to disseminate research at scientific conferences or as a published paper in journals. Although the results showed that publishers were also more likely to participate in research after graduation (e.g. a PhD programme) compared to non-publishers, this difference was not significant. Our results illustrated that mandatory research projects not only equip all future doctors with basic research knowledge, skills and attitude to practice evidence-based medicine, but also can be a stepping stone towards a research-oriented career and, subsequently, be part of the solution for the current decline in clinician-scientists.

In the following study (**chapter 3**) we investigated if and how this mandatory research experience in undergraduate medical education affects medical students' motivation for research during the research project, using the Self-Determination Theory (SDT). Both intrinsic and extrinsic motivation (IM and EM) increased in the majority of students during the research project. Next, to further unravel motivational development (the 'how'), we included the following psycho-cognitive determinants for motivation: research perceptions, research self-efficacy, autonomy, and relatedness. All motivational determinants positively affected intrinsic motivation, while research perceptions and self-efficacy also strengthened extrinsic motivation. In turn, higher levels of intrinsic motivation and to a lesser extent extrinsic motivation after the research project resulted in greater research career ambitions. Lastly, we focused on 29% of the students who stated beforehand that they would not have participated if it had not been mandatory. Without a mandatory research project, it is assumable that this group would not have initiated research involvement and, subsequently, would have graduated as a doctor without research experience. This group showed to have less intrinsic and extrinsic motivation, and, likewise, less research career ambitions beforehand. After the research project however, one out of three students changed their mind and stated that they would participate in research even if not mandatory. Similar to all students involved, intrinsic and extrinsic motivation increased during the research project in the majority of this group. Despite not reaching equal final levels of motivation and research career ambitions, their intrinsic motivation and research career ambitions on average increased twice to triple as much compared to students interested in research participation without it being imposed on them. Although most students benefitted from a mandatory research experience, especially when they were not willing to participate in research beforehand, some declined in research motivation (IM 29%, EM 40%), research perceptions (32%), research self-efficacy (23%), relatedness (45%), autonomy (44%), and/or research career ambitions (31%). This can be due to, for example, regression to the mean, overvaluing research beforehand, impact of COVID-19 pandemic with poor home working conditions, or insufficient supervision. Only one out of ten students did not have research interest beforehand together with a decline in their intrinsic motivation for research during the research project. Our study suggested that high educational investments in and allocation of resources for mandatory research projects can be considered as a valuable

investment in (intrinsic) motivation when aiming to train scholarly doctors able to both apply and develop evidence-based medicine.

Scholarly doctors require research knowledge and skills (*Ausbildung*), as well as an academic mindset, including curiosity, creativity, and critical thinking (*Bildung*). When assessing these scholarly competencies, for example during undergraduate mandatory research training, multiple challenges arise. We elaborated on these challenges and their consequences in **chapter 4**. It is a common belief that educational procedures, including learning pathways and assessment, should be fair. In addition, objective (i.e. standardized, equal, and unbiased) assessment is often assumed to be a prerequisite for fairness. In contrast to knowledge and skills (*Ausbildung*), it is challenging to assess an academic mindset (*Bildung*) in an objective and so-called fair way. We illustrated that objectivity to safeguard fairness as main guiding principle leads to standardized educational procedures and learning pathways. For example if the amount of feedback or time provided is strictly regulated and limited. We argued that eventually this objective approach may even result in hampered development of a true academic mindset and that the combined *Ausbildung* and *Bildung* approach in academic research courses is dominated by *Ausbildung*. This can be considered *un*fair rather than fair when aiming to train scholarly doctors. As a consequence of this focus on objectivity, some even argue that academic medical education trains knowledge storing zombies, rather than scholarly doctors. Therefore, we plea for rebalancing *Ausbildung* and *Bildung* in academic education. We suggest that changing focus from objectivity to objectivity *and* subjectivity in educational procedures, including learning pathways and assessment, can assist in protecting fairness and, as a result, bring back *Bildung* to medical education to ensure future doctors to be true scholars.

As the role of scholar according to CanMEDS is mainly comprised of research competencies, but also entails teaching competencies, **chapter 5** focuses on educating teaching competencies in future scholarly doctors. Similar to clinician-scientists, concerns are rising regarding the supply of medical teachers. Likewise, all (future) doctors should be able to teach students, residents, other healthcare professionals and patients, while some of them are needed to actually specialise as medical teacher. A targeted (elective) course in medical education enables students to get inspired before they need to take on their clinical role and consider future specialisation. Drawing on our experiences, literature, and theories, we proposed the following twelve tips to foster the next generation of medical teachers: (1) Catch them young: Motivate students for teaching early in your program; (2) Put students in the driver's seat; (3) Discuss epistemology and paradigms of teaching as starting point for students to explore their views on teaching; (4) Be an implicit and explicit role model: Practice what you preach

and let students in on your own reflection; (5) Zoom out and show students the bigger educational picture; (6) Introduce the basics of educational design, learning principles and theories; (7) Integrate designing for learning: Let students bring learning principles and theories into practice; (8) Provide (near-)peer education opportunities; (9) Provide students with knowledge about Technology Enhanced Learning to prepare them for tomorrow's education; (10) Focus on reflection and involve peers in this process; (11) Introduce the world of medical education research and let students participate; (12) Build steppingstones for future educational steps.

Part II: Postgraduate research training

After graduation, many pathways exist of which one is the clinician-scientist pathway. Medical doctors can enrol in a PhD (Doctor of Philosophy) programme, also considered as the third cycle after the bachelor's and master's degree. Such programmes are globally perceived as training to become a clinician-scientist. In **chapter 6** we compared medical PhD training programmes of the top ten leading countries in life sciences research (the United States of America, the United Kingdom, China, Germany, Japan, France, Canada, Australia, Switzerland, and the Netherlands). The results showed that, although medical PhD training programmes around the world have a common goal (i.e. training clinician-scientists) and the number of agreements regarding mutual recognition of this degree increases, the structure, requirements and characteristics of these programmes highly differ between and even within countries. PhD pathways even differ between institutes of the same country, between departments within institutes, and between research teams within departments. We concluded that the definition and value of 'the medical PhD' is challenging to capture. Transparency of the differences and similarities between medical PhD training programmes can improve international recognition, mobility, and quality of medical PhD candidates and MD-PhDs (Doctor of Medicine and Philosophy). In addition, this is relevant for sharing, interpreting and generalising outcomes of research on medical PhD candidates and doctoral education.

Chapter 7 describes our nationwide study on motivation of Dutch medical PhD candidates. The number of medical doctors embarking on a PhD trajectory has tremendously increased in the past two decades. At the same time, an increased subset drops out during their PhD or becomes scientifically inactive soon after obtaining their PhD. To gain better insight in these leaks, we investigated over 1300 PhD candidates' quantity and quality of motivation for participating in a PhD programme. Over 70% of the participants were medical doctors not in training before enrolment in a PhD programme and doing a PhD in a competitive specialty. This study found that both quantity and quality of motivation for research are relevant factors in the leaky clinician-scientist pipeline. The majority of medical PhD candidates was highly autonomously motivated for their PhD. However, of those with (very) high autonomous motivation, almost a quarter had (very) high controlled motivation for their PhD as well. Furthermore, one out of seven medical PhD candidates showed to have very low to low autonomous motivation for a PhD. Autonomous motivation was fostered by expectancy of success beliefs and when PhD candidates perceived their PhD as valuable for a career as clinician-scientist and/or for personal development. When PhD candidates valued their PhD as beneficial for their clinical career, autonomous motivation was diminished and controlled motivation enhanced. PhD candidates with higher levels of autonomous motivation reached higher levels of work engagement, were less likely to consider dropping out, and more likely to pursuit a clinician-scientist career than those with lower levels of autonomous motivation. Contrary, PhD candidates with higher levels of controlled motivation had lower levels of work engagement, were more likely to consider dropping out, and less likely to pursuit a clinician-scientist career than those with lower levels of controlled motivation. As autonomous motivation and controlled motivation coexist within PhD candidates, in addition to the separate effects of autonomous and controlled motivation, we examined their combined effect. We found that within PhD candidates with similar levels of autonomous motivation, an increase in levels of controlled motivation was associated with lower levels of expectancy of success beliefs; a PhD was less valued as useful for a clinician-scientist career, personal development and interest; less work engagement; and less ambitions for a career as clinician-scientist. In short, controlled motivation was detrimental for the positive effects related to autonomous motivation.

Following on this study, in the next chapter (**chapter 8**) we qualitatively identified factors influencing PhD candidates' motivation for obtaining a PhD during their PhD trajectory. This study revealed the following six factors that contributed positively and/or negatively to motivation: (1) Initial motivation to start a PhD matters; (2) Autonomy, a matter of the right dose at the right time; (3) PhD as proof of competence and/or as learning trajectory?; (4) It takes (at least) two to tango; (5) Peers can make or break your PhD; (6) Strategies to stay or get back on track. We found that some factors could be experienced positively, while a lack of it can be experienced negatively, and vice versa. Additionally, some factors had different effects on motivation as they could change over time and often depended on the phase of the PhD. For example, the need for autonomy often became stronger with further progression of the PhD. If the same amount of autonomy was provided in the first phase as in the final phase, it was often perceived as a frustration in the first phase, while being positively perceived in the final phase. This study also highlighted the impact of vulnerable positions that most PhD candidates were in, as they were often in a dependency relationship, for example regarding future (clinical) career steps. This fostered feelings of the imposter syndrome and feelings of pressure to fit in while standing out, and challenged individual coping strategies in case of conflicts with personal values. Coping strategies to get back or stay on track varied from acceptance (e.g. being part of a PhD and finish what you have started) to active solution seeking approaches (e.g. change workspace or discussing supervision dissatisfaction). A supportive environment, including both peers and a good fit with at least one supervisor, appeared to be crucial in fostering autonomous motivation, and hence, a successful PhD trajectory.

In **chapter 9**, the results of this thesis are put into a broader perspective and suggestions for both practice and future directions are made. We elaborated on the supply, leaks and perspectives of the clinician-scientist pipeline. We critically appraised the value of undergraduate research programmes for the supply of the clinician-scientist pipeline. Thereafter, we elaborated on the role and development of quantity and quality of motivation for research in different phases in the leaky clinician-scientist pipeline.

Samenvatting

In **hoofdstuk 1** wordt een algemene inleiding over de rationale van dit proefschrift gegeven. Arts-onderzoekers zijn de drijvende kracht achter ontwikkelingen in de medische wereld door klinische zorg en medisch wetenschappelijk onderzoek te verbinden. De loopbaan van arts-onderzoekers wordt vaak aangeduid als 'de lekkende pijplijn', omdat een substantieel deel van (potentieel toekomstige) arts-onderzoekers tijdens hun medische carrière uit deze pijplijn 'lekken', wat resulteert in een huidig wereldwijd tekort aan arts-onderzoekers. Dit tekort aan arts-onderzoekers wordt toegeschreven aan een te kleine toestroom in wetenschappelijke loopbanen en/of (te veel) barrières om actief te blijven in wetenschappelijk onderzoek, ook wel beschouwd als 'lekkages'. Wetenschappelijke vorming in het medisch onderwijs wordt vaak beschouwd als onderdeel van de oplossing om deze zogenoemde 'lekkages' tegen te gaan. In dit proefschrift hebben we onderzoeksprogramma's tijdens en na de Geneeskunde opleiding onderzocht, inclusief de uitdagingen, uitkomsten en de rol van motivatie voor onderzoek tijdens deze programma's, met als doel bij te dragen aan een duurzaam arts-onderzoeker werkveld.

Deel I: Wetenschappelijke vorming tijdens de opleiding Geneeskunde

Het onderzoeken van wetenschappelijke vorming binnen de opleiding Geneeskunde en de uitkomsten hiervan is de eerste stap in het begrijpen hoe motivatie voor onderzoek het beste kan worden gestimuleerd, een essentiële stap in het proces van het verbeteren van de loopbaan van arts-onderzoekers. In onze eerste retrospectieve cohort studie (**hoofdstuk 2**) hebben we de wetenschappelijke opbrengst van de wetenschappelijke master stage zowel tijdens als na de opleiding Geneeskunde van meer dan 2000 Geneeskunde-studenten onderzocht. Wetenschappelijke uitkomsten zoals publicaties werden hierbij beschouwd als een meetbare proxy voor wetenschappelijk succes, tevens een belangrijke voorspeller voor wetenschappelijke activiteit na afstuderen. Onze studie toonde dat ten minste één op de vier wetenschappelijke stages resulteerde in een peer-reviewed gepubliceerd artikel, waarbij studenten voornamelijk eerste (42,5%) of tweede (25,3%) auteur waren. Ondanks dat deze studenten kunnen worden beschouwd als relatief jonge onderzoekers die meestal hun eerste wetenschappelijke praktijkervaring opdoen, bleken hun artikelen van goede kwaliteit daar ze de peer-reviewprocedures doorstonden en een bovengemiddelde citatie-impact hadden. Om verder inzicht te verkrijgen in hoe we optimale academische niveaus onder Geneeskunde-studenten kunnen bereiken, toonde deze studie de volgende vier student- en stage-gerelateerde factoren die positief geassocieerd zijn met publicaties: het uitvoeren van onderzoek in een academisch centrum, het doen van een verlengde wetenschappelijke stage, een klinische of laboratoriumstudie en deelname aan een excellentieprogramma. De timing van de

wetenschappelijke stage (voor of na de coschappen) en het uitvoeren van onderzoek in Nederland in vergelijking met het buitenland hadden geen invloed op publiceren. Na het afstuderen bleken artsen bijna twee keer zo vaak hun wetenschappelijke resultaten te verspreiden op congressen of middels wetenschappelijke tijdschriften wanneer zij reeds een gepubliceerd artikel hadden dat voortkwam uit hun wetenschappelijke stage tijdens de master fase. Hoewel onze resultaten lieten zien dat artsen die hun wetenschappelijke stage als student hadden gepubliceerd na het afstuderen ook vaker betrokken waren bij wetenschappelijk onderzoek (bijv. een PhD) in vergelijking met collega's die hun stage niet hadden gepubliceerd, was dit verschil niet significant. Onze resultaten toonden dat verplichte wetenschappelijke stages niet alleen alle toekomstig artsen voorzien van basis onderzoekskennis, -vaardigheden en -attitude om evidence-based medicine te beoefenen, maar ook een opstap kunnen zijn naar een wetenschappelijke loopbaan en daarmee deel kunnen uitmaken van de oplossing voor de huidige afname in arts-onderzoekers.

In de volgende studie (**hoofdstuk 3**) onderzochten we of en hoe deze verplichte wetenschappelijke stage de motivatie van Geneeskunde-studenten voor onderzoek tijdens de stage beïnvloedt, gebruikmakend van de Self-Determination Theory (SDT). Zowel intrinsieke als extrinsieke motivatie (IM en EM) voor onderzoek nam toe in de meerderheid van de studenten tijdens hun wetenschappelijke stage. Om de ontwikkeling van motivatie verder te ontrafelen (de 'hoe'-vraag), hebben we de volgende psycho-cognitieve determinanten voor motivatie opgenomen: percepties van onderzoek, self-efficacy gevoelens, autonomie en verbondenheid. Al deze determinanten hadden een positief effect op intrinsieke motivatie, waar percepties van onderzoek en self-efficacy gevoelens ook extrinsieke motivatie versterkten. Hogere niveaus van intrinsieke motivatie en in mindere mate extrinsieke motivatie aan het eind van de wetenschappelijke stage resulteerden in meer ambitie voor een wetenschappelijke loopbaan. Ten slotte richtten we ons op 29% van de Geneeskunde-studenten die vóór start van de stage hadden aangegeven geen wetenschappelijk onderzoek te willen doen wanneer het niet verplicht was geweest voor hun opleiding. Zonder een verplichte wetenschappelijke stage zou deze groep vermoedelijk geen onderzoeksinspanningen hebben geleverd en als gevolg daarvan afstuderen als arts zonder praktische onderzoekservaring. Deze groep had vooraf minder intrinsieke en extrinsieke motivatie voor onderzoek en eveneens minder ambities voor een wetenschappelijke loopbaan. Na de wetenschappelijke stage veranderde echter één op de drie studenten van gedachten en gaf aan een wetenschappelijke stage te willen doen, zelfs wanneer dit niet verplicht was. Net als bij alle betrokken studenten nam intrinsieke en extrinsieke motivatie – inclusief de determinanten ervan – tijdens de wetenschappelijke stage in de meerderheid van deze groep toe. Ondanks dat deze groep studenten niet dezelfde eindniveaus van motivatie en wetenschappelijke ambitie bereikten, nam hun intrinsieke motivatie en ambitie voor wetenschap gemiddeld twee tot drie keer zoveel toe in vergelijking met studenten die voorafgaand aan de stage geïnteresseerd waren in een onderzoekservaring wanneer dit geen verplicht onderdeel van de opleiding was. Hoewel de meeste studenten profiteerden van verplichte onderzoeksstages, vooral wanneer ze van tevoren niet bereid waren deel te nemen aan deze stage wanneer die niet verplicht was geweest, was bij sommigen sprake van een afname van motivatie voor onderzoek (IM 29%, EM 40%), positieve percepties van onderzoek (32%), self-efficacy gevoelens (23%), verbondenheid (45%), autonomie (44%) en/of ambities voor wetenschappelijke loopbanen (31%). Dit kan te wijten zijn aan, bijvoorbeeld, regressie naar het gemiddelde, overwaardering van onderzoek voorafgaand aan de stage, impact van COVID-19 met matige thuiswerkomstandigheden, of onvoldoende en insufficiënte supervisie. Slechts één op de tien studenten had voorafgaand aan hun onderzoeksstage geen interesse in wetenschappelijk onderzoek en vertoonde tijdens de onderzoeksstage een (verdere) afname in hun intrinsieke motivatie voor onderzoek. Ons onderzoek suggereert dat onderwijsinspanningen en investeringen in verplichte wetenschappelijke stages beschouwd kunnen worden als een waardevolle investering in (intrinsieke) motivatie voor onderzoek bij het opleiden van academische artsen die in staat zijn om zowel evidence-based medicine toe te passen, als hier aan bij te dragen.

Academische artsen hebben wetenschappelijke kennis en vaardigheden (*Ausbildung*) nodig, evenals een academische attitude, waaronder nieuwsgierigheid, creativiteit en kritisch denkvermogen (*Bildung*). Bij het beoordelen van deze wetenschappelijke competenties, bijvoorbeeld tijdens verplichte wetenschappelijke stages, ontstaan meerdere uitdagingen. We hebben deze uitdagingen en de gevolgen ervan uitgebreid beschreven in **hoofdstuk 4.** Het is een algemene overtuiging dat onderwijsprocedures, inclusief leerpaden en toetsing, eerlijk moeten zijn. Bovendien wordt vaak aangenomen dat objectieve (dat wil zeggen gestandaardiseerde, gelijke en onbevooroordeelde) toetsing een voorwaarde is voor eerlijkheid. In tegenstelling tot kennis en vaardigheden (*Ausbildung*) is het echter moeilijk om een academische attitude (*Bildung*) op een objectieve en zogenaamd eerlijke manier te beoordelen. We illustreerden dat uitgaan van objectiviteit als belangrijkste leidraad om eerlijkheid te waarborgen, leidt tot gestandaardiseerde onderwijsprocedures en leerpaden, bijvoorbeeld wanneer de hoeveelheid feedback of tijd die wordt gegeven strikt wordt gereguleerd en beperkt. We betoogden dat deze objectieve benadering uiteindelijk kan leiden tot belemmering van de ontwikkeling van academische attitude en dat de wenselijke gecombineerde *Ausbildung*- en *Bildung*-benadering in academische en wetenschappelijke vorming wordt gedomineerd door enkel *Ausbildung*. Dit zou eerder als *on*eerlijk dan eerlijk kunnen worden beschouwd bij het opleiden van academische artsen. Als gevolg van deze focus op objectiviteit stellen sommigen zelfs dat medische faculteiten 'kennis zombies' opleiden in plaats van academische artsen. Derhalve pleiten we voor herstel van de balans tussen *Ausbildung* en *Bildung* in de Geneeskunde opleiding. We opperen dat een verschuiving van focus van objectiviteit naar objectiviteit *en* subjectiviteit in onderwijsprocedures, inclusief leerpaden en toetsing, kan helpen bij het beschermen van eerlijkheid en daarmee *Bildung* kan terugbrengen in het medisch onderwijs om te waarborgen dat toekomstige artsen academici zijn.

Aangezien de rol als academicus volgens de CanMEDS voornamelijk bestaat uit wetenschappelijke competenties, maar daarnaast ook onderwijscompetenties omvat, richt **hoofdstuk 5** zich op de ontwikkeling van onderwijscompetenties in toekomstig academische artsen. Net als bezorgdheid om een tekort aan arts-onderzoekers, zijn er zorgen met betrekking tot het aantal medisch docenten. Vergelijkbaar met wetenschappelijke profilering zouden alle (toekomstige) artsen in staat moeten zijn om studenten, arts-assistenten, andere gezondheidszorgprofessionals en patiënten te onderwijzen, waarbij het noodzakelijk is dat een deel verder profileert tot medisch docent. Een gericht (keuze)vak in medisch onderwijs stelt studenten in staat om geïnspireerd te raken voordat ze zich klinisch verder ontwikkelen en zich oriënteren op toekomstige specialisatie. Op basis van onze ervaringen, literatuur en theorieën hebben we de volgende twaalf tips voorgesteld om de toekomstige generatie medische docenten op te leiden: (1) Vang ze jong: motiveer studenten voor het geven van onderwijs vroeg in de opleiding; (2) Laat studenten de leiding nemen; (3) Bespreek epistemologie en paradigma's van onderwijs als startpunt voor studenten om hun opvattingen over onderwijs te verkennen; (4) Wees een impliciet en expliciet rolmodel: 'practice what you preach' en laat studenten deelnemen aan je zelfreflectie; (5) Zoom uit en laat studenten het grotere onderwijsplaatje zien; (6) Introduceer de basisprincipes van onderwijskundige ontwerpen, leerprincipes en theorieën; (7) Integreer het ontwerpen van onderwijs: laat studenten leerprincipes en theorieën in de praktijk brengen; (8) Bied (mede)student educatie mogelijkheden; (9) Geef studenten kennis over *Technology Enhanced Learning* om hen voor te bereiden op het onderwijs van de toekomst; (10) Richt je op reflectie en betrek (mede)studenten bij dit proces; (11) Maak studenten bekend met de wereld van medisch onderwijskundig onderzoek en laat hen deelnemen; (12) Creëer mogelijkheden voor toekomstige onderwijsstappen.

Deel II: Wetenschappelijke vorming na de Geneeskunde opleiding

Na het afstuderen als arts bestaan diverse vervolgtrajecten, waaronder het traject van arts-onderzoeker. Artsen kunnen een promotietraject aangaan, dat ook wel beschouwd wordt als de derde cyclus na de bachelor- en masteropleiding. Dergelijke trajecten in het medisch domein worden wereldwijd beschouwd als opleiding tot arts-onderzoeker. In **hoofdstuk 6** hebben we medische promotietrajecten vergeleken in de top tien landen in life science onderzoek (de Verenigde Staten, het Verenigd Koninkrijk, China, Duitsland, Japan, Frankrijk, Canada, Australië, Zwitserland en Nederland). Hoewel medische promotietrajecten wereldwijd eenzelfde doel dienen (namelijk het opleiden van arts-onderzoekers) en het aantal afspraken over wederzijdse erkenning van deze graad toeneemt, bleek uit onze resultaten dat de structuur, vereisten en kenmerken van deze programma's sterk verschillen tussen en zelfs binnen landen. Medische promotietrajecten verschillen eveneens tussen instituten binnen hetzelfde land, tussen afdelingen binnen instituten en tussen onderzoeksteams binnen afdelingen. We concludeerden dat de definitie en waarde van 'de medische PhD' (Doctor of Philosophy) moeilijk te vatten is. Transparantie in de verschillen en overeenkomsten tussen medische promotietrajecten kan internationale erkenning, mobiliteit en kwaliteit van medische promovendi en uiteindelijk arts-onderzoekers bevorderen. Tevens is dit relevant voor het delen, de interpretatie en de generaliseerbaarheid van uitkomsten van wetenschappelijk onderzoek betreffende medische promovendi en promotietrajecten.

Hoofdstuk 7 beschrijft onze landelijke studie naar de motivatie van Nederlandse medische promovendi. Het aantal artsen dat een promotietraject begint is de afgelopen twee decennia aanzienlijk toegenomen. Tegelijkertijd valt een toenemend aantal promovendi uit tijdens hun PhD of wordt wetenschappelijk inactief kort na het behalen van hun PhD. Om beter inzicht te krijgen in deze 'lekkages' hebben we onderzocht wat de kwantiteit en kwaliteit van de motivatie voor onderzoek is om deel te nemen aan een promotietraject bij meer dan 1300 medische promovendi. Ruim 70% van de deelnemers was basisarts zonder opleidingsplek bij aanvang van hun promotietraject en promoveerde binnen een competitief specialisme. Uit dit onderzoek bleek dat zowel kwantiteit als kwaliteit van de motivatie voor onderzoek relevante factoren zijn in de 'lekkage' van (toekomstige) arts-onderzoekers. De meerderheid van de medische promovendi was (zeer) hoog autonoom gemotiveerd voor hun PhD. Echter, van degenen met (zeer) hoge autonome motivatie had bijna een kwart ook (zeer) hoge gecontroleerde motivatie voor hun PhD. Bovendien toonde één op de zeven medische PhD-kandidaten zeer lage tot lage autonome motivatie voor een PhD. Autonome motivatie werd bevorderd door self-efficacy gevoelens en het waardevol achten van een promotietraject voor een carrière als arts-onderzoeker en/of voor persoonlijke ontwikkeling. Wanneer promovendi hun promotietraject waardevol achtten voor hun

klinische carrière was autonome motivatie lager en gecontroleerde motivatie hoger. Promovendi met hogere niveaus van autonome motivatie bereikten hogere niveaus van bevlogenheid, overwogen minder vaak te stoppen en ambieerden vaker een carrière als arts-onderzoeker dan promovendi met lagere niveaus van autonome motivatie. Promovendi met hogere niveaus van gecontroleerde motivatie hadden daarentegen lagere niveaus van bevlogenheid, overwogen vaker om te stoppen en kozen minder vaak voor een carrière als arts-onderzoeker dan promovendi met lagere niveaus van gecontroleerde motivatie. Aangezien autonome motivatie en gecontroleerde motivatie beide aanwezig zijn, hebben we naast de individuele effecten van autonome en gecontroleerde motivatie ook hun gecombineerde effect onderzocht. We vonden dat binnen promovendi met vergelijkbare niveaus van autonome motivatie, een toename van gecontroleerde motivatie gepaard ging met lagere niveaus van self-efficacy gevoelens, waardering van een PhD voor een carrière als arts-onderzoeker, persoonlijke ontwikkeling en interesse, bevlogenheid en ambities voor een carrière als arts-onderzoeker. Kortom, gecontroleerde motivatie bleek nadelig voor de positieve effecten die verband houden met autonome motivatie.

Als vervolg op deze studie hebben we in **hoofdstuk 8** kwalitatief onderzocht welke factoren de motivatie van promovendi tijdens hun promotietraject beïnvloeden. In dit hoofdstuk beschreven we de volgende zes factoren die positief en/of negatief bijdragen aan motivatie: (1) Motivatie om aan een PhD te beginnen; (2) Autonomie, een kwestie van de juiste dosis op het juiste moment; (3) PhD als bewijs van competentie en/of als leertraject?; (4) 'It takes (at least) two to tango'; (5) Medepromovendi kunnen je promotietraject maken of breken; (6) Strategieën om op koers te blijven of komen. We ontdekten dat sommige factoren positief ervaren kunnen worden, terwijl een gebrek eraan negatief ervaren kan worden, en vice versa. Bovendien hadden sommige factoren een verschillend effect op motivatie, omdat ze in de loop der tijd konden veranderen en vaak afhankelijk waren van de fase van het promotietraject. Zo werd bijvoorbeeld de behoefte aan autonomie vaak sterker naarmate het promotietraject vorderde. Waar een bepaalde dosis aan autonomie in de beginfase als frustrerend ervaren kon worden, kon dezelfde dosis in de laatste fase juist positief worden ervaren. Dit onderzoek benadrukte ook de impact van kwetsbare posities waarin promovendi zich veelal bevonden, aangezien ze vaak in een afhankelijkheidsrelatie verkeerden, bijvoorbeeld met betrekking tot toekomstige (klinische) carrièrestappen zoals een opleidingsplek. Dit bevorderde gevoelens van het imposter syndroom, daarnaast de drang om in de groep te passen en toch op te vallen, en uitdagingen voor individuele coping strategieën wanneer conflicten met persoonlijke waarden ontstonden. Coping strategieën om weer op koers te komen of te blijven varieerden van acceptatie (bijvoorbeeld het hoort erbij en afmaken waar je aan begonnen bent) tot actieve oplossingsgerichte benaderingen (bijvoorbeeld veranderen van werkplek of het bespreekbaar maken van ontevredenheid over supervisie). Een ondersteunende omgeving, inclusief zowel medepromovendi als een klik met ten minste één supervisor, bleek cruciaal te zijn voor het bevorderen van autonome motivatie en dus een succesvol promotietraject.

In **hoofdstuk 9** worden de resultaten van dit proefschrift in een breder perspectief geplaatst en worden suggesties gedaan voor zowel de praktijk als toekomstige onderzoeksrichtingen. We gingen dieper in op de aanvoer, 'lekkages' en perspectieven van de arts-onderzoekers pijplijn. We hebben de waarde van onderzoeksprogramma's voor studenten voor de aanvoer van arts-onderzoekers in de pijplijn kritisch bestudeerd. Vervolgens zijn we uitgebreid ingegaan op de rol en ontwikkeling van de kwantiteit en kwaliteit van motivatie voor onderzoek in verschillende fasen van de lekkende arts-onderzoeker pijplijn.

Appendices

Supplemental material

PhD Portfolio

Dankwoord

Curriculum Vitae

Appendix A: Questionnaire postgraduate research engagement (translated to English)

[Chapter 2]

1. Have you conducted research after graduation?
O No, and I am not interested in doing research.
O Not yet, but I am intending to.
O Yes.

2. Did research engagement after graduation result in (a) peer-reviewed publication(s)?
O No
O Not yet, I am working on it.
O Yes.

3. How many peer-reviewed publications as a result of research conducted after graduation do you have and (if applicable) what is your position as author?

	0	1	2	3	4	≥5
First author	O	O	O	O	O	O
Second author	O	O	O	O	O	O
Co- author	O	O	O	O	O	O
Final author	O	O	O	O	O	O

4. Have you contributed to an oral or poster at a scientific conference as a result of research conducted after graduation. If not applicable, please tick '0'.

	0	1	2	3	4	≥5
First author	O	O	O	O	O	O
Second author	O	O	O	O	O	O
Co- author	O	O	O	O	O	O
Final author	O	O	O	O	O	O

5. Have you ever participate(d) in a PhD programme?
O No, and I am not intending to.
O No, but I would like to participate in a PhD programme in the future.
O Yes, I am currently participating in a PhD programme.
O Yes, but I prematurely quit the PhD programme.
O Yes, and I have obtained my PhD degree.

Appendix B: Questionnaire undergraduate mandatory research project (translated to English)

[Chapter 3]

1. Demographics (T0)

1. Gender:
   O Male
   O Female
   O Other

2. Age: ... years

3. Department(s) of your research project:

4. Institute of your research project:

Please read the statements below and choose what applies to you.

5. I am doing my research project prior to my clerkships.
   yes / no

6. I did/am doing extracurricular research (e.g. Honours track) during my medical studies.
   yes / no

1.1 Demographics (T2)

1. The formal duration of my research project was:
O 18 weeks
O 23 weeks
O 28 weeks

2. Are you intending to publish your research project as scientific paper?
O No
O Most likely not, but I am not sure yet
O Most likely, but I am not sure yet
O Yes

3. Are you going to conduct (follow-up) research (e.g. a PhD trajectory or other research) at the department where you have conducted your research project (this can also be in cooperation with someone other than your research project supervisor)?
O No
O Most likely not, but I am not sure yet
O Most likely, but I am not sure yet
O Yes

4. What part of your internship (%) did you work at home due to COVID-19 restrictions?
   0% / 10% / 20% / 30% / 40% / 50% / 60%/ 70% / 80% /90% / 100%

2. Motivation for research (T0–T1–T2)

Students received the instruction to score items on a 7-point Likert scale, defined as 1 'completely disagree' – 7 'completely agree'

1. I find doing research interesting.
2. I enjoy doing research.
3. I find doing research challenging.
4. I like solving puzzles and problems.
5. By doing research I can further develop myself
6. I think that doing research is good for my CV.
7. I think that by doing research I can distinguish myself from others.
8. I think that doing research helps me to get a good job in the future.
9. I think that doing research increases my chances to get in to the specialization I prefer.

3. Research Self-Efficacy (T0–T1–T2)

Students received the instruction to score items on a 7-point Likert scale, defined as 1 'completely disagree' – 7 'completely agree'.

1. I think I am good at doing research.
2. I feel competent enough to do research.
3. I think I have the skills to be able to do research.

4. Research Perceptions (T0–T1–T2)

Students received the instruction to score items on a 7-point Likert scale, defined as 1 'completely disagree' – 7 'completely agree'.

1. Scientific skills are important for the medical profession.
2. Scientific education is important to me.
3. I like scientific aspects of the curricular programme.
4. The medical curricular programme should be scientific.
5. Every doctor should be able to independently conduct research.

5. Autonomy (T1–T2)

Students received the instruction to score items on a 7-point Likert scale, defined as 1 'completely disagree' – 7 'completely agree'.

1. The tasks I have to do during my research internship are in line with what I really want to do. . . . .
2. During my research internship, I often feel like I have to follow other people's commands. (R)
3. I feel like I can be myself at my research internship.
4. If I could choose, I would do things at my research internship differently.
5. During my research internship, I feel forced to do things I do not want to do. (R)
6. I feel free to do my research internship the way I think it could be done best.ree to do my research internship the way I think it could be done best.

6. Relatedness (T1–T2)

Students received the instruction to score items on a 7-point Likert scale, defined as 1 'completely disagree' – 7 'completely agree'.

1. I don't really feel connected with other people at the department from my research internship. (R)
2. During my research internship, I feel part of a group.
3. I don't really mix with other people at my job. (R)
4. During my research internship, I can talk with people about things that really matter to me.
5. I often feel alone when I am with my colleagues.
6. Some people I work with are close friends of mine.
7. During my research internship, I feel part of the academic community of the hospital/institute.
8. During my research internship, I feel involved in the research culture of the department.

7. Academic career ambitions (T0–T1–T2)

Students received the instruction to score items on a 7-point Likert scale, defined as 1 'completely disagree' – 7 'completely agree'.

1. In the future, I would like to do a PhD programme.
2. In the future as a clinician, I would like to have research tasks.
3. In the future, I would like to conduct research as part of my (clinical) work.

8. Final statements (T0–T1–T2)

Students received the instruction to score items on a 7-point Likert scale, defined as 1 'completely disagree' – 7 'completely agree'.

1. If the research internship would not have been part of the curriculum, I would like to participate in extracurricular research.
2. In my opinion, research internships belong in the medical curriculum.
3. My view on research has changed because of my research internship. (T2 only)

Appendix C: Medical PhD programme questionnaire
[Chapter 6]

General situation

(1) Are you aware of national guidelines for PhD programmes in your country?
(if yes: could you please provide link/ document)
(2) Does your institution have guidelines for PhD programmes?
(if yes: could you please provide link/ document)
(3) Can you give an estimate of the ratio between medical students/doctors with and without a PhD degree?
(4) Does this significantly differ between medical specialties?

Prior to entry

(1) What is the position (e.g. before, during or after medical school) of a PhD training programme in the educational system or clinician-scientist career pathway?
(2) How do people get into a PhD training programme? Are there entry criteria (e.g. completed a master's degree)?
(3) Please share your thoughts about what motivations medical students/doctors mainly have when participating in a PhD training programme.
(4) What is the value of a PhD training programme in the medical field?
(5) Which ambitions do participants may have regarding an academic career?

During the programme

(1) Has the PhD training programme a fixed duration? If so, how long? (years) If not, how does a programme typically last?
(2) Is it a paid job? please elaborate, and if yes, how are PhD training programmes funded in general?
(3) Can you describe what a PhD training programme looks like regarding (core) activities (e.g. research only or for example also educational activities/requirements or traineeship)?
(4) What does the supervisory team look like? Please elaborate.
(5) What is the role of this team ideally?

Thesis and defense

(1) Are there requirements with respect to thesis content (e.g. published articles, number of chapters, pages etc)?
(2) Who are typically in the defense committee?
(3) How many members are on the committee?
(4) Is the time for defense fixed? If so, how long does the defense last? If not, what is range of the defense duration (min-max in hours)?
(5) Can the candidate fail? Please elaborate.
(6) What title do you get after successfully finishing a PhD? What is the value of this title for future career?

To finish...

(1) Is there anything else we should know about the system of PhD training programmes in your country?
(2) Do you have suggestions for other sources of information or references which could be useful for us?

Appendix D: PhD questionnaire

[Chapter 7]

[Some questions were conditional and only displayed depending on answers given]

1. Demographics

1. What is your age?

2. To which gender identity do you most identify?
   O Men
   O Female
   O I'd rather not say
   O Other

3. Which institution are you connected to?

4. What job position did you had prior to your PhD trajectory?
   O Medical students (e.g. MD-PhD track) and I still had/have to graduate as junior doctor
   O Graduated without working experience as medical doctor
   O Graduated with working experience as medical doctor
   O Doctor in training (hospital based specialty)
   O Doctor in training (non-hospital based specialty)
   O Specialist (hospital or non-hospital based)
   O Others, namely...

5. What type of PhD-programme do/did you follow in the main part of your PhD programme?
   O MD-PhD trajectory as medical student (e.g. Honours programme)
   O Paid PhD trajectory as doctor not in training or specialist
   O Resident with training temporarily interrupted for a paid PhD trajectory
   O Unpaid PhD trajectory as junior doctor, resident, or specialist
   O Resident in training in a residency combined with PhD trajectory
   O Other situation, namely...

6. When did you start your PhD trajectory (month-year)?

7. What was the formal end date of your PhD trajectory (month-year)? This can also be in the past when your formal PhD trajectory has expired.

8. To what specialty/specialties is your PhD trajectory connected?

9. How many papers for your thesis have been published so far?

10. What type of research are you doing?
    O Fundamental research
    O Clinical research
    O Public health and primary care
    O Epidemiological research
    O Others, namely...

11. Which specialty did you prefer most with regard to your future career as a doctor when you started your PhD? If you did not have a clear preference or did not aspire a career as a doctor at that time, you can also fill that in.

12. Which specialty do you prefer most at the moment with regard to your future career as a doctor? If you did not have a clear preference or did not aspire a career as a doctor, you can also fill that in.

13. Are you assured of a specialty trainings position or are you currently in training?
    O No, not yet
    O Yes

14. In which specialty are you working as specialist or resident?

15. So far, I am on schedule with my PhD trajectory (compared to the current official end date).

16. I expect that I will be (further) delayed during my PhD trajectory.

2. Expectancy for success

PhD candidates received the instruction to score items on a 7-point Likert scale, defined as 1 'completely disagree' – 7 'completely agree'.

1. I think I have the skills to be able to do research as a PhD candidate.
2. I feel competent enough to do research as a PhD candidate.
3. I think I am good at doing research.

3. Values

PhD candidates received the instruction to score items on a 7-point Likert scale, defined as 1 'completely disagree' – 7 'completely agree'.

The statements below are about the possible perceived value of a PhD (trajectory). To what extent do you think these values are assigned to a PhD in the medical field?

1. A PhD trajectory improves the quality of clinical work as a doctor.
2. By doing a PhD trajectory, you develop relevant skills that you would not have been able to develop without a PhD.
3. A PhD offers advantages for your further career as a doctor, even if you doNot continue in research.
4. A PhD increases the chance of future jobs (e.g. specialty training, fellowship).
5. Only with a PhD degree do you have a chance to get into specialty training in the specialty that I aspire.
6. A PhD increases the chance of staying involved in scientific research.
7. A PhD is an important step towards a career as a medical researcher.
8. A PhD trajectory is valuable for the network within the field.
9. A PhD trajectory is valuable for the social contacts it can bring.
10. Completing a PhD programme is something to be proud of.
11. A PhD trajectory makes you more resilient as a person.
12. A PhD trajectory offers an opportunity for personal growth in dealing with challenges and boundaries.

13. With a PhD trajectory, you contribute to the quality of healthcare.
14. A PhD programme has societal relevance.
15. Programme directors in my (preferred) specialty field attach value to a PhD in selection procedures.
16. Within my (preferred) specialty field, colleagues attach value to a PhD.

4. Motivation

PhD candidates received the instruction to score items on a 7-point Likert scale, defined as 1 'Not applicable at all' – 7 'Fully applicable'.

Indicate to what extent the motivations below apply to you at this time in your PhD programme. I am doing a PhD…:

1. For the satisfaction I feel when I surpass myself in my PhD activities (e.g. work, presentations).
2. For the satisfaction I have in facing challenges in my PhD trajectory.
3. For the pleasure I feel in accomplishing my PhD project (e.g. thesis).
4. Because I find doing a PhD interesting.*
5. Because the subject of my PhD project is close to my heart.*
6. Because my PhD is consistent with my values (e.g. curiosity, ambition, success).
7. Because my PhD is a fundamental part of who I am and my identity.
8. Because my PhD meets my goals and my objectives in life.
9. Because it suits me to finish what I started.*
10. Because I want to improve my skills in my field of study.
11. Because it is important for me to advance knowledge in my field of study.
12. Because I have the opportunity to take my first steps in research (e.g. publications, collaborations) while benefitting from supervision.
13. To thoroughly explore whether a future career as a clinician-scientist suits me.*
14. Because as a doctor (in training) I do not yet feel sufficiently competent in doing research.*
15. Because my supervisor would be disappointed or angry if I gave up.
16. Because I have made commitments that I must fulfil (e.g. with funding agencies, employers, collaborators, a research director).
17. Because I do not want to be perceived as a quitter.
18. To show others that I can do this.*
19. For the prestige associated with a PhD.
20. To increase the chance of future clinical positions (e.g. training place, fellowship, place in partnership).*
21. Because others advise me to do a PhD project (e.g. programme directors).*
22. To distinguish me from others.*
23. Because many colleagues around me are doing a PhD.*
24. Because I have already invested so much in it (time, energy) that I really want to finish it.*
25. Because the secondary employment conditions appeal to me (e.g. no shifts etc).*
26. To not work in the clinic (yet) for a period of time.*
27. Because I am not sure yet in which clinical job or specialty (e.g. specialty training) I want to continue.*
28. I wouldn't pursue a PhD if it didn't affect the chances of being selected (e.g. for specialty training or other desired job positions).*

** Added items to original Motivation for PhD Studies Scale (MPhD)*

5. Work Engagement

PhD candidates received the instruction to score items on a 7-point Likert scale, defined as 1 'Not applicable at all' – 7 'Fully applicable'.

Indicate to what extent the following statements apply to you in this phase of your PhD:

1. My PhD trajectory inspires me.
2. I am enthusiastic about my PhD trajectory.
3. I am proud on the work that I do during my PhD.
4. When I get up in the morning, I feel like going to work.
5. At my work, I feel bursting with energy.
6. At my job, I feel strong and vigorous.
7. I feel happy when I am working intensely.
8. I am immersed in my PhD.
9. When I am working, I forget everything else around me.

6. Drop-out intentions

PhD candidates received the instruction to score items on a 7-point Likert scale, defined as 1 'Not applicable at all' – 7 'Fully applicable'.

Indicate to what extent the following statements apply to you in this phase of your PhD:

1. If I could choose again, I would start a PhD programme again. *(R)*
2. I expect to finish my PhD. *(R)*
3. I feel pressure to finish my PhD.
4. I am considering quitting my PhD trajectory.

7. Clinician-scientist Career Ambitions

PhD candidates received the instruction to score items on a 7-point Likert scale, defined as 1 'Not applicable at all' – 7 'Fully applicable'.

Indicate to what extent the following statements apply to you in this phase of your PhD:

1. After my PhD, I would prefer to be affiliated as a doctor at an academic medical centre or other institution where research has a primary focus.
2. I consider my PhD to be a specialisation in science, without necessarily pursuing an academic career in the long term.
   [Reflected item]
3. As a doctor, I want to continue doing *little to no* scientific research after my PhD.
   [Reflected item]
4. As a doctor, I want to combine scientific research and clinical tasks after my PhD.
5. As a doctor, I mainly want to do research after my PhD.
6. I would like to work as a post-doc in the future.

Appendix E: Interview Guide (translated to English)
[Chapter 8]

1. Introduction interview
- Introduction interviewer
- Explaining methods (timeline construction)
- Repeat information stated in the pre-sent information letter (e.g. privacy regulation, etc.)
- Informed consent (recording interview and use of anonymised data in research paper)

2. Start of the interview

2.1 Prior to starting a PhD trajectory
a. At which medical school did you study? If applicable; What job(s) did you have after graduation and before starting your PhD trajectory? When did you decide you wanted to pursue a PhD? And how did you find your current PhD program?
b. What were your motives to initiate a PhD several years ago? What expectations did you have of your PhD program? What was your view on doing a PhD? What was (less) appealing? *[motivations & values]*
c. At that time, did you already have some ideas about what career you aspired after your PhD? If so, what ideas did you have regarding your career after your PhD? Did you (already) have a preferred specialty in mind? Did you (already) have ideas about applying for future job positions? (How) Did science play a part in your career ambitions? What role for science did you see in your future career? *[ambitions]*

2.2 Construction of timeline during the PhD trajectory
1. Explaining the timeline and different colours of post-its for different phases.
2. Interviewee is writing remarkable, important and meaningful events or experiences on the post-its.
3. Hereafter, the interviewee puts the post-its on the timeline in chronological order. The higher a post-it is pasted on the Y-axis, the more positive the participant looked back on it.

2.3 Discussing and reflecting on the PhD trajectory timeline

2.3.1 Start of the PhD trajectory
a. You just started your PhD trajectory. Can you tell me something about this time? What were your first impressions? Was it what you expected it to be? *[potential in-depth questions regarding work/life factors, support (team), autonomy, research topic and content, culture]*
b. Can you tell me something about what you wrote on these post-its? How do you think this experience or event might have impacted your motivation for your PhD programme and your (academic) ambitions after your PhD?
c. Overall, how do you look back on this initial phase now? *[when only a few post-its have been pasted, potential deepening questions can be: what did you like, like less/dislike, or find difficult? Did your motivation, job satisfaction and/or ambition changed in this initial phase, if so, how come? What were your ambitions for the future at that moment? Looking back at that time, do you wanted things to be different? Is there any advice you would like have to have given yourself at that time?]*

2.3.2 Mid-stage of the PhD trajectory
a. We are now continuing to the mid-phase of your PhD trajectory. Can you tell me something about this time? *[potential in-depth questions regarding work/life factors, support (team), autonomy, research topic and content, culture]*
b. Can you tell me something about what you wrote on these post-its? How do you think this experience or event might have impacted your motivation for your PhD programme and your (academic) ambitions after your PhD? *[potential in-depth questions can be: Were there times when you had serious doubts about whether you were being able to or wanting to finish your PhD? When was it? Where did these doubts came from? If not spontaneously addressed: How would you describe the relationship with your supervisors? How was the collaboration? What role did they fulfill in your trajectory?]*
c. Overall, how do you look back on this mid-phase of your PhD trajectory now? *[when only a few post-its have been pasted, potential deepening questions can be: what did you like, like less/dislike, or find difficult? Did your motivation, job satisfaction and/or ambition changed in this mid-phase, if so, how come? What were your ambitions for the future at that moment? Looking back at that time, do you wanted things to be different? Is there any advice you would like have to have given yourself at that time?]*

2.3.3 Final stage of the PhD trajectory
a. We are now progressing to the final and current phase of your PhD trajectory. Can you tell me something about this time? *[potential in-depth questions regarding work/life factors, support (team), autonomy, research topic and content, culture]*
b. Can you tell me something about what you wrote on these post-its? How do you think this experience or event might have impacted your motivation for your PhD programme and your (academic) ambitions after your PhD? *[when only a few post-its have been pasted, potential deepening questions can be: Can you tell me something more about how you are doing in this phase? What are your expectations? Do you have any doubts about finishing your PhD trajectory? What in particular motivates you in this phase of your PhD trajectory? Are there things you find difficult at this time? What are your ambitions for the future (after your PhD)? (How) Does science play a part in your career ambitions? What role for science do you see in your future career?]*

2.3.4 Finalizing the timeline of the PhD trajectory
a. Are there things you would like to add or have not discussed yet?
b. Can you summarize in a few sentences how your motivation and ambition has changed throughout your PhD trajectory? Can you also indicate what has been decisive for your motivation?
c. If you could give your younger self any advice at the time you started to consider pursuing a PhD, what advice would you have given yourself?

3. End of the interview

- Reflecting on the interview
- Repeat information about confidentiality, member check etc.
- Check contact information for future contact
- Thank you!

4. Check for interviewer

- Clarity (Do I get it? Only one interpretation possible?)
- Relevance (Does this answer the question?)
- Completeness
- Validity (interviewee's opinion)

Appendix F: Overview of all emerged themes and sub-themes

[Chapter 8]

Themes	Sub-themes
1. Initial motivation to start a PhD matters	1.1 As stepping stone towards a clinician-scientist career *1.1.1 Longing for extra (academic) challenges next to clinical tasks (e.g. due to the need 'to think out of the box' instead of following protocols)* *1.1.2 Develop research skills* *1.1.3 Would like to become an expert on and/or contribute to the research topic* *1.1.4 Research is important for being a good doctor* *1.1.5 Research might be more appealing than clinical work (only)* *1.1.6 To get into and get to know the academic world* 1.2 As stop-over for career orientation purposes *1.2.1 To buy time for future career steps e.g. specialty decision* *1.2.2 Preferring a PhD over working as DNIT for years* 1.3 As vehicle to get into future clinical job positions *1.3.1 Pursuing a PhD to get into the desired (sub)specialty* *1.3.2 Pursuing a PhD to increase chances to get into specialty training* 1.4 Others *1.4.1 It (i.e. PhD) came across my path* *1.4.2 A PhD degree can only benefit and won't harm you*
2. Autonomy, a matter of the right dose at the right time	2.1 Autonomy in research projects and initiatives 2.2 (Un)clarity in tasks and expectations 2.3 Need for more guidance 2.4 Pressure to publish (soown) 2.5 (Dis)Liking imposed (clinical) tasks 2.6 Autonomy in (daily) time management within work 2.7 Work life balance
3. PhD as proof of competence and/or as learning trajectory?	3.1 (Not) Feeling competent (enough) 3.2 Comparing to others 3.3 Urge to stand out and show your competence 3.4 Wants to do well in the eyes of others 3.5 Opportunity for education 3.6 Protected time to (further) develop skills and knowledge

A

4. It takes (at least) two to tango	4.1 (Lack of) Commitment and guidance from research team 4.2 (Lack of) Academic guidance 4.3 (Lack of) Mental and personal support 4.4 Supervisor (does not) make(s) time for me 4.5 (Lack of) Clear and constructive feedback 4.6 Credibility supervisor 4.7 (No) Click with supervisor(s) 4.8 Feeling alone in my projects 4.9 Conflicts of interest 4.10 Dependency relationship(s) 4.11 Role model 4.12 Same or different expectations 4.13 Trust in supervisor 4.14 Supervisor is open to my ideas 4.15 Team is proud of my work 4.16 Compassion of team when facing difficulties 4.17 Supervision matching needs 4.18 Feeling safe to talk about PhD struggles with team
5. Peers can make or break your PhD	5.1 (Lack of) Relatedness with peers 5.2 (Lack of) Shared experiences with peers 5.3 Peers became friends 5.4 Support from peers 5.5 Informal meetings and activities 5.6 Competitive environment
6. Strategies to stay or get back on track	6.1 Active solution-seeking approach *6.1.1 Switch to other supportive working environment* *6.1.2 Turning conflicts into positive learning experiences* *6.1.3 Transform own experiences into the ambition to do things differently in future academic career* 6.2 Accept that lows are part of a PhD journey *6.2.1 Having the end in view* *6.2.2 Last mile is the longest* *6.2.3 Finish what you have started* *6.2.4 Invested so much time, energy, and effort* *6.2.5 Take it as it comes* *6.2.6 Not feeling able to change difficulties* *6.2.7 Accepting although it was essentially not OK* *6.2.8 Not feeling safe to speak up*

A