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

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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.

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