NAVIGATING TRANSLATIONAL MEDICINE IN ACADEMIA

How Can Translational Scientists Be Rewarded and Supported in Their Careers?

Farah R.W. Kools

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About the cover:
I first saw Blaschka glass models during my student job at the University Museum in Utrecht. The models were made by a German father and son for universities in the late 19th century to study difficult to preserve flowers, plants, and marine life. Especially aquatic soft-bodied invertebrates are difficult to preserve without losing their shape and color. The Blaschka's were extraordinary in creating incredibly detailed, life-like, and scientifically accurate models out of glass. When I was at Harvard Medical School during my master's internship, I learned about their Blaschka collection. I saw this glass octopus at the Harvard Museum of Natural History in Boston and have always been mesmerized by it. When searching for a cover photo for my dissertation, I realized the symbolic comparison between this glass octopus and the translational scientists that I studied as both are intelligent, creative, adaptable, and both deserve to be preserved.

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How Can Translational Scientists Be Rewarded and Supported in Their Careers?

Academische Carrières in Translationeel Biomedisch Onderzoek

Hoe Kunnen Translationele Wetenschappers Worden Beloond en Ondersteund?

(met een samenvatting in het Nederlands)

Proefschrift

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"*The patient always comes first*"

– Dr. W.H.D. Kools, General Surgeon, Utrecht University class of 1983

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PROLOGUE

A postdoctoral researcher at a university medical center finds herself at a crossroads. Eager to bridge the gap between biomedical theory and practice, she is driven by her intrinsic motivation to tackle real-world clinical problems while balancing responsibilities as a clinician, educator, and researcher. However, the demands of the scientific world loom large. Publications and research grants are the currency of recognition at her university, and she watches her colleagues race to progress their scientific careers. The pressure is palpable, a constant reminder that academia's priorities often eclipse the broader societal impact she is searching for.

During her education she had trouble finding guidance that went beyond textbooks and experiments. She knew from an early stage that she wanted a career that connected her research with real-world impact but grappled with career choices and a lack of potential career path examples. The courses available to her during her studies did not provide the real-world applicability and hands-on experience she needed to gain insights that transcended her lab work.

Balancing multiple ambitions, she struggles with the challenges she faces navigating a career path that translates her theoretical expertise into real-world impact. Intrinsically she cannot and will not give up on this ambition. She questions publications and research grants as academia's main currency and feels a conflict of interest between what she needs to do to advance her career and where real impact lies. She wonders how a translational career can be fully recognized beyond her research output.

In this dissertation we explore this narrative, which serves as a reflection of the common struggles faced by translational scientists navigating the current academic system while working towards their translational goals. While this dissertation does not claim to provide definitive solutions, it aims to offer incremental insights, recognizing that even modest progress can lead to meaningful change.

CHAPTER 1

General Introduction

The Emergence of Translational Medicine

The foundation of translational medicine can trace its origins to the observational methods of Hippocrates, who emphasized the study of patient symptoms to guide treatment strategies (1). This approach was significantly improved upon in the 19th century by people such as Robert Koch and Louis Pasteur, and their seminal works on germ theory to improve patient care. However, the 20th century saw a trend towards increased specialization with the rapid expansion of biotechnology, leading to a division between medical doctors and medical scientists (2). This specialization allowed for profound advancements within individual fields, but it also resulted in many clinicians distancing themselves from research, and scientists becoming increasingly removed from clinical practice (2). Consequently, the collaborative link between medical research and patient care began to weaken. In response to this growing divide, a resurgence of translational medicine began in the 1970s, and aimed to re-establish a direct connection between the lab bench and patient bedside (3). This movement sought to accelerate the translation of clinically relevant scientific discoveries into medical practice to help unmet patient needs (3,4).

An important characteristic of translational medicine is multidisciplinary collaboration between scientists, clinicians, industry partners and other stakeholders to expedite the development of new diagnostics, therapies, and medical practices (4). In the early 2000's the Institute of Medicine, now the National Academy of Medicine, published several reports highlighting the need for better integration of basic research and clinical practice. These reports emphasized the importance of translational research in improving patient outcomes (5,6). Around that same time, the National Institutes of Health (NIH) launched its Roadmap for Medical Research. This initiative identified the critical need for translational research and introduced programs such as the Clinical and Translational Science Awards (CTSA) to promote collaboration between researchers from different fields with a clear focus on creating clinical impact (7).

The Translational Scientist and Translational Research Pipeline

Within translational medicine, translational scientists hold many different professional identities. For instance, they can be biomedical, bioinformatics, pharmacology, epidemiology researchers with a clear interest in clinical research, clinician-scientists who combine clinical practice with clinical research, or possess another scientific expertise from in or outside academia that contributes to the advancement or improvement of the translational field, while often also being involved in education (8,9). Depending on where a translational scientist's interests lie and whether they go through medical training, many career paths are possible. The diverse nature of

a translational scientist's career can provide a number of opportunities along what is known as the translational research pipeline, or bench-to-bedside research (4). This pipeline consists of six phases:

- **T-1 Clinical problem**: Patient-derived unmet needs are translated into scientific research questions.
- **T0 Fundamental research**: Preclinical studies using cell cultures and animal models are performed to understand the mechanisms of a disease and to identify potential therapeutic targets.
- **T1 Studies in humans**: Promising findings are tested for proof of concept involving safety and efficacy assessments of potential treatments before being translated to studies in humans and moving to phase 1 clinical trials.
- **T2 Studies in patients**: Clinical trials are continued through phases 2 and 3 translating studies from humans to patients, assessment of safety and efficacy continues according to evidence-based guidelines.
- **T3 Clinical implementation**: Phase 4 clinical trial outcomes are translated into clinical practice and implementation studies are performed.
- **T4 Population health studies**: Population-level outcome studies help assess the safety and efficacy of newly developed treatments towards reaching societal impact, and help pinpoint new clinical problems to bring into T-1 (4).

While laboratory research during the T0 phase generates a growing body of knowledge about disease mechanisms and potential treatments, these findings often remain isolated from moving forward in the pipeline towards becoming practical clinical applications, exposing what is referred to as the "valley of death" in translational medicine (3,10). Several challenges have been identified that cause this difficulty in advancing from preclinical to clinical studies. They include 1) financial challenges; developing a new drug or treatment is expensive, and many potential therapies fail to make it through this stage due to lack of funding, 2) regulatory hurdles; getting regulatory approval to conduct clinical trials can be a lengthy and complex process, 3) scientific uncertainty; promising therapies in cell cultures and animal models may not always translate to humans successfully, and 4) commercial viability; companies may be hesitant to invest in therapies that are not yet proven in humans as the risk of failure is high (11–14). Various initiatives and funding opportunities have been established to bridge this "valley of death". These include government grants, venture capital funding, public-private partnerships, and initiatives such as the "fast track" designation by regulatory agencies, which expedites the development and review of treatments for serious conditions (11–14).

In addition to the challenges within the translational research pipeline, translational scientists themselves also face a number of challenges within their career development. Specifically, in finding relevant guidance regarding their translational goals and finding direction during their education.

Career Guidance and Education

Since there is such variety in career options, there is not one straight forward way to become a translational scientist and their day-to-day working lives can differ greatly. Becoming a translational scientist involves a multidisciplinary approach requiring education within the life sciences, specialized training, and an intrinsic commitment to work towards achieving translational goals (8,9). Translational scientists usually balance responsibilities within two or three working domains: research, education, and healthcare (8,9). Pressure to publish within the research domain for career advancement or securing funding often has to be balanced with educational commitments and if also involved in clinical care, patient needs (Figure 1). This raises questions on how translational scientists divide their time to meet all employer requirements, how they could be rewarded for working towards translational goals for the benefit of patients and society, and how they can be supported in this role specifically compared to their non-translational colleagues. The absence of a structured framework for tailored professional development leaves many translational scientists navigating this complex field largely on their own (15,16). This underscores a need for specialized career guidance and development.

Moreover, traditional educational systems are often monodisciplinary and may not always offer dedicated programs or coursework tailored to this interdisciplinary field (17). While academic institutions excel in providing foundational knowledge in the life sciences, and MD/PhD programs exist that bring together medical and research training, comprehensive translational science programs remain relatively scarce (17). As a result, aspiring translational scientists often find themselves charting their own course, piecing together a curriculum including various expertise from in and outside of the biomedical field (18).

As the field of translational medicine advances, more complexities have emerged. In addition to the challenges mentioned above, another concern has gradually materialized and requires attention: publication pressure.

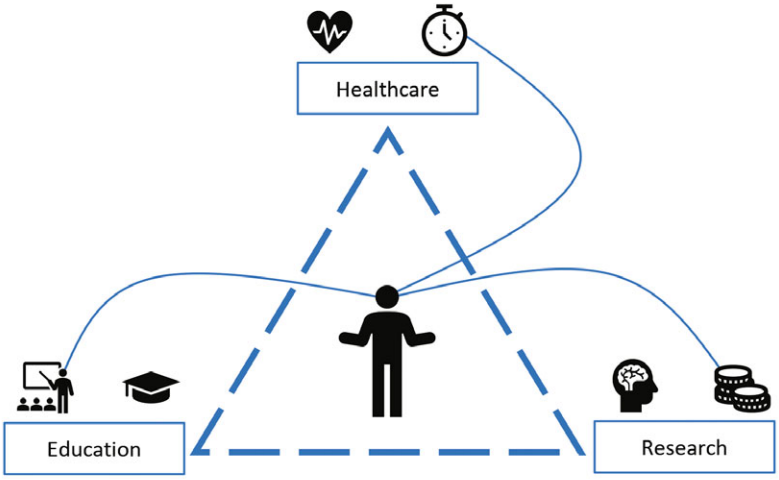

Figure 1. The three working domains of translational scientists where patient needs have to be balanced with educational commitments and pressure to publish within research.

Publication Pressure

Publication pressure in the context of scientific research refers to the expectation or demand placed upon researchers to publish their findings in prestigious peer-reviewed journals in order to advance their scientific careers (19). This includes pressure to publish to obtain funding opportunities and to build scientific reputation amongst peers and academic institutions (19–21). When publication pressure turns negative, unintended side-effects arise and can push scientists towards questionable research practices (e.g., describing a hypothesis after finding significant results, selective publication of results, and concealing conflicts of interests), scientific misconduct (e.g., plagiarism, falsification, and fabrication of data), and burnout (21–23). Publication pressure is not inherently bad, it can even be motivating, and publications are still the main mode of communication within the scientific community. However, in the context of translational medicine where bench-to-bedside research is meant to serve patient needs, an additional layer of complexity is added.

Publication pressure in the biomedical sciences favors fundamental research findings (T0) and clinical trial outcomes (T2) (24). Studies before, in between, and after these phases, which are indispensable for the translational pipeline, fall into a so called "citation valley of death" with less prestigious journals accepting them for publication (24). This can discourage translational scientists from prioritizing collaborations with clinical partners and industry because they feel pressured to prioritize publications in more prestigious journals as this is a common metric for career advancement and securing research funding (24).

Publication pressure for translational scientists also leads to financial and time constraints. Overcoming the "valley of death" within the translational pipeline is resource-intensive requiring significant funding, time, and effort, with uncertain outcomes (11–14). When under pressure to produce results in the form of publications, allocating the necessary resources to advance translational research projects can become challenging compared to pursuing less risky projects with shorter timelines and publishable prospects to augment publication records.

Several initiatives have been put forward to counteract the negative effects of publication pressure. These include the Open Science movement that aims for more open and collaborative research, i.e., sharing publications, data, software, and other types of academic output, and re-evaluating the academic reward system within research in the context of career advancement (25).[1] Institutions and funding agencies are also being encouraged to place greater emphasis on evaluating someone based on impact and real-world outcomes of their work such as patents, successful clinical trials, and the development of new therapies or medical devices, rather than solely on publication metrics (24,26,27). Increased funding and support for translational research specifically, and encouraging interdisciplinary collaboration, could help translational scientists navigate both "valleys of death" without feeling the need to prioritize publications over progress.

Across the academic landscape, individuals and organizations such as universities are increasingly acknowledging the importance of broader research evaluation criteria. In 2019 Utrecht University (UU), for example, signed the San Francisco Declaration on Research Assessment (DORA). The aim of this declaration is to improve how the output of scientific research is evaluated by academic institutions and funding agencies.[2] By signing this declaration, the UU and other organizations are making a commitment to value the quality and impact of research over publication quantity. This initiative, part of the broader Open Science movement, is a positive step towards altering traditional academic reward systems, which could in turn alleviate some of the pressures faced by researchers. Additionally, some universities, including the UU, have made the strategic decision to withdraw from the Times Higher Education (THE) World University Rankings. By opting out of the 2024 rankings, the UU is showing its commitment to prioritize collaborative achievements and real-world impact over traditional ranking scores.[3,4]

1 https://www.nwo.nl/en/open-science
2 https://sfdora.org
3 https://www.uu.nl/en/news/why-uu-is-missing-in-the-the-ranking
4 ttps://www.iau-aiu.net/utrecht-university-withdrew-from-the-times-higher-education-THE-rankings-2024

By addressing the negative effects of publication pressure, fostering a research environment that values translational work, and developing tailored career guidance and education, the field of translational medicine can strive to become more effective in bringing scientific discoveries into clinical practice for the benefit of patients. In order to address these issues, a methodological approach encompassing both theory and practice that has the potential to lead to actionable change is required.

Action-Based Research

To study these translational challenges, an action-based approach was chosen. Action-based research, or action research, is a research methodology that focuses on solving complex real-world problems through an iterative and collaborative process between researchers and stakeholders in the field (28). It is primarily used in education (e.g., working with teachers to improve student engagement), social sciences (e.g., working with policymakers to study policy impact), organizational development (e.g., working with organizations to improve internal processes), and healthcare (e.g., working with health care providers to enhance patient care), but its principles can be applied in many domains (29,30).

- Action-based research begins by identifying a specific problem that needs attention or improvement in a practical setting. This problem is often rooted in the experiences and concerns of the stakeholders involved. An example of this is the James Lindt Alliance, which is an initiative that brings together clinicians, patients, and carers to identify and prioritize more immediate healthcare needs.[5]
- Researchers work in active collaboration with stakeholders in the field (e.g., clinicians and educators) to design a research plan that allows the collection of relevant data related to the problem. Data can be collected through various quantitative and qualitative methods such as surveys, interviews, observations, or document analysis.
- The collected data is analyzed, often collaboratively, to gain a deeper understanding of the problem and to help identify patterns, causes, and potential solutions.
- Based on the analysis, an action plan is developed that outlines specific steps or interventions that can be taken to address the identified problem or improve the situation.
- The action plan is put into practice where researchers and stakeholders ideally work together to implement the planned changes or interventions.
- After implementing the action plan, researchers assess the outcomes and effects of the changes. This evaluation helps determine whether the interventions were

5 https://www.jla.nihr.ac.uk

successful in addressing the problem or achieving the desired improvements and helps stakeholders in the field make informed decisions based on evidence.
- Action-based research is an iterative process, meaning that results and experiences are continually reflected upon and if the initial actions did not fully solve the problem, the process is repeated, with adjustments made to the action plan based on lessons learned from the previous cycle.
- The findings and insights from action-based research are often shared with a wider community of stakeholders in the field, educators, and other researchers. This helps disseminate knowledge and potentially benefits others facing similar challenges (28,29,31–33).

Action-based research, however, has its limitations and potential drawbacks. Due to the nature of this approach, it can be more susceptible to researcher subjectivity and biases, and the overgeneralization of findings (31). To mitigate these limitations, it is important that researchers are transparent about the extent of their role within a project, that each study's methodology is explicitly clear, and that precautions are taken to seek external feedback to verify methodological approaches and the analyses of study results (31). Furthermore, action-based research is context-specific, and its conclusions should always reflect the appropriate scope of each study and target group (29). This can then serve as the base for additional studies with more quantifiable aims (29).

Nevertheless, action-based research can be a powerful approach for addressing complex, context-specific issues and can improve practices in various fields (28,31). It emphasizes the importance of bridging the gap between theory and practice to create meaningful change (29). While it does require long-term commitment, the results from this type of research can foster continuous and sustainable improvements within organizations and communities (30).

The overarching goal of this dissertation is to use an action-based approach to provide evidence-based practical solutions for translational scientists. Specifically, to gain insight into the dynamics of publication pressure in this patient-driven field, to explore options for recognition that are less publication-focused, and to find ways to support and educate its future generation.

Dissertation Context

The Graduate School of Life Sciences (GSLS) within Utrecht University together with the Department of Biomedical Sciences within the Center of Education and Training of the University Medical Center Utrecht (UMCU) created the opportunity to

design this action-based dissertation revolving around career support for translational scientists. This research is housed in the newly developed PhD program Life Sciences Education Research (LSER) because of its focus on education.[6] Various other educational initiatives have arisen concentrated on creating sustainable career pathways for this subset of life scientists specifically.

The Erasmus+ PATHWAY Project was one of these initiatives. Created in 2017 as a strategic partnership in higher education, five European institutions (University Medical Center Utrecht, Nutricia Research BV, Ghent University, University College London, and University of Granada) formed a consortium for the exchange of good practices and the development of international career pathways and online curricula for translational scientists. The objectives were to create sustainable and attractive career pathways while simultaneously designing educational building blocks geared towards the development of domain-specific skills and to raise awareness amongst stakeholders in and outside academia of the added value of translational scientists.[7]

One of four associated partners of the PATHWAY Project was the Eureka Institute. This non-governmental organization aims to develop a community of translational scientists equipped to inspire and catalyze the application of discoveries for the benefit of human health through education. The institute offers several educational opportunities for translational scientists of different career stages.[8]

What unifies these three parties is their common interest to support translational scientists through education. The studies within this dissertation are all in collaboration with one or more of these parties and described below.

Dissertation Outline

The following four chapters of this dissertation each highlight a different aspect of the working lives of translational scientists with the purpose of answering the overall research question: *"How can translational scientists be rewarded and supported in their careers?"*. As part of the Center of Education and Training, the focus of this dissertation is to use education as a vehicle for creating awareness about the specific challenges translational scientists face within the broader scientific community, while developing education to support translational scientists. Each chapter explores a specific facet: the dynamics

6 https://www.uu.nl/en/education/graduate-school-of-life-sciences/phd/starting-your-phd/phd-programmes-gsls/life-sciences-education-research

7 https://pathwayproject.eu

8 https://eurekainstitute.org

of publication pressure (Chapter 2), perspectives from postgraduates (Chapter 3), support for graduate students (Chapter 4), and opportunities within graduate schools (Chapter 5) (Figure 2). This action-based approach integrates an empirical study with a supplementary piece for each chapter.

Beginning with **Chapter 2**, literature regarding publication pressure in the biomedical sciences was investigated through a scoping review and interview study. The scoping review addressed the ongoing debate within the academic community about publication pressure, specifically its nuances for biomedical sciences. The semi-structured interview component added further understanding of the literature by discussing the review findings from different points of view with professionals working in the field. This chapter is supplemented by an opinion piece discussing the societal impact of publications with the aim of bringing further awareness to this topic within the broader scientific community.

In **Chapter 3**, an exploratory interview study was conducted under postgraduate translational scientists on how they navigate the current academic reward system. This study was part of the PATHWAY Project which the author was a member of. By analyzing the results of semi-structured interviews with translational scientists from varying countries, subspecialties, and career stages, their thoughts on publication pressure and potential solutions were investigated. Additionally, light was shed on how they managed their working lives, as many translational scientists balance clinical, educational, and research duties simultaneously in varying settings. This chapter is supplemented by a correspondence piece on clinician-scientists specifically, highlighting the unique struggles of this subset of translational scientists.

Support for graduate students is the focus of **Chapter 4**, with a longitudinal exploratory mixed method study into online mentorship to support early-career translational scientists and to foster a translational community. The online mentorship program featured in this study was developed, run, and evaluated by the PATHWAY Project. By analyzing participant input data from the newly developed mentorship program over two pilot years, mentee (early-career) and mentor (more senior) mentorship needs, and program evaluations were shown. Additionally, their thoughts on the program's online aspect using follow-up survey data were gathered. This chapter is supplemented by several practical application pieces for implementing and sustaining such a mentorship program.

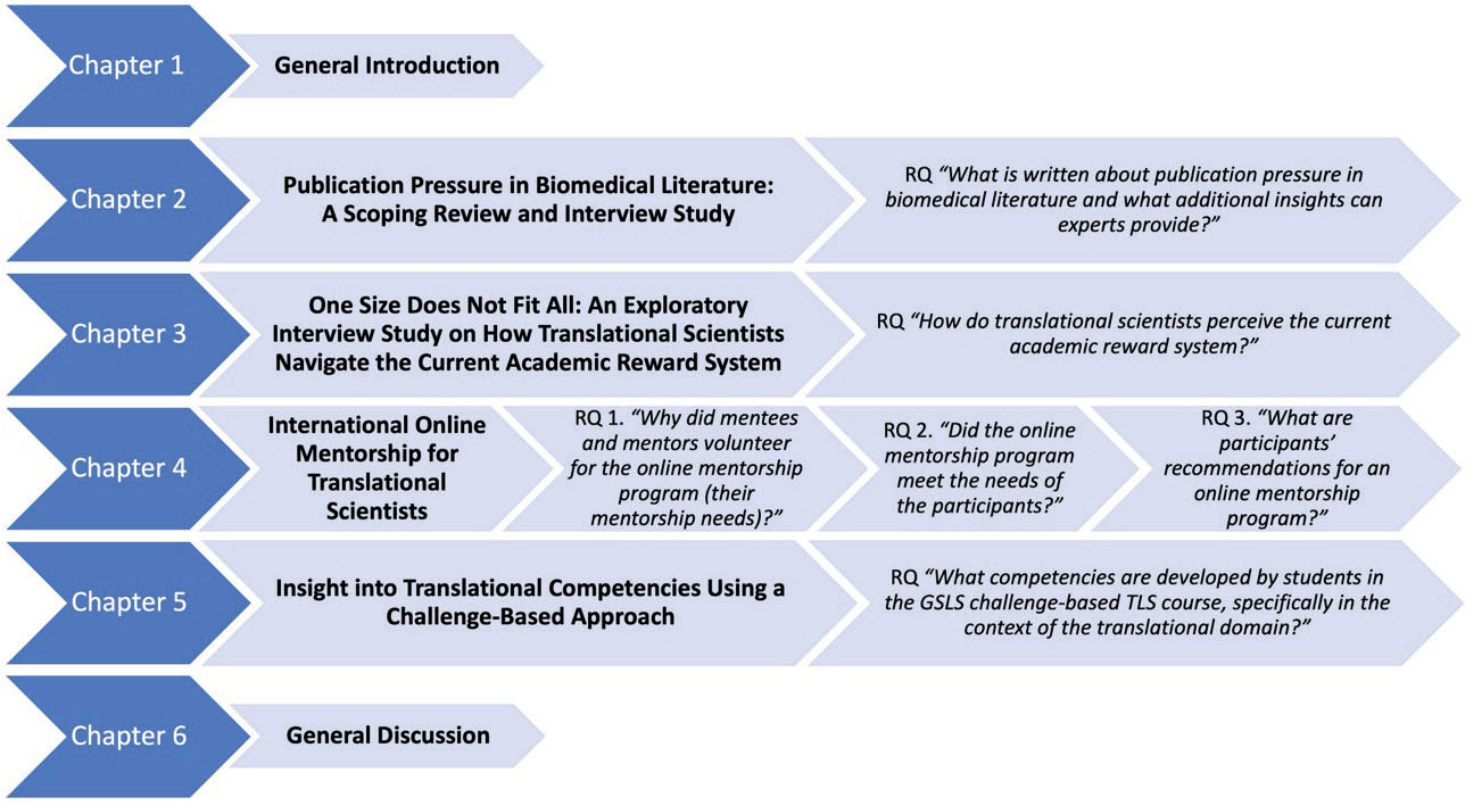

Figure 2. Dissertation outline.

Lastly in **Chapter 5**, potential educational opportunities within graduate schools to prepare students for a translational career were investigated by studying the development of translational competencies during a graduate-level challenge-based course. In challenge-based learning, students are tasked to provide potential solutions for complex problems that have societal impact (34,35). The translational domain lends itself well to this type of educational framework, as it strives to create patient impact and requires competencies transcending disciplinary boundaries. The course was developed by a team from the Department of Biomedical Sciences which the author was a member of and a convergent parallel mixed method design was chosen for this study. Using survey and semi-structured interview data, reported competency development from both student and expert perspectives was compared to two existing competency frameworks. This chapter is supplemented by a practical piece providing tips for organizing challenge-based learning in biomedical education.

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CHAPTER 2.1

Publication Pressure in Biomedical Literature: A Scoping Review and Interview Study

Publication Status

An adapted version of this study is under review at a peer-reviewed journal as "van der Veen H, Kools FRW, and de Kleijn RAM. Publication Pressure in Biomedical Literature: A Scoping Review and Interview Study. 2022.".

Author Contributions

FK conceptualized the study. HV conducted the literature review and interviews, and authored the manuscript with FK as second researcher and author. RK supervised the methodology and guided the writing process. All authors contributed to the manuscript and approved the submitted version.

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ABSTRACT

Introduction: There is an ongoing debate about publication pressure within the biomedical community. To contribute to this debate, we aimed to investigate what has been written about publication pressure in biomedical literature and what additional insights different expert perspectives can provide to enhance our understanding of the topic.

Methods: We performed a scoping review of 31 articles from two search terms using the biomedical search engine PubMed and subsequently conducted semi-structured interviews with three experts. The three expert perspectives we chose to highlight were from a biomedical researcher, a journal editor, and a policy advisor at a university medical center.

Results: The reviewed studies showed that publication pressure is experienced as high, possibly leading to stress and burnout. Consequences of publication pressure are an increase in publications, number of authors per paper, and scientific misconduct. Causes and solutions of publication pressure found in the literature were mainly focused on the availability of resources and the use of bibliometric models for the attribution of funding and promotion. The interviews confirmed the findings from the review and added negative consequences for the potential societal impact of research, as well as self-imposed publication pressure by researchers themselves.

Conclusions: Publication pressure and the negative consequences thereof are complex challenges researchers face. More awareness on the impact of publication pressure on the tasks and goals of researchers in the context of societal impact is needed. We recommend that the topic of publication pressure should 1) be recognized and discussed at all levels of institutes and graduate schools, and 2) that criteria and processes for hiring, promotion, and funding should be as transparent as possible, and not solely based on bibliometrics.

INTRODUCTION

Academic publishing is crucial for the advancement of science. It is done to share important findings and increase scientific knowledge. There are, however, other factors that add to the importance of publishing. One of these factors is the need to publish to advance academic careers (1,2). For example, allocation of grants and funding is (to larger or smaller extent) dependent on metrics such as the number of publications and citations one has (3). A consequence of this is that research and researchers seem to be valued based on publication metrics instead of the societal impact of their research (4,5). Related to this, the term "publish or perish" was first introduced by sociologist Wilson in 1942 (6,7). This term is now a common expression in academia and is also prevalent in the biomedical sciences. Pressure to publish is perceived as high throughout the world, and highest in Anglo-Saxon countries (1).

Publication pressure has been associated with both positive and negative effects. By publishing, important findings are shared with the biomedical community, which contributes to expanding knowledge and makes health innovations possible. In this sense, the pressure to publish could be constructive pressure. However, publication pressure can also be destructive. It is believed to be the cause of complex problems within the research system (2,4). For example, it has been associated with stress, burnout, unethical publishing activities, and encouraging quantity over quality of publications (5,8). This is exacerbated by things such as status bias, where journals and reviewers are more likely to accept articles from more esteemed authors, making publishing in high profile journals nearly impossible for early-career researchers, which in turn creates pressure to publish in order to create a scientific career (9,10). This drive to increase publications can also cause research to drift away from reaching societal impact, on account of researchers focusing more on their publication track records in order to be able to continue their academic work (2).

An escalation of publication pressure notably intensified in the 2000s, a period marked by several pivotal changes. The advent of the digital revolution in scholarly publishing not only expanded the reach and volume of scientific output, but also increased metric-based evaluations (11,12). This was compounded by the global economic crisis of 2008, which placed additional strain on research funding, leading to increased pressure on institutions to perform (11,12). Another effect was an increase in short-term contracts, placing pressure on scientists to show research output in the form of publications (11,12). A knock-on effect of this was the rise of predatory publishing entities, who target scientists directly with invitations to publish in faux journals or journals that do not uphold proper scientific rigor (13). These negative associations have led to a debate about the "publish or perish" mentality and the way research and

researchers are valued (3,14). Does publication pressure help to advance science, or should we look for a different way of valuing research and researchers?

One systematic review on the "publish or perish" phenomenon has previously been performed and was conducted in the medical field in 2016 by Guraya et al. (15). They found that the pressure to publish can be caused by factors such as criteria for recruitment, measurements for institutional performance, requirements for promotion, and pressure by pharmaceutical companies looking to advance clinical trials. In addition, they found article retractions, plagiarism, and a competitive work atmosphere as negative consequences of publication pressure. As solutions, they reported that quality of scientific work should be valued over quantity, and that collaboration of everyone involved in the publishing process is needed in order to ensure good quality of publications.

In the last ten years, a series of initiatives have emerged, each addressing the multi-faceted challenges of publication pressure. For example, the Declaration on Research Assessment (DORA), established in San Francisco in 2012, recognizes the critical need for refined evaluation methods for scholarly outputs.[1] One of the key features of this initiative is that it includes a diverse array of stakeholders including publishers, funders, institutions, and researchers from all scholarly disciplines, emphasizing the need for a collective approach to bring about systemic change. One way in which DORA is actively working towards catalyzing change is with a project providing Tools to Advance Research Assessment (TARA). Project TARA, launched in 2021, aims to facilitate the development of new policies and practices for academic career assessment.[2] Its progress, while in its early stages, suggests a promising trajectory toward transforming research evaluation norms.

Parallel to these efforts, the Wellcome Trust's 2020 report: "What Researchers Think About the Culture They Work In" sheds light on publication pressure within current research culture (16).[3] The report not only discusses the topic of publication pressure, but also proposes possible solutions from changes to research funding criteria and structures, to supporting early-career researchers. Similarly, a Dutch initiative, Science in Transition (SiT), has been advocating for reform.[4] In their 2013 position paper, SiT argued for a new research paradigm, pleading for new checks and balances in the

1 https://sfdora.org
2 https://sfdora.org/project-tara
3 https://wellcome.org/who-we-are
4 https://scienceintransition.nl/en/about-science-in-transition

scientific system (17). They also argued that science should be valued for its potential societal impact and that research agendas should be set by societal stakeholders.

While these initiatives signal a growing acknowledgement and concerted response to publication pressure, there is still ongoing debate within the biomedical community about publication pressure and how it is affecting the field. More specifically, the mental health of researchers, the quality of research output, and consequences for achieving societal impact. This ongoing debate has led us to the following research question: *"What is written about publication pressure in biomedical literature and what additional insights can experts provide?"*. By exploring this question, we aim to inform and contribute to the development of solutions that address the negative consequences of publication pressure for the biomedical community.

METHODS

In order to investigate what has been written about publication pressure in biomedical literature, a scoping review was performed. Additionally, to discuss the results found in the literature and to put them into context, we performed semi-structured interviews with three different experts.

Scoping Review

The literature review in this study is specifically focused on the biomedical community, reflecting the field of study of the research team. This concentration enabled an informed and contextually relevant investigation of publication pressure. In aligning the literature search with this focus, PubMed was selected as the primary search engine. This choice was made after a comparative evaluation of various databases, including Scopus, Science Direct, and Google Scholar, revealed that PubMed's biomedical orientation significantly mitigated the retrieval of articles that did not directly address our specific research question (18).[5] To explore the body of literature in PubMed about publication pressure, we opted for a scoping review (19). Before starting the review, several search terms were tested. All terms were searched for in full text. These were "publication pressure", "publish or perish", "pressure to publish", "publish pressure", (publication AND pressure), (publish AND perish), and (pressure AND publish). The terms "publication pressure" and "publish or perish" yielded results that were most connected to the topic of publication pressure based on article titles. Therefore, these two terms were used for the literature search of this article.

5 https://pubmed.ncbi.nlm.nih.gov/about

An overview of the selection process can be found in Figure 1. At the time of the search, all articles published before November 1st, 2021, were eligible for inclusion. The search term "publication pressure" resulted in 26 hits, and "publish or perish" gave 235 hits. Out of both of these, 33 articles could not be accessed, and 10 articles were not available in English, so were therefore excluded. Furthermore, one article was found in both searches and one article was retracted. The 216 publications left, were filtered further based on their focus on the topics "publication pressure" and "publish or perish". In this step, 185 articles were excluded because publication pressure was not the main focus of their title and abstract. This resulted in a final selection of 31 included publications. Article types ranged from 17 original research articles to 14 other publications such as editorials, comments, and viewpoints. From the included articles, the main messages, and where applicable results and methods related to publication pressure, were summarized by the first author. These summaries were categorized into four main themes: experienced publication pressure, consequences of publication pressure, causes of publication pressure, and solutions to publication pressure. An overview of included articles, article type, participants, and corresponding results section(s) can be found in Appendix I.

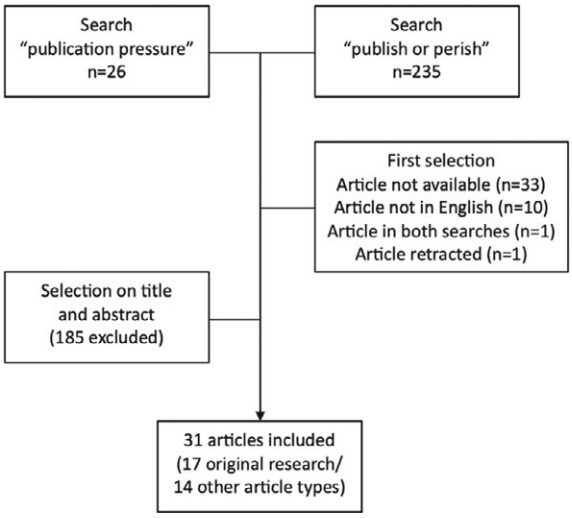

Figure 1. Selection process for the scoping review.

Interviews

After performing the literature review, three semi-structured interviews were held to deepen the understanding about publication pressure in the biomedical community. Because we wanted to include views from different perspectives, the interviews were

performed with 1) a researcher/psychiatrist active in the field of publication pressure, 2) a journal editor/researcher whose journal publishes about research ethics, and 3) a senior strategic policy advisor at a university medical center who is also a researcher in the field of incentives and rewards for researchers. The interviewees were chosen based on firstly their expertise, secondly relevance to the topic, and thirdly convenience. All were male and all responded to our initial interview invitation. The interviews were conducted and recorded in online video sessions using Microsoft Teams due to the COVID-19 pandemic. Informed consent was obtained before each interview.

Semi-structured interviews were chosen because it allowed the interviewer to explore interesting and novel areas with each interviewee (20). At the interviews both the first author, who was the main interviewer, and the second author, who checked the analysis of the interviews for accuracy, were present. At the beginning of the interviews, the interviewer shortly summarized the results of the literature review. The interviewer also explained that the goal of the interview was to gain insight into their perspective on and experience with publication pressure in the biomedical field. The questions in each interview were tailored to the function of the interviewee. A full list of prepared questions, used as an interview guide, can be found in Appendix II. During the interview, the final questions asked depended on the natural course of the interview. Interviews were performed in Dutch (n=2) or English (n=1). Interview audio was used to extract key messages from each interview by the first author. Afterwards, the key messages were categorized into two main themes, partially based on the themes found in the literature search: consequences and causes of publication pressure, and solutions to (negative effects of) publication pressure. Because two of the interviews were performed in Dutch, quotes were translated to English.

RESULTS

Literature Search

In this section, the results of the literature search are described. The results have been divided into four main themes: experienced publication pressure, consequences of publication pressure, causes of publication pressure, and solutions to publication pressure. Some articles discussed multiple aspects of publication pressure and are therefore included in more than one theme. Each theme contains original research articles, other publications such as reviews, editorials, comments, and viewpoints, or a combination thereof. If an article is not an original research article, this is explicitly mentioned in the text.

1. Experienced Publication Pressure

Several studies have been performed to evaluate experienced publication pressure. These were done with researchers from varying academic positions and institutions, and in different countries. In a study using a questionnaire about publication pressure with a 5-point Likert Scale (5=totally agree, 1=totally disagree), Haven et al. (2019) showed that academic researchers in the Netherlands experienced publication stress (M=3.22) and had a negative attitude towards the publication climate (M=3.59) (21). Postdocs and assistant professors experienced more publication stress and a negative attitude towards the publication climate compared to other academic positions, such as PhD students and full professors. Similarly, a study using a publication pressure questionnaire and a burnout inventory in Dutch medical professors by Tijdink et al. (2013) found that 54% of the professors said publication pressure has become excessive (22). In addition, 39% said publication pressure affects the credibility of medical research, and 26% considered publication pressure as having a sickening effect on medical science. Tijdink et al. (2013) also found experienced publication pressure to be related to burnout, and that 24% of the professors who responded to the questionnaires had signs of burnout. Professors who had been in academia for more years, experienced less publication pressure than professors with less years in academia. In Flanders, Belgium, 72% of medical researchers rated publication pressure as too high in a quantitative study using a publication pressure questionnaire, and a questionnaire assessing scientific misconduct by Tijdink et al. (2014) (23). Fifty two percent of these medical researchers said publication pressure harms science. Apart from medical researchers, publication pressure under medical students has also been investigated. Pang et al. (2020) showed that almost 70% of final year medical students in the United Kingdom (UK) who filled in their questionnaire about the students' perception of the publication component of the UK foundation program, said they felt under pressure to achieve publications during medical school (24). Reports on publication pressure were also found from non-European countries. In a study using a research misconduct questionnaire with Iranian medical faculty members by Shamsoddin et al. (2021), 65% of respondents said that the competitive scientific culture stimulates them to publish more (25). In addition, almost 85% of respondents said that the pressure to publish has become excessive, and 85% said the urge to publish makes science sick. In semi-structured interviews with South-African academic employees performed by Naidoo-Chetty et al. (2021), publication pressure was mentioned as the most prominent job demand, followed by a too high workload and conflicting demands (26).

2. Consequences of Publication Pressure

Consequences of publication pressure found in the literature search ranged from an increase in publications to authorship issues and scientific misconduct.

2.1 Increase in Publications

Several researchers have voiced their concerns about the increase in number of publications over the last decades. In a short communication, Peterse et al. (2017) indicated that when searching for literature about *in vitro* osteosarcoma cells, they saw the number of publications on osteosarcoma cells had almost increased exponentially from 1996 to 2015 (27). Additionally, bias to publishing positive results has been shown by Fanelli (2010), with an association between competitive academic environments and the amount of bias (28). Fronczak et al. (2007), who did a database search on the "publish or perish" phenomenon, found that scientific productivity, as measured by the number of papers authored, increased in the period from 1969 to 2004 (29). They also found large differences in the productivity of researchers, and a decrease in researchers who stay in science for a long time. In contrast, Fanelli et al. (2016) found no increase in individual productivity measured by number of publications, when taking the average number of co-authors into account, or by counting only the papers published as first author (30).

2.2 Authorship Issues

Researchers have also reported an increase in authors per paper. Van Wesel (2016) investigated the results of the strive for high impact publications by comparing papers published in the period 1960-1974 and 1990-2004 (31). Amongst others, a rise in number of authors contributing to a paper was found in this study. An increase in the number of authors per paper was also seen in a review by Pintér (2013), who analyzed authorship patterns in articles published in the Journal of Pediatric Surgery from 1981 to 2010 (32). In this study, the number of authors on original papers and case reports increased significantly. The percentage of papers with less than three authors decreased, whilst manuscripts with more than six authors increased. In addition, Olesen et al. (2018) found that authorship disputes were regularly witnessed in Malaysian universities (33). The interviewees in that study stated that the main contributor of such unethical authorship issues could be the culture of "publish or perish". Other authorship issues were also reported on. In telephone interviews, Decullier et al. (2020) found that ghost-authorship, defined as a person who contributed to a study significantly without being named as author, was well known in France, and that no improvement in ghost-authorship was seen compared to interviews they performed 17 years prior (34). In a review, Gasparyan et al. (2012) said: "*Authorship problems in scholarly journals shake the foundations of research, diminish scientific quality of papers, and devalue records of citation tracking services.*" (p.277) (35). In addition, concerns about the growing number of authors per

paper, and the listing of authors who are only marginally involved in the study were mentioned in a review by Mussurakis (1994) and a perspective by Angell (1986) (36,37).

2.3 Scientific Misconduct

Apart from the increase in publications and authorship issues, researchers have also expressed concerns about the quality and reliability of research that is published. This ranges from flaws in methodology to actual fraud. Several studies have evaluated the relationship between publication pressure and scientific misconduct. In this section, perceived scientific misconduct, and effects of scientific misconduct are discussed.

2.3.1 Perceived Scientific Misconduct

Olesen et al. (2020) conducted in-depth interviews amongst 22 researchers from Malaysian universities (38). In their research the pressure to perform, the research environment, and reward systems which are dependent on publication records were reported to result in unethical research and research misconduct. Similar results were found in a study using a research misconduct questionnaire amongst Iranian medical faculty members by Shamsoddin et al. (2021) (25). Eighty percent of their respondents suspected that publication pressure leads to (un)intentional data manipulation in some colleagues. In addition, almost 70% said their scientific output would be of higher quality without publication pressure, and 78% said that publication pressure causes serious doubts regarding the validity of research results on a global scale. In the same study, pressure for tenure (80%) and need for publication (71%) were noted most as factors that have a strong effect on conducting scientific misconduct. Li et al. (2021) compared Belgian and Chinese views on scientific misconduct (39). In line with the previous results, they found that Belgian researchers pointed to the "publish or perish" pressure and other extrinsic factors as causes for scientific misconduct. However, Chinese researchers believed the "bad apple" theory as the main cause. Examples of scientific misconduct also differed between Belgian and Chinese researchers. Belgian researchers mainly brought up fabrication and falsification, whereas Chinese researchers brought up plagiarism and inappropriate authorship. In addition, some studies found a relationship between the amount of publication pressure and perceived scientific misconduct. In their study about publication pressure amongst academic researchers in the Netherlands, Haven et al. (2021) studied the relationship between publication pressure and scientific misconduct (40). In this study, variance in perceived frequency and impact of research misbehavior was found to be influenced by research climate, publication pressure, and individual factors. This finding indicates that the likelihood of researchers perceiving research misbehavior is higher in a research environment with high publication pressure, than in an environment with low publication pressure. Similarly, Maggio et al. (2019) used a survey on publication pressure and questionable

research practices and found that publication pressure was related to self-reported irresponsible research behaviors in health professions education researchers (41). In addition, Tijdink et al. (2014) found that researchers in medical centers in Flanders, Belgium, not only experience publication pressure, but that experienced publication pressure was also strongly and significantly associated with scores on severity of scientific misconduct (23).

2.3.2 The Effects of Scientific Misconduct

Issues with scientific misconduct, quality, and reliability of published results are supported by retractions and problems with reproducibility. Lei et al. (2018) found that misconduct in the form of plagiarism, fraud, and faked peer-review, caused about three quarters of retractions in publications from Chinese researchers (42). In addition, they found that the retraction ratio (exact values of the retraction ratio were not mentioned) of Chinese researchers had increased significantly in the past two decades. Worries have also been expressed about the quality and reliability of published research in editorials and other commentary papers. In their review, Begley et al. (2015) named low reproducibility as a consequence of a competitive research system in which: "*Scientists are scrambling to get their share of a dwindling national research budget.*" (p.118) (43). Qiu (2010) reported in a news article that the market for dubious publishing activities in 2019 is estimated to be five times larger than in 2007 (44). Angell (1986) addressed publication pressure in their perspective, leading to trivial studies that yield rapid results, reporting a study more than once, and it being a motivation for fraud (36). Likewise, publication pressure, with the need to publish large amounts and achieve frequent citations, has been indicated as *"a perverse incentive"* for violation of academic integrity in a commentary by Bouter (2015) (45). Also, Gandevia (2018) noted hasty publications, poor-quality work, and irreproducible results in their editorial (46). They went on to say that statistical power in biomedical and clinical sciences, and the rate of translation of new findings to the clinic are low. Ware et al. (2015) too named questionable research practices and poor study reliability as a result of the "publish or perish" culture in their review (47). Lastly, Farlin et al. (2013) wrote a viewpoint stating that publication pressure could lead to publishing superficial and rushed analyses, and falsified results (48). Furthermore, they noted that this can undermine trust within the scientific community as well as society.

3. Causes of Publication Pressure

Within the literature, several causes for publication pressure were mentioned. In their study about publication pressure amongst researchers in the Netherlands, Haven et al. (2019) found that one of the causes of experienced publication pressure is a lack of resources (21). Amongst PhD students, this lack of resources was larger than in other academic ranks. In a world view article, Wu et al. (2019) wrote that amongst PhD students in the Max Planck Society, financial pressure and uncertainty about legal residency are associated with publication pressure (49). Qiu (2010) reported in a news article that cash prizes and housing benefits were based on high-profile publications in Chinese universities and thus contributed to publication pressure in China (44).

4. Solutions to Publication Pressure

Several solutions to lower publication pressure have been proposed in the literature. In a review Loadsman (2012) called for the entire industry to leave traditional values such as the value of publications and the anonymous peer-review process, and to settle on alternative models of funding to alleviate publication pressure (50). A change in evaluation for funding was already brought up in the 80's in a perspective by Angell (1986), who suggested to place a ceiling on the number of publications that are considered when a candidate is assessed for funding or promotion (36). According to Angell, this could lead to publications receiving more attention from both the researcher and from those evaluating the work, with the most important result being that quality would be valued over quantity in scientific research. In line with this, Farlin et al. (2013) advocated to rethink the publishing philosophy and to encourage thoroughness rather than speed in their viewpoint (48). They recommended awareness at all levels in order to break free of seeing publication pressure as a necessary stimulus. Diversity in criteria for evaluation, promotion, and career decisions, as well as in the composition of selection committees of both universities and funding organizations was recommended in a commentary by Bouter (2015) (45). A different solution was put forward in a world view by Wu et al. (2019), who suggested that PhD students should be supervised by independent supervisors in order to lower dependency on a single supervisor, and to provide clearer extension guidelines for PhD projects to decrease financial pressure (49). In contrast to most literature found, Chen et al. (2014) promoted publication pressure in their correspondence, they believed it to be a necessary motivator for doctors to be engaged in research (51).

Interviews

To better understand the results from the literature review and gather additional insights about the topic of publication pressure, interviews were held with a researcher/psychiatrist active in the field of publication pressure, a journal editor/researcher whose journal publishes about research ethics, and a senior strategic policy advisor at a university medical center who is also a researcher in the field of incentives and rewards for researchers. Results from these interviews were divided into two themes related to those of the literature review: consequences and causes of publication pressure, and solutions to (negative consequences of) publication pressure. Because questions asked during the interviews were dependent on the function of the interviewee, not all themes were discussed with all interviewees. Because two of the interviews were performed in Dutch, quotes were translated to English.

1. Consequences and Causes of Publication Pressure

The editor experienced consequences of publication pressure by seeing that authors expect their paper to be published as soon as possible and after the first round of review. In addition, they indicated scientific misconduct to be the biggest consequence of publication pressure. Consequences of publication pressure were not explicitly discussed with the other interviewees. The editor stated they believed that the main causes of publication pressure are that requirements for promotion and the way people are selected for positions, are not transparent. The researcher pointed out the same causes of publication pressure and also noted more internal causes. They stated that researchers put pressure onto themselves, and that: *"We as researchers are educated with organized skepticism [...], we look critically at publications but also at researchers themselves, that happens automatically."*. In addition, the researcher added that because there are limited places at high academic ranks, this leads to competition and this competition makes people compare themselves to others, contributing to feeling pressure to publish. About causes of publication pressure at higher academic ranks they mentioned that what might contribute is that everyone needs to feel acknowledged and in science, publications are the way to get acknowledged as a researcher. Causes of publication pressure were not explicitly discussed with the policy advisor.

2. Solutions to (Negative Consequences of) Publication Pressure

Solutions to publication pressure and its negative consequences were discussed with all interviewees. All interviewees noted that publications are needed in science, but that they should not be the only measure for quality of a researcher. In line with the causes of publication pressure mentioned by the researcher, they also posed that: *"There is not one*

solution.", and noted that valuing researchers differently and focusing less on publications could help. In addition, the researcher said that it would take a long time for change to happen and that universities must act. They also thought, for example, having a maximum of two publications per year would make science better. Additionally, the policy advisor pointed out that giving the amount of publications less value as a measure for quality would help and that this is a measure their university medical center is taking. They said that as a university medical center: *"We tried to lower publication pressure top down [...], but there is also a culture with measures of quality that are not stated anywhere by universities."*. The solutions mentioned by the editor differed from the other interviewees, they advocated for more social security, for example by more permanent positions in research. In addition, they stated: *"Misconduct is preventable and must be prevented at universities."*, and asked for internal checks, protocol reviews, and education on publication and research integrity, because it is difficult for a third party such as journals to perform quality controls on how experiments are performed. The main solution put forward by the editor was that more transparency about hiring requirements could alleviate publication pressure. In contrast, the policy advisor said that it is impossible to make promotion processes completely transparent.

2.1 Societal Impact of Research

With the policy advisor and the researcher, societal impact of research was discussed. The policy advisor stated that valuing science in a different way than with bibliometrics could increase societal impact, because achieving that aspect could get more attention and would be valued more over publication counting. They, however, also noted that their experience with this was mainly anecdotal and contradictive in practice. The researcher named other ways to increase the societal impact of research. They stated that there should be less researchers, or "*slow science*", because they believed that doing less research would make research better. In addition, they deemed that researchers have great ideas and good ideals, and that they think almost all researchers have good intentions, but that: *"Bad guidance causes research with low value that could have been better."*.

2.2 Valuing Researchers

The topic of valuing researchers was discussed with the policy advisor and the researcher. The policy advisor proposed that researchers should be valued based on a qualification portfolio with a broad description of someone's qualities and activities you can value. In line with this, the researcher stated: *"You are not your h-index [...], things like working together and leadership are also important [...], if you only look at publications you only get one type of researcher and not a team with the different types of people you need."*. Both interviewees felt that there is some resistance about changing the way researchers are valued. The researcher discussed that the older generation of researchers got into top positions using metrics, so they often say we should keep using metrics whereas

the younger generation thinks they will not get to the top because the competition is too big. In addition, the policy advisor noticed that changes in valuing researchers causes uncertainty amongst younger researchers. The policy advisor also noted that: *"To some professors it can seem like the bar is lowered when not looking at publications anymore for promotion."*. The policy advisor and researcher both said that the way researchers are valued is changing. The policy advisor stated: *"There are a lot of initiatives to change the way we value research [...], that the transition continues is clear."*. The researcher noted that: "*There are many other criteria that are now used to value researchers, but publications still predominate.*". They said there had been a change in acknowledging publication pressure during their years of doing research on the topic: "*People now take it seriously and talk about it, now there is a lot more attention [...], so there is momentum, but it takes a long time because science is conservative.*".

DISCUSSION

Within this scoping review and interview study, we aimed to investigate what was written about publication pressure in biomedical literature and what additional insights experts could provide. All reviewed articles except for one discussed different aspects of the negative effects of publication pressure. In summary, the results showed that publication pressure is perceived as high from students to full professors. Consequences noted in literature related to an increase in publications, number of authors per paper, and scientific misconduct. Causes and solutions mentioned were mainly related to the availability of resources and models for funding and promotion. These findings were supported by the interviews performed. The interviews furthermore pointed towards more internal causes of publication pressure, such as researchers being self-critical and publications as a means of feeling acknowledged. What became clear from the interviews is that publication pressure is complex and that there is not just one solution to it. In addition, the interviews pointed to the topic of societal impact and the need to value researchers in a different way other than using bibliometrics. An overview of the results from the literature and interviews combined, plus connections between them that could alleviate the negative consequences of publication pressure can be found in Figure 2.

In our review, we found similar results to those of Guraya et al. from 2016 (15). Interestingly, apart from including literature published after 2016, only two of the articles we included in our review were also included in theirs. Some causes of publication pressure they found, such as perks from pharmaceutical companies, did not come forward in the literature that was included in the current review. This difference can likely be explained by differences in search terms used. For example,

Guraya et al. used search terms such as "research ethics" and "article retraction", which could be seen as broader than the search terms we used for this review. In addition, we found that an increase in publications, number of authors per paper, and authorship issues are consequences of publication pressure, whereas Guraya et al. did not mention these topics or experiences with publication pressure as such. The interviews also pointed towards the existence of more internal causes of publication pressure and to effects of publication pressure on the societal impact of research. These findings align with the Wellcome Trust's 2020 report on what researchers think about the culture they work in, specifically the negative effects of publication pressure on researchers, research, and society (16). It also aligns with the SiT initiative, which advocates for valuing researchers beyond bibliometrics, emphasizing the attribution of greater value to societally relevant research (17).

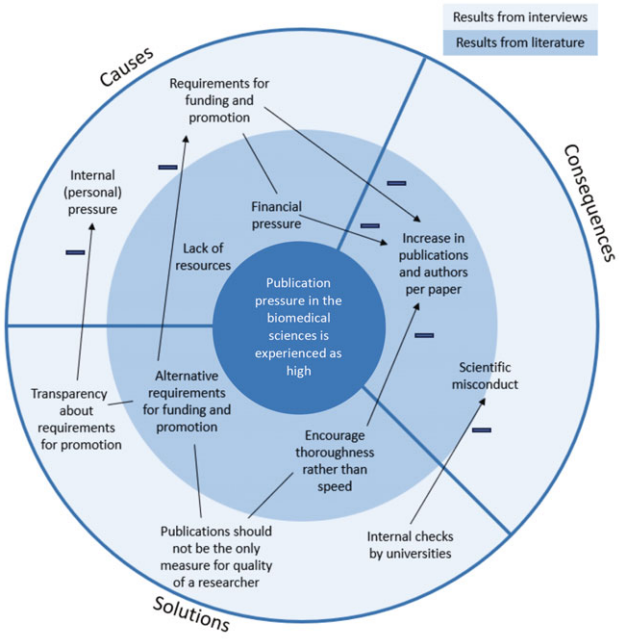

Figure 2. An overview of the main topics of the results from the literature review and interviews regarding the experiences, causes, consequences, and solutions regarding publication pressure. Connecting lines show relationships between topics and arrows point to potential solutions or alleviating factors.

Generalizability of the results from our literature review could prove difficult because they are heterogenous in type and methodology. As also noticed during the interviews, even the term "publication pressure" is difficult to define because the perception of it is inherently personal. Therefore, this term could have dissimilar meanings within

literature. In addition, ways of measuring publication pressure differed amongst the included articles. Agreement on and clarification of the term "publication pressure" and ways to measure it could help increase comparability of results amongst studies. Furthermore, looking more closely at other factors such as culture, personality traits, and access to resources, which can also influence publication pressure and its consequences, could increase the validity and translatability of the research performed (29,52).

Interestingly, little information was found in the literature on the impact of publication pressure on the tasks and goals of researchers in the context of societal impact, which was mentioned in the interviews. This could be due to the justifiably narrow search terms used for this review. Although a large proportion of researchers were said to experience publication pressure in the literature, which might indicate awareness on the subject, no articles actually studied this awareness. Furthermore, although some articles mentioned causes of and solutions to publication pressure, we did not find qualitative or quantitative research investigating the views of researchers on this. Lastly, what stood out to us is that worries about the effects of scientific misconduct were mentioned in several editorials and other commentary papers, but we did not find information about these effects in original research articles. Because of the implications mentioned in non-research articles, this would be an interesting topic for future research.

There are several other topics that could be linked to publication pressure but were not explicitly mentioned in the included literature of this review or the interviews. An example are predatory publishing entities such as journals without or inadequate peer-review or misleading metrics, which are also a negative consequence of publication pressure (8,53). Another topic that was not addressed but deserves attention within unethical publishing activities is "salami slicing", also known as "publishing the least publishable amount", where researchers publish as little as possible per paper to publish as many papers as possible. This phenomenon is not new and was already mentioned by J. Broad in 1981 (5). It has been suggested to be related to the pressure to publish (54,55). Another interesting observation, when looking at the included article list for the literature review in Appendix I, is that only two articles were published before 2010. This finding may correlate with the digital revolution of the 2000s and the global economic crash of 2008, leading to an increased prevalence of publication pressure (11,12). Future research could help understand this phenomenon.

What stood out to us is that little information was found in PubMed about initiatives to value research and researchers differently, whereas the current way of valuing researchers was seen as a major cause of publication pressure. Apparently, the concept

of publication pressure is not explicitly addressed in papers on these issues, or the papers on these issues are not indexed in PubMed. Still, we know that there are several initiatives that are actively working on this. For example, project TARA, which is working towards creating resources and practical guidance on reform of research assessments as part of the larger DORA initiative, which aims to improve how the output of scientific research is evaluated by academic institutions and funding agencies globally.[6] These initiatives could help to reduce experienced publication pressure and thereby the negative consequences thereof. We believe that awareness of these initiatives could help speed towards a change in the current publication culture.

As with any scoping review and interview study, this study has its limitations. Firstly, only two search terms were chosen for the literature search, so articles on this topic could have been missed. Secondly, the literature included is very heterogenous, also in scientific underpinning. Thirdly, it could be questioned if PubMed is the correct source of literature on this topic. The choice for PubMed was made with the goal to investigate what is published about publication pressure in biomedical literature. However, research on publication pressure might likely be published in sociological journals. Searches with the same terms and with the same date as the data gathering for this review in two other search engines, Science Direct and Google Scholar, lead to substantially more hits, 3.086 and >25.000 respectively. However, most of these hits were not focused on publication pressure in biomedical sciences, but on publication pressure in general. Similarly, other search terms used in PubMed generated a large proportion of hits that were not related to the topic of publication pressure based on titles. Therefore, we believe that the search terms we chose in PubMed are a good starting point to delve into the experiences of biomedical scientists specifically with regard to publication pressure.

Despite the limitations, we believe that this scoping review and interview study provides an informative and insightful overview of experiences regarding publication pressure in the biomedical sciences domain. Within this review, we bring together experiences with, consequences of, causes of, and solutions to publication pressure. Most articles on this topic found in PubMed only focused on one or two of these themes, as can be seen in Appendix I. The findings from the literature are further supported and put into context by the views of a researcher, editor, and policy advisor who are all actively involved in this topic. We only interviewed one person per perspective and thus views of other researchers, editors, and policy advisors could be different. However, we believe the interviews are a valuable addition to the literature review.

6 https://sfdora.org/project-tara

A finding that stands out from the interviews compared to the literature review is the mentioning of internal factors such as researchers being self-critical people and "*organized skepticism*" as causes of publication pressure, reported by the researcher. Most solutions mentioned in both the interviews and the literature, however, do not directly address these internal factors. Interestingly, both the researcher and editor mentioned a lack of transparency in promotion procedures as causes of publication pressure, and both the researcher and policy advisor mentioned valuing researchers using broader qualities and focusing less on bibliometrics as solutions to publication pressure. This seems contradictory because quantitative measurements such as bibliometrics seem more transparent than qualitative measures such as leadership qualities and collaboration skills but could help alleviate stress and burnout from publication pressure.

In conclusion, negative consequences of publication pressure are complex challenges researchers face, which is shown by all the publications on this topic except one in PubMed and by the interviews discussed in this article. More research on awareness and the impact of publication pressure on the tasks and goals of biomedical scientists in the context of societal impact is needed. This would contribute to the greater debate on publication pressure and to changing the way research and researchers are valued.

CONCLUSIONS

Based on this scoping review and the interviews performed. We would like to end with two specific and applicable recommendations which we believe could contribute to alleviating publication pressure and some of the negative consequences thereof. First, we believe that the topic of publication pressure should be recognized and considered at all levels from students to full professors. For example, by it being part of curricula and by it being on the agenda in academic meetings. Second, we are of the opinion that the criteria and processes for hiring, promotion, and funding, should be as transparent as possible, and include qualitative measures aside from bibliometrics. Initiatives such as Science in Transition and project TARA are good examples. Doing this, could increase awareness and relieve some of both internal and external causes of publication pressure and negative consequences thereof.

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APPENDIX I

Overview of reviewed articles in order of appearance. 31 articles included (17 original research vs. 14 other types), article type as categorized by the publisher. N/A = not applicable.

	Article	Year of Publication	Article Type	Participants	Results Section(s)
1	Haven et al. (21)	2019	Original Research	Researchers at two universities and two academic medical centers in the Netherlands	1. Experienced Publication Pressure 3. Causes of Publication Pressure
2	Tijdink et al. (22)	2013	Original Research	Medical professors at academic medical centers in the Netherlands	1. Experienced Publication Pressure
3	Tijdink et al. (23)	2014	Original Research	Medical researchers at academic medical centers in Belgium	1. Experienced Publication Pressure 2. Consequences of Publication Pressure
4	Pang et al. (24)	2020	Original Research	Senior medical students from medical schools in the United Kingdom	1. Experienced Publication Pressure
5	Shamsoddin et al. (25)	2021	Original Research	Medical faculty members in Iran	1. Experienced Publication Pressure 2. Consequences of Publication Pressure
6	Naidoo-Chetty et al. (26)	2021	Original Research	Academic staff of a public university in South Africa	1. Experienced Publication Pressure
7	Peterse et al. (27)	2017	Short Communication	N/A	2. Consequences of Publication Pressure
8	Fanelli (28)	2010	Original Research	N/A	2. Consequences of Publication Pressure
9	Fronczak et al. (29)	2007	Original Research	N/A	2. Consequences of Publication Pressure
10	Fanelli et al. (30)	2016	Original Research	N/A	2. Consequences of Publication Pressure
11	Van Wesel (31)	2016	Original Research	N/A	2. Consequences of Publication Pressure
12	Pintér (32)	2013	Review	N/A	2. Consequences of Publication Pressure
13	Olesen et al. (33)	2018	Original Research	Academic researchers at universities in Malaysia	2. Consequences of Publication Pressure
14	Decullier et al. (34)	2020	Original Research	Medical practitioners from a hospital in France	2. Consequences of Publication Pressure
15	Gasparyan et al. (35)	2012	Review	N/A	2. Consequences of Publication Pressure

	Article	Year of Publication	Article Type	Participants	Results Section(s)
16	Mussurakis (36)	1994	Review	N/A	2. Consequences of Publication Pressure
17	Angell (37)	1986	Perspective	N/A	2. Consequences of Publication Pressure 4. Solutions to Publication Pressure
18	Olesen et al. (38)	2022	Original Research	Researchers working in public and private Malaysian universities	2. Consequences of Publication Pressure
19	Li et al. (39)	2021	Original Research	Researchers from China and Belgium	2. Consequences of Publication Pressure
20	Haven et al. (40)	2021	Original Research	Researchers at two universities and two academic medical centers in the Netherlands	2. Consequences of Publication Pressure
21	Maggio et al. (41)	2019	Original Research	Researchers in health professions education	2. Consequences of Publication Pressure
22	Lei et al. (42)	2018	Original Research	N/A	2. Consequences of Publication Pressure
23	Begley et al. (43)	2015	Review	N/A	2. Consequences of Publication Pressure
24	Qiu (44)	2010	News Article	N/A	2. Consequences of Publication Pressure 3. Causes of Publication Pressure
25	Bouter (45)	2015	Commentary	N/A	2. Consequences of Publication Pressure 4. Solutions to Publication Pressure
26	Gandevia (46)	2018	Editorial	N/A	2. Consequences of Publication Pressure
27	Ware et al. (47)	2015	Review	N/A	2. Consequences of Publication Pressure
28	Farlin et al. (48)	2013	Viewpoint	N/A	2. Consequences of Publication Pressure 4. Solutions
29	Wu et al. (49)	2019	World View	N/A	3. Causes of Publication Pressure 4. Solutions to Publication Pressure
30	Loadsman (50)	2012	Review	N/A	4. Solutions to Publication Pressure
31	Chen et al. (51)	2014	Correspondence	N/A	4. Solutions to Publication Pressure

APPENDIX II

Semi-structured interview guide per expert perspective.

Interview Guide: Researcher

1. Why do you do research about publication pressure? Why did you start with it?
2. What is most noteworthy to you?
3. Do you think publication pressure affects science?
4. Is publication pressure something of the last few years?
5. How are the tasks and goals of researchers impacted by publication pressure in the context of having societal impact?
6. Do you think publication pressure affects science?
7. Do you think publication pressure is a problem from the perspective of a psychiatrist?
8. What do you think publication pressure is caused by?
9. Do you think researchers are aware of the effects of publication pressure?
10. What should change? How should we value research and researchers?

Interview Guide: Editor

1. Why did you become an editor of your journal? What interests you about the topic?
2. Is the topic of publication pressure prevalent in your field?
3. What do you think about the discrepancy between the value that is given to publications in some top journals and other publications?
4. Did you notice differences in publication pressure amongst different countries you worked in?
5. Do you think publication pressure has an effect on publication bias for positive results? Do you see this in your journal?
6. Do you think publication pressure affects the quality of research?
7. In literature, results pointed towards research drifting away from socially relevant topics. Have you noticed a change in article topics?
8. Consequences of publication pressure found in literature were amongst others an increase of publications, number of authors per paper, and scientific misconduct. Do you see that in the journal you edit for?
9. Do you think researchers are aware of authorship criteria/unethical authorship?
10. Can journals play a role in for example combatting scientific misconduct? If yes, what? If no, who should?
11. Metrics play an important role in the advancement of careers and funding opportunities, which might contribute to publication pressure. Do you think journals have a role in this?

Interview Guide: Policy Advisor

1. What do you see as the biggest cause of publication pressure?
2. What do you see as the biggest consequence of publication pressure?
3. How does publication pressure influence the quality of research?
4. How should we value the quality of research?
5. Is there resistance to changes in how to value science differently?
6. What do you think makes publication pressure complex?
7. How could we lessen publication pressure and its negative effects?
8. At what level do you think things should change in order to lessen publication pressure and its negative effects?
9. How can we increase the value science has for society?
10. If you could change the scientific reward system unhindered, what would you change?

CHAPTER 2.2

Opinion – Publications Are Not the Finish Line: Focusing on Societal Rather Than Publication Impact

Publication Status

An adapted version of this opinion is published as "Kools FRW, Mirali S, Holst-Bernal S, Nijhof SL, Cavalli G, and Grandner MA. Publications Are Not the Finish Line: Focusing on Societal Rather Than Publication Impact. Front Med. 2018;5:314. doi: 10.3389/fmed.2018.00314.".

Author Contributions

FK, SM, and SH-B conducted the literature research and authored the manuscript. SN and GC advised and guided the writing process. MG revised and edited the final manuscript. All authors contributed to the manuscript and approved the submitted version.

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INTRODUCTION

Have bibliographical quantification of publications and the subsequent accompanying rewards perverted the incentives of scientists? Are we lost in a "publish or perish" research culture? Alarmingly, ample (bio)medical research findings intended to improve patient outcomes and lead to innovations in patient care never leave the lab (1–3). This widening gap between discovery and implementation undermines the social responsibility of scientists and erodes their public stature. When research findings have the potential to improve the health and well-being of society but are not translated into real-world benefits, it represents a failure of the system and a failure to society.

A re-evaluation of the parameters that define scientific success is imperative. Climbing the academic ladder and securing financial support relies heavily on a scientist's productivity, which is typically defined by the number of publications and their bibliometric scores (4,5). Several groups are working towards developing novel measures for impact, but so far traditional bibliometric evaluation criteria prevail (6,7). Whilst understandable that a quantitative system of evaluation might fulfill a desire for objectivity, this creates an intrinsically competitive culture in which regularly publishing ever-novel work is key to individual career success and open collaboration is undermined.

When novel discoveries are incentivized over refinement and implementation, it becomes strategically disadvantageous to do the work needed to translate discoveries into working strategies that benefit patients, the ultimate goal of translational medicine (1–3). Proper recognition and rewards for aiding efforts to achieve this goal must be advocated for, guided by the principles of social accountability and fostered by the support of key stakeholders (8).

JOURNALS AS GATEKEEPERS

One way in which the scientific community is not serving society well is reflected in the current publishing environment. The pressure to publish quantity over quality in order to build a successful scientific career has cultivated a rapidly expanding ecosystem of thousands of journals publishing millions of papers per year (9). Many of these papers are seldom read or cited, and many contain non-reproducible or even fraudulent data (10,11). Simultaneously, and partially because of the proliferating abundance of journals, there is increased pressure to publish in so-called "high impact" journals, which have achieved recognition in the (bio)medical field as being highly desirable to publish in (12–16). Through their selection of what to publish and what not, these journals often become gatekeepers that define what is seen as "good" science by not only the research community, but also the general public.

In an effort to impress the editors of these aggrandized journals, scientists increasingly focus on "cutting-edge" questions, rather than validating previous results or pushing them towards further development. Thus, there is a paradoxical problem of too many publications in too many journals, but also too much pressure to publish in too few journals. This creates a conflict where potential scientific advances are lost in the increasingly distracting background noise.

Similar to the role of the free press, scientific journals have a responsibility to the public: to objectively communicate advancements in scientific research and to foster productive exchange of ideas and information. How can journals fulfill this great responsibility? First, by realizing the impact their selection bias has and how strongly it shapes the global scientific research culture. Translational research cannot be accomplished by one individual at a time, it relies heavily on interdisciplinary collaboration and studies at all stages of the research pipeline deserve to be appreciated and rewarded. Second, by helping to shift the focus away from individual achievements and vacuous publication or citation counting, but conversely onto a common goal of achieving real societal impact through collaboration. Encouraging open-access platforms that provide full data sets helps ensure the full use of generated data, reducing scientific waste (17,18). Web platforms could also implement new evaluation systems, rating scientists on their interdisciplinarity and collaborations. Finally, by revising the peer-review system. Despite holding a very important role in the publishing process, the current system offers little incentive for quality reviewing (19). Unmasking peer-review, and rewarding the intellectual contribution and time dedicated by reviewers may promote a fairer process that is in line with the mission of the work. Adding an assessment of the potential for knowledge utilization and societal impact to be published alongside the article would also promote a healthier science culture.

If journals are gatekeepers through which all (bio)medical research must pass, it is time to redefine their role and influence. Translational medicine involves much work beyond initial discovery. The long and tedious but vitally important process of seeing research findings through to clinical practice is one of the field's most overwhelmingly difficult yet largely under-appreciated burdens (20,21).

THE ROLE OF INDUSTRY, COMMUNITY, AND OTHER STAKEHOLDERS

In the case of (bio)medicine, there is a long and risky path from discovery to real-world clinical implementation (22). One research group cannot do all of this alone, especially since the later stages require partnership among many stakeholders (23,24).

If the goal of translational medicine is to implement research that has a meaningful societal impact, academia must collaborate more closely with all stakeholders involved, including industry, patients, and community leaders (6).

A current obstacle to translation is that partnerships among stakeholders are difficult to establish and maintain (25). Specifically, better partnerships between academia and industry would be instrumental to more time- and cost-efficient implementation of research findings (26). Although setting up shared platforms may demand sizeable initial investments, timely and continuing validation of research findings according to companies' pre-approved standards can save time and expenses at later stages of the translation process. More importantly, this facilitates a more efficient pipeline from discovery to societal benefit.

On a more individual scale, Technical Transfer Offices (TTOs) and similar programs housed within academic institutions can also help bridge the gap between academia and industry (27), yet this can be difficult if they are not involved early in the research process and do not remain engaged throughout. Therefore, academic institutions must create awareness amongst scientists and TTOs about their respective value. Specific programs, such as scouting systems to identify potentially impactful research findings, educational initiatives that promote the latest developments, and including TTOs as part of trans-institutional partnerships, might more efficiently establish a pipeline for ideas and networks including international collaborations. Funders could facilitate this by assessing knowledge utilization and societal impact by a third party, e.g., TTO or patient organization, mandatory in annual reports. Sponsored networking events and training programs may also help overcome barriers and facilitate knowledge exchange between these key stakeholders. Developing a more collegial relationship based on shared goals can add momentum to this cooperative process and strengthen the scientific infrastructure as a whole.

Better engagement with other stakeholder groups will facilitate other aspects of the translational enterprise. Patient groups are an increasingly integral part of the scientific process, driving scientific questions (28–30). The voice of the patient in translational research is extremely important and must play a crucial role in the whole process (28). In a similar way, translational medicine has eschewed approaches such as community-based participatory research (CBPR) or community-engaged research (CER) (31,32). These types of studies, which include community members in the generation of research questions and implementation of research studies, are a valuable approach toward improving the quality and value of the science itself. Involving the community may lead to the identification of underrecognized or underappreciated problems faced

by the community, which in turn drives innovation. It may also serve to give a voice to underrepresented and disadvantaged groups that typically fall off the radar. These approaches not only improve scientific validity, innovation, and feasibility, but by including the community as a partner in the work, they kindle a bidirectional dialogue between scientists and society, which is ever more needed.

SCIENTIFIC COMMUNICATION

Science in general is facing a growing problem of insufficient resources and eroding public appreciation (33–35). One reason for this is that the public, and funding bodies that often represent the public, are increasingly skeptical about the return on their investment (33,36). A bench-to-bedside approach to research can help bridge gaps among basic discovery, clinical investigation, implementation, and application in society (37,38). Effective communication with the public is an important part of this process.

As patients are increasingly confronted by misinformation and charlatanism, the public expresses a desire for clear-cut answers to what they perceive are clear-cut questions. But scientists notoriously provide overly nuanced and seemingly obfuscated conclusions. This creates a situation where media reporting of science tends toward overextrapolation and oversimplification which, in turn, leads to scientists being unenthusiastic about engagement with the media or public and the public's distrust of science growing as inaccuracies and exaggerations are borne out, e.g., "miracle cures" that are not miracles. It is essential that scientists take on their role in guiding the scientific discourse. This is especially true in the field of translational medicine, where discoveries have the potential to directly impact lives.

Communicating science in a way that maintains accuracy, context, and nuance, is accessible to a nonscientific audience, and is as brief as a short news article is difficult, even for seasoned journalists. Additionally, journalists who are expected to cover a wide variety of topics often do not have the expertise or time to assess an individual study's relevance or integrity. It is up to the academics, who have a responsibility to maintain scientific integrity, to accurately interact with the press and advocate for appropriate representation of their work. If academics neglect this role, it will be filled by others who may not hold themselves to the same standards. Yet, scientists are often actively discouraged by peers from collaborating with the media. It is often seen as a distraction or, worse, as unprofessional. Currently though, the ability of scientists to engage the public is greater than it has ever been. More and more news outlets are seeking content, more people than ever are seeking information, and more direct lines of communication are available than there have ever been, e.g., social media.

Issues regarding scientific communication require initiatives at several levels. Academic institutions should better teach scientists how to communicate with the public, ensure that any press releases fairly represent their work, and also powerfully convey relevance to a lay audience. News organizations should collaborate more closely with academia to ensure that reported findings are not overly sensationalized. The public should be encouraged to engage with research with the understanding that while science is rigid in some ways, it reflects a constantly evolving process and an everchanging knowledge base. Improving scientific communication is a critical step in informing everyone, including patients and caregivers, on the relevance and merits of translational medicine. The importance of scientific literacy in communicating the societal impact of research is often and wrongfully neglected.

CONCLUSIONS

Society expects translational scientists to address relevant matters that aim to improve human health and well-being. Indeed, successful translational research has resulted in the clinical application of promising therapies such as CAR-T cell immunotherapy in leukemia and novel HIV antivirals (39,40). However, the gap between society and academics is widening. Scientists find themselves enthralled in a vicious exercise: publish, secure funding, repeat. The public and other stakeholders are largely absent from this process. Scientists have become so accustomed to this unhealthy system, that they equate "success" with mere survival in the current "publish or perish" culture. Additionally, the perception of science by society and vice versa is dangerously perturbed.

Breaking free from the current failing system will require disrupting this vicious cycle and realigning (bio)medical research with its original mission (Figure 1). This requires reconsideration of the publication system and strategies for including important stakeholders throughout the process. Society must be better informed about the importance of research and play a larger role in its advancement. To accomplish this, scientists and other stakeholders need to take more responsibility in facilitating discussion in a way that effectively communicates and serves the public, while maintaining scientific integrity. Translational scientists should also remember the societal context of their work, recognizing their social accountability and the need for proper two-way dialogue with the public, driving innovation in both directions.

In conclusion, publication should not be the finish line scientists strive to, it should be a steppingstone towards a greater good.

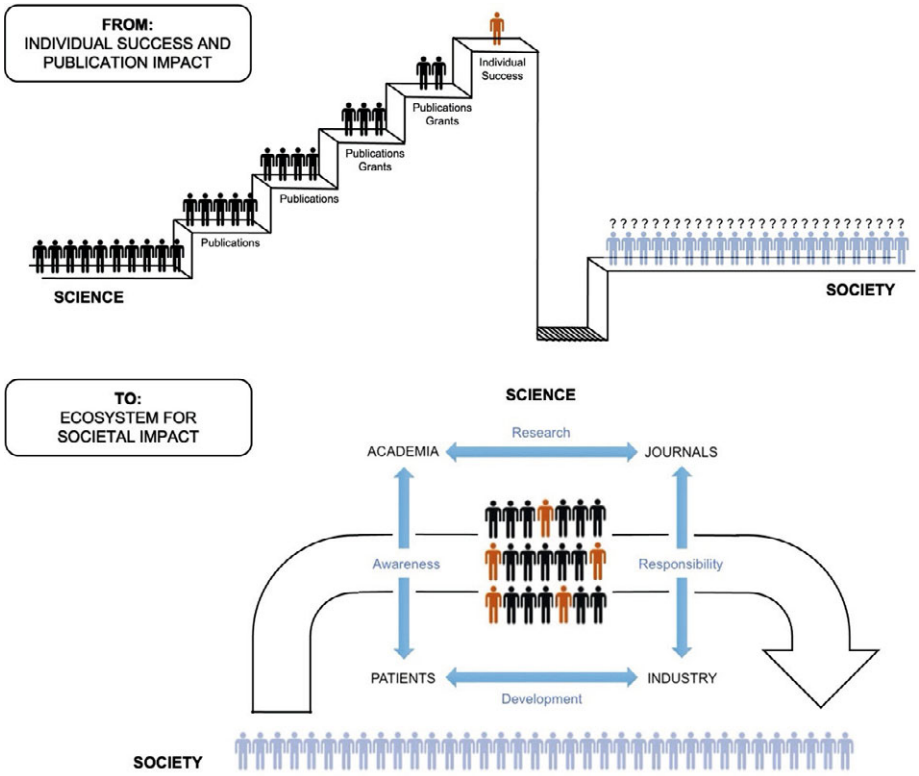

Figure 1. From individual career success and publication impact to a collaborative multidirectional ecosystem for societal impact.

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CHAPTER 3.1

One Size Does Not Fit All: An Exploratory Interview Study on How Translational Scientists Navigate the Current Academic Reward System

Publication Status

An adapted version of this study is published as "Kools FRW, Fox CM, Prakken BJ, and van Rijen HVM. One Size Does Not Fit All: An Exploratory Interview Study on How Translational Researchers Navigate the Current Academic Reward System. Front Med. 2023;10:1109297. doi: 10.3389/fmed.2023.1109297.".[1]

Author Contributions

FK conducted the interviews, performed the analyses, and authored the manuscript with CF as second reviewer, substantive editor, and proofreader. BP recruited the study participants and together with HR reviewed the final manuscript. All authors contributed to the manuscript and approved the submitted version.

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1 After publication the authors decided to change "translational researchers" to "translational scientists". This was done for uniformity throughout the dissertation as these terms are used interchangeably in literature and in practice.

ABSTRACT

Introduction: Translational research is a subfield of the biomedical life sciences that focuses on clinically driven healthcare innovations. The workforce of this field, i.e., translational scientists, are diversely specialized and collaborate with a multitude of stakeholders from diverse disciplines in and outside academia in order to navigate the complex path of translating unmet clinical needs into research questions and ultimately into advancements for patient care. Translational scientists have varying responsibilities in the clinical, educational, and research domains requiring them to split their time two- or three-ways. Working between these domains and alongside peers who do not split their time as such, raises questions about the academic reward system used to recognize their performance, which mainly focuses on publication metrics within the research domain. What is unclear is how combining research tasks with tasks in the clinical and/or educational domains effects translational scientists and how they navigate the academic reward system.

Methods: In this exploratory interview study, semi-structured interviews were conducted to gain a deeper understanding of the current academic reward system for translational scientists. Stratified purposeful sampling was used to recruit fourteen translational scientists from varying countries, subspecialties, and career stages. The interviews were coded after data collection was complete and arranged into three overarching result categories: intrinsic motivation, extrinsic factors, and ideal academic reward system and advice.

Results: We found that these fourteen translational scientists were intrinsically motivated to achieve their translational goals while working in settings where clinical work was reported to take priority over teaching which in turn took priority over time for research. However, it is the latter that was explained to be essential in the academic reward system which currently measures scientific impact largely based on publications metrics.

Conclusions: In this study, translational scientists were asked about their thoughts regarding the current academic reward system. Participants shared possible structural improvements and ideas for specialized support on an individual, institutional, and also international level. Their recommendations focused on acknowledging all aspects of their work and led to the conclusion that traditional quantitative academic reward metrics do not fully align with their translational goals.

INTRODUCTION

Research-driven healthcare innovations improve patient care across the entire patient journey, from diagnosis to treatment and from prevention to quality of life (1). These innovations come about through the work of committed professionals in the life sciences field. Translational research is a subfield of the biomedical life sciences that turns observations of unmet patient needs into interventions that improve the health of individuals and the public.[2] The term translational is used to describe the iterative process of translating clinical problems from patients into research questions that are then translated again into viable solutions that ultimately impact patients' lives (1). All research along these lines is part of the translational pipeline, this involves basic research, preclinical research, clinical research, clinical implementation, public health, and patient involvement (Figure 1).[3]

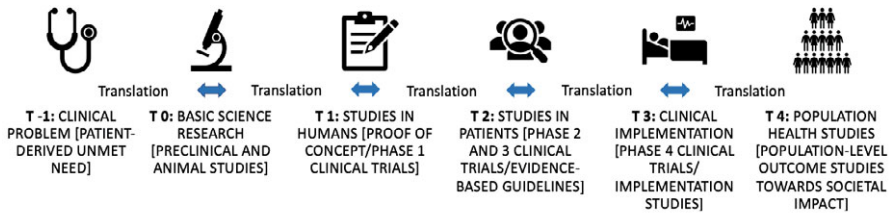

Figure 1. The translational research pipeline.

Translational scientists constitute the workforce of translational research. They combine varying levels of responsibilities in the clinical and/or research domains while often also being involved in education. Translational research is highly multidisciplinary with opportunities for specialization into clinical medicine, molecular research, pharmaceutical science, epidemiology, community health, population, and policy science (2). Creating solutions that impact patients requires adequate knowledge, robust methodology, and long-term collaboration across multiple disciplines, involving stakeholders from both academia and outside, who work together to navigate the complex path towards successful translation (2). However, translational scientists must balance multiple roles simultaneously, including coping with unaligned priorities within the clinical and research domains, educational roles, and financial burdens (3). This balancing act is not always maintainable, and some translational scientists struggle to manage their often splintered affiliations (3).

2 https://ncats.nih.gov/about/about-translational-science/spectrum

3 The information in this figure is based on Fernandez-Moure (2016).

Most of the literature on translational research focusses on a subset of translational scientists: physician-scientists. These are translational scientists that often hold an MD as well as a PhD degree and predominantly work in academic settings. Physician-scientists bring a valuable perspective to translational research because they are in direct contact with patients and thus form a link that steers research in the direction of patient relevant outcomes (4). However, according to Hurst et al. (2019) the amount of physicians attributing a sizeable portion of their time to research has decreased in the last 40 years (4). In fact, the term "endangered species" has been used since 1979 to describe what was then called "clinical investigator" but is now known as a translational scientist (5). According to Brown et al. (2018) the global downward trend in the number of physician-scientists is caused by structural faults within the career progression of translational scientists (6).

Translational scientists have varying responsibilities in the clinical and educational domains. However, their success is mostly judged based on their scientific publication achievements which drives funding and helps further researchers' careers but does not directly help patients (7). This divergency emerged in the 1970s when rapid technical advancement of molecular biology began to separate clinics from science and sprouted the hypercompetitive scientific environment of biomedical sciences (8). Butler (2008) stated that this system holds little incentive to promote translational research as choosing to spend time on the clinical implementation phase of the translational pipeline takes away from doing what the system rewards, namely producing publications (8). Fernandez-Moure (2016) went on to link the limited amount of time available for this clinical implementation to employers' priorities and demands for funding and publication output. They explained that a lack of financial support limits research time for clinicians and that funding demands limit time to implement research findings for researchers (1). This cycle of funding and publication output is even more pronounced for translational scientists because they must balance their multiple domains, therefore, the emphasis on publications creates structural faults within their work settings. This has the potential to drive out translational scientists because they are unable to maintain status quo.

To increase the number of physician-scientists, Brown et al. (2018) described multiple initiatives that have been created to help reverse the declining numbers, such as moving away from publication pressure and publication counting (6). Recent discussions in the scientific community about alternative ways of rewarding researchers have addressed the direct link between the number of publications, citations, journal impact factor, and a researcher's h-index to measure success (9–16). While these initiatives focus on improving some of the imbalance within the career progression of translational

scientists, no overall viable solution has been established. The discussions in this area are largely in the form of perspectives, commentaries, and editorials. In a perspective by Moher et al. (2018) recommendations from an expert panel reported the misalignment of faculty incentives and rewards with the needs of society (9). The focus of their discussion centered around the reproducibility crisis and suboptimal quality of the publication system. The use of journal impact factor in academic review, promotion, and tenure evaluations was also addressed in a study by McKiernan et al. (2019), which raised concerns about its misuse in evaluating the quality and significance of research (10). Moustafa (2015), in their commentary, went as far as calling the misuse of the journal impact factor a disaster (11). In 2016, Nature published two items that focused on impact factor as an unfit measurement for clinical impact that encourages quantity over quality and perverts research priorities away from unmet patient needs (12,13). In their perspective, Casadevall & Fang (2014) named the persistent misuse of the impact factor an epidemic mania that afflicts all researchers (14). In an editorial a year later, they wrote that science has always been competitive, however, adverse effects on creativity, resource sharing, and research integrity are now apparent (15). While its creator Eugene Garfield had intended to create an algorithm to ostensibly measure the importance of scientific research, he recognized early on that: "*Like nuclear energy, the impact factor was a mixed blessing.*" and that: "*[...] in the wrong hands it might be abused.*" (16).

Consequences of the culture surrounding the push for publications have also been discussed. In their study Tijdink et al. (2016) found that the current research system focused on publication led to counterproductive stress, negative sentiments, and questionable research practices (17). Adding to this, Alberts et al. (2014) explained in their perspective that researchers now find themselves in an: "*[...] unsustainable hyper-competitive environment that is discouraging for prospective researchers.*" (18). In their study Quan et al. (2017) described great monetary advantages for authors who publish in high impact journals replacing the goal of publishing to disseminate knowledge with personal gain, coining the term "publish or impoverish" (19). Trends in publication behavior were also addressed in an editorial by Tshomba & Cavalli (2017) and study by Wesel (2016) exposing the strive for publications in high-impact journals and the use of citation metrics in an evaluative way (20,21).

All of these studies and discussions highlight the need for a deeper understanding of the academic reward system, especially in regard to translational scientists, who find themselves juggling responsibilities outside of the research domain but are still held accountable by its reward system. To understand how this publication-focused reward system influences the work of translational scientists, we designed this exploratory interview study consisting of semi-structured interviews with translational scientists

from different countries, subspecialties, and at different career stages to help us answer the research question: "*How do translational scientists perceive the current academic reward system?*". In order to answer this question, we investigated the current academic reward system and institutional structures that are in place to reward translational scientists. The aim of this study was to understand what motivates translational scientists to continue their work in an environment that is not conducive to all aspects of their work, in addition to highlighting actionable points of improvement regarding the current academic reward system. Ultimately, we hope this research will contribute to the continued advancement of translational research by understanding the best way for rewarding all aspects of its main workforce.

METHODS

Study Context

In 2017, a European strategic partnership consisting of the University Medical Center Utrecht, Nutricia Research BV, Ghent University, University College London, and University of Granada procured a three-year Erasmus+ KA203 (Strategic Partnerships for Higher Education) grant within the KA2 (Cooperation for Innovation and the Exchange of Good Practices) category for the PATHWAY Project. The aim of the PATHWAY Project was to aid the advancement of translational research by supporting the career pathways of translational scientists. As part of the PATHWAY Project deliverables, this exploratory interview study was designed to gain first-hand insight into the current working experiences of translational scientists. The granting authority performed project reviews and audits to ensure compliance with the grant agreement rules.

Study Participants

To collect a variety of perspectives for this exploratory interview study, a stratified purposeful sampling technique was used to increase the credibility of our research findings and to facilitate comparisons between interviewees. The sampling stratification focused on geographical locations, educational backgrounds, work experiences, and areas of expertise. Fourteen translational scientists were identified by the project's Principal Investigator (PI) through the consortium's own network and the networks of their associated partners: University of Toronto, Ljubljana University, Eureka Institute, and European Network for Children with Arthritis/Pediatric Rheumatology European Society (ENCA/PRES). They were invited via email to participate in our study and all fourteen researchers agreed. It must be noted that these participants were not part of the PATHWAY Project team.

The interviewees consisted of twelve MD/PhDs and two PhDs (five female and nine male) employed in nine different countries within Europe, the United Kingdom, and North America, representing diverse subspecialties (e.g., pediatrics, rheumatology, neuroscience, psychology, cardiology, pharmacology) and varying years of work experience (e.g., from MD/PhD candidate to twenty-nine years post PhD). Further information was withheld to protect the anonymity of the study participants, see Table 1 for a breakdown of their characteristics.

Table 1. Study participant characteristics.

Interviewee	Female/Male	Employed in	MD/PhD	Years post PhD
1	Male	Europe	MD PhD	22
2	Female	Europe	MD PhD	12
3	Male	Europe	MD PhD	29
4	Male	Europe	MD PhD	8
5	Male	North America	MD PhD candidate	N/A
6	Female	Europe	MD PhD	17
7	Female	United Kingdom	MD PhD	6
8	Male	Europe	MD PhD	19
9	Female	Europe	MD PhD	8
10	Male	North America	PhD	15
11	Male	Europe	MD PhD	10
12	Male	United Kingdom	MD PhD	16
13	Male	Europe	MD PhD	3
14	Female	Europe	PhD	11

Study Design

The fourteen participants were invited via email for a 45-minute online semi-structured interview with the first author using Zoom video conferencing. The interviews took place in October and November 2020. Before the start of each interview, oral informed consent was obtained for the study and to record the audio of the conversation. To protect the privacy of the participants, participant information was anonymized and given a number for further data processing. Questions asked during the interviews covered the participants' current responsibilities within the clinical, educational, and research domains. Interviewees were asked to explain how they were able to combine their separate domain tasks in order to further their translational goals. They were also asked to put into context how they were rewarded for their work in each of the three domains (clinical, educational, and research) and to name areas of improvement. A full list of interview questions can be found in Appendix I.

Data Analysis

To preserve the authenticity of the interviews, an intelligent verbatim transcription was done in Microsoft Word eliminating pauses, repetitive wording, and inserting context where needed to ensure more clarity of the interviewees' answers. The full intelligent verbatim transcripts can be requested. The information from each interview Word file answering the following six interview questions was then copied into Microsoft Excel: (1) What is the definition of a translational scientist in your eyes? (2) What is your personal goal within translational research? (3) Which categories can your work be divided into? (4) Would you need to divide your time differently to optimally achieve your personal goals? (5) What is your advice for early-career translational scientists? (6) What is your advice for policymakers?

Six additional thematic categories were identified in the texts during analysis and highlighted in each Word file before being grouped in Excel: (1) Balancing multiple roles; (2) Current clinical reward system; (3) Current educational reward system; (4) Current research reward system; (5) Areas of improvement; and (6) Financial burdens. After reviewing the Excel file containing the answers of all fourteen participants to the six questions and six additional identified themes, all authors agreed that the data should be categorized into: intrinsic motivation, extrinsic factors, and ideal academic reward system and advice.

All coding was done after data collection and sorting was complete. Using descriptive coding, labels were assigned to mark the first subcategory within intrinsic motivation pertaining to what goals the interviewees want to achieve within translational research. This coding method was used to identify the main themes within this subcategory: for themselves, for research, for patients, and beyond research and patients. For the second subcategory on how the interviewees want to achieve their goals, process coding was chosen to help identify specific actions within the data. This led to the themes: connecting and collaborating, generating new knowledge, and clinical development. Descriptive coding was used again in the extrinsic factors category to sort data into clinical, educational, and research domains. This section was re-sorted into the subcategories: scheduling and priorities, reward systems and metrics, and the impact of extrinsic factors on intrinsic motivation. Evaluation coding was then used to decipher positive and negative remarks of the interviewees to assign judgement about the extrinsic factors affecting their current working systems. Data regarding the category ideal academic reward system and advice was coded using both descriptive and process coding to capture the multi-level nature of this final category pertaining to ideal situations and advice on the subcategories: individual level, institutional level, and international level (22).

RESULTS

The results of this study were divided into three main categories describing what the fourteen interviewed translational scientists reported after being asked about various facets of their working lives: intrinsic motivation, illustrating what participants want to achieve within translational research and how; extrinsic factors, descriptions of current working experiences in the clinical, educational, and research domains and how these affect their intrinsic motivation; and ideal academic reward system and advice, possible multi-level adaptations, and advice for early-career translational scientists in addition to policymakers on how to make these adaptations. To improve the readability and clarity of the findings, quotes have been further edited from the intelligent verbatim transcription, omitting unnecessary and repetitive sentences and phrases without affecting the meaning and tone of the interviews.

1. Intrinsic Motivation

To understand how translational scientists perceived the academic reward system within their careers, we first explored the intrinsic motivation of participants and their goals within translational research. Their answers were separated into two subcategories: what goals interviewees want to achieve, and how interviewees want to achieve their goals.

1.1 What Goals Interviewees Want to Achieve

The first subcategory was sorted into four themes: for themselves, for research, for patients, and beyond research and patients. Six interviewees stated goals for themselves. Their answers related to feelings of happiness and social responsibility, achieving a sense of purpose and fulfillment, being useful, and being a better clinician:

> *"The research and teaching are something I do because I like it, just for my motivation. […]. The satisfaction is something personal, I feel my career is more brilliant. I feel more satisfaction, and I think in life what you need is to be happy, and if I'm happy doing this I don't need an external reassurance of what I'm doing. Being useful for the science, that's the main reason why I do this. […]. I think my career is better […], because I think you are a better clinician if you are also a researcher." (Participant 11)*

Goals for research were mentioned by two interviewees, with one mentioning discovering and gaining knowledge, and another mentioning understanding the impact of a certain condition and how to treat it:

"My overall goal is to better understand the real-world impact of [condition x], what those impacts mean physiologically and what we can do about them. […]. I'm less disease focused and more health focused." (Participant 10)

Goals for patients, stated by six interviewees, included achieving the application of new diagnostic tests and therapies, in addition to improving patient outcomes and quality of life:

"My personal goal within translational medicine is to use the work that I do to create better quality of life for patients. [...]. That's a niche that I think has gone very much underappreciated, and so that's where I found my role." (Participant 5)

Goals beyond research and patients were mentioned by five interviewees. Answers revolved around the broader sense of creating impact, from common knowledge to clinical practice, and beyond:

"The idea that my science could impact either common knowledge or clinical practice is satisfying, but that is ephemeral, because whether or not it will actually [have impact] and how, and how much and to what extent […], is something I'll see years down the line." (Participant 13)

1.2 How Interviewees Want to Achieve Their Goals

The second subcategory was sorted into three themes: connecting and collaborating, generating new knowledge, and clinical development. For connecting and collaborating, four interviewees described activities related to underpinning clinical studies with basic science, and building bridges between people and fields to progress research:

"[To achieve my goals] I feel like the majority of my time is spent more on the population community side, but a lot of my brain time is spent in between a lot of these [domains]: helping to bring community research into a more translational perspective, and helping to bring basic research into a more translational perspective, and helping to get clinicians to think a little more in both directions." (Participant 10)

"By making effective and fulfilling or rewarding collaborations, by developing myself as a scientist, and by making inventions, or by actually making progress in the field." (Participant 1)

For generation of new knowledge, five interviewees mentioned activities within research. Answers varied from understanding the pathophysiology of a disease, predicting disease courses, detecting and validating novel disease markers, and developing research models:

"The functional validation of the novel genetic variants will not only improve the diagnosis in this patient but will also improve the knowledge on the underlying pathogenesis […], and with this improvement of knowledge on underlying pathogenesis, this will improve or, let's say, enhance novel therapeutic possibilities." (Participant 9)

"If you look at the translational aspect, my goal would be to develop a [model] for [condition x], so that we can do studies in it to really improve this outcome." (Participant 6)

For clinical development, five interviewees described activities supporting patients. These included the improvement and development of diagnostic assays, as well as early disease detection tools:

"We are developing early risk stratification tools for early detection and with that we hope to, in the sense of benefiting patients, have an impact on the way these programs are structured, with the ultimate aim of providing a cost return to larger health care systems because it would be easier, in the end cheaper, to catch patients early rather than to see patients at a later stage of disease." (Participant 12)

2. Extrinsic Factors

After discussing their goals, participants were asked about external influences that affect their work. They provided statements about their current working experiences which were divided into three subcategories identified within the overarching clinical, educational, and research domains: scheduling and priorities, reward systems and metrics, and the impact of extrinsic factors on intrinsic motivation.

2.1 Scheduling and Priorities

Within scheduling and priorities, clinical and educational tasks were described by eight interviewees as taking priority over time for research. Answers varied from having to earn research time while fulfilling clinical and educational duties, to allocating time outside of work hours to review research papers, secure research funding, as well as sacrificing one's own research time to help more junior researchers:

"My clinical work is getting very demanding, and I usually have to use my free time at home. I don't deny that when the children go to bed, I start with the computer to review the papers, to see the databases, and that kind of thing." (Participant 11)

"For me it's difficult to say 'OK, now I will focus on my research work'. I still try to have some protected time, but this is usually protected time at home not at work. At work my research time

is more focused on helping younger colleagues in their research. I'm much more organized with reviewing other research than my own research because I try to be responsible to other colleagues, I think that I have to be in this respect, consistent. […]. So, I try to adapt my balance to incoming duties, clinical, research, educational. But it's a constant struggle." (Participant 8)

Six interviewees explained scheduling and priorities to also be challenging. Answers varied from misunderstanding between different work cultures and ideological differences from peers and seniors about their different roles outside of clinical work, managing the administration of their combined roles, to meeting the expectations of employers with different priorities:

"I'm always trying to balance between the time I would dedicate to science, but also the time I have to advance in [my clinical subspecialty]. […]. I have sick kids near me, and I have to do my best to help them as best as I can when I admit them. So yeah, I'm just trying to swim. I would say that the real conflictions are that my surroundings, like in the hospital, they don't have a clear view of a translational scientist and they don't understand that somebody would like to do science. There is absolutely no education in this way." (Participant 4)

"When I'm in my clinical role, there's always things like meetings that certain researchers can only do obviously on the day that I've got a clinical thing. So, it's trying to fit those things in without upsetting the clinical team and without people thinking that I'm reducing my responsibilities and am not interested. And then in the other direction, when I'm on a research day, I might get the secretary from the clinical saying this patient wants to get a hold of you, or have you seen that letter, can you sign it off, or can you come and help us with this clinic because so and so is off. So, I can get pulled in the other direction as well." (Participant 7)

2.2 Reward Systems and Metrics

All participants were asked to describe reward systems and metrics, i.e., systems or standards of measurement regarding evaluations that they were aware of for their work within the clinical, educational, and research domains. Regarding the clinical domain, one interviewee stated that there was no reward system for clinical work, while another explained that metrics for clinical work existed, however, it was unclear if they were used for evaluations:

"I mean there are metrics for my work in the clinic, meaning how many patients opt to be seen by me specifically, how long a waiting list I have, and I get the sense that patients are pleased with my work because my outpatient clinic is constantly full. […]. I guess metrics would be available for that if I asked my hospital administration, it never occurred to me to do so because I get a very immediate reward from patients […], I don't need a metric for that.

Also, I am not being evaluated by my hospital based on these metrics or they probably do, but they've kept it to themselves so far." (Participant 13)

Regarding tasks in the educational domain, four interviewees said that there was almost no known reward system. Participants mentioned it was just part of their job, and while valued, it was not seen as an important aspect of their job or evaluated as such. They said that its impact was difficult to compare to publication counting, but that some institutions weigh educational activates as part of academic performance:

"Publications are simple, you have them, or you don't. Education is very vague. You could hold an educational event with, let's say 100 people and then you could hold another separate educational event with 1000 people, but the impact of the first educational event, even though it had less people, could be greater. […]. Because of that fluidity of education work, or the fluidity of even patient advocacy work, it's exceedingly difficult to put a grade on it, or a way to compare it to other forms of academic work. I think that's one of the biggest challenges. How do we quantify something that in its very nature is very qualitative? I would not be surprised if that's the biggest reason why institutions have had a hard time moving away from this publication merit system and being able to give merit and credit to other forms of qualitative work that psychologically are very important and do great things for society and for patients. […]. Thankfully there are institutions that have a credit system where educational activities are weighted as well as looking at your academic performance. If you were to run an educational activity, or a patient engagement activity, there are some institutions that are beginning to look at these things. But in other places, where it's old-fashioned and all they look at is your publication record, it's very challenging to allocate time to things that you feel are more impactful when they're not leading to a publication that your boss thinks has more impact." (Participant 5)

The reward system and metrics within the research domain were discussed with all fourteen interviewees. Their answers have been organized into five subthemes: publications, publication pressure, combining domains, financial situations, and overarching remarks.

Regarding publications, answers varied from the use of publications to inform colleagues about research findings, obtaining funding and future collaborations, to job security. Participants also mentioned that publishing in journals with higher impact factors did not necessarily mean higher impact in their fields. Publications were explained to be the main measurement for gauging success, however, it was also stressed that this was neither reliable, transparent, or valid:

"As a postdoc you need to publish, otherwise you cannot ask for money if you have no manuscript or some kind of proof that you're doing good work or have good ideas. […]. If you don't publish manuscripts in high impact journals, the chances are small that you get a scholarship or a PhD student, or money to get your project going and that's a shame. […]. In academia you have to basically fight for your own money. […]. After your thirties and after you did your PhD and postdoc-ed etc., you might want to start a family. But it's very difficult, at least in my opinion, I found it pretty difficult to start a family without knowing whether I have a job the next year. Because most projects were for two years, maybe four if you had a lot of luck, and it was just the uncertainty that I hated." (Participant 14)

"Publications are a terrible measurement of success. I would argue that they're neither reliable nor valid. They're just objective, and so, if we were going to use any of these metrics in our experiments as a measure of an outcome, we would never be able to justify it. What does number of publications measure? First of all is it reliable? Well, it's not reliable, because every single field, subfield and sub subfield, has different journals that they publish in, with different types of impact factors, with different scopes. I feel a lot of it [counting publications] is pseudointellectual handwaving nonsense. […]. It's not intellectual because it's actually a poor metric, and if you ask anybody, they all know it's a poor metric. You're comparing numerators without adjusting for denominators, which is what the impact factor was supposed to solve. But even across fields, impact factors mean different things. […]. If number of papers becomes important, it shouldn't necessarily matter where the papers are [published]. […]. My fourth most cited paper is in a journal that isn't even in PubMed by default and it's not in a journal that anyone would find remotely impressive, but it's quite impactful." (Participant 10)

"Sometimes it's not clear how you are able to publish in one journal or another; you have a name, or you don't have a name. I've seen very good works that have not been accepted, the group is not very important in the world, and then you see very weak papers from very important groups [get accepted], and that's something that could be better. […]. Ultimately, I prefer a researcher who does just one work in one year but of very high quality, then the one that did ten papers but are not really useful, so that's the problem of this system." (Participant 11)

Regarding the second subtheme publication pressure, external pressure to fulfill faculty requirements, along with internal pressure to be seen as being productive were mentioned. One interviewee stated that at their institution, publications were not the main focus of an academic career but that a person's network played an important role. Two participants described feeling pressure to publish during the beginning of their career, while others reported that publication pressure created constructive

competition amongst their colleagues. Publication pressure was also mentioned as potentially creating a detrimental hierarchal system for researchers, which has now led to re-evaluating the use of publication metrics at some universities:

"I didn't receive constant pressure by the institution, but I know that unfortunately there's a linear correlation between how many papers I publish and my career advancements. I want to stress that it's a quantitative correlation, not a qualitative one." (Participant 13)

"The pressure to publish is one of these metrics that people judge you by and this is the reality of the world we have to work in. There is internal pressure because the idea is that if you're not publishing, you must not be productive […], and there's external pressure [because] you're expected to have a certain minimum number of publications of varying impact. […]. Once I get to the point where I'm a fully appointed professor or assistant professor, the metric is how much you're publishing in a year, and that's how you keep your job, and that's how you get promoted, so it's a harsh reality of the world that we live in." (Participant 5)

"It [publication pressure] comes from a pressure to be promoted, but there's peer pressure as well, a sort of pecking order within the institute, who's better, who's best? I know that the fellowship that I'm on […], will have to be renewed, and I need to make sure that I have enough publications on the bill to make that a credible proposal, because I will have to put in a new proposal for the next five years with a budget and I know that reviewers immediately go to your publication page to see what your output has been over the last five years." (Participant 12)

The third subtheme addressed the challenges of combining responsibilities across multiple domains while being evaluated on the same criteria as non-translational colleagues. Answers varied from difficulties meeting standards and goals, to being at a disadvantage when competing for research grants with non-translational colleagues who have more time for research:

"Trying to do everything well is difficult. So, trying to meet all your research goals when you've got all this other stuff going on, is difficult, so you might set yourself this list of tasks and only get halfway through and then before you know it, you're back on a clinical day and then you just can't do it. Or similarly, with the clinical side of things, comparing yourself to other clinical trainees who aren't doing any research, who are just doing clinical all the time, they will be much better clinically. […]. It's just quite difficult to do both of them really well, and difficult to stay up to date with all the clinical stuff, as much as someone who's doing that all the time, in terms of continuity. So, I might see a patient when I'm doing clinical work and then the next week, I'll be doing research and might not find out what happened to them. […]. I think it's this constant push and pull in both directions and feeling like you're not doing

either of them to the standard that you'd like to. Not feeling like you're completely failing, but feeling like this isn't satisfactory to me, the level of what I've done in this or in that. […]. Also, as a clinical academic we all get allocated medical students for different projects. […]. So, I'm getting all these students, but with far less time than the people who are full-time academics." (Participant 7)

"Let's say that if I would have 100% time for research, then of course I would have more time to write grants. […]. The competition is not always fair because I don't have 100% time for research and to be as innovative as other people who do. […]. In the past, I may not have complained about getting grants, but I was really afraid in the beginning because I don't have 1% time to do research, while I was still needing to apply for the same grants as other people who are doing 100% research." (Participant 9)

The fourth subtheme addressed the financial situations translational scientists face when performing their jobs. Participants mentioned not receiving any additional salary as a PI, that their research salary had to come through grants, and that they often have to make financial sacrifices in order to continue their work:

"In terms of research, I'm not receiving any additional money. […]. As a scientific director, I'm not receiving any supplementary salary, and this is not fair. […]. The grants here are for hiring PhDs and paying their salaries, or for getting consumables and so on. So, it's different to other European countries where PIs also receive additional funding. […]. My basic salary now is very low […], and the only institution that is paying me is the university. So, I don't receive a second part or a supplement as a researcher. I don't receive a supplement as a clinician. […]. I always complain because here the money goes in a very scattered way, and [they] give small amounts of money to each research group […], [which makes it] difficult to publish in high [impact] journals […], so [to achieve] very good publications with a small amount of money, and because of this scatter, you are limited, and you cannot go beyond. […]. How can I compete with people that have these possibilities. This is a major problem for us." (Participant 3)

"That's what translation really is all about. It's going into this area that's completely unknown. We don't know how to measure it. But there's this feeling in our hearts that it's the right thing to do, and we have to go for it, and for a lot of translational scientists, what that ends up becoming is the realization that you need to take a pay cut somewhere to be able to do what you love and what you think is important. It's much more lucrative from a salary perspective to just do 100% clinical work. You can live lavishly. You can make tons of money. You won't have to worry about job security. But it's just a loop and you'll be stuck in that loop, and you won't be able to change the status quo." (Participant 5)

Finally, the current overarching reward system of the research domain was discussed. One interviewee mentioned that the only reward system they knew was in research and that this system was not working properly. Another participant said they had no knowledge of formal rewards in the research domain, but that informal rewards included respect, freedom, opportunities for collaboration, and how their work impacts people:

> *"For the research work there is this rewarding system of publications and impact, and the system of the grants that you receive or manage but that is […], not really doing what it should do. It's not rewarding what it should in my opinion. […]. But it is something, so people tend to use it […], but there is virtually no rewarding system for the other fields." (Participant 1)*

> *"The rewards are respect in the field. Rewards are the freedom to ask the questions that I want to ask and to do the projects that I find interesting and fun to do. The rewards are, you know, respect from peers. Rewards are opportunities to collaborate with fun people and do fun things. Those are the rewards, and another important reward is feeling like the work that I'm doing is making an impact on actual people, and is interesting to people. I mean that's a reward in and of itself." (Participant 10)*

2.3 The Impact of Extrinsic Factors on Intrinsic Motivation

The final result category explored how the current working experiences of translational scientists influenced their work and how these extrinsic factors affected their intrinsic motivation. Three interviewees described clinical work to be intrinsically rewarding and that no further external rewards were needed. Two of the three interviewees who gave this response also said the same about teaching. However, one interviewee specifically mentioned they were not happy with the lack of recognition about their translational work:

> *"The inner reward is the only kind of reward I can get. There is no recognition. There is no salary. When I speak about what I do at conferences, that's also rewarding, when I spread it [the research]. I like to talk to students about it [the research]. I think that the only chance to change something is by intervening with new generations. We don't have the infrastructure [referring to their country]. […]. If you're applying for a grant, you have all the basic principles like in every other European country. But in practice this doesn't work. They ask about the amount of time, your head of institution even signs that you're allowed to work this certain amount of time in science, but nobody actually follows this. They don't care about this […], other colleagues don't understand this. They don't like it. They don't get it. Why are you doing this? They don't see the reason." (Participant 4)*

The impact of extrinsic factors on intrinsic motivation within research was described by four interviewees. Answers ranged from feeling respected and freedom in their work, to having close patient relationships and creating patient impact. Publications were mentioned as not intrinsically motivating and that years of work culminating into a publication had a protracted sense of fulfillment:

> *"I really don't see publications as a reward at this point. Of course, you need them. But if I were to say that I extract my emotional satisfaction from publications that will not be true. I'm actually satisfied when I submit a paper and then my emotional attachment to that paper ceases to exist, and that's good because oftentimes you get dismembered by some reviewer, so I wouldn't say that publications are my reward." (Participant 13)*

3. Ideal Academic Reward System and Advice

Following the discussions on intrinsic motivation and extrinsic factors, interviewees were asked to provide statements on what they felt would be the ideal academic reward system regarding their translational work and advice to early-career translational scientists and policymakers. The results were divided into three subcategories: individual level, institutional level, and international level.

3.1 Individual Level

All interviewees gave advice on the individual level. Answers included finding and following what intrinsically motivated them and being a good advocate for the translational field, as well as being dedicated, well-organized, and having good time management skills. Participants also mentioned that early-career researchers should find the right environment to develop and grow, and to find a peer mentor just one step ahead of them. Regarding translational work, interviewees mentioned that leading the change sometimes meant taking criticism and to show active efforts to inform the community about research to help foster accountability, transparency, and education:

> *"If you don't have a sense of internal gratification or internal drive, you are going to get burnt out and it doesn't matter how many grants you get, it doesn't matter how many publications you get, if you don't maintain and foster that internal sense of why you're doing this, the external rewards will not be enough. […]. Thus far, the best way that I have dealt with this conflict [working as a translational scientist] is by being a very good advocate for the work that we do, and showing that through academic means, through personal means, through collegiality with colleagues, how important and fundamental the work [of a translational scientist is] and why it is necessary. So, you begin from the ground up to change the minds and the ideologies of those people around you, so that they recognize how important these things are and that*

[translational scientists] are really working within a niche that people have forgotten about." (Participant 5)

"Life in research is very hard, you need to be a very dedicated person and you have to make sacrifices, sometimes personal sacrifices. […]. I consider myself a very well-organized person in terms that if you're trying to do four jobs, which is what I have right now, you need to be very organized in terms of schedule." (Participant 3)

I would say, it's often said go and find a mentor, and the advice then tends to imply, go and find a professor who's achieved that goal that you want to reach. Actually, there should be a greater emphasis on finding peers who are maybe just one small step ahead of you." (Participant 12)

3.2 Institutional Level

When asked to give advice to policymakers, twelve interviewees discussed what institutions could do to help translational scientists. Equally rewarding work in all three (clinical, educational, and research) domains was suggested, as well as having engaged superiors who understood their translational goals. It was mentioned that institutions could also help translational scientists by supporting continuous employment while they navigate their different roles, and by combining evaluations for clinics and research to avoid duplication. One interviewee explained the need for a culture shift to a more qualitative reward system, while another said that metrics such as number of publications could be involved in evaluations, however, not solely, and that context should be thoughtfully considered. Lastly, one interviewee mentioned that policymakers should look at research more as a long-term investment in human capital, and should invest in supporting researchers to build long-lasting projects that result in clinical changes:

"Dedicated clinicians, dedicated researchers, dedicated educators […], all being rewarded in a similar way. […]. For a good academic hospital, you need all three categories well represented. […]. Some people will value research higher than clinics and some other will value clinics higher than education, but for me I'm very unfond of all the comparison things that we're doing now. […]. You can never completely compare the different specialties. […]. I think if we had the feeling that we want to be a top hospital on all three domains and we're happy with everyone who's contributing to that, that would be the best reward to me. […]. Put people in places where they're best and let them do what they're really good at and what they really want to do. […]. That's a principle that you see coming around, people who are really good at something and then they become the head of the department, and they have to do a lot of management things and they're not specifically good at that. So, I'd like to invest in the people who are really good at what they're doing in remaining there and then they don't need to be the boss." (Participant 2)

"I think places that are being more thoughtful are considering context. I think they're not removing the metrics, but they're saying […], 'What is the quality of those publications?'. So that's where you can get into things like citation counts, but even with citations you have to look at that in context, because some fields cite heavily, and some fields cite sparsely. I think places are becoming increasingly flexible, and to be honest, I think the innovation is happening not in the places of privilege. I think that the institutions who have no incentive to change, are not changing. […]. There are many institutions that [make you] feel like it's a privilege to work there and to associate with their name, and don't have the motivation to evaluate themselves because they don't really care. They don't care that these measures are somewhat arbitrary, because they're good enough and they're hard to reach, and then being hard to reach is itself a test that they're willing to place on people, even if the metrics are stupid and invalid and unreliable, at least they're difficult and then they can claim exclusivity. But I think honestly, I think that is diminishing, at least from what I've seen." (Participant 10)

"If they [policymakers] would consider not looking at money or impact points but also at science that is a long-term investment, a long-term strategy focused on implementing therapies or regiments that really make a difference. Then you can start to look at your researchers, the ones that actually have to make these changes, as people that you want to nurture. So, you don't want to only calculate the money they bring in or the impact points they make but also the collaborations they can build, the research lines they can build, that will have a long-lasting stream of inventions, changes, implementations. The impact points and the money is short-term, and the long-term is actually the changes that this research will make. So, they can focus on research lines that actually will make differences. So, it's not the topic of a research line it is also the fact that this line needs to result in clinical implementations. So, we have a lot of research lines or long-lasting projects, this is not new, but the question is whether this results in clinical changes that is not asked so often, I think." (Participant 1)

3.3 International Level

All fourteen interviewees suggested improvements on an international level. Recommendations related to building bridges and collaborations that help the translational field grow, and that focus on creating patient impact. Two participants discussed the need for new ways of measuring scientific impact and the faults of a fully objective system. While two other interviewees mentioned removing financial pressures from researchers, especially early-career researcher and those wanting to start families, in addition to asking for different contractual rules from the government to be able to keep longer-term academic positions. Additionally, one participant recommended translational research be recognized as an independent career, while another purposed establishing an educational path for translational research, which included core criteria that institutions had to respect. These core criteria, which were

described by another interviewee, should contain clear rules for fair competition and equal opportunities between organizations geographically, in addition to being aware of the favoritism towards more famous institutions. Finally, it was suggested by one participant to included more and different stakeholders in the policymaking process, to reflect the diversity of the population:

"It's really disappointing that people tell you 'You do great work, you have great ideas, we just don't have the money.'. You'd rather hear 'You know what, let's part ways because we don't agree, your ideas are not the ideas we want to follow' or whatever. 'No, your ideas are good, it's just we don't have the money and our government tells us that we can only renew your contract once' and that's it. Of course, there are ways around that sometimes. […]. But after a while, sometimes you have to disappoint people and they leave your network or do something else while it would have been easier if people could just have different contracts." (Participant 14)

"There needs to be more funding available for early-career researchers to get little grants to build up towards bigger grants. […]. It's important that there are things that don't disadvantage women, so having grants specifically for women who have come back from maternity leave and are already on the back foot and need a bit of money to buy out someone's time to help them. […]. There are other things that can be done around childcare and conference days, maybe a creche at these conference days. If you're getting a bursary to go to a conference or something like that, could there be a childcare bursary? […]. There's a lot of things that could be done that aren't done to support women, particularly to be able to do everything they want to do." (Participant 7)

"To the policymakers, I think that they have to recognize the figure of clinician-researchers as an independent career. I mean, at the hospital, you need to have full-time clinicians, but also the number of clinician-researchers that we have right now, is very small; less than 5%, and these types of people are people that should be leading the research inside the hospital." (Participant 3)

DISCUSSION

This exploratory interview study, consisting of semi-structured interviews with fourteen translational scientists from different countries, subspecialties, and at different career stages, aimed to provide real-life accounts of the current working experiences of translational scientists and to gather suggestions for an ideal academic reward system that considers all facets of their work. Our study showed that this group of translational scientists is intrinsically motivated to achieve their translational goals. In their current work settings, clinical work was reported to take priority over

teaching, which in turn took priority over time for research. However, dedicated research time was explained as essential for satisfying the current academic reward system that measures scientific impact and the awarding of grants largely based on research metrics such as publications, citations, journal impact factors, and h-indexes. The translational scientists we interviewed suggested that for their ideal academic reward system, both a top-down and bottom-up cultural shift is required to allow for more qualitative performance measurements within institutional structures and facilitate understanding between them and their non-translational colleagues.

When looking more closely at the results, one finding that stood out was that while the current reward systems within the clinical, educational, and research domains were reported as not being geared towards translational scientists, this did not prevent them from meeting their translational goals. Time commitment beyond working hours and perseverance to combine domains, even when employers' demands would not allow it, were reported as necessary for translational scientists in their current work settings. What appears to keep them in this line of work is their strong intrinsic motivation, connected to long-term, domain-overarching goals, and feelings of happiness that come from working towards some form of societal impact. Clay et al. (2019), in a perspective on translational medicine training, recognized that identifying and acknowledging one's own motivations was required to achieve effective training. However, they did not discuss the impact of external factors on intrinsic motivation which was a focal point in our interview discussions (23).

External factors, namely the current reward system within the research domain revolving around publication metrics, was proposed as being the main currency of evaluations and the attainment of grants. Reward systems for clinical and educational roles were reported to be less obvious. When time is factored into this equation, translational scientists, who spend time outside the research domain, reported being at a disadvantage (Figure 2). This disadvantage was also said to be apparent when considering how the distribution of time affects translational scientists financially. Several interviewees mentioned having to forgo income to perform their translational tasks. They explained that it could be more lucrative to spend more time in clinics or to have more dedicated research time to secure research grants. To attain their translational goals however, they reported having to satisfy the current reward system within research. This finding aligns with the biomedical literature which has highlighted the negative effects of publication pressure on researchers such as their struggle for dedicated research time, burnout, and scientific misconduct (18,24–26). This literature also addresses the misuse of the journal impact factor as explained by some of our participants and additionally points out potential biases of the peer-review system (27,28).

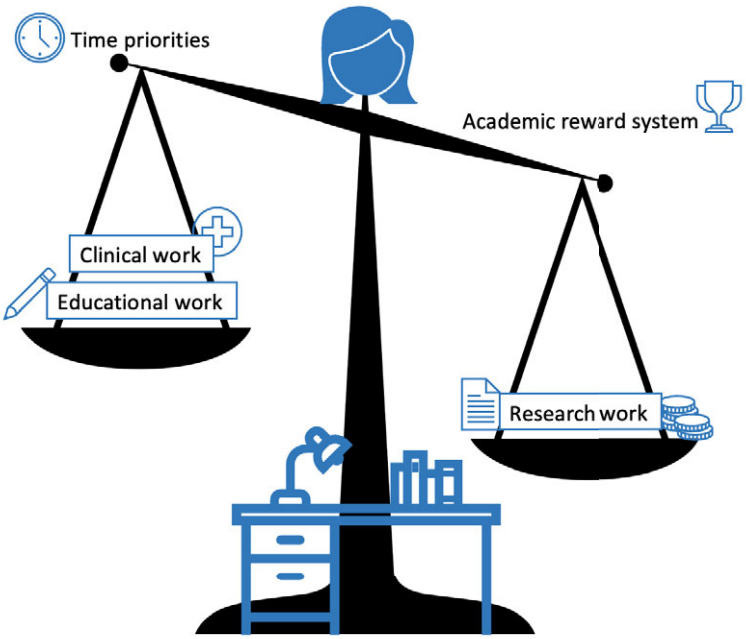

Figure 2. The imbalance of time priorities and the academic reward system for translational scientists. Clinical work takes priority over educational work which in turn takes priority over time for research work, while research work is heavily weighted in the current academic reward system.

Not all translational scientists formally work within the three domains. Two out of the fourteen interviewees were not medical doctors, however, they held responsibilities in the clinical domain and their work was closely connected to patient relevant outcomes. This illustrates the variety of roles that translational scientists can hold, and that one solution will not fit all. Rubio et al. (2010) agreed that because translational research is not clearly defined, developers of translational research programs struggle to set program objectives, define the knowledge and skills that must be attained, and assess when program objectives and competency requirements have been met (29).

When asked about areas of improvement within the academic reward system, the majority of the interview participants focused on the research reward system, while the reward systems within the clinical and educational domains were addressed less. It was explained by the participants that reward systems in these two domains are less obvious and experienced as more intrinsically rewarding. All interviewees were asked to share ideas on how their current working experiences could be improved and to provide advice to early-career translational scientists. None of the participants advised them to try and change the current academic reward system. The advice, they did share, focused

on how to be successful within the current system. Interviewees did, however, provide actionable advice for policymakers, suggesting that performance measurements should take into consideration all tasks of a translational scientist and not just the research domain, which would require a clearer definition of what a translational scientist is and does. To address this need, participants suggested specialized training programs for translational scientists that help create sustainable career pathways with metrics that reward work across all their domains. The advice of our participants concurs with other recommendations that suggest multi-level adaptations for the research system and reorganization to better support translational scientists (30,31). Further literature in this area also suggests using different measurements of impact, moving away from classic bibliometrics in academia and towards measurements of impact on society and legislation (32,33). In addition, in 2016, Elsevier launched CiteScore as a rival to the impact factor in assessing the quality of academic journals (34) and other suggestions have been made to counter the traditional use of citation metrics and h-indexes (35,36)

Limitations

We used a stratified purposeful sampling technique to select fourteen translational scientists. They were from varying countries, subspecialties, and career stages, and identified as being an accurate representative sample to understand how translational scientists perceive the current academic reward system within their career pathways. Extrapolating the results from our sample to the global population of translational scientists must be done with care. These findings provide empirical evidence of the real-life working experiences of these specific participants. Nevertheless, unless otherwise stated, the interviewees' answers overall aligned with one another, making the information potentially more generalizable. Additionally, all participants came from the network of the PATHWAY Project's PI, and have all been able to navigate the complex work settings they operate in. Future research including translational scientists that have left this field would offer additional insights on the sustainability of this career pathway, however, locating them could prove difficult.

CONCLUSIONS

The aim of this study was to better understand what motivates translational scientists to continue their work in an environment that is not conducive to all aspects of their job, and to seek advice on points of improvement within the current academic reward system. Participants provided several suggestions for specialized support on an individual, institutional, and international level. A top academic institution should acknowledge and support different employee tracks, allowing individuals to customize

their focus by choosing from various combinations of clinical work, educational involvement, and research. Translational research should focus on healthcare innovations based on patient and population needs, rather than publication metrics. The main finding of this study is that there are currently limited reward systems in place that acknowledge all aspects of the specialized work of translational scientists. However, these translational scientists remain intrinsically motivated to achieve their translational goals. Our findings confirm what previous studies have highlighted, that the work of translational scientists is challenging, and that traditional quantitative research reward metrics do not fully align with their translational goals or fully encompass all aspects of their work.

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APPENDIX I

Semi-structured interview questions.

1. What is the definition of a translational scientist in your eyes?
2. What is your personal goal within translational research?
3. Which categories can your work be divided into?
4. How is your time currently divided between these categories? In percentages?
    a. Did this evolve over time?
    b. Would you need to divide your time differently to optimally achieve your personal goal?
5. Do you now or have you ever experienced conflicting interests between categories?
    a. If so, describe them? How did you overcome them? Are there still conflicts?
    b. Why do you think there are conflicting interests? Because of current reward systems?
    c. What would be an ideal reward system per category? Do you feel pressure to publish?
    d. What considerations do you make between work tasks? Do you agree with the priorities?
6. What is your advice for:
    a. Early-career translational scientists
    b. Policymakers

CHAPTER 3.2

Correspondence – Clinician-Scientists: How to Reverse Their Declining Numbers

Publication Status

An adapted version of this correspondence is published as "Kools FRW and Prakken BJ. Clinician-Scientists: How to Reverse Their Declining Numbers. Nature. 2022; 601(7893):318. doi: 10.1038/d41586-022-00095-6.".

Author Contributions

FK authored the manuscript with BP as substantive editor and proofreader. All authors contributed to the manuscript and approved the submitted version.

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CORRESPONDENCE

The COVID-19 pandemic has underscored the immense importance of clinician-scientists. Central to translational medicine, they are expected to bridge the "valley of death" — the gap between bench and bedside. But clinician-scientists have faced difficult career paths for decades. They must juggle demanding duties in patient care with being judged mostly on grant, publication and citation records. The result? A noticeable decline in the number of clinician-scientists (1).

To help clinician-scientists to thrive, institutions should offer bespoke mentorship programs, educational tools and career tracks. For example, the Eureka Institute for Translational Medicine, a non-profit support network of universities and research organizations worldwide that is based in Italy, offers virtual schools and international courses at the graduate and postgraduate levels. These courses have been shown to boost the implementation of research and the motivation to pursue translational projects (2).

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CHAPTER 4.1

International Online Mentorship for Translational Scientists

Publication Status

An adapted version of this study is under review at a peer-reviewed journal as "Kools FRW, Fox CM, van Rijen HVM, and Prakken BJ. International Online Mentorship for Translational Scientists. 2023.".

Author Contributions

FK performed the data collection, analyses, and authored the manuscript with CF as second researcher, substantive editor, and proofreader. HR and BP reviewed the final manuscript. All authors contributed to the manuscript and approved the submitted version.

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ABSTRACT

Introduction: Translational scientists fulfill various roles across clinical, educational, and research domains with the ultimate goal of positively impacting patients. Mentorship has been recognized as an important means of career support for translational scientists, particularly when navigating the complex translational research pipeline and adapting to evolving roles. In response, the Erasmus+ PATHWAY Project developed and piloted an extra-curricular online preparatory course and mentorship program in 2019 and 2020 to help translational scientists build mentorship skills, develop their careers, and create an online community.

Methods: To assess the pilot online mentorship program, a longitudinal exploratory mixed method study was conducted.

Results: Mentees and mentors from both years reported that they joined the program to learn mentorship skills, gain career support, and expand their (international) network. Analysis of evaluation forms indicated that the online preparatory course was evaluated largely positively, with participants suggesting improvements for future iterations. Results of a follow-up survey in 2022 revealed that mentorship was considered helpful in supporting translational scientists' work within translational research, and an online mentorship program was useful, provided it included interactive online training, multiple mentee-mentor matching rounds, compatible time zones and professional experience for matched pairs, active program moderation with offline activities, and effective online tools.

Conclusions: This study revealed the mentorship needs of translational scientists and their recommendations for international online mentorship. The innovative PATHWAY program's online format, mentee-driven matching, and preparatory training for both mentees and mentors contribute to the development of mentorship for the translational community that could potentially have broader applications, especially in a post-COVID-19 environment.

INTRODUCTION

Background

When choosing a higher educational career within the life sciences field, students commit to a long academic path filled with content-dense programs that lead them towards their prospective careers. One of the more complex career pathways within the biomedical life sciences is translational research. Becoming a translational scientist can mean combining medical and research training in varying degrees that differ per individual while often also being involved in education (1–4). While it is not a requirement for a translational scientist to have a clinical background, what distinguishes them is their ability to bridge the gap between clinical demands and biomedical research, due to their specialized training (1–3). In addition to translational scientists commonly combining responsibilities across multiple domains (clinical, research, and education), they also collaborate with various stakeholders within healthcare in order to help solve unmet patient needs following a complex translational pipeline (Figure 1)[1] (1,5). As there are many possible career pathways and points along the translational research pipeline where translational scientists can focus their career, demands can become overwhelming and their professional development needs supporting (6,7). Therefore, institutional mentorship programs designed to assist early-career translational scientists during their studies and beyond could help the profession to grow and stimulate more health innovations reaching patient impact (1,6,7).

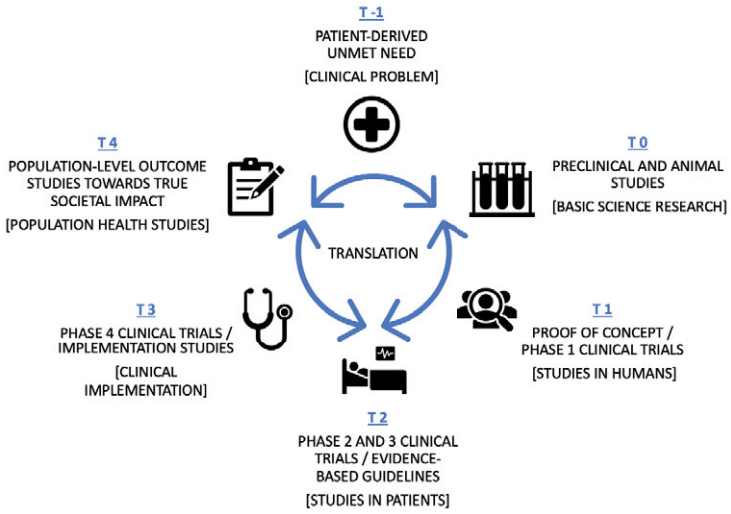

Figure 1. The translational research pipeline.

1 The information in Figure 1 is based on Fernandez-Moure (2016).

According to the National Institutes of Health (NIH) and the Institute of Medicine, mentoring is: "*[...] critically important to increase the capacity and number of clinical and translational scientists and to enhance scientific productivity.*" (8). This support is even more fundamental for early-career translational scientists, who face complex decisions developing their careers (6). Mentorship programs come in many different forms. In a systematic review by Kashiwagi et al. (2013) seven types of mentoring for physicians were found in various combinations within mentorship programs: traditional (long-term), functional (project related short-term), speed (one-time event), peer (mentee-mentee), facilitated peer (oversight by mentor), group (one mentor with multiple mentees), and distance mentoring (across institutions) (9). The degree of mentorship training also differed. Pfund et al. (2013) described six competencies in a training program for mentors of clinical and translational scientists: effective communication, aligning expectations, assessing understanding, addressing diversity, fostering independence, and promoting professional development (10). Another training program for mentors described by Feldman et al. (2009) educated prospective research mentors on subjects such as defining mentorship (its potential rewards and challenges), balancing work and life, and fiscal realities for successful academic careers (acquisition and management of research funds) (11). A different approach was described by Byington et al. (2016) using a matrix model that focused on self-, senior, scientific-, peer-, and staff-mentorship for clinical and translational scientists (12). Most of these mentorship programs have focused on the role of mentors and less on the role of mentees. However, mentees can take an active role in their mentorship to ascertain what they want to achieve, develop mentorship skills, and gain tools to effectively achieve their goals, which they can then continue to use during the course of their careers (13,14).

Context

To assist translational scientists in their career development, a European strategic partnership was formed in 2017 between University Medical Center Utrecht, Nutricia Research BV, Ghent University, University College London, and University of Granada. An Erasmus+ KA203 (Strategic Partnerships for Higher Education) grant within the KA2 (Cooperation for Innovation and the Exchange of Good Practices) category was obtained to create the PATHWAY Project. The project ran from 2017 to 2020 and one of the project's deliverables was an extra-curricular online mentorship program for translational scientists. The intention of the mentorship program was to create opportunities for early-career translational scientists to connect with more senior translational scientists and to simultaneously educate both groups about good mentorship practices while strengthening and stimulating the growth of the translational community. The mentorship program was designed by a delegation of the

PATHWAY team together with the online learning academy Elevate over the course of 2018 and 2019.[2]

The PATHWAY Project collaborated with one of its associated partners, the Eureka Institute, to pilot their newly developed online mentorship program for translational scientists. Founded in 2008, the Eureka Institute is an innovative initiative with the mission to advance the benefits of translational research for patients and society worldwide by focusing on nurturing its workforce, i.e., translational scientists. Eureka aims to achieve this through education, community building, and research. Their educational curricula address the professional landscape of translational research and the researcher's role in it. One educational activity that takes place annually in Utrecht, Netherlands is the Eureka summer school. This program invites advanced master's students, PhD students, early-career postdocs, and fellows for a week of intense training and reflection about the challenges of practicing translational research.[3]

After the 2019 and 2020 summer schools, students were given the opportunity to volunteer for the online mentorship program as mentees. Senior translational scientists from Eureka's alumni network were asked to volunteer as mentors via recruitment emails. Both mentees and mentors started the mentorship program with moderated online mentorship training in separate online preparatory course environments containing learning units about mentorship, 21st century skills, career pathways in translational research, and ending in mentee-mentor matching. Activities within the learning units of the online course were either individual and compiled into an online professional development mentorship portfolio for mentees, or collaborative. These collaborative exercises were designed for peer-to-peer mentorship. The online courses were moderated to encourage participation and to assist with technical issues. As the emphasis of the online preparatory course was focused on training mentees, their course load was higher than that of the mentors (seven hours and twenty-five minutes vs. two hours and forty-five minutes). Both groups were expected to complete all learning units within two weeks for matching to take place. Mentee-driven matching was informed, but not mandated, by complementary ranking results of potential mentorship discussion topics filled out by both mentees and mentors. Once mentees had chosen a mentor, mentee-mentor pairs were introduced by the moderator and left to apply what they had learned during the online course to their one-on-one online meetings as they saw fit, using the mentee's online professional development portfolio as a guide. A detailed online course design overview can be found in Appendix I.

2 www.pathwayproject.eu

3 www.eurekainstitute.org

Additionally, implementation and sustainability handbooks for the online mentorship program are available upon request.

Research Questions

This study aimed to answer the following three research questions (RQs): RQ 1. "*Why did mentees and mentors volunteer for the online mentorship program (their mentorship needs)?*". RQ 2. "*Did the online mentorship program meet the needs of the participants?*". RQ 3. "*What are participants' recommendations for an online mentorship program?*". To answer these questions, a longitudinal exploratory mixed method study was designed.

METHODS

Study Participants

Ethical approval for this pilot project was obtained from the Ethical Review Board of the Netherlands Association of Medical Education. The two online mentorship programs had forty-three participants in total: eleven mentees and eight mentors in 2019; seventeen mentees and seven mentors in 2020. Additionally, fifteen out of the total forty-three participants responded to an online follow-up survey in 2022: two mentees and five mentors from 2019; five mentees and three mentors from 2020. The mentee sample included international masters' students, PhD students, early-career postdocs, and fellows with a life science and/or medical background that had participated in the 2019 and 2020 Eureka summer school. The mentor sample consisted of mid-level career and more senior Eureka alumni currently working within translational research in and outside academia.

Study Design

This study was divided into three parts based on the three research questions. Approaching this study as a pilot project allowed the researchers to explore the newly developed online mentorship program over time and gain insights about its utility for future iterations. A triangulation design was used to analyze the findings per RQ and deepen the understanding of both the quantitative and qualitative data (Figure 2)[4] (15).

4 The information in Figure 2 is based on Creswell & Plano (2007).

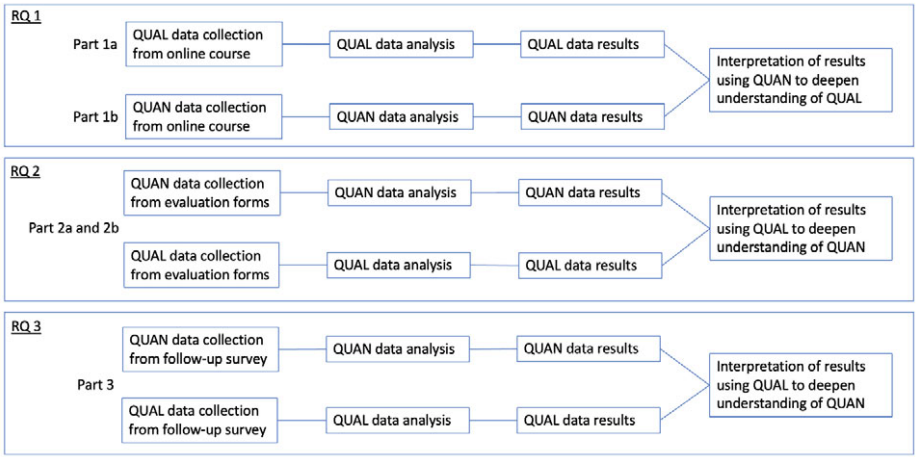

Figure 2. Conceptual framework per research question (RQ) for this longitudinal exploratory mixed method study using a triangulation design.

To answer RQs 1 and 2, the two separate online preparatory course environments for mentees and mentors from 2019 and 2020 were used (Figure 3 and 4). These online course environments are currently housed on the ULearning Platform of Utrecht University and the University Medical Center Utrecht.

To answer RQ 3, an online follow-up survey was designed in the online Qualtrics platform. The online survey was sent to all forty-three participants of both 2019 and 2020 online mentorship programs via email and consisted of two quantitative questions, three quantitative and qualitative questions, and one qualitative question. A full list of the survey questions can be found in Appendix II.

Data Collection

This study contained data generated during both the 2019 and 2020 online mentorship programs and from an online follow-up survey from 2022. All data collection took place simultaneously in 2022. To give an overview of participation during the online preparatory courses for mentees and mentors of both years, quantitative analytical data was collected from the administrative records of the online course environments. This analytical information consisted of participation data (e.g., how many participants started the online course assignments and how many evaluation forms were completed). From 2019, qualitative data generated via email between sign-up and the start of the online course regarding reasons for non-participation was collected. This data was not available from 2020. An overview of all data collection per part can be seen in Table 1, divided per year and mentee or mentor participation.

Table 1. Overview of all data collection per result part divided by year and mentee or mentor participation.

	2019		2020	
Results	**Mentees**	**Mentors**	**Mentees**	**Mentors**
Part 1a	n=11	n=8	n=17	n=7
Part 1b	n=10	n=6	n=12	n=3
Part 2a	n=4	n=5	n=7	n=0
Part 2b	n=4	n=2	N/A	N/A
Part 3	n=2	n=5	n=5	n=3

- Part 1a. Reasons for Joining the Online Mentorship Program

To answer RQ 1, qualitative data was collected from the online preparatory course exercise 1.4 "What do you expect" about mentees and mentors' reasons for joining the online mentorship program and what they hoped to learn. Mentees were also asked how they foresaw the mentorship program supporting their careers, and mentors were asked what impact the mentorship program could have on them and on mentees.

- Part 1b. Mentorship Discussion Topics

Additionally, quantitative data was collected from the online course exercise 6.3 for mentees and 3.2 for mentors "Matching process", which asked each individual to rank seven potential mentorship discussion topics. Mentees were asked which topics they would like to discuss with a mentor and mentors were asked which topics they felt comfortable discussing. These topics were: combination work-life and family-life, combination research and clinical work, career options and career growth, relationship with superiors and colleagues, time-management, translational pipeline, and non-content related skills (e.g., leadership, project management, etc.).

- Part 2a. Online Course Evaluation Forms

To answer RQ 2, quantitative and qualitative data was collected from online preparatory course evaluation forms filled in by mentees and mentors immediately after completing the online course in 2019 and 2020. Quantitative questions addressed the need and use for mentorship training, and the quality of the online course design (e.g., clarity of learning objectives, relevancy of learning activities, course materials, and moderation). This data was gathered on a five-point Likert scale ranging from strongly agree, agree, neutral, disagree, strongly disagree. Qualitative questions addressed what participants liked about the online course and possible improvements. An example online course evaluation form can be found in Appendix III.

- Part 2b. Supplementary Evaluation Forms

To gain a longitudinal perspective about the participants' experiences, quantitative and qualitative data generated from a supplementary evaluation form was collected asking about the quality of the mentee-mentor matching process and their mentoring sessions,

two months after completing the online course in 2019. An example supplementary evaluation form can be found in Appendix IV. This data was not available from 2020.

- Part 3. Recommendations for an Online Mentorship Program

To answer RQ 3, quantitative and qualitative data from an online follow-up survey in 2022 was collected three and two years after the 2019 and 2020 online mentorship programs, respectively. The questions on the follow-up survey asked participants which year they participated and whether they were a mentee or mentor. It then asked them if they were still in contact with their mentor or mentee, if they think mentorship can help their work in translational research, if they think an online mentorship program is feasible, and to explain why. Lastly, participants were asked what was needed in their opinion to make an online mentorship program successful.

Data Analysis

All data for this study was analyzed in 2022 after data collection was complete by the first author unless stated otherwise. To give an overview of participation, quantitative analytical participation data of mentees and mentors from the online preparatory course environments of both 2019 and 2020 was downloaded and placed in Table 2 showing each year and mentee or mentor status. Additional qualitative data collected in 2019 on reasons for non-participation was summarized by the PATHWAY delegation and described in the text. Although other direct measures of outcomes may exist, this pilot project prioritized participant perceptions in evaluating program success and identifying areas of improvement for future programs. Additionally, direct quotes from participants were omitted because of the ethical agreement. Participant answers to open questions were therefore summarized in the text.

- Part 1a. Reasons for Joining the Online Mentorship Program

The relevant qualitative data of all forty-three participants from 2019 and 2020 was downloaded from the online preparatory course environments and uploaded into Microsoft Excel. This data was then anonymized after differentiating a participant's program year and mentee or mentor status. Answers to the online course exercise "What do you expect" were summarized and then coded per participant using descriptive coding (16). The coding process underwent multiple rounds of systematic checks for reliability using a test-retest coding process. Additionally, the supervision team performed an inter-rater reliability test to ensure the accuracy and consistency of the coding process. These codes where amalgamated into three main themes: mentorship skills, career support, and network, and described in the text separated into mentor and mentee responses aggregated for both years.

- Part 1b. Mentorship Discussion Topics

Each participant's quantitative answers to the online preparatory course ranking exercise "Matching process", were placed in Figure 5 aggregated for both years showing the most popular (number one ranked) and least popular (number seven ranked) ranking results separated for mentees and mentors. This quantitative data was used to deepen the understanding of participants' mentorship needs and described in the text.

- Part 2a. Online Course Evaluation Forms

Quantitative data from eighteen questions on the online preparatory course evaluation form was organized into two categories: (1) the "need and use for mentorship training" (questions one and two, and eleven through fifteen) and (2) the "quality of structural elements of the online course" (questions three through ten and sixteen through eighteen). This data was separated into mentee and mentor responses aggregated for both years in Figure 6, showing the Likert scale results in percentages after grouping strongly agree with agree and disagree with strongly disagree. Answers to three qualitative questions at the end of the evaluation form regarding improvements for the online course were summarized by the PATHWAY delegation and described in the text. This qualitative data was used to deepen the understanding of the quantitative data from the evaluation forms.

- Part 2b. Supplementary Evaluation Forms

Quantitative data from the supplementary evaluation form generated two months after the 2019 online preparatory course was organized into one category for both mentee and mentor responses: the "quality of mentee-mentor matching" (questions one through six for mentees; questions one through four for mentors). Due to the low response rate, this data was not put into a figure but described in the text separating mentee and mentor responses. Quantitative data about participants' mentoring sessions was also described in the text (questions seven and eight for mentees; questions seven through nine for mentors). Answers to qualitative questions on the supplementary evaluation form regarding the mentoring sessions (two questions for mentees; three questions for mentors) were summarized by the PATHWAY delegation and described in the text. This qualitative data was used to deepen the understanding of the quantitative data from the supplementary evaluation forms.

- Part 3. Recommendations for an Online Mentorship Program

Anonymous responses from the online follow-up survey in 2022 were collected and downloaded sorting responses per year and mentee or mentor status. Answers to the quantitative questions (questions three through five) were placed in Figure 7 separated into mentee and mentor responses and aggregated for both years. Answers

to the qualitative questions (questions three through six) were summarized per survey question and described in the text, separated into mentor and mentee responses, and aggregated for both years.

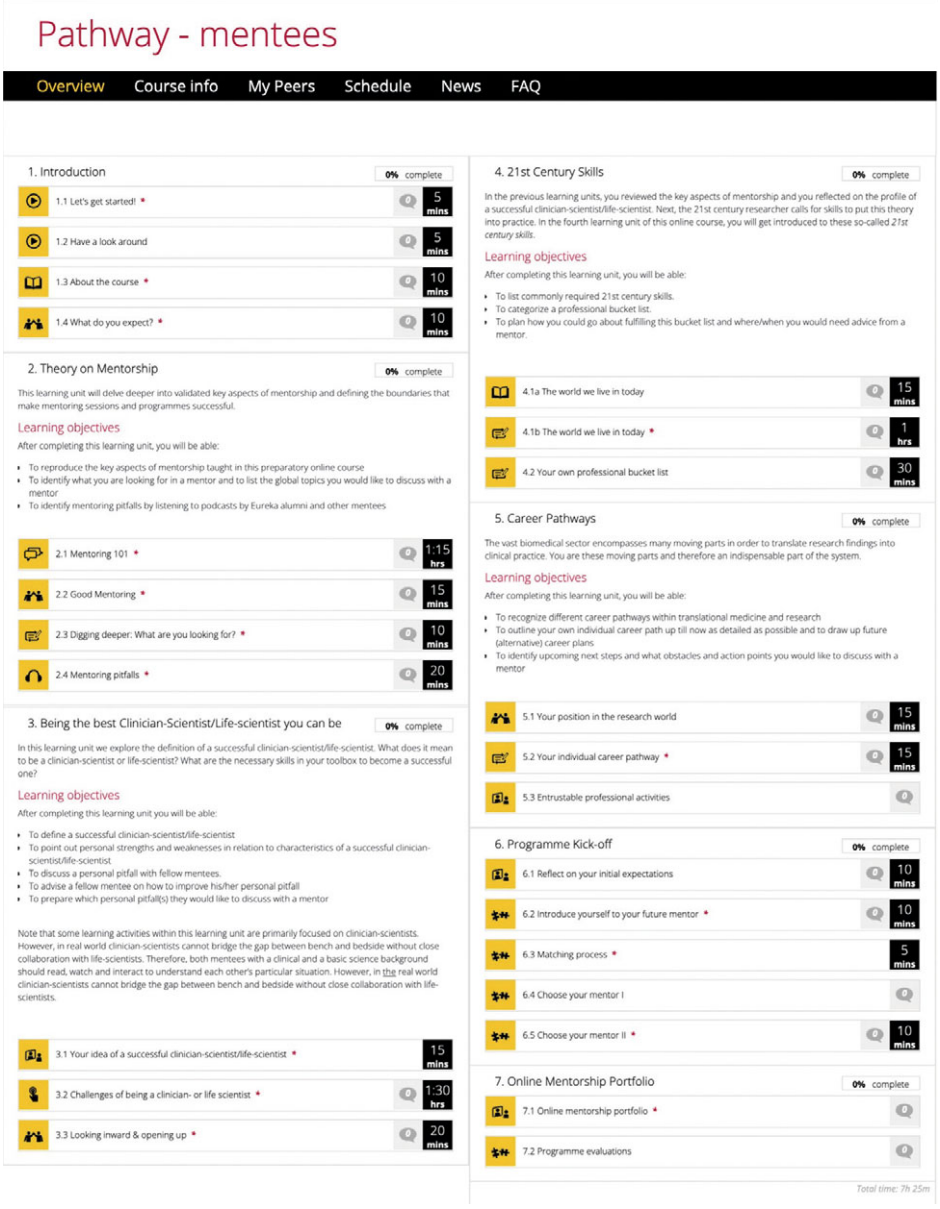

Figure 3. Online preparatory course environment of the PATHWAY online mentorship program for mentees.

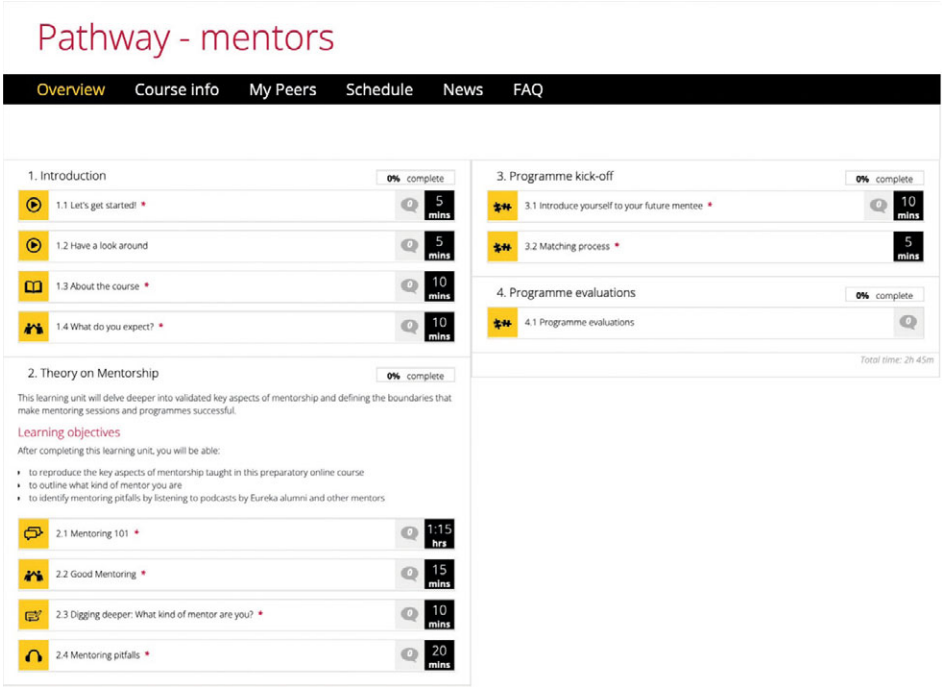

Figure 4. Online preparatory course environment of the PATHWAY online mentorship program for mentors.

RESULTS

Online Participation Overview

An overview of online participation in both the 2019 and 2020 online preparatory courses can be seen in Table 2. In 2019, twenty-five mentees signed up for the online mentorship program after the Eureka summer school and twelve of them logged in to the online course environment. Thirty-six mentors signed up after recruitment emails were sent to the entire Eureka alumni network and eight of them logged in to the online course environment. Reasons for non-participation between sign-up and the start of the online course were available from thirteen mentors (no mentees responded). Their reasons were: no time (n=4), bad timing (n=5), do not want a mentee at the moment (n=1), forgot it (n=1), I feel too inexperienced (n=1), I received too little information (n=1). A decline in participation can be seen through the start and completion of the online course assignments, matching, and completion of the online course evaluation form. From 2020, limited participation data was available, however, a similar decline in participation can be seen.

Table 2. Online preparatory course participation data for mentees and mentors from 2019 and 2020.

	2019		2020	
How many participants:	**Mentees**	**Mentors**	**Mentees**	**Mentors**
Signed up	25	36	N/A	N/A
Logged in	12	8	N/A	N/A
Started assignments	11	8	17	7
Completed assignments	10	6	12	3
Matched with a mentor or mentee	9	9*	N/A	N/A
Completed the evaluation form	4	5	7	0

**Of the nine matched mentors, five started the online course but did not finish it, while four did not take the online course but were chosen by a mentee regardless of this, and three mentors who did complete the online course were not chosen by a mentee.*

Part 1a. Reasons for Joining the Online Mentorship Program

Mentorship Skills

Mentees described mentorship as having a distinct part in their future careers and being curious about the online mentorship training. In their answers, they mentioned hoping to learn how mentorship worked and wanting to experience a mentee-mentor relationship. Mentees were excited to learn skills on how to build and maintain effective and fulfilling mentorship relationships, and to understand its potential value and possible applications. They described wanting to learn skills to maximize the benefits of a mentee-mentor relationship, including what to expect from a mentor, what their role was as a mentee, what types of questions to discuss with their mentor, and how to communicate with mentors. Mentees also mentioned wanting to work on their self-development. Specifically, wanting to learn more about their strengths and weaknesses, discover talents and ambitions they might not know they had, and to clarify their needs, intentions, and goals to reach their full potential. The mentees recognized that in order to do this they needed to gain a flexible mindset to help put their ideas into action and to build skills that would help guide them if their career goals changed, leading them to make more conscious career choices. Lastly, mentees thought these mentorship and self-development skills would help them to become better mentors in the future.

Mentors reported wanting to learn mentorship skills to improve themselves and become better and more effective mentors to more junior translational scientists. In their answers, mentors hoped the online mentorship program would provide inspiration and practical advice on how to get the most out of a mentee-mentor relationship, and the opportunity to learn about what it means to be a good mentor. Mentors described wanting to learn about defining a good mentee-mentor match, how to structure a mentorship session, what mentees were looking for in their mentors,

what uncertainties or questions mentees had, what questions to ask, and how to respond to difficult situations. Mentors also mentioned wanting to learn how to be better mentees themselves and to motivate their mentees to become future mentors. Lastly, they hoped to use their mentorship skills to make an impact on the mentees from the online mentorship program and on other mentees in the future.

Career Support

One of the most common reasons for joining the online mentorship program for the mentees was to receive career support. Mentees wanted to discuss their role and value as translational scientists. They described feeling lost and struggling to combine clinical and research tasks in environments where their colleagues did not. The early-career translational scientists hoped to learn from the experiences and be inspired by more senior translational scientists about possible future career pathways in translational research. They emphasized that this support would be best from someone outside of their own working environment and explained that an external point of view could provide insights into new perspectives and future career directions. Mentees also mentioned that mentors were crucial for guidance and support in making career decisions during transitional periods, regardless of their career stage, and could provide the structure and focus they needed to achieve their long-term goals. Additionally, it was said that mentors could help advise mentees on the possible threats that came with certain career choices, or what skills they may need to develop and how to market theses skills to future employers and funding agencies. Finally, mentees described feeling inspired and supported by the Eureka summer school and wanted to continue their personal and professional development by learning how to apply their new knowledge to their translational goals and future careers as translational scientists.

One of the most prominent reasons for mentors joining the online mentorship program was to provide more junior translational scientists with career support. Some mentors described not having a mentor during their early career stages and wanting to make it easier for the next generation, while those that had benefitted from mentors wanted to give back and support the career development of early-career translational scientists. Several mentors who had benefitted from mentorship said that it helped them either clinically or with their research careers but that they had missed the perspective of a translational scientists who combined both roles and was familiar with the challenges. They said that they wanted to be that person for a mentee, to help them navigate a career within translational research. The mentors described being a translational scientist as fascinating but also frustrating and considered their mentorship role a success if they could transfer their knowledge of career pathways and their potential

hurdles, to encourage mentees to learn from their mistakes. They elaborated that difficult career decisions could be made easier by a mentor who provided a different angle and could equip their mentee with skills and tools to achieve their career goals. Finally, mentors disclosed that mentorship could positively impact their own career development in addition to that of their mentees'.

Network

Mentees believed that the online mentorship program was an opportunity to make valuable connections with other (international) translational scientists as well as to connect with a mentor outside of their direct working environment. They mentioned being interested in sharing and learning from the experiences and struggles of others, discussing challenges and hurdles that they faced in their professional and personal lives, and to learn from the perspectives of translational scientists in different career paths. These different perspectives were explained to be especially important in translational research, where translational scientists collaborate with people from different backgrounds. Mentees also mentioned that the extensive (international) networks of their mentors could help foster potential collaborations in the future and that it could provide them with international perspectives regarding their work in translational research.

Mentors described wanting to establish a global scientific network of translational scientists representing different backgrounds and expertise to share valuable experiences with, and help grow the translational community. They said that translational research encompasses many different areas and career options, therefore understanding other people's career paths would widen their horizons and enable them to learn from each other. The mentors described this global scientific network as a space to communicate concerns, learn how to approach common challenges from different perspectives, and find new effective ways to move forward together. According to the mentors, this space could also be used to discuss different perspectives on mentorship and international mentorship practices.

Part 1b. Mentorship Discussion Topics

The ranking results of potential mentorship discussion topics mentees would like to discuss with their mentor revealed that time-management was both most and least popular (n=6 each). The second most popular discussion topics were relationship with superiors and colleagues and translational pipeline (n=5 each). The second least popular discussion topics were combination work-life and family-life and combination research and clinical work (n=4 each) (Figure 5).

The ranking results of potential mentorship discussion topics mentors felt comfortable discussing with their mentees revealed that relationship with superiors and colleagues was both most and least popular (n=4 and n=2). The second most popular discussion topics were combination work-life and family-life and time-management (n=2 each). Next to relationship with superiors and colleagues, combination research and clinical work was also least popular (n=2) (Figure 5).

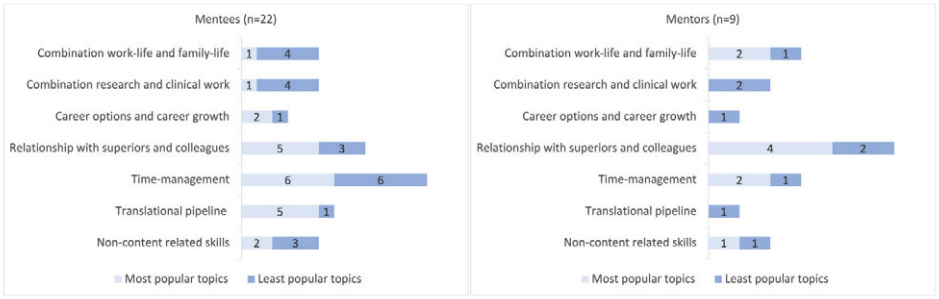

Figure 5. Ranking results of the most popular and least popular mentorship topics mentees would like to discuss with a mentor or topics that mentors felt comfortable discussing, aggregated for both years.

Part 2a. Online Course Evaluation Forms

Mentees and mentors evaluated the need and use for mentorship training from (strongly) agree to (strongly) disagree for both years. (Strongly) agree was the most common answer (78% of mentees; 80% of mentors). Four mentees (one from 2019 and three from 2020) and one mentor (from 2019) (strongly) disagreed about the need and use for mentorship training. Specifically, with the questions on the need for a mentor or mentee and the need for mentorship training before hearing about the mentorship program. One mentee (from 2020) disagreed with the question that the online training helped to maintain a better personal and social atmosphere, and that the training improved their confidence and commitment (Figure 6).

The quality of structural elements of the online course was also evaluated from (strongly) agree to (strongly) disagree for both years. With (strongly) agree being the most common answer (89% of mentees; 87% of mentors) in all cases except by two mentees in 2020 and two mentors in 2019. Mentees disagreed with the question that the length and pace of the online course were appropriate. Mentors disagreed with the questions that the online assignments were clearly explained, that online group discussion gave added value to the online course, and that the moderator significantly contributed to them achieving the online course learning objectives (Figure 6).

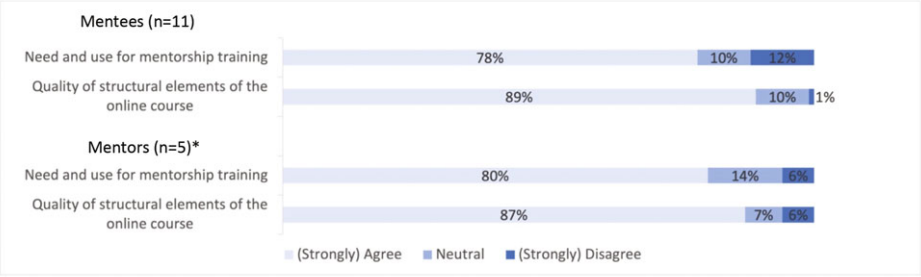

*Figure 6. Online preparatory course evaluation form results for the need and use for mentorship training (seven questions) and the quality of structural elements of the online course (eleven questions) separated by mentee and mentor responses, aggregated for both years. *No mentors from 2020 filled out this evaluation form.*

In open questions at the end of the evaluation form, participants were asked what they liked most about the online course and about possible improvements. The online peer-to-peer group discussions were named as an element both mentees and mentors liked most about the online course from both years. Mentees also mentioned that they liked discussing their personal goals and weaknesses, the personal reflection exercises (e.g., on their professional development portfolio), and the course structure (e.g., being required to engage in online peer-to-peer group discussions). Mentors listed reading the personal stories of participants and listening to prerecorded podcasts by translational scientists about mentorship as elements of the online course they liked most, as well as reading mentees' expectations and the course materials (e.g., the video on mentorship).

When asked if there were any content-related topics that participants had missed during the online course, almost all respondents said they had not missed anything. However, one mentee from 2019 missed decision-making as a topic, and two mentees from 2020 missed self-confidence and tips on speaking up, respectively, as topics.

General improvements regarding structural elements of the online course varied from organizational suggestions to ways of developing the learning activities. Mentees suggested real-time interaction (e.g., Zoom discussions), inviting mentors to occasionally participate in their online course exercises, more videos instead of reading material, and structural improvements (e.g., intermediate due dates, duration of course, and more space for comments). Mentors suggested organizational improvements (e.g., less e-mails but more reminders), fewer reading assignments, more space for comments, and noted that group discussions sometimes felt forced.

Part 2b. Supplementary Evaluation Forms

Approximately two months after completing the online preparatory course, matched participants of the 2019 online mentorship program were asked to fill out a supplementary evaluation form. Four mentees and three mentors responded. For all respondents, their first mentoring session had taken place within the first two months. This was either via a video call (mentees n=2; mentors n=1), an audio call (mentees n=1; mentors n=1), or face-to-face (mentees n=1; mentors n=1).

Mentees

The quality of mentee-mentor matching was evaluated from (strongly) agree to (strongly) disagree in six questions by four mentees, with (strongly) agree as the most common answer (63%) followed by neutral (29%). Two mentees disagreed with the question that the online preparatory course changed the characteristics they based their list of preferred mentors on and that there was enough information available to compile their list of preferred mentors in an informed manner.

Following the questions about the quality of mentee-mentor matching, mentees were asked if their first mentoring session was satisfactory. This was evaluated from (strongly) agree (n=2), neutral (n=1), and (strongly) disagree (n=1). Half of the mentees had planned their next contact moment.

Answers to the open questions on the supplementary evaluation form showed that characteristics mentees found important when choosing their mentor were sufficient experience in research and/or clinic, common interests, friendliness, and approachability.

Mentors

Mentors' answers to four questions about the quality of mentee-mentor matching were divided, however, because only two participants responded to this question it is difficult to place value on this data. The areas where mentors disagreed were whether discussing their comfort zone as a mentor seemed relevant, the introduction movie or text made by their mentee was of added value, if they were satisfied with the mentee that was assigned to them, and if they were pleased by the way the moderator brought them into contact with their mentee.

Following the questions about the quality of mentee-mentor matching, mentors were asked if the information in the online course created added value to their mentoring session. The two mentor's answers were split between (strongly) agree and (strongly)

disagree, again making it difficult to draw conclusions from this data. However, one of the two mentors had planned a next contact moment with their mentee.

Answers to the open questions on the supplementary evaluation form mentioned that the matching process was adequate considering everyone was busy. When asked about their next mentoring session, the mentors commented that their mentee would be in contact whenever necessary or that they were in contact and were providing suitable activities to assist their career goals. One mentor added that they had an advantage because their mentee was based in the same institution.

Part 3. Recommendations for an Online Mentorship Program

Online follow-up survey results showed that out of the seven mentee and eight mentor respondents, three and two years after their respective online mentorship program, one mentee and one mentor were still in contact with their mentor or mentee. Six out of the seven mentees and all eight mentors thought mentorship could help their work within translational research, and all respondents thought an online mentorship program is feasible (Figure 7).

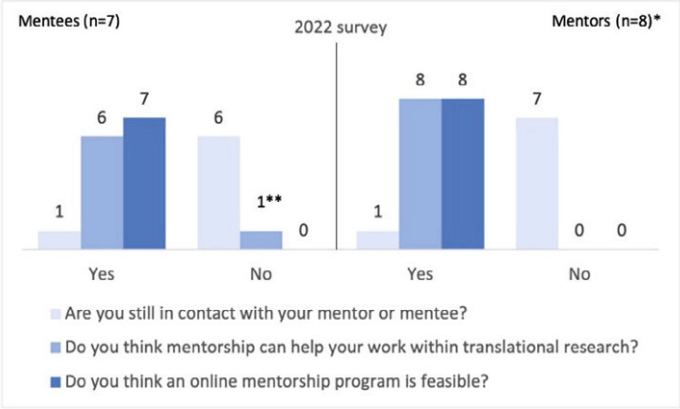

*Figure 7. Online follow-up survey results from 2022, three and two years after the 2019 and 2020 online mentorship programs, respectively. *1 mentor participated in both 2019 and 2020. ** This respondent said their profile did not fit the program as they were a basic scientist.*

Mentees

Out of the seven mentees from both the 2019 and 2020 online mentorship programs that responded to the online follow-up survey, one mentee was still in contact with their mentor. Their mentorship sessions took place virtually and bi-monthly. The other

six mentees were no longer in contact with their mentor and listed time constraints, including busy schedules and difficulties coordinating meeting times, as the main reason. This was followed by lack of commitment on their part and personal reasons.

Six mentees thought mentorship could help their work within translational research. They said that a mentor could provide them with different perspectives on problems, career guidance, and a greater network for future collaborations. The one mentee that answered no said that their profile did not fit this online mentorship program as they were a basic scientist.

All seven mentees thought an online mentorship program was feasible. They said it was practical, that it removed geographical restrictions and the need for expensive travel, which in turn saved time that could be used to prepare for the mentorship meeting. The mentees disclosed that if both mentors and mentees had the time to devote to the program, meeting online helped facilitate interaction between them. It was also noted, however, that meeting online could make it difficult to establish a more personal relationship to help the mentorship evolve into something more long-term. Mentees described this online mentorship program as easy to follow, however, that it could have more structured meeting times, which was part of the advice mentees gave about how to make an online mentorship program successful.

Mentees' advice included that an online mentorship program should have mandatory tutorials, fixed program evaluation checkpoints, and coordinated meeting times. The mentees also emphasized that an online mentorship program should provide a diverse mentor pool with multiple matching rounds to ensure personal rapport between mentee-mentor pairs, encourage both mentees and mentors to schedule meetings and make time for the program, and facilitate more online interactivity and live sessions.

Mentors

Out of the eight mentors from both the 2019 and 2020 online mentorship programs that responded to the online follow-up survey, one mentor was still in contact with their mentee. Their mentorship sessions took place virtually and bi-monthly. The other seven mentors were no longer in contact with their mentee and listed time constraints, including busy schedules and different time zones, no follow-up by them or their mentee, not having been matched with a mentee, and not being needed, as reasons for no longer being in contact.

All eight mentors stated that mentorship could help their work within translational research. They said that a mentorship program provided career advice and guidance by learning from and supporting each other within the multidisciplinary landscape of translational research, and that it could help them develop themselves as mentors. It could also help mentors identify and understand the needs of their mentees, especially in the broader context of helping them connect their training with the current job market. However, it was noted that commitment from both mentees and mentors was needed to make this work.

All eight mentors stated that an online mentorship program was feasible. They based this on their previous experiences with online mentoring, their experiences with online tools (such as Zoom or Teams) in facilitating online mentorship, and their belief that an online program saves travel time and overcomes geographical barriers. It was emphasized, however, that they preferred face-to-face mentorship because they thought it was more effective than online and mentioned that time zones needed to be compatible with frequent points of contact between mentees and mentors.

To make an online mentorship program successful, mentors advised that programs should include structure with clearly defined roles and responsibilities for mentees and mentors, and regular meeting schedules and events with the opportunity to meet in person at least once. They also mentioned the availability of reliable and easy to use online tools. Mentors advised providing a diverse mentee and mentor pool, partnering mentees and mentors from the same region to bypass time zones or professional differences, and clear instructions for mentees to take the lead in the mentee-mentor relationship to maintain contact with their mentor and update them on their progress.

DISCUSSION

The aim of this longitudinal exploratory mixed method study was to understand why mentees and mentors volunteered for the online mentorship program (their mentorship needs) (RQ 1). Analysis of the participants' reasons for joining revealed that both mentee and mentor translational scientists wanted to learn mentorship skills, receive and provide career support, and gain an (international) network. Additionally, this study assessed if the mentorship program met their needs (RQ 2) and collected recommendations for future iterations (RQ 3). While the overall feedback from the evaluations were positive, the most insightful information came from participants' feedback on how to improve the online preparatory course and overall mentorship program.

Translational Scientists' Reasons for Joining the Online Mentorship Program

When looking at the results more closely, it was clear that the translational scientists had a wide range of needs regarding a mentorship program. Most mentioned wanting to learn mentorship skills as one of their main reasons for joining. This included understanding more about mentee-mentor relationships, as well as self-development to help further their career goals within translational research. These findings aligned with those of Nearing et al. (2020), who found a gap in mentorship training specifically for mentees in clinical and translational research (13). While their study focused on the growth of skills in existing mentee-mentor pairs after following their mentorship program, the results from their pre- and post-evaluation survey found that both groups reported self-knowledge and goal setting as areas of growth, which our participants mentioned as reasons for joining our online mentorship program (13).

In addition to mentorship skills, our participants mentioned a need for career support and developing an (international) network. This included wanting to discuss their roles within the broader context of translational research, especially with other translational scientists from outside their own working environments. While our follow-up survey did not ask participants whether their mentorship needs listed at the beginning of the online mentorship program had been met, Nearing et al. (2020) showed positive growth for both mentees and mentors in these areas (13). Moreover, in a systematic review Kashiwagi et al. (2013) found that career development and networking were the most commonly named objectives in mentorship programs for physicians, and in their study Frei et al. (2010) reported career support in the form of career counseling as one of the main goals for medical student mentorship programs (9,17). In another systematic review on mentoring in academic medicine, Sambunjak et al. (2006) found that the influence of a mentor was an important factor for allocating time to research (18). According to McGinn et al. (2015) clinical and translational trainees were mostly interested in accessing their mentor's career expertise specifically related to research skills (e.g., research design and academic writing), and career support (e.g., providing constructive feedback and motivation) (19). However, their study did find that mentees reported less effective mentorship regarding career guidance and work-life balance, something our participants ranked both most and least popular in the mentorship topics matching exercise (19).

The inconclusive results from our ranking exercise accentuated the complexity of mentee and mentor needs. For instance, time management was ranked both most popular and least popular by mentees and even though mentors' reasons for joining included passing on their knowledge about careers for translational scientists, this

was not reflected in their ranking results. In a focus group study Keller et al. (2014) found that early-career translational scientist mentees were interested in discussing time management (e.g., balancing conflicting employer demands) and climbing the academic ladder towards becoming principal investigators (e.g., negotiating dedicated time and resources for research) (20). These mentees also described struggling to find career examples specific to their interests as their mentors often had different career paths, a point that was raised by our mentors when asked about their reasons for joining the online course (20). To solve this lack of career examples, many of the mentees from the Keller et al. (2014) study sought mentorship from multiple mentors to help bridge the unique clinical and scientific combinations of their translational work (20). McGinn et al. (2015) also found that having multiple mentors with different strengths, opposed to one-on-one mentorship, led to more effective mentoring (19). However, it was noted that a team mentoring approach also had its drawbacks, for instance, dealing with multiple mentorship styles and expectations (19).

General Feedback and Recommendations for an Online Mentorship Program

Online participation data showed a decrease in mentees and mentors for both years. This began between sign-up for the online mentorship program, logging into the online preparatory course, and continued to decline through the duration of the mentorship program. According to a case study on the factors that influence participation in online graduate courses by Vonderwell & Zachariah (2005), participation was often affected by technological factors (e.g., user-friendliness), assigned participant roles and tasks, participants' online presence, the behavior of the group as a whole, prior experience with the course content, and information overload (21). It was unclear from our data set which factors contributed to this decline, however, according to our data from mentors who signed up for the mentorship program in 2019 but who did not start the online course, and our participants' feedback from the follow-up survey on reasons for no longer being in contact with their mentor or mentee, time constraints may have been the underlying cause. Additionally, both mentees and mentors indicated a need for long-term program moderation in order to help sustain the mentee-mentor relationship and encourage their continued commitment. This structured approach may help mentee-mentor duo's overcome time constraints, which may have been enhanced by the clinical demands of the COVID-19 pandemic on our participants. Another factor contributing to time constrains could be departmental priorities our participants had to adhere to. If mentorship programs would be prioritized at an institutional level, time for participation could be factored into translational scientists' work schedules.

The participants that completed the online preparatory course and filled in the evaluation forms, were mostly positive about the need and use for mentorship training, the quality of the online course's structural elements, and the quality of mentee-mentor matching. However, there were also participants who (strongly) disagreed about these same points, making it difficult to draw conclusions from this small sample size.

One of the unique features of our online mentorship program was the mentee-mentor matching process. In their systematic review, Kashiwagi et al. (2013) described two ways of mentee-mentor matching, the most common being matching by an external party and the other allowing the mentee to choose their mentor(s) (9). In our online mentorship program, we opted for mentee driven matching informed by compatible ranking results of potential mentorship discussion topics. Our mentees disclosed that biographical information (sufficient experience in research or clinic and common interests) and personality traits (friendliness and approachability) were important characteristics for choosing their mentor. However, we know from the follow-up survey, three years later, that these choices did not lead to long-term mentorship. There could be a variety of reasons for this, such as incongruent personalities, as well as changes in the professional needs of mentees or mentors. Therefore, an online mentorship program should provide un-matching and re-matching possibilities to meet these changing needs and to ensure optimal compatibility.

In a systematic review on mentoring relationships between physicians, Sng et al. (2017) summarized mentor characteristics important to mentees (22). These were professional experience, professional support, and network connections, as well as trustworthiness, approachability, ability to connect, and emotional support (22). In their study regarding competencies for clinical and translational mentorship, Abedin et al. (2012) identified communication and relation management, psychosocial support, career and professional development, and professional enculturation and scientific integrity as mentor competencies and skill sets important to mentees (23). Conversely, characteristics important to mentors regarding mentees were exhibiting ownership, showing initiative, responsibility, open minded, and respectful (23). All of these features were identified by our mentees and mentors as important characteristics they were looking for in a mentorship match and when making recommendations for future matching processes, which also included time zone and geographical compatibility, mandatory program follow-ups, and clearly defined roles.

When asked about participants' most liked element of the online preparatory course, task-related online peer-to-peer group discussions were universally identified by mentees and mentors of both years. Topics for these discussions ranged from good mentoring

practices and mentoring pitfalls to mentees' position in the research world (see Figures 3 and 4). In their study on student engagement in asynchronous online courses, Morris et al. (2005) found a correlation between online participation in group discussions and successful online learning (24). Ozkara & Cakir (2018) confirmed that a lack of online interaction led to drop-out in their study on the students' perspective of online courses (25). However, Poole (2000) found that given the option for synchronous online group discussions, students preferred time-independent options (26). Our findings indicate that participants expressed interest in both synchronous and asynchronous engagement and emphasized the critical role of online tools to achieve success in future courses. While our participants provided feedback for enhancing the online course, it is worth noting that certain recommendations conflicted with one another. For instance, participants requested fewer emails while simultaneous requesting more reminders. This inconsistent feedback echoed the findings of Tan et al. (2018) who found a need for both flexibility and structure in their thematic analysis of medical mentoring programs, and highlighted that participants, particularly translational scientists, may have different needs when it comes to online mentorship training (27).

Our study revealed that only one mentee and one mentor from 2020 were still in contact, however, it is unclear whether they were a matched pair. We do not know whether this same outcome would be seen post COVID-19 pandemic, with the normalization of online education. What our findings can tell us though is that a personal connection is necessary to make online mentorship effective and that online mentorship is perceived as less effective than face-to-face mentoring. However, Rogers et al. (2022) found no significant differences of perceived training outcomes when comparing the effectiveness of synchronous online and face-to-face mentor training (28). Fornari et al. (2014) described reasons for the dissolution of randomly assigned mentee-mentor pairings across medical schools (29). These included poor communication and personality differences and suggested that allowing mentees to choose their mentor could lead to more favorable outcomes (29). Conversely, Straus et al. (2013) identified key factors contributing to successful mentee-mentor relationships, including mutual respect and reciprocity, clear expectations, and personal connections based on shared values (30). Alternatively, failed relationships were found to be caused by poor communication, personality differences, lack of commitment, lack of experience, and perceived or actual competition or conflicts of interest (30). In another study, Limeri et al. (2019) identified seven categories of negative mentoring experiences in undergraduate life science researchers: mentor absenteeism, unequal treatment, abuse of power, misaligned expectations, lack of psychosocial support, lack of career support, and interpersonal mismatch (31). This was mirrored in an exploratory interview study by Tuma et al. (2021) who found negative mentoring experiences in doctoral life sciences

students ranging from interpersonal differences and poor relationship quality to issues at the research group, departmental, organizational, and discipline levels (32).

The limited data from our study makes it difficult to draw conclusions about why or why not our mentees and mentors were no longer in contact. However, what the data does suggest, alongside previous research, is that the matching process should be approached from both the mentees' and mentors' perspectives. Although most of our participants did not maintain a long-term mentoring relationship, all respondents acknowledged that mentorship could aid their work in translational research through the development of mentorship skills, career support, and networking. Moreover, studies have shown that mentors of undergraduate life sciences students significantly outperformed non-mentors in critical thinking skills (33). Furthermore, our study found that an online mentorship program is practical and an effective means of facilitating interaction, which can overcome barriers of time and location.

Recommendations

From our study we know that one size may not fit all, however, we hereby share some recommendations for future online mentorship program designs based on our participants' input and secondary literature.

1. **Interactive online preparatory training for both mentees and mentors**
   Exact online course structure and components should be determined according to the target group's needs but should include synchronous and asynchronous task-related group discussions to encourage online participation.

2. **Multiple mentee-mentor matching rounds and moments**
   This should include un-matching and re-matching possibilities according to mentees' and mentors' needs per career stage and to help ensure a good personality match. Mentors should also receive acknowledgement for their invested time to help retain them in the mentor pool, especially when not currently matched with a mentee.

3. **Time zone and geographical compatibility in mentee-mentor pairs**
   This is recommended for logistical purposes (scheduling meetings), to help create opportunities to meet offline, and to promote professional and cultural understanding in order to strengthen the mentee-mentor relationship.

4. **Active program moderation and community building**
   After online preparatory training and matching, fixed check-in points should be

organized by a moderator or program manager to stimulate continued contact. Additionally, offline community building events should be organized to enhance the mentee-mentor bond and grow the whole group's (international) network.

5. **Easy to use online tools**
   In the age of generative AI and post-COVID-19 online work flexibility and education, it is important to consider that the online tools used should facilitate not only online meetings, but also pre-meeting preparations and post-meeting reflections to make the mentorship process more efficient and to enhance the experience for all users.

Limitations

One of the potential limitations of this study was that the seven mentorship topics of the ranking exercise were provided during the online preparatory course and were open to interpretation. Therefore, participants' answers could not be categorized into overarching themes to provide conclusive statements about their preferred mentorship topics. To be able to use such a ranking exercise to draw conclusions from, provided topics should be well defined or left open for participants to fill out themselves. The ranking exercise for our online mentorship program was mainly used to facilitate mentee-mentor compatible matches and not for conclusive statements about preferred topics. Additionally, to be able to offer all mentees a mentor of their choice, mentees were informed which mentors had corresponding ranking results but were free to choose from the entire mentor pool. This led to some mentors being chosen who had not received the preparatory training and some mentors who had completed the training to not be matched with a mentee. It would have been preferable for all mentors who had taken the time to complete the online course to either have been matched or to have received some form of certification to acknowledge their learning achievements that qualify them as future mentors.

For this study, participation data from 2020 was missing, therefore, it was difficult to formulate a complete picture of the participation drop-out trend. In addition, we were also missing online course evaluation forms from the 2020 mentors and supplementary evaluation forms from 2020. Participation data and evaluation forms should be collected from all participant groups at multiple time points to gather valuable information about how participants experienced the mentorship program. Finally, we collected follow-up survey data from fifteen out of a possible forty-three participants. To be able to make more robust conclusions about the feasibility of an online mentorship program, more data should be collected.

CONCLUSIONS

This study revealed the challenges of mentorship for translational scientists. Although both programs did not result in long-term mentorship, participants had positive experiences and deemed online mentorship useful. The innovative PATHWAY program's online format, mentee-driven matching, and preparatory training for both mentees and mentors contribute to the development of mentorship for the translational community that could potentially have broader applications in the future, especially in a post-COVID-19 online world. The aim of the PATHWAY Project was to support translational scientists' career development beyond the project's lifetime, offering online training and matching tools for mentees and mentors that can be applied in other mentorship programs and their careers. Additionally, the project aimed to provide career support and an (international) network for translational scientists, this need was confirmed by participants as their reasons for joining the mentorship program.

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Appendix I

Online preparatory course design of the PATHWAY online mentorship program.

Course Design Title Learning Unit	Title Learning Activity	Required?	Learning Objective(s)	Description	Developer	Peer Interaction?	Duration	Total time
1. Introduction to the Mentorship Program	1.1 Let's get started!	Yes	[2/3min introductory video]	Watch	UMCU	Yes	5	
	1.2 About the course	Yes	To be able to explain the structure of the mentorship program by reading the handbook for mentees and mentors provided by the PATHWAY Project and to understand the main objectives of this preparatory online course	Read	UMCU	Yes	10	
	1.3 What do you expect?	Yes	To outline what they expect from the mentorship program both in terms of content as well as practical issues	To do/ Discuss	UMCU	Yes	10	25 min
2. Theory on Mentorship	2.1 Mentoring 101	Yes	To be able to reproduce the key aspects of mentorship taught in this preparatory online course	All	UMCU	Yes	60	
	2.2 Digging deeper	Yes						
	2.2a What you are looking for? (for mentees)	Yes	To identify what they are looking for in a mentor and to list the global topics they would like to discuss with a mentor	To do/ Discuss	UMCU	Yes	10	
	2.2b What kind of mentor are you? (for mentors)	Yes	To outline what kind of mentor they are	To do/ Discuss	UMCU	Yes	10	
	2.3 Mentoring pitfalls (for mentees and mentors)	Yes	To identify mentoring pitfalls by listening to 5x2/3min podcasts by Eureka alumni and other mentees	Listen/ Discuss	UMCU	Yes	15	85 min

Course Design Title Learning Unit	Title Learning Activity	Required?	Learning Objective(s)	Description	Developer	Peer Interaction?	Duration	Total time
3a. Being the best Clinician-Scientist you can be	3.1 Your idea of a successful clinician-scientist	Yes	To formulate what they define as a successful clinician-scientist	To do/ Discuss	UGhent	Yes	15	
	3.2 Meet-The-Expert	Yes	[5x2/3min videos of different translational medicine experts]	Watch	UGhent	Yes	15	
	3.3 Looking inward	Yes	To point out personal strengths and weaknesses in relation to characteristics of a successful clinician-scientist	To do	UGhent	No	30	
	3.4 Opening up	Yes	To discuss a personal pitfall with fellow mentees and to advise a fellow mentee on how to improve his/her personal pitfall (To prepare which personal pitfall(s) they would like to discuss with a mentor)	Discuss	UGhent	Yes	15	75 min
3b. Being the best Life-Scientist you can be	3.1 Your idea of a successful life-scientist	Yes	To formulate what they define as a successful life-scientist	To do/ Discuss	UGhent	Yes	15	
	3.2 Meet-The-Expert	Yes	[5x2/3min videos of different translational medicine experts]	Watch	UGhent	Yes	15	
	3.3 Looking inward	Yes	To point out personal strengths and weaknesses in relation to characteristics of a successful life-scientist	To do	UGhent	No	30	
	3.4 Opening up	Yes	To discuss a personal pitfall with fellow mentees and to advise a fellow mentee on how to improve his/her personal pitfall (To prepare which personal pitfall(s) they would like to discuss with a mentor)	Discuss	UGhent	Yes	15	75 min
4. 21st Century Skills	4.1 The world we live in today	Yes	To list commonly required 21st century skills	All	UGhent	Yes	60	
	4.2 Your own professional bucket list	Yes	To categorize a professional bucket list and to plan how they could go about fulfilling this bucket list and where/when they would need advice from a mentor	To do/ Discuss	UGhent	Yes	15	75 min

Course Design Title Learning Unit	Title Learning Activity	Required?	Learning Objective(s)	Description	Developer	Peer Interaction?	Duration	Total time
5. Career Pathways	5.1 Your position in the research world	Yes	To recognize different career pathways within translational medicine	Read/To do	UMCU	Yes	30	
	5.2 Your individual career pathway	Yes	To outline their own individual career pathway so far as detailed as possible and to draw up their future career plan (especially the upcoming next step(s)) and what obstacles and action points they would like to discuss with a mentor	To do	UMCU	No	30	60 min
6. Program Kick-off	6.1 Reflect on your initial expectations	Yes	To contemplate on previous answers and thoughts during this course: What did you learn? Do you reconsider initial views and opinions?	Read/To do	UGhent	No	15	
	6.2 Introduce yourself to your future mentor	Yes	[2/3min introductory video]	To do	UGhent	No	15	
	6.3 Matching questions	Yes	[Individual matching questionnaire]	To do	UGhent	No	5	
	6.4 Choose your mentor	Yes	To select an appropriate mentor and to distinguish an appropriate mentee/mentor match	To do	UGhent	No	30	65 or 35 min
	6.5 Start of the mentorship program	Yes	To apply what has been learned during mentoring sessions	To do	UGhent	No	N/A	
7. Online Mentorship Portfolio	7.1 Timetable	Yes	[To record mentoring sessions in]					
	7.2 Online mentorship portfolio	Yes	[Online portfolio only accessible for mentee]					
	7.3 Program evaluation	Yes	[Evaluation of pilot per cohort by PATHWAY Project team]					

Appendix II

Online follow-up survey questions.

1. When did you participate in the Eureka Online Mentorship Program? 2019/2020
2. Did you participate as a Mentee or Mentor? Mentee/Mentor
3. Are you still in contact with your Mentor or Mentee?
   If Yes; How often? Online or offline?
   If No; Why not?
4. Do you think mentorship can help your work within Translational Research?
   If Yes; How?
   If No; Why not?
5. Do you think an Online Mentorship Program is feasible?
   If Yes; Why?
   If No; Why not?
6. What is needed in your opinion to make an Online Mentorship Program successful?

Appendix III

Example online course evaluation form for mentees and mentors of both the 2019 and 2020 pilots.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1. I felt the need to have a mentor before I heard about this pilot					
2. I felt the need for training on mentorship before starting this online course					
3. The learning objectives of the online course and its learning units were clear					
4. The online training activities were relevant to the learning objectives					
5. The online course was well structured					
6. The online materials offered during the online course were clear and useful for the different online training activities					
7. The online assignments were clearly explained					
8. The online assignments were fit for online group discussion					
9. Online group discussion gave added value to the online course					
10. The length and pace of the online course were appropriate					
11. After this online training, I will be able to improve the way I do my current job					
12. This online training was relevant to my professional growth and development					
13. After this online training, I think I can maintain a better atmosphere in my job					
14. After this online training, I think I can maintain a better personal and social atmosphere					
15. This online training improved my confidence and commitment					
16. The online course met my expectations					
17. The online course was well managed					
18. The moderator significantly contributed to achieving the online course learning objectives					
19. What did you most like about the online course?					
20. Where there any content-related topics you missed in the online course?					
21. What could be improved regarding the general aspects, logistics, and organization of the online course?					

Appendix IV

Example supplementary evaluation form for mentees and mentors of both the 2019 and 2020 pilots.

FOR MENTEES	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1. Taking into account the whole mentor pool, there was enough variation in background and type of mentor to choose from					
2. The online course changed the characteristics on which I have based my list of preferred mentors					
3. There was enough information available to compile my list of preferred mentors in an informed manner					
4. I was satisfied with the mentor that was assigned to me					
5. I was pleased by the way the moderator put me in touch with my mentor					
6. I have used the tips from the online course for this first contact					
7. The first mentoring session was satisfactory to me					
8. We have already planned a next contact moment					
9. Which characteristics did you find important when choosing your mentor?					
10. Do you have any remarks on the mentee-mentor matching process?					

FOR MENTORS	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1. The questions regarding my comfort zone as a mentor seemed relevant to me					
2. The introduction movie/text made by my mentee was an added value to me					
3. I was satisfied with the mentee that was assigned to me					
4. I was pleased by the way the moderator put me in touch with my mentee					
5. Do you have any remarks on the mentee-mentor matching process?					
6. What could be improved regarding the communication and logistics around introducing the mentor and mentee?					
7. The information in the online course created added value to the mentoring session					
8. This first mentoring session was satisfactory to me					
9. We have already planned a next contact moment					
10. Only if you have already had a first mentoring session, but you will not plan a second: What is the reason?					

CHAPTER 4.2

PATHWAY Project – Mentorship Program Implementation Handbook

Publication Status

The EU Erasmus+ funded PATHWAY Project's mentorship program material is available upon request.

Author Contributions

All PATHWAY Project team members contributed to the mentorship program material.

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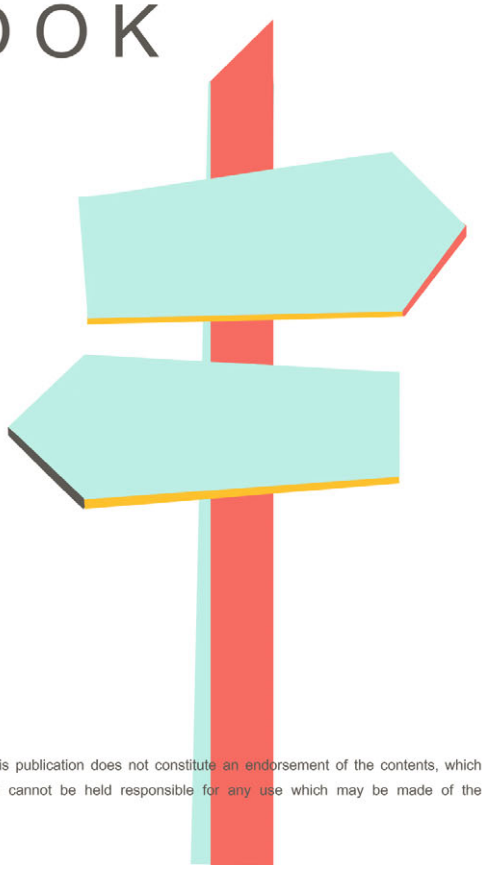
PATHWAY PROJECT

INTERNATIONAL CAREER PATHWAYS AND ONLINE CURRICULUM FOR TRANSLATIONAL SCIENTISTS

MENTORSHIP PROGRAM IMPLEMENTATION HANDBOOK



Erasmus+

INDEX

CHAPTER 1: INTRODUCTION

A. BACKGROUND INFORMATION ON THE PATHWAY PROGRAM

It is broadly agreed that current translational medicine fails to sufficiently bridge the gap between bench and bedside. This results in tremendous waste in research investments and numerous biomedical innovations that never reach patients.

There is general consensus that clinician-scientists hold the key to bridge this gap. However, their numbers seem to be declining due to failure to attract and retain them in the academic workforce. To this end the **PATHWAY Project** was started (www.pathwayproject.eu).

After being granted an Erasmus+ fund, its initial **objectives** included:

- Creating efficient, sustainable, and attractive career pathways for the advancement of translational medicine;
- Innovating extracurricular education to provide tools to successfully transverse the complicated (bio)medical landscape;
- Generating impact by raising awareness amongst all stakeholders throughout Europe about the added value of this project.

When designing deliverables to achieve these objectives, the PATHWAY Project team quickly discovered that the key to this complex problem is not to focus on clinician-scientists solely, but to appreciate the interdisciplinary environment they work in and include other life-scientists in some of the building blocks as well.

A major international problem PATHWAY wants to tackle, is the difficulty to attract and retain clinician-scientists in academia. In the experience of the different PATHWAY partners, a lot of young medical students and doctors are enthusiastic about research and translational medicine. However, several factors make it difficult for them to perform it in practice. High clinical demands and limited time, poor training on research during MD degrees, legal and administrative difficulties, difficult relationships between hospitals and universities, lower salary expectancies, and more employment uncertainty in research than in clinical practice are just some factors that are drawing MDs away from research. Policy changes should be made to structurally tackle these issues.

In the meantime, good guidance for enthusiastic students, PhD candidates, and early-career clinician-scientists is key and could contribute to the solution. A more experienced scientist, assigned as a personal mentor, is well equipped to perform this function.

Keeping this in mind, a mentorship program for translational scientists (clinician-scientists and other life-scientists together) was developed as part of the PATHWAY Project. The goal of this program was not solely to bring mentees and mentors together, but also to create an environment that augments chances of successful partnership. To do so, the matching of mentees and mentors was preceded by an online course to prepare both mentee and mentor for their role.

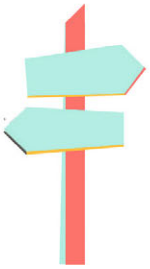
More information about the set-up of this mentorship program, including the online preparatory course, can be found at www.pathwayproject.eu/intellectual-outputs/.

B. INTRODUCTION TO THE IMPLEMENTATION HANDBOOK

This implementation handbook aims to guide institutions that want to offer an adapted version of the PATHWAY mentorship program to their students. As every context is different, it is not always possible or desirable to make an exact copy. The following chapters will discuss every part of the development of the PATHWAY program and will provide you with handholds for the development of your own project. The primary aim of this handbook is to serve as a guide for the development of new mentorship programs in other institutions, but it could also be used to evaluate existing programs.

In this handbook, different stages of the development process are discussed. The same scheme will be used throughout this handbook. Each chapter starts with an introduction to the development phase with the PATHWAY program as an example and concludes with an implementation checklist.

Further information regarding this project can be found on the website:
www. pathwayproject.eu



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CHAPTER 2: SETTING THE CONTEXT

To be relevant and durable, your mentorship program must fit its specific context. Whether the mentoring is part of a formal academic program, a summer school, or a voluntary stand-alone program, might influence its set-up. Several aspects must be thought trough in this first design phase.

First of all, the goals of your program must be determined. What do you want to achieve for the participants? When will you consider your program to be successful? Whether you want to make young students curious about translational research or you want to support PhD applicants during their PhD track, will influence all following steps of the design process. It is important to clarify this completely before going further. Keep this goal in mind throughout the entire development process and make sure it is clear for the whole development team.

When you have set your goals, your target audience should be determined. Who will be eligible to enroll as a mentee in the mentorship program? In some settings, this question will be very easily answered, in others it might require some debate. In the case that the target audience is predefined due to a specific context, the program goals must be defined accordingly.

Guiding questions to help determine your target audience:

- Who does your program target? (e.g., first year medical students, students interested in research, high achieving students, PhD students, postdocs, etc.)
- Is prior knowledge or a certain educational level required?
- Are there certain limitations for enrolment? (e.g., age, geographical area, participants not affiliated to your institution, etc.)
- Is participation in this program obligatory or voluntary?
- Does a mentee or mentor benefit from participating in this program?

Guiding questions about potential mentors:

- Who is eligible to act as a mentor in this program?
- Amongst whom could you recruit mentors?
- Is mentoring obligatory or voluntary?
- Do mentors need a certain background or training?

To conclude this phase, the rough outlines of your program must be defined. The setting in which it will exist is key in doing this. Consider at least the following questions:

- Need for preparation by mentees and/or mentors?
- One-on-one mentoring or meetings in (fixed) groups?
- Are mentees assigned a mentor or do they get to choose?
- Planning of meetings at fixed moments or free to choose?
- Set end date or duration of the program?
- Possibility to change mentor in case of a mismatch?

The **PATHWAY Project** was initiated to attract and retain clinician-scientists in translational science. The mentorship program plays an important role in this and aims to support early-career translational scientists. Mentees are voluntarily recruited amongst participants of the Eureka summer school 'Translational Medicine: Doing the Right Research Right' as it targets the same audience as the PATHWAY Project. The Eureka institute is a non-profit organization, its mission is to develop a community of translational medicine professionals equipped to inspire and catalyze the application of discoveries for the benefit of human health.

Mentors are recruited on a voluntary basis amongst Eureka alumni. We considered this a great source of mentors as they are all interested and experienced in translational science.

Our program starts with a preparatory online course, for both mentees and mentors, followed by one-on-one mentoring sessions organized on own initiative. The program ends when mentees or mentors indicate that the relationship has no further advantage for them.

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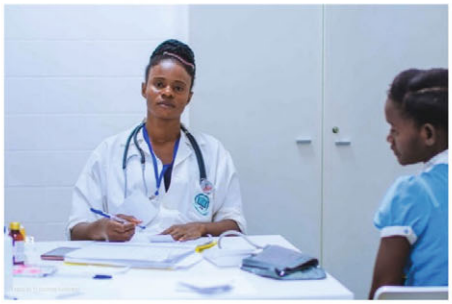
Implementation Checklist

- ☐ Overarching goal of the mentorship program?
- ☐ How will possible mentees be recruited?
- ☐ How will possible mentors be recruited?
- ☐ Rough outline of the program determined?

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CHAPTER 3: DESIGN PHASE

This phase will probably take the most time. You will determine every aspect of the mentorship program, but always within the outlines you previously defined. In the following paragraphs we will highlight some important aspects to consider while doing so. However, as the aims and the context of your program might differ, possibly not all topics will be covered, and some topics could be less interesting for you.

Preparation before start of mentorship program

To start with, you must decide whether you want to prepare your mentees and/or mentors for their mentorship relation or if you will just match them and let them go. Preparation could take various forms and intensities (e.g., online course, introduction video, talk with a coordinator, etc.). Before you start choosing your preparatory activities, it is important to define their goals based on the needs. The content will follow from this. In this handbook, we will not go deeper into the content development of the preparatory materials.

In case you choose not to prepare your participants, think about other ways to ensure quality in your program. There are many options to do so, use your creativity (e.g., strict selection of mentors, more materials to guide them through the mentoring, mandatory follow-ups, etc.).

Organization of meetings

How will the mentorship meetings take place (e.g., F2F, online, over the phone, etc.)? Does this format require preparation? Online meetings for example require a communication medium, do participants choose this themselves? Do specific rules on this matter apply at your institute? If so, make sure to inform the participants. Face-to-face meetings in groups might require a meeting room, who is responsible for the reservation?

Discussion topics

Are discussion topics for the mentee-mentor meetings predetermined or freely chosen by either the mentee or mentor? Make sure this is clearly communicated to the participants. If you chose to have set topics during meetings, this is the moment to work them out. We will not go into detail about the choice of possible topics but remember to always keep the goal of your program in mind when working on this.

Mentee - Mentor matching

A good mentee-mentor match is key for the success of a mentoring relationship. For this reason, it is important to think about how you will match mentees to their mentor. Are mentees able to give preferences? Do mentors choose their own mentees? Are mentees and mentors matched with similar or complementary backgrounds?

Back-office

There will always be questions or problems while the program is running. Make sure you have a (team of) dedicated people to solve these issues. Make sure all participants know where they can ask for help. A well-working back-office is key to keep your program going.

The aspects mentioned above should be thought out during the development of every mentorship program. However, many other aspects should be considered depending on the specific design of your program. The more a program is regulated by the organizers, the more preparation will be needed.

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For the **PATHWAY mentorship program**, we chose to let all mentees and preferably all mentors follow a preparatory online course. Its main goal is to maximize the chances for fruitful mentoring. The online course is run on the Elevate platform, a private platform that develops e-learning solutions for Health and Life Sciences. The preparatory online course guides the mentees and mentors through the theory of good mentoring and provides opportunities for personal reflection and group discussion on a broad array of topics related to translational research and their career pathways. The content of the preparatory course was determined by a team of clinician-scientists and experts in education and mentoring. As such we tried to touch on topics relevant for the translational scientist and to fill their unmet need. Mentees are also encouraged to point out topics they would like to discuss with their mentors, why do they want a mentor and what do they want to get out if this relationship? On the other hand, the preparatory course is meant to facilitate mentee-mentor matching. Both parties get the opportunity to indicate topics they would like to discuss and topics they feel comfortable talking about/giving advice on.

We decided to allow mentors who did not follow the preparatory course into our program. As the mentors are recruited from Eureka alumni, we feel comfortable that they have the background knowledge and capacities for high quality mentoring.

In the PATHWAY mentorship program, the matching is done by the back-office personnel based on preferences indicated by the mentee, after reading mentor biographies and the topics they felt comfortable discussing. The matching procedure is part of the preparatory online course.

Because the participants of our mentorship program come from around the world, we chose to give free choice for the meeting medium. We observed that some decided to meet face-to-face, while others organized Zoom or Skype meetings. Topics, nor frequency of the meetings are predefined. Although mentees are encouraged to raise topics that came up during the online course, this is not mandatory nor controlled.

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Implementation Checklist

- ☐ Preparation for mentees?
- ☐ Preparation for mentors?
- ☐ Quality assurance?
- ☐ Technical support for meetings?
- ☐ Content of the meetings?
- ☐ Matching procedure?

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CHAPTER 4: START OF THE MENTORSHIP PROGRAM

Before the kick-off, go through the whole program yourself to detect possible issues and last-minute mistakes. Have you thought about potential problems? Are all (technical) issues resolved?

A couple of weeks before the start of the program, inform your participants about what they can expect from the program. Most importantly, what is the expected workload. Clearly communicate this to the participants so they can plan. Before the start of the program, when you are sure it will start as planned, update the participants with more specific information about any preparations that must be made. Preferably you always use the same email address for program-related communication. When different people take care of these back-office tasks, it is best to create a dedicated, shared address for them.

The back-office stays very important during the program, make sure there is always a dedicated person available for questions or problems from mentees or mentors. Make sure contact information is easily accessible for participants.

Depending on the format of your program, mentee- mentor matching will either be done before or after kick-off. When done during the program itself, make sure you have a plan on how to do the matching and communicate when the participants may expect the result. Inform the participants on how they will be put in touch with their mentor/ mentee and what is expected of them afterwards.

For the **PATHWAY mentorship program**, we communicated workload and general information a couple of weeks before the start of the preparatory online course and sent specific information on the course some days before the start. During the online course, the moderator was responsible for answering questions and dealing with any problems. Matching was done by the moderator and other members of the PATHWAY team, after the course had ended. The moderator sent an email to each mentor introducing them to their mentee. [13]

In this email, a short introduction movie by the mentee was attached, which they made during the online preparatory course.

After this introduction, it was up to the mentees and mentors to arrange meetings and choose discussion topics. However, as mentioned before, we did encourage them to use the assignments from the online course as starting point for the meetings. If they chose to do so, they could use their professional development portfolio (free to download from the PATHWAY website: https://pathwayproject.eu/intellectual-outputs/) which holds an overview of all reflections made during the course. The portfolio also offers the possibility to write a summary or reflection after each mentoring session.

Implementation Checklist

- ☐ No more technical problems?
- ☐ Back-office
- ☐ How / When to contact participants?
- ☐ Communication after mentee-mentor matching

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CHAPTER 5: EVALUATION

In order to keep an eye on your mentees and mentors, but equally important to keep improving the program, it is important to perform evaluations. Depending on the goal of the evaluation this can be done in a personalized or anonymous way. Inform all participants beforehand that they are expected to fill out evaluation forms on a regular basis. Clearly state the aim of the evaluations and clarify how the results will be used.

In the mentorship program of the **PATHWAY Project** all participants, both mentees and mentors, are asked to fill out an evaluation form one week after the end of the online course, which is also the moment of mentee-mentor matching. This evaluation focusses on the experiences during the online course, satisfaction about the matching procedure, and communication afterwards. Another questionnaire is sent three months after the matching procedure to see whether mentees and mentors have already been in touch, whether they were satisfied with the contact, etc.

These evaluations are filled out on the same platform as the online course. As this works with personal credentials, all results are coupled to the respondent but are stored privately.

Implementation Checklist

- ☐ Evaluation survey?
- ☐ Platform for evaluation?
- ☐ Communication about evaluation

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CHAPTER 6: SUSTAINABILITY

Right from the start it is important to think about a long-term plan to guarantee a long life for your mentorship program. In some settings, for example if mentorship is part of an educational program, this can be very straightforward. In other situations, however, it might take some more brainstorming and planning to create a sustainable business model. If needed, also think about ways to finance your program now and in the future.

We decided to attach the **PATHWAY Project**, with the mentorship program, to the Eureka institute. The mission of this organization is closely related to ours. Linking this project to an existing organization with a dedicated staff guarantees continuation of the program after the end of our ERASMUS+ funding.

Implementation Checklist

- ☐ Responsible for the program long-term?
- ☐ Financing?

CHAPTER 7: IMPLEMENTATION IN OWN SETTING

Running a mentoring program is never completely straightforward. There are always issues that need to be resolved by the program managers that may be difficult to predict. It is important for program managers to brainstorm what those issues might be before the program begins and to decide what should be done to resolve these issues.

Below we have listed some examples of situations to consider and discuss before the start of the program. These are all common issues that will need action from a program manager to help smooth things over.

What if...

- ... a mentee wants a second mentor or wants to change their mentor?
- ... one of your mentees has trouble contacting their mentor?
- ... too many mentees joined compared to the number of available mentors?
- ... mentees joined the program outside of the suggested timeframe?
  ... expectations are not met during the mentoring sessions?
- ...

One of the situations we thought we might encounter during the mentorship program of the **PATHWAY Project** was a mentee or mentor who did not participate in the preparatory online course due to e.g., time constraints. Would we let them start the mentorship program or not?

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We decided to keep the course open longer and to encourage all participants to follow and finish the online course. As we were unsure about the number of dedicated mentors we would have, we decided to make an exception and to allow mentoring by mentors who didn't follow the online course. We know they are all Eureka alumni and thus could expect a certain background in mentoring. However, we would encourage them to take the course the year afterwards.

The aspects mentioned above should be thought out during the development of every mentorship program. However, many other aspects should be considered depending on the specific design of your program. The more a program is regulated by the organizers, the more preparation will be needed.

COLOPHON

This Mentorship Program Implementation Handbook has been compiled in accordance with PATHWAY Project approved Intellectual Output 6 and was written for the kick-off of the online PATHWAY Mentorship Program.

The information gathered in this Mentorship Program Implementation Handbook is to be disseminated for use by other (online) mentorship programs after the lifetime of this project. We welcome any feedback and suggestions to improve the content or the structure of this portfolio via the email address below.

Email: info@pathwayproject.eu

PATHWAY Partners

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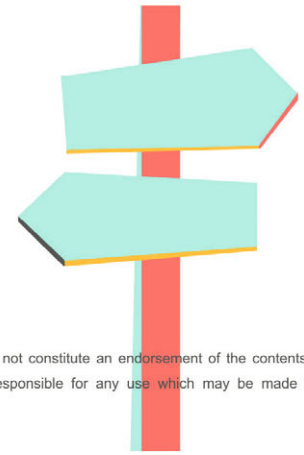

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CHAPTER 4.3

PATHWAY Project – Handbook for Mentees and Mentors

Publication Status

The EU Erasmus+ funded PATHWAY Project's mentorship program material is available upon request.

Author Contributions

All PATHWAY Project team members contributed to the mentorship program material.

- University Medical Center Utrecht: Prof. dr. Berent Prakken, Prof. dr. Olle ten Cate, Prof. dr. Annet van Royen, Dr. Margot Weggemans, Nadine Nonnekes, and Farah Kools
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Acknowledgements

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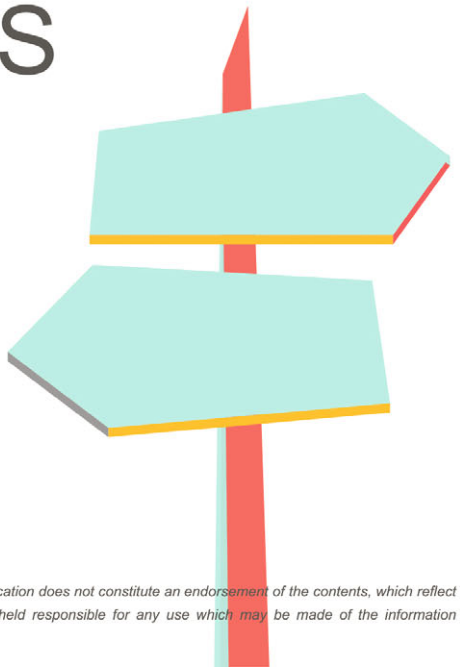
PATHWAY PROJECT

INTERNATIONAL CAREER PATHWAYS AND ONLINE CURRICULUM FOR TRANSLATIONAL SCIENTISTS

HANDBOOK FOR MENTEES AND MENTORS



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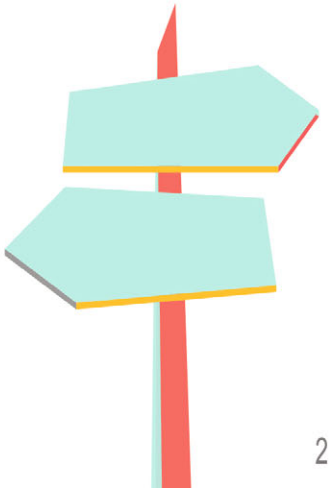
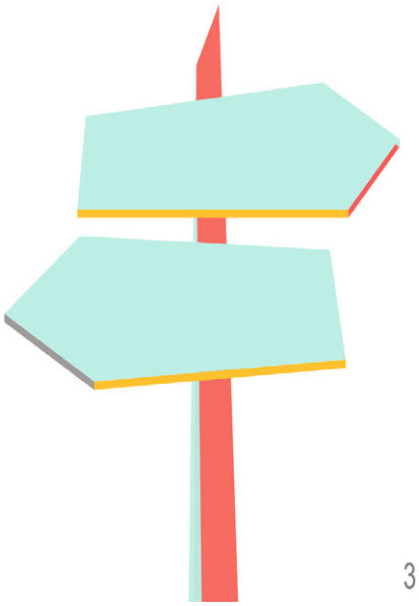


CHAPTER 1

INTRODUCTION



BACKGROUND INFORMATION

It is broadly agreed that current translational medicine fails to sufficiently bridge the gap between bench and bedside. This results in tremendous waste in research investments and numerous biomedical innovations that never reach patients. There is general consensus that clinician-scientists hold the key to bridge this gap, however their numbers seem to be declining due to failure to attract and retain them in the academic workforce. To this end the PATHWAY Project was started (www.pathwayproject.eu).

After being granted an **Erasmus+** fund, its initial objectives included:

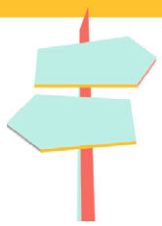
- Creating efficient, sustainable, and attractive career pathways for the advancement of translational medicine;
- Innovating extracurricular education to provide tools to successfully transverse the complicated (bio)medical landscape;
- Generating impact by raising awareness amongst all stakeholders throughout Europe about the added value of this project.

When designing deliverables to achieve these objectives the PATHWAY Project team quickly discovered that the key to this complex problem is not to focus on clinician-scientists solely, but to appreciate the interdisciplinary environment they work in and include other life-scientists in some of the building blocks as well.

Thus, it was decided that the mentorship program should be open to a mix of participants from the clinical and research world in order to foster fruitful working relationships and together work towards the advancement of translational medicine.

Further information regarding this project can be found at:

www.pathwayproject.eu



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INTRODUCTION

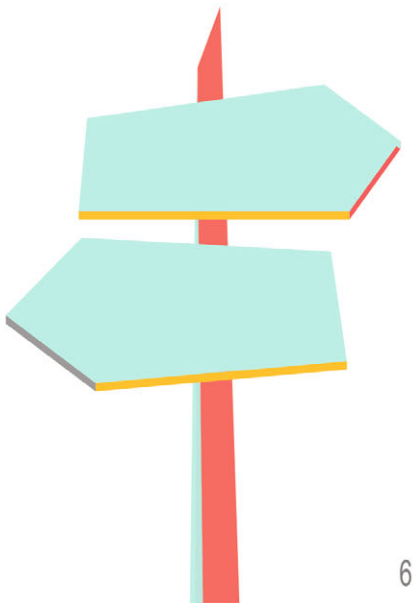
The aim of the PATHWAY mentorship program is to support clinician-scientists and other life-scientists in training (all translational scientists) to further their career goals and to remain in a translational academic career pathway.

Mentors can provide critical support at a time when early-career translational scientists are facing complex professional and personal issues and decisions.

Mentoring during this period provides understanding, reassurance, and guidance that ultimately strives to retain translational scientists in academia where they form an indispensable link between research and clinical practice within the field of translational medicine.

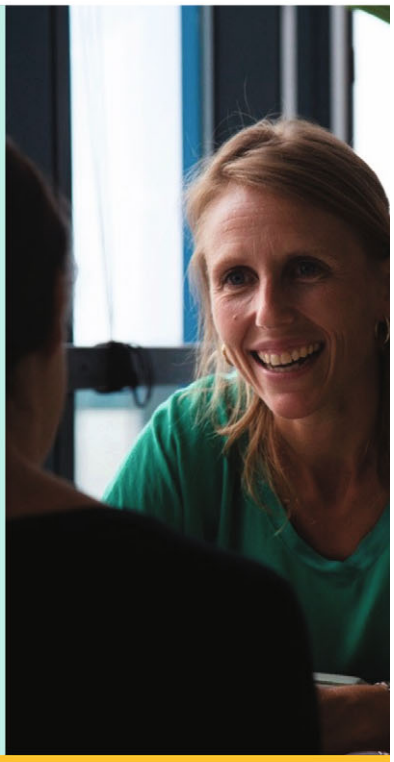
CHAPTER 2

MENTEES AND MENTORS



SELECTION AND TRAINING

The yearly Eureka summer school, *"Translational Medicine: Doing the Right Research Right"*, hosted by Utrecht University welcomes students from around the world to an intense week of sessions and discussions about the current (bio)medical research landscape. During the summer school clinician-scientists and life-scientists in training are given the opportunity to sign up for the mentorship program which is designed to complement the summer school curriculum and to provide further support once participants return to their home institutions. Mentors are experienced researchers/clinical academics with established research and/or clinical practice within the field of translational medicine, selected from the ever-growing Eureka alumni network.



Online training will be available to both mentees and mentors before the start of the mentorship program. This training will prepare both sides before the start of the program and include:

- Mentorship theory; roles of the mentee/mentor and framework for mentoring sessions
- Being a successful clinician-scientist/life-scientist; specific aspects and issues of these careers
- 21st century skills; professional transferable soft skills
- Individual career roadmap; based on an overview of known career pathways and options

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THE MATCHING PROCESS

During the online training course mentees and mentors follow modules that educate them about how to foster successful and fruitful mentoring relationships. During each module, mentees and mentors will be asked to answer and discuss specific questions that will be used to create an individual profile to facilitate the matching process. It will be stated clearly which answers will be shared with the rest of the online group to stimulate discussion and which answers will be private or anonymous.

For **mentees** these questions will be more exploratory to discover where they are in their career and where they would like to go, what kind of skills they are looking to develop further, and what they would like to take from the mentorship program. For **mentors** the profile will describe both their professional and personal qualities, giving mentees an understanding of who they are as a person, what drives them, and their general outlook on life rather than focusing solely on their career successes.

Mentees will choose from a shortlist of potential mentor matches, using both their own profile and that of the mentors to narrow down their choice. Pairs will be put in touch with each other via email by the PATHWAY Project team and an initial online introductory meeting will follow. In the case of a mismatch, the team will mediate to make sure the mentee finds a suitable mentor to begin the program. It is our goal to provide a rich mentor pool for mentors to choose from, let it be noted that it is possible that not every mentor will be matched with a mentee and that some may have multiple matches.

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MENTEE AND MENTOR PROFILES

For mentee profiles example questions include:

- What kind of mentor are you looking for?
- What kind of topics would you discuss with a mentor?
- Which professional pitfalls would you like to discuss with a mentor?
- What would you like to improve? Write your own professional wish list.
- Contact preferences: frequency, meetings online vs face-to-face, country, languages, etc.

For mentor profiles example questions include:

- What makes a good mentor in your eyes?
- How do you make tough decisions?
- How do you ensure a healthy work/life balance?
- What is the hardest professional obstacle that you have had to overcome?
- Contact preferences: frequency, meetings online vs face-to-face, country, languages, etc.

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CHAPTER 3

MENTORING SESSIONS

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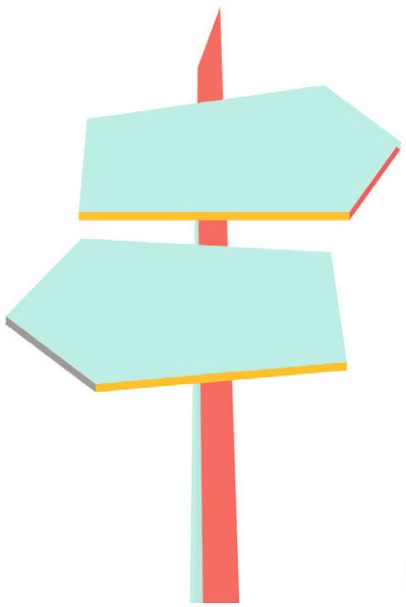

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MENTORING SESSIONS

Mentoring sessions will take place (online) at least twice per year. It is up to the mentee and mentor to schedule these meetings at their preferred frequency.

An initial minimal commitment of two years is asked of all participating mentees and mentors. After this time period both mentees and mentors are free to continue or terminate the program as they see fit.

Mentoring sessions should be prepared and documented using the provided 'Individual Career Roadmap' in the online course environment which is designed to provide guidance and insight into important crossroads early-career clinician-scientists and life-scientists generally face. Both the mentee and mentor are responsible for keeping track of their meetings and the development of this roadmap as their online portfolio.

GETTING THE MOST OUT OF MENTORING

In order to get the most out of mentoring a framework for the mentoring sessions is provided.

Both the mentee and mentor should:

- Focus on contributing their time and knowledge freely
- Talk about how they will communicate and set boundaries for their relationship
- Talk about what they expect to achieve in the mentoring relationship
- Speak up if they want to take the discussion in a new direction or if something isn't working

Mentees should:

- Prepare for meetings by thinking of topics for discussion and sharing these beforehand with the mentor so that they can also prepare

- Be open to challenging questions and to being out of their comfort zone

- Take time to reflect after mentoring sessions

Mentors should:

- Not feel like they have to know everything

- Ask questions and do more listening than talking during the mentoring sessions

- Give advice from their experience but remind the mentee that they should also seek the views of others before making decisions

- Remember that the mentee might not take their advice, mentors are not responsible for the mentee's development

- Remember that a mentor is not a patron or coach. Mentors should not be 'taking mentees under their wing'. Mentoring is about supporting mentees to make their own decisions

- Use the GROW model to structure the mentoring session (see chapter 3)

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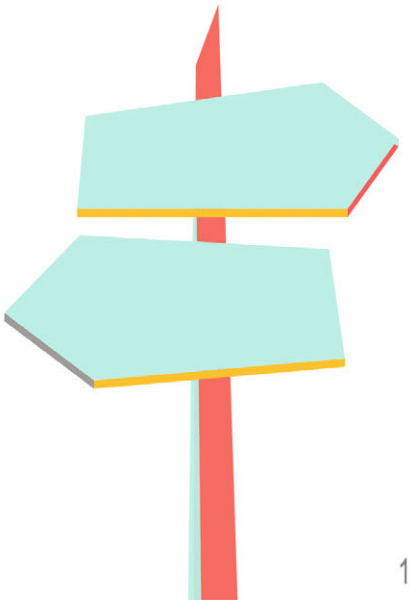
CHAPTER 4

ADDITIONAL RESOURCES



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GROW MODEL

GROW is a useful model for structuring a mentoring session and can help mentors keep the session focused and on track. Use each point of the model to engage in a discussion with the mentee and find their views.

GOAL: Clarify the desired outcomes:
- What would you like to achieve from our mentoring sessions?
- What is your long-term outcome?
- What would success look like?

REALITY: Clarify the current situation:
- What's actually happening?

OPTIONS: Evaluate alternative choices and clarify the next steps forward:
- What choices do you have?
- What are the consequences of each choice?
- What actions will you take and who will support you?
- Who will support you in taking action?

WAY FORWARD: Identifying and reviewing progress:
- On a scale of 1 to 10 how willing are you to take action?
- Are the actions being taken?
- Are the actions moving you towards your outcome?

BACK-OFFICE SUPPORT

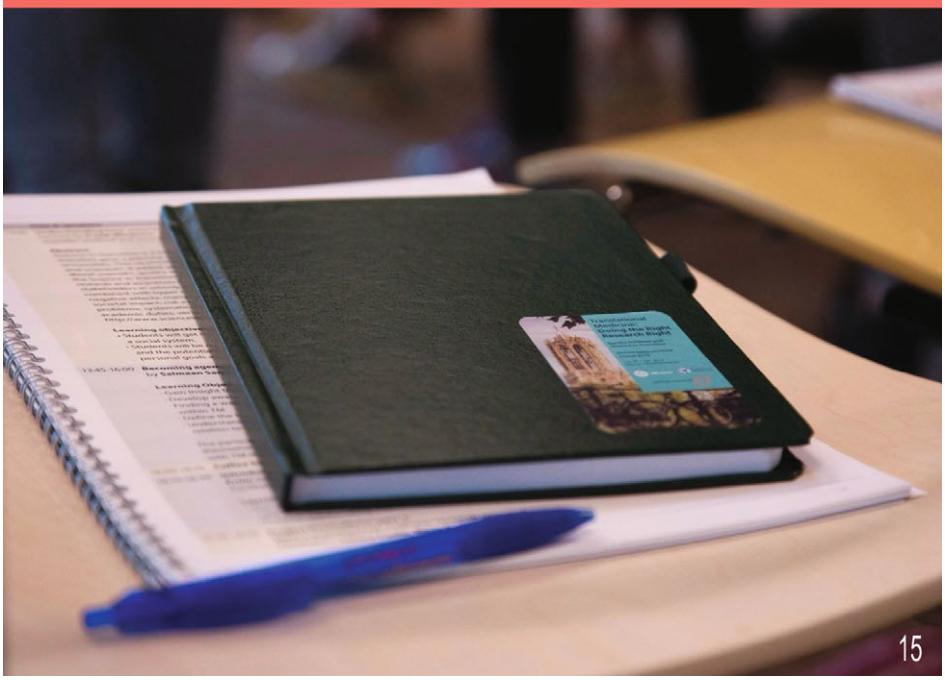
The PATHWAY Project team will monitor the online training and matching process.

After this they will make sure that both mentees and mentors know who to contact in case any questions arise.

As this is a pilot mentorship program, it will be closely studied and evaluated. All participants will be formally asked for their informed consent and evaluations will take place at several timepoints during the year.

CONTACT

Email: info@pathwayproject.eu



COLOPHON

This Handbook for Mentees and Mentors has been compiled in accordance with PATHWAY Project approved Intellectual Outputs 4 and 5 and was written for the kick-off of the online PATHWAY Mentorship Program.

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CHAPTER 4.4

PATHWAY Project – Mentee Professional Development Portfolio

Publication Status

The EU Erasmus+ funded PATHWAY Project's mentorship program material is available upon request.

Author Contributions

All PATHWAY Project team members contributed to the mentorship program material.

- University Medical Center Utrecht: Prof. dr. Berent Prakken, Prof. dr. Olle ten Cate, Prof. dr. Annet van Royen, Dr. Margot Weggemans, Nadine Nonnekes, and Farah Kools
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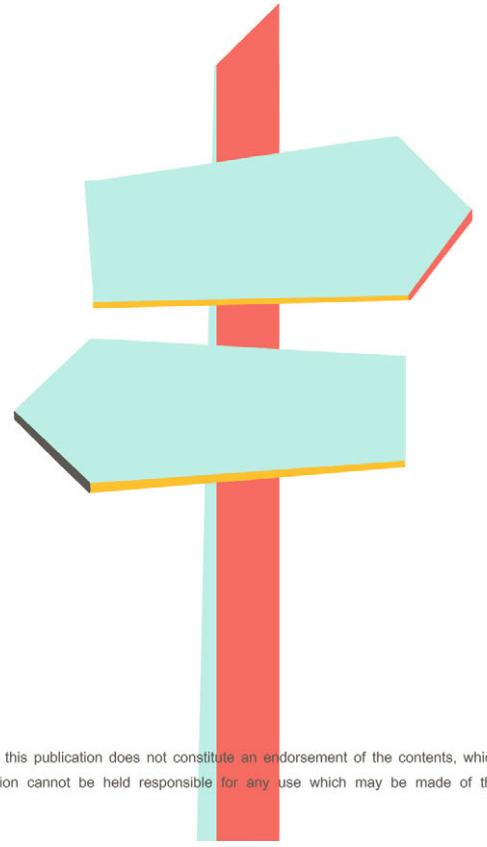
PATHWAY PROJECT

INTERNATIONAL CAREER PATHWAYS AND ONLINE CURRICULUM FOR TRANSLATIONAL SCIENTISTS

PROFESSIONAL DEVELOPMENT PORTFOLIO



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Welcome to your personal Professional Development Portfolio!

Per definition, a portfolio is “a collection of samples of a person's work, typically intended to convey the quality and breadth of his or her achievement in a particular field”. In this case, the portfolio won’t be used to persuade a possible employer, but to guide your professional development through a mentee-mentor relationship.

As no stipulated career pathway for translational scientists exists, this road is often full of uncertainties, failures, disappointments and unexpected turns. However, it is important to be able to see these aspects as inevitable steps on a road to success and as learning opportunities. This is easily said, tough not always easily done. Having a more senior scientist as a mentor could play an important role in this learning process, as he or she has undoubtedly experienced similar situations.

To maximize your chances to build a fruitful mentee-mentor interaction, there are some important things to keep in mind. First, as in any collaboration, it is important to clearly state the boundaries of the relationship and manage expectations. In this way, you create a safe environment in which both parties feel respected. On the other hand, it is important to prepare mentee-mentor meetings and to think about your expectations of the sessions. Which experiences would you like to share? Do you have specific questions you would like to receive advice on? If you have a clear view on this, the outcome of a session will likely improve for both mentee and mentor.

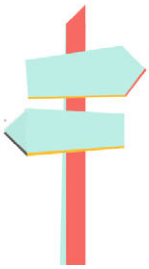
This portfolio offers you tools to achieve these goals. The assignments in part one will make you think about topics related to mentorship and personal development. The second part is focused on possible career pathways. We encourage you to use these reflections as topics for your future mentoring sessions and as such, to get the most out of your mentee-mentor relationship.

The third part of this portfolio provides the opportunity to write a short reflection after contact moments with your mentor. Obviously, this is not mandatory, however, we do encourage you to do so. Certain ideas or topics might be interesting for next sessions: maybe you received some very good advice or felt encouraged by the conversation? A written reflection can always be read again, as thoughts are sometimes difficult to recall.

This portfolio is strictly personal and designed to help you reflect on topics related to mentoring and the professional pathways of translational scientists. You are free to share this document with others if you think it could be interesting or beneficial, but this is not obligatory. We encourage you to use this portfolio as a working instrument for mentoring sessions, but it is up to you to decide how you want to do this.

We wish you a very fruitful collaboration!

Further information regarding this project can be found on the website:
www. pathwayproject.eu



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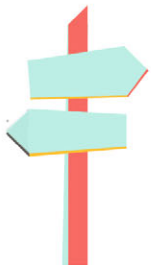
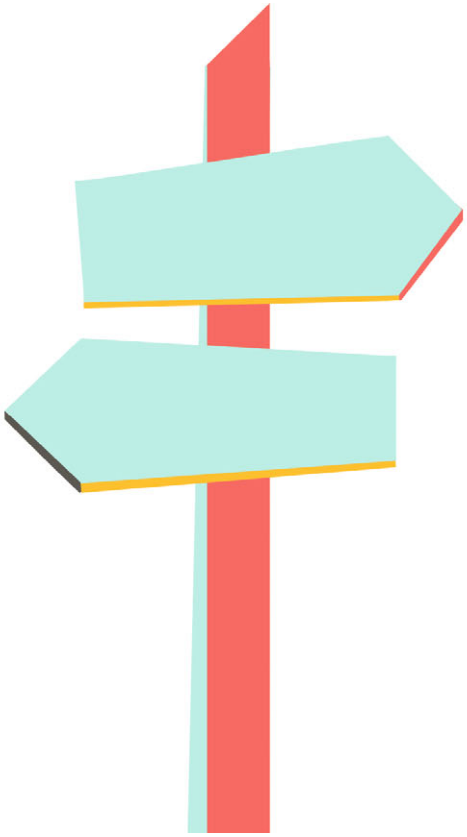


PART 1

PERSONAL DEVELOPMENT



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1.1 WHAT ARE YOU LOOKING FOR?

As mentioned in the introduction, it is crucial to think about your **expectations** of a mentorship program before you start. Reflect shortly on this important question. Why do you want a mentor? How do you think a mentor could boost your career?

This portfolio is designed to guide you to and through your mentoring relationship. Many assignments will follow to help you define where you want your sessions to go. However, you probably already have some **first questions** regarding your career path and related topics, which you would like to discuss with your mentor. Write them down shortly as a reminder.

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As in any relationship, it is important to define **boundaries**. Ask your mentor whether he or she feels comfortable to talk about certain topics or to give you certain advice. Equally important, indicate when you would feel uncomfortable. Which topics could make you or your mentor feel uneasy?

Obviously, your expectations of the program will determine how you envision **your ideal mentor**. Take some time to think about this. What traits and expertise are you looking for? Do you look for a mentor in the same field or do you think a mentor with a different background could have certain advantages? Why?

1.2 BEING THE BEST TRANSLATIONAL SCIENTIST YOU CAN BE

The career of a translational scientist contains many specific hurdles. Being 'the best' translational scientist doesn't mean you can avoid these hurdles, but merely that you can overcome them and use them to do even better in the future. How do you define a good translational scientist? Which characteristics do you think are important to define one? Think of a role model in your specific working environment.

In relation to this definition, point out three of your own personal strengths and aspects you would like to improve. These strengths and aspects to be improved, could be the starting point of an interesting conversation with your mentor in which he or she will get to know you much better.

Personal strengths	Aspects to be improved
•	•
•	•
•	•

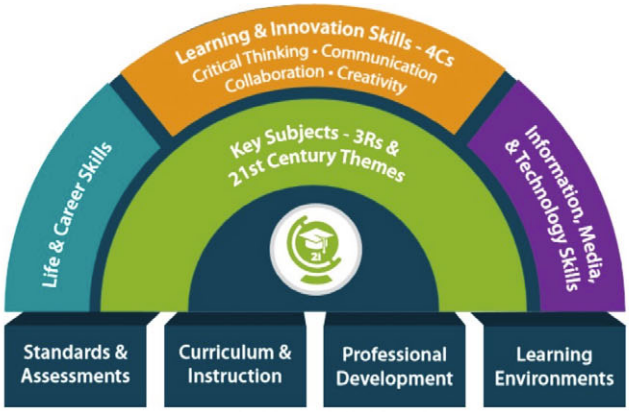
8

1.3 21ST CENTURY SKILLS

21st century skills are competences and qualities that are widely considered as important tools to become successful in the modern society and professional world. These skills are usually divided in three groups: learning and innovation skills, digital literacy skills and career and life skills.

In this portfolio, we dive a little deeper in some learning and innovation skills and career and life skills as these are specifically related to personal development and could be interesting to discuss with a mentor.

You can go through all the skills and accompanying assignments or select those that could be of added value for your personal career development.



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1.3.1 CREATIVITY & INNOVATION

Do you perceive yourself as creative? We suggest you to take this **online creativity test** and to read the four recommendations to enhance your creativity in this article.

Reflect on the following questions. Do the results of the creativity test surprise you? Do you (dis)agree with the conclusion on the four recommendations (capturing, challenging, broadening and surrounding) for creative expression? Which would you like to train?

In which way do you think **creativity** is important for translational scientists? Can you give an example of a professional issue for which you delivered a creative solution? Which competency area did you apply in this situation?

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1.3.2 COMMUNICATION

Good communication is keu in every part of your research and in every step of your career. What starts as an interesting discussion with your principal investigator, could end as a talk on a conference and maybe even as an article in a scientific journal.
Although the story you want to tell might be similar on both occasions, you will probably need to adapt your communication style according to the type of audience.

This list suggests some **theory** on **communication techniques**. Read or watch the one(s) that seem interesting or relevant in your work.

- Oral presentation for peers: Blome C, Sondermann H, Augustin M. Accepted standards on how to give a Medical Research Presentation: a systematic review of expert opinion papers. GMS J Med Educ. 2017; 34(1):
- Sharing science through story: Fergus McAuliffe at TEDxDublin
- How to give a scientific flash talk
- How to create a better research poster in less time

Now reflect on the following questions: Can you remember a situation in which your communication technique didn't get your message across properly? Do you think some of the tips above could help you to avoid similar situations in the future?

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1.3.3 COLLABORATION

Translational science is not a "one-man show"; it's a matter of teamwork. Working as a team allows the accomplishment of larger, more complex goals than would be possible when working independently.
It may sound counterintuitive, but a group of kindred colleagues does not make up the best team. Due to personal characteristics, some people perform certain team roles better than others. However, in smaller teams, a good coverage of the spectrum can be obtained when each member takes more than one role. Studies show that individuals who are aware of team roles perform better than individuals who are not.
A thorough literature review on team roles conducted by Mumford et al., resulted in the identification of 120 different team roles. Grouping of similar roles resulted in ten key roles that can be divided in three groups: task, boundary-spanning and social roles.

Take a look at the different team roles defined by Mumford et al. here (p. 254 - 255). Which team roles fit your personality best? Reflecting on this, what could be your main personal strengths (opportunities) and/or weaknesses (gaps) in relation to teamwork?

Team roles

-
-
-

Strengths and Weaknesses

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Reflect on a team in which you currently work or used to work. Do you recognize different team roles in yourself and other team members during collaboration? If there are struggles in teamwork, can you trace this to the diversity or lack of diversity in team roles?

1.3.4 CRITICAL THINKING AND PROBLEM SOLVING

Critical thinking and problem solving are crucial 21st century skills. However, it is important to realize that everybody gets familiarized with a specific type of problem solving during his or her education. In this blog, Dan Buckland gives his view on the style of problem solving of engineers, physicians and scientists.

Have you already encountered difficulties while working with colleagues with different perspectives in your own (work)life? Provide one or two examples.

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Thinking about your own research project, could an approach from a different angle (e.g., clinician-scientist instead of informatician, engineer instead of physician) result in additional solutions?

1.3.5 TIME MANAGEMENT

A lot of translational scientists experience the feeling of not having enough hours in a day to finish everything they want. There is always more work to be done. However, even scientists have plans and obligations besides their professional lives. Nowadays you are expected to combine work and private life effortlessly in order to be seen as 'successful'. Unfortunately, a day only counts 24 hours for all of us.

Time itself cannot be changed, but you can determine how to spend your available time. A lot is written about time management, several people have documented their views on **efficient time use**.

Do you think you spend your time efficiently? Why (not)? Which aspects could still be improved?

Not only a good planning, but also the ability to **work focused** is needed to be efficient. In this modern world where continuous (online) availability is the standard, it can be difficult to completely focus on work. Deep work is the ability to focus on a cognitively demanding task without distraction, an indispensable skill for every researcher.

Do you sometimes experience difficulties to stay focused on your work? What are your pitfalls? And on the contrary, do you have personal tricks to get in a good workflow?

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It is important to keep in mind that as a translational scientist, you do not always fully control your agenda. Equally important as efficiency, is **daring to say 'no'** to certain tasks. Although it may seem ' not-done', saying no is often possible and worth the effort. In this blogpost, Megan Duffy, an ecologist at the University of Michigan, talks about the moment she realized that there was not enough time to do 'everything', that choices had to be made and priorities had to be set.

Do you sometimes say 'yes' to tasks that seem not really for you? Dare you say 'no' to this? Do you think you could do this? Why (not)?

1.3.6 PERSONAL EFFECTIVENESS

As the career pathway of a translational scientist is not perfectly paved, it is impossible to take it without falling. More importantly, this falling shouldn't be perceived as failure, but merely as a learning opportunity.

Reflect on a moment in your professional life that felt as a failure (e.g., failed to get the funding you applied for, article didn't get published, didn't get the job you wanted, etc.)

How did you feel initially? How did you cope with this disappointment?

Did you learn anything from this experience? Have you changed your behavior somehow afterwards? Could you turn this experience into something positive?

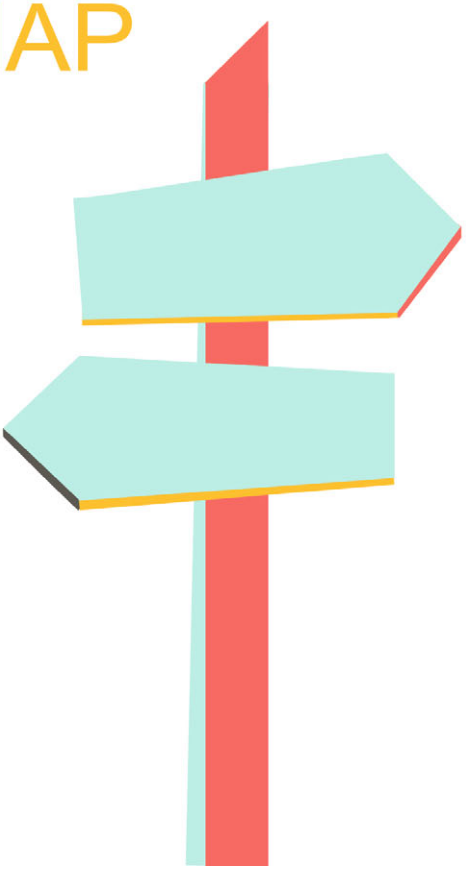
17

1.4 INTRODUCE YOURSELF TO YOUR FUTURE MENTOR

We ask you to make a short (±2 minutes) video in which you introduce yourself to your future mentor or to write a short text about yourself. This video or text is meant to facilitate the first meeting with your mentor.

PART 2

INDIVIDUAL CAREER ROADMAP

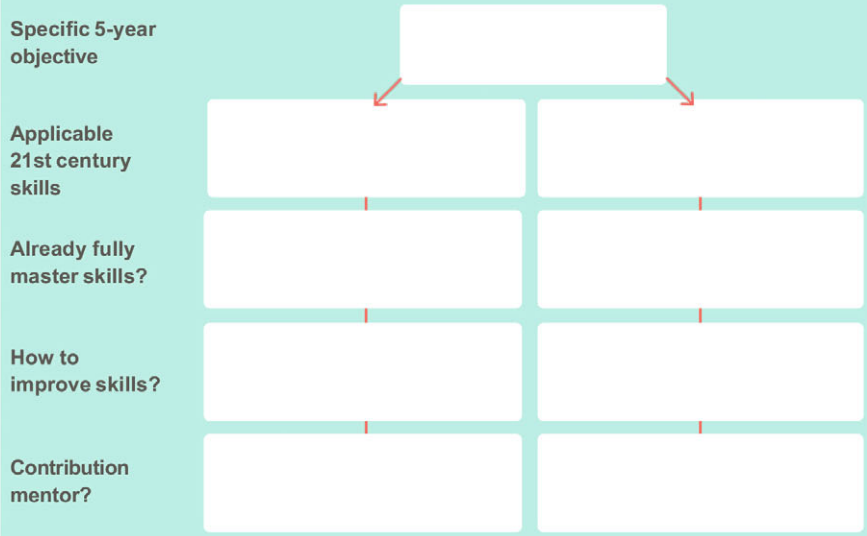


19

2.1 PROFESSIONAL BUCKET LIST

As a translational scientist, it is important to know where you want to go and to have professional goals. However, these goals often seem very far away and out of reach. If this is the case, it is important to split them up in SMART goals, these are smaller objectives that conform to the following criteria: Specific, Measurable, Attainable, Relevant and Timely. This way of working will keep you focused on the long-term goal but will also give you a regular feeling of success when you have achieved a smaller objective.

Do you have long-term professional goals? Try to split them up in different smaller, more manageable objectives. Which **5-year objectives** could contribute to your long-term goal (e.g. publishing an article, research stay abroad, etc.)? How could you attain these objectives? Which 21st century skills could help you to achieve this? Do you feel like you fully master these skills? If not, what actions could you take to further improve them? Do you think your mentor could contribute to this? Remember to keep it SMART!



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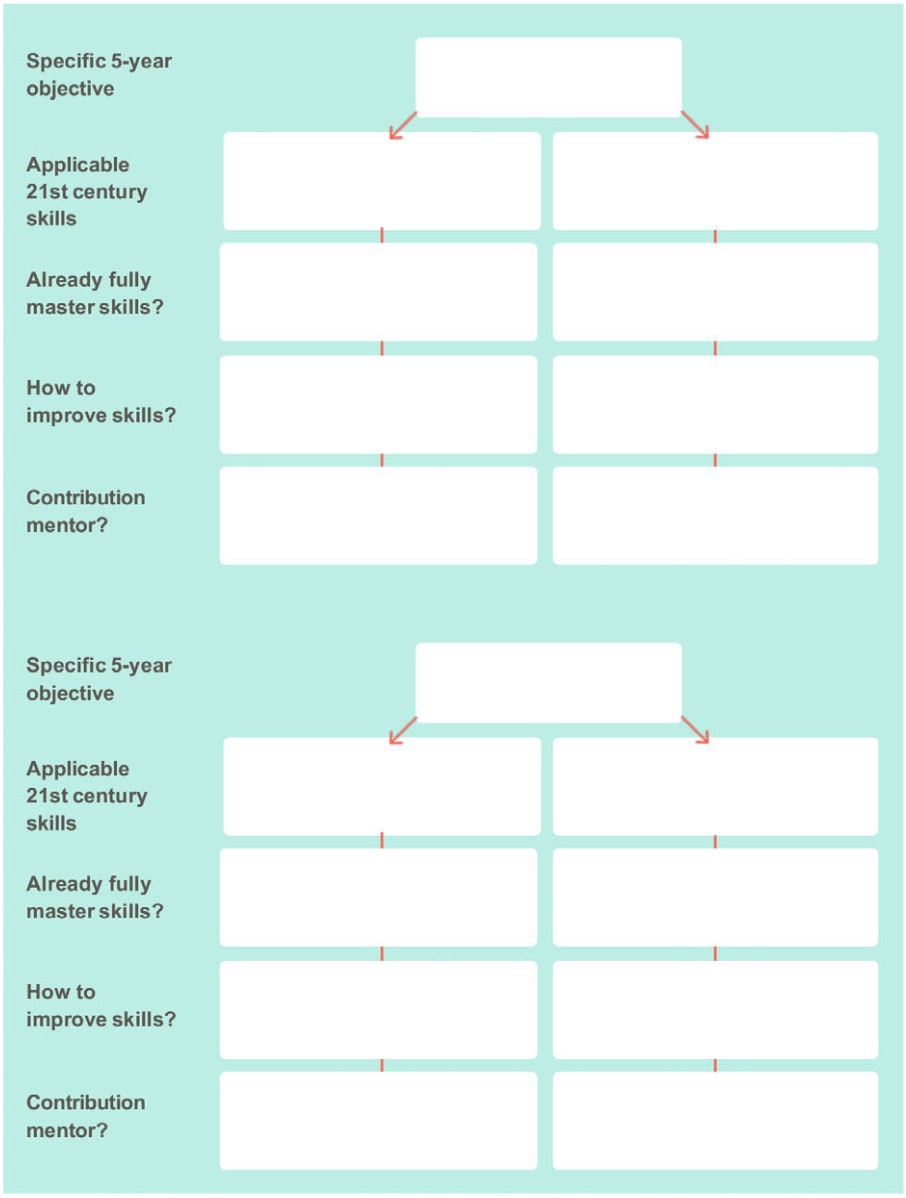

Specific 5-year objective
Applicable 21st century skills
Already fully master skills?
How to improve skills?
Contribution mentor?
Specific 5-year objective
Applicable 21st century skills
Already fully master skills?
How to improve skills?
Contribution mentor?

21

2.2 YOUR INDIVIDUAL CAREER PATHWAY

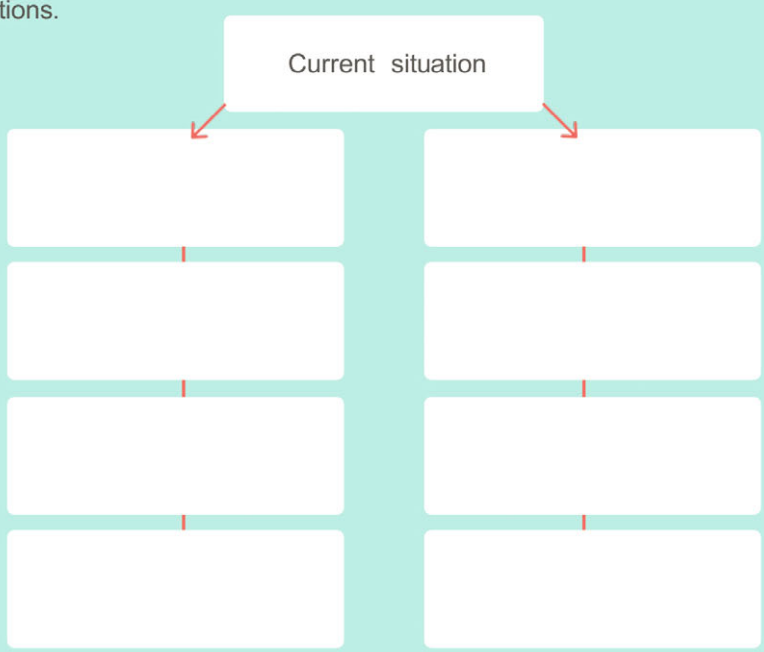
Reflect on your professional path until now. How did you get to this point in your career? You can use following figures to rebuild your own career path until now. Think out of the box, not only education and jobs can attribute to this path.

Example career path:

Sciences in high school → Bachelor in Medicine → Master in medicine → Masters' thesis → Clinical PhD

Your career path:

We would also like you to think about possible paths that could still lay ahead of you. Where do you see yourself in the long run and which crossroads do you think you will have to take to get there? As the future is not fixed, think of at least two possible directions.



Where do you see potential hurdles? Which aspects would you like to discuss with a mentor?

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2.3 ENTRUSTABLE PROFESSIONAL ACTIVITIES

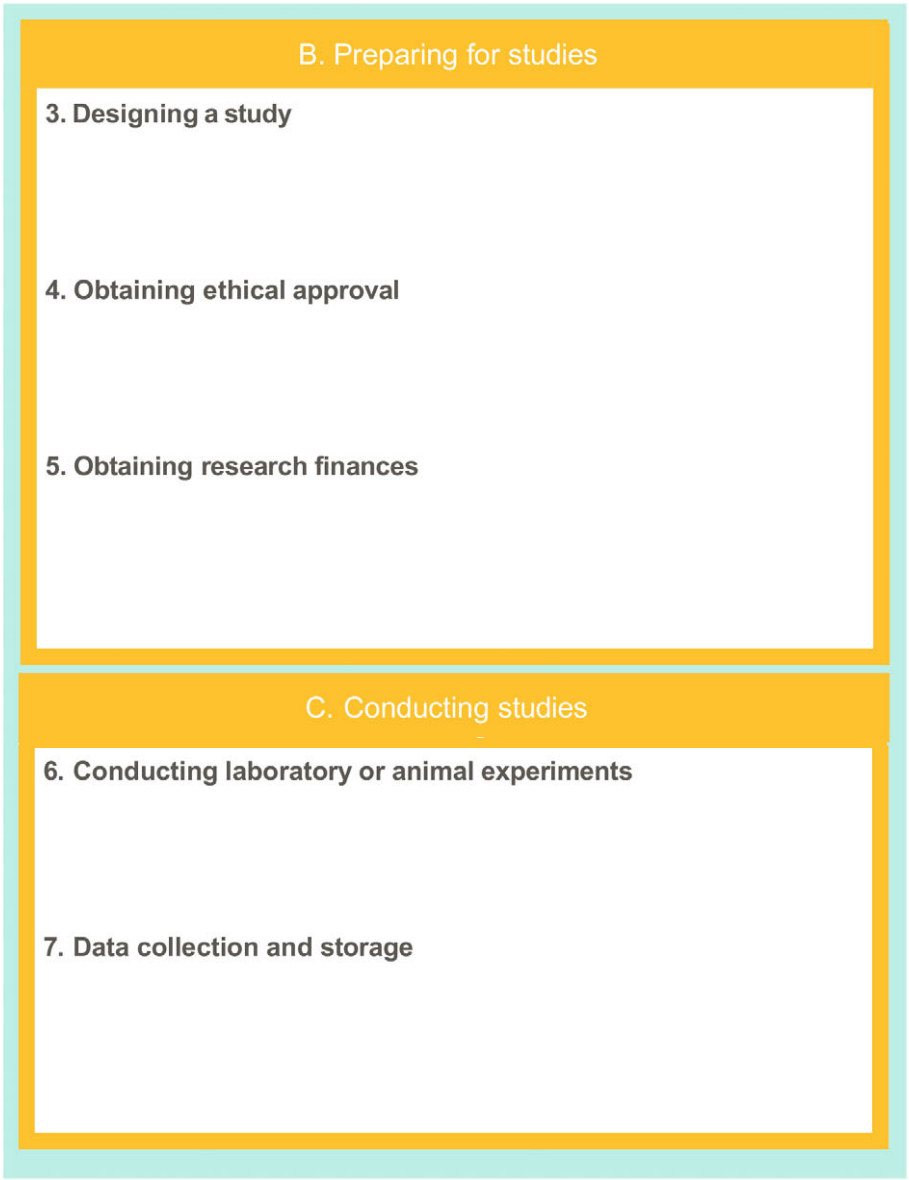
An **Entrustable Professional Activity** (EPA) is a key task of a discipline that an individual can be trusted to perform in a given (healthcare) context once sufficient competence has been demonstrated. Take a look at the list of EPA's (in attachment) specifically relevant for translational sciences. Each EPA has a title, a specification, limitations and a description of risks in case of failure.

Reflect on the following question for each EPA. Do you feel you have mastered this EPA to a level that supervision would not be necessary for you? When would you like to have mastered it and what will be your pathway to mastery?

A. Identifying and translating unmet clinical needs to research

1. Translating clinical needs into a research question

2. Performing literature reviews


B. Preparing for studies
3. Designing a study
4. Obtaining ethical approval
5. Obtaining research finances
C. Conducting studies
6. Conducting laboratory or animal experiments
7. Data collection and storage

25


D. Data management and analysis
8. Data management
9. Analyzing research data
E. Dissemination
10. Writing and publishing scientific reports
11. Communicating research to the scientific and general public
F. Academic collaboration
12. Peer reviewing

26

13. Managing research teams

14. Mentoring, teaching, and supervising trainees

G. Translating outcomes to care

15. Managing intellectual property

16. Negotiating with industry, funding agencies, and other parties

17. Translating research outcomes into clinical practice

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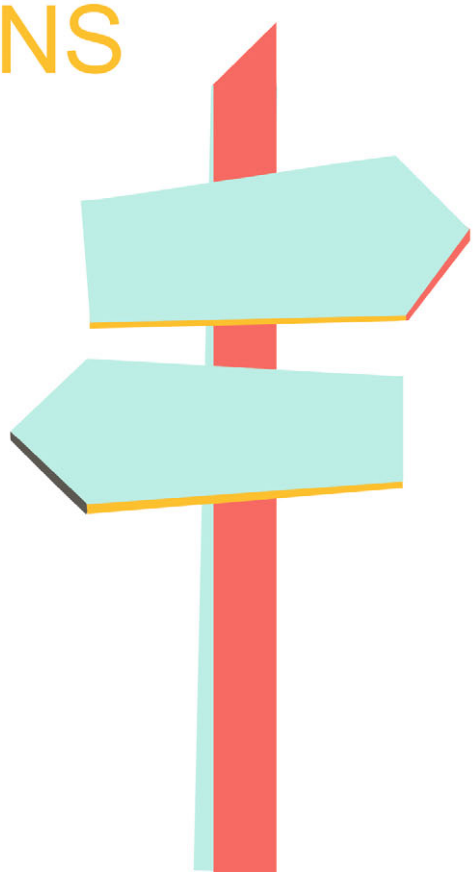
PART 3

REFLECTIONS ON MENTORING SESSIONS



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28

You can use this part of the portfolio to keep track of your mentoring meetings. There is room to write a short summary after each one to remind you of what was discussed and advice you received, topics you want to take to another session or anything else that you would like to remember. This could just be a few key words or a paragraph, whichever you see fit. Use this moment to reflect on what the meeting meant for you and which aspects you could potentially implement in your life.

MENTORING SESSION 1

Date:

Keywords:

Reflection:

MENTORING SESSION 2

Date:

Keywords:

Reflection:

MENTORING SESSION 3

Date:

Keywords:

Reflection:

MENTORING SESSION 4

Date:

Keywords:

Reflection:

MENTORING SESSION 5

Date:

Keywords:

Reflection:

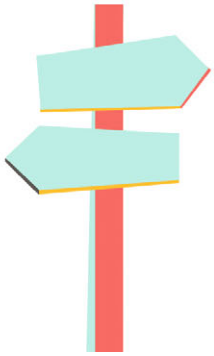
31

Final remarks

This portfolio is meant to capture your professional development as a translational scientist. We recommend you not to consider this portfolio as a goal in itself, but rather as a working instrument and guide for your mentoring sessions. Don't hesitate to update some of your initial views and answers as you grow in your professional career. Ideally, this portfolio combines your past and upcoming career path at every point in time, now and in the future.

One of the ultimate goals of a successful mentoring relationship is to come to a level where you feel experienced and mature enough to be a mentor yourself. There is no pre-defined timeframe to achieve this goal, so you may use the portfolio as long as needed.

Finally, every once in a while, take your time to see the bigger picture of your professional development towards a successful translational scientist. Ultimately, your career path may inspire other young clinicians and scientists to pursue a career in translational medicine. This portfolio will not only assist you in doing so but may also be an example for the future generation.



COLOPHON

This Professional Development Portfolio has been compiled in accordance with PATHWAY Project approved Intellectual Output 6 and was written for the kick-off of the online PATHWAY Mentorship Program.

The information gathered in this Professional Development Portfolio is to be disseminated for use by other (online) mentorship programs after the lifetime of this project. We welcome any feedback and suggestions to improve the content or the structure of this portfolio via the e-mail address below.

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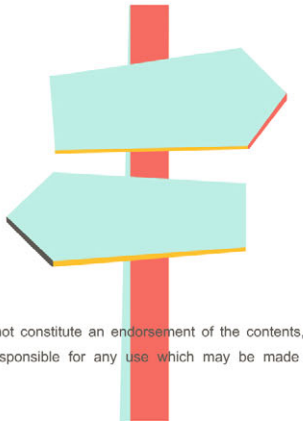

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CHAPTER 5.1

Insight into Translational Competencies Using a Challenge-Based Approach

Publication Status

An adapted version of this study is under review at a peer-reviewed journal as "Kools FRW, Fox CM, Prakken BJ, and van Rijen HVM. Insight into Translational Competencies Using a Challenge-Based Approach. 2023.".

Author Contributions

FK performed the data collection, analyses, and authored the manuscript with CF as second researcher, substantive editor, and proofreader. BP and HR reviewed the final manuscript. All authors contributed to the manuscript and approved the submitted version.

Acknowledgements

The authors would like to thank all study participants, the TLS course coordinator Dr. Sanne de Jong, and Dr. Renske de Kleijn and Dr. Rianne Bouwmeester for their contributions to the methodology and guidance during the writing process.

ABSTRACT

Introduction: The translational domain is a complex subfield of the biomedical life sciences seeking to improve patient care through clinically driven healthcare innovations. Professionals in this field require specific core competencies identified in previous studies.

Methods: We investigated the development of translational competencies during a six-month challenge-based course at a Dutch graduate school. Quantitative and qualitative student survey data, and semi-structured expert interview data were collected and analyzed using two existing translational competency frameworks.

Results: Communication was the most listed competency category by both students and experts, and a new competency category was identified named Self-Development Tools, which included competencies related to decision-making, reflection, feedback, and creative thinking. Student data showed that the course influenced their choice in pursuing a translational career path. Thus, these findings are relevant for both educators and prospective employers in the translational domain.

Conclusions: This study provides insight into translational competencies students developed during the course and insight into competencies that may be part of their continued education after graduation from both student and expert perspectives. Ultimately, this research enriches the existing literature on translational competencies and how to optimally prepare life sciences graduates towards a translational career.

INTRODUCTION

Translational Competencies

To address the evolving landscape of the translational domain and meet the demands of interdisciplinary team science as put forward by Ameredes et al. (2015) and Lotrecchiano et al. (2020), there is a need for the development of competency-based training programs to ensure that research quality and ethical standards are continuously met (1–3). The translational domain is a complex subfield of the biomedical life sciences which combines multiple disciplines with the aim of improving patient care by focusing on clinically driven healthcare innovations (4).

In order to train professionals working in the translational domain, core competencies have been identified. The Clinical and Translational Science Awards (CTSA), a program funded by the National Center for Advancing Translational Science (NCATS), a branch of the National Institutes of Health (NIH), have outlined ninety-seven core competencies within fourteen domains, as detailed in their Translational Researcher (TR) Competency Framework (see Appendix I).[1] This framework defines translational research as the scientific process leading to clinical interventions that improve health.[2] A decade later, Gilliland et al. (2019) went on to propose seven fundamental characteristics, presented in their Translational Scientist (TS) Competency Framework (see Appendix II) (5). This framework defines translational science as a field focused on addressing the core challenges of translational research, with the aim of enhancing efficiency, effectiveness, and innovativeness.[1] Recognizing the complementarity of these frameworks, Tsevat and Smyth (2020) in their educational perspective recommended incorporating both frameworks in future translational training programs, given their overlapping nature and the need for competencies from both frameworks to improve the translational process (6). Additionally, Faupel-Badger et al. (2022), in their article on advancing translational science education, suggested an overlay of both frameworks, see Table 1 (7).

1 https://clic-ctsa.org/education/competencies

2 https://ncats.nih.gov/training-education/translational-science-principles

Table 1. Proposed overlay of TR and TS Competency Frameworks by Faupel-Badger et al. (2022).

TR Competency Framework	TS Competency Framework
1. Clinical and Translational Research Questions	1. Domain Expert
2. Study Design	2. Rigorous Researcher
3. Scientific Communication	3. Skilled Communicator
4. Translational Teamwork	4. Team Player
5. Literature Critique	5. Systems Thinker
6. Research Implementation	6. Boundary Crosser
7. Sources of Error	7. Process Innovator
8. Statistical Approaches	-
9. Biomedical Informatics	-
10. Clinical Research Interaction	-
11. Cultural Diversity	-
12. Leadership	-
13. Cross-Disciplinary Training	-
14. Community Engagement	-

In line with this training need, Dilmore et al. (2013) proposed the development of a competency-based educational structure within clinical and translational science to ensure translational competence is reached, and Begg et al. (2015) argued that it is critical to prepare and educate the future translational workforce to adopt an interdisciplinary approach to avoid the risk of "*siloed*" research efforts or attrition from the field (1,8). Given that the translational domain is relatively new and distinct in its training requirements, Austin (2021) also suggested tailored curricula and academic environments conducive to inter- and multidisciplinary collaboration to foster cutting-edge translation and Weggemans et al. (2021) developed entrustable professional activities for translational scientists in order to improve their training and assessment (9,10).

Teaching and assessing the development of competencies within competency-based education is a critical aspect for any training program. In their study, Robinson et al. (2015) described a comprehensive competency review in clinical research master's students. The review consisted of metacognitive reflection, reporting on each competency with examples and explanations, and a meeting to further discuss the development of each competency in-depth (11). However, assessing competencies can pose challenges. Lichtenberg et al. (2007) encountered difficulties in their study within professional psychology (12). These difficulties arose in defining core competencies in measurable terms, developing appropriate assessment tools, establishing minimal competence level for different training stages, and implementing effecting feedback mechanisms (12). In their study on competency-based assessment, Mayowski et al.

(2018) concluded that competency-based clinical and translational research education is still very much in its infancy (13). To aid the teaching and assessment of competency-based education, innovative approaches such as challenge-based learning has gained popularity in recent years.

The Challenge-Based Translational Life Sciences Course

Challenged-based learning (CBL) is a pedagogical approach that utilizes real-world issues as the foundation for structuring student learning, with the aim of developing versatile professional competencies.[3] In CBL, students often work in small teams, drawing upon their own expertise and collaborating with different disciplines from within and outside academia to devise possible solutions for current open-ended and complex societal issues, thereby creating societal impact. As highlighted in a white paper published by Apple Inc, Nichols and Cator (2008) emphasized the strengths of CBL in achieving student engagement by integrating real-world context into curricula and challenging students to take action (14). CBL can be found across all levels of education. At university-level, Malmqvist et al. (2015) defined it as student learning through identifying, analyzing, and designing an economically and environmentally sustainable solution to a sociotechnical problem using a multidisciplinary approach in an international context (15).

According to the comparative analysis of challenge-based learning experiences conducted by Malmqvist et al. (2015), CBL provided students with an opportunity to connect their education with societal meaning, while simultaneously training non-content-related skills such as communication, decision-making, leadership, and multidisciplinary teamwork (15). This is supported by a longitudinal case study conducted by Radberg et al. (2018) on a Challenge Lab, where students perceived the development of skills associated with sustainable development, problem formulation, and multidisciplinary collaboration, including engagement with different stakeholders (16).

By integrating real-world challenges into the learning process, CBL offers a dynamic and relevant approach to education that prepares students for the complex demands of the modern working world. The potential power of CBL lies in its dual impact. On one hand, it promotes student engagement and the development of versatile professional competencies, as demonstrated by Malmqvist et al. (2015) and Radberg et al. (2018) (15,16). On the other hand, CBL also draws attention to current largescale societal issues and inspires efforts towards their resolution. This makes CBL particularly

3 https://www.challengebasedlearning.org

suitable for the translational domain, which inherently presents an endless source of biomedical life sciences challenges that require competencies transcending disciplinary boundaries, while working towards potential societal solutions.

Over the past years, challenge-based education has gained noticeable momentum in higher education. The Graduate School of Life Sciences (GSLS) at Utrecht University in the Netherlands has embraced this approach and aims to train future professionals in the translational domain. In January 2021, the six-month full-time Translational Life Sciences (TLS) course,[4] worth 33 credits, commenced for the first time with seventeen master's students from the GSLS, divided into five capstone projects submitted by biomedical life sciences experts from various fields of study, see Table 2.

Table 2. 2021 TLS course capstone projects and fields of study.

Capstone Project	Field of Study
Dampening the side effects of Methotrexate in Juvenile Rheumatism (JR)	Pediatric Rheumatology
Diagnosing heart failure with preserved ejection fraction (HF)	Cardiology/ Pulmonology
Differentiation in the measurement of renal function (RF)	Nephrology
Genetic screening of the family members of patients with genetic disorders (GS)	Clinical Genetics
Preventing Parkinson's Disease as a result of pesticide use in agriculture (PD)	Disease Prevention

The concept of the TLS course aligns with the overarching principles of CBL, where unmet biomedical life sciences needs from society form the basis of the capstone projects. Within the projects, the unmet needs are translated into well-defined research questions and tangible solutions for relevant stakeholders. To achieve this, students are guided to meet learning objectives within the five core pillars of the course: translational science, boundary crossing, communication with stakeholders, collaboration, and reflection. The competencies that students develop during the course not only aid their academic growth but also shape them into future professionals for the translational domain.

The TLS course is structured according to the Design Thinking model proposed by Dam and Siang (2021), which encompasses five phases: Discover, Define, Develop, Deliver, and Evolve.[5] While students actively work on their capstone projects, they also partake in recurrent meetings and workshops with a strong focus on their personal development (Figure 1).

4 https://students.uu.nl/en/gsls/education/courses/translational-life-sciences-course

5 https://www.interaction-design.org/literature/article/5-stages-in-the-design-thinking-process

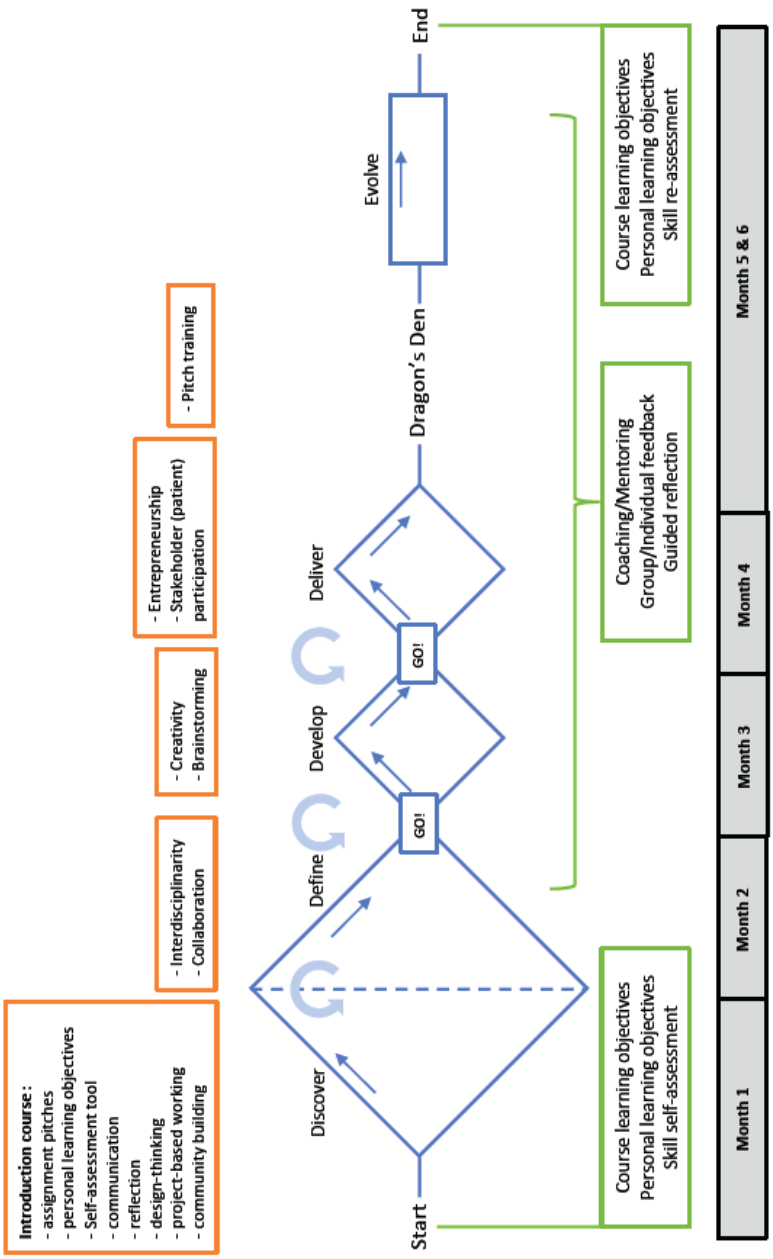

Figure 1. Blueprint of the TLS course. Orange = courses and workshops; Blue = capstone project; Green = personal development.

Research Question

The research question guiding this study was: *"What competencies are developed by students in the GSLS challenge-based TLS course, specifically in the context of the translational domain?"*. The findings of this study will provide valuable insights for educators, prospective employers, and students themselves, shedding light on competencies developed during this educational program. The chosen theoretical framework for this study encompasses both sets of core competencies for TRs and TSs, as also proposed by Tsevat and Smyth (2020) and Faupel-Badger et al. (2022), and aims to comprehensively showcase the diverse skillset needed within the translational domain (6,7). The ultimate goal of this research is to assist with educating the translational workforce and to enrich existing literature on translational competencies. Notably, our study also incorporated the student perspective, which is a unique contribution to the existing literature.

METHODS

Study Participants

Ethical approval for this study was obtained from the ethical review board of the Netherlands Association of Medical Education. Our two target groups were the seventeen second year GSLS masters' students enrolled in the TLS course from January to July 2021, and the five biomedical experts that submitted a capstone project for the course and acted as each student-team's client. Input from the students informed us of their perceived development of translational competencies during the course, and the biomedical experts provided insight into translational competencies required in general, in addition to all competencies they observed in their student-team while working on their capstone projects over a six-month period.

Study Design

A convergent parallel mixed method study was designed to investigate translational competencies, using both quantitative and qualitative student survey data, as well as semi-structured expert interview data (17). In designing this study, the TR and TS Competency Frameworks were consulted, however, specific terminology from the frameworks was intentionally omitted to avoid influencing participant responses and to assess the validity of the two frameworks.

Data Collection

All data was collected by the first author in November and December 2021 after the TLS course of that year had ended. All seventeen students were invited via email to fill in an anonymous online ten-minute survey consisting of eight questions (four quantitative questions and four qualitative questions) created in the online Qualtrics platform. The questions were designed around gaining knowledge about which competencies students developed during the TLS course and their plans after graduation. Ten students chose to participate, see Table 3 for a breakdown of participants per capstone project. During the online survey, students were asked which capstone project they were a part of (Q1 multiple choice), which competencies they developed during the TLS course (Q2 open question), if they expected these competencies to be important (Q4 yes/no/maybe), and to explain their answers (Q3&5 open questions). Students were then asked if they were planning on choosing a translational career path after graduation (Q6 yes/no/maybe), if their participation in the TLS course had influenced this decision (Q7 yes/no/maybe), and to explain their answers (Q8 open question). The list of survey questions can be found in Appendix III. The five biomedical experts that served as each student-team's client, were invited via email to an online forty-five-minute semi-structured interview in Microsoft Teams. Three out of the five clients accepted the invitation (one client asked to respond to the interview questions in writing, and one client did not respond to the invitation, see Table 3). The experts were asked to explain their translational work and capstone project, to list competencies needed for translational work in general and for their capstone project specifically, and what the TLS course could do to better prepare students for a translational career path after graduation. The full list of interview questions can be found in Appendix IV.

Table 3. 2021 TLS course capstone projects, fields of study, and number of study participants.

Capstone Project	Field of Study	Study Participants
Dampening the side effects of Methotrexate in Juvenile Rheumatism (JR)	Pediatric Rheumatology	1 out of 3 Students
Diagnosing heart failure with preserved ejection fraction (HF)	Cardiology/ Pulmonology	2 out of 3 Students + Client
Differentiation in the measurement of renal function (RF)	Nephrology	3 out of 4 Students + Client
Genetic screening of the family members of patients with genetic disorders (GS)	Clinical Genetics	1 out of 4 Students + Client
Preventing Parkinson's Disease as a result of pesticide use in agriculture (PD)	Disease Prevention	3 out of 3 Students + Client

Data Analysis

All data analysis was carried out by the first author in 2023. The ten anonymous responses from the online student survey were collected and downloaded in Microsoft Excel sorting responses per TLS capstone project (Q1). The three semi-structured expert interviews were recorded in Microsoft Teams and transcribed in Microsoft Word. An intelligent transcription was used to preserve the accuracy of the interviews, eliminate repetitive wording and pauses, and inserting contextual information where needed to clarify each interviewee's answers. Full intelligent transcripts are available upon request. The written responses of one additional interviewee that responded via email, were also added to Word.

Qualitative student survey data on translational competencies (Q2&3) and all expert interview data were coded using an *a priori* system based on the categories from the TR and TS Competency Frameworks, and the proposed overlay of these categories by Faupel-Badger et al. (2022) (18). Based on the coding, the TS Competency Framework was adapted. There were two instances where two categories were merged since the data did not present significant differentiation between them. The adapted TS Competency Framework consisted of five competency categories: Skilled Communicator, Process Innovator & Systems Thinker, Boundary Crosser, Team Player, and Domain Expert & Rigorous Researcher. Additionally, a new category Self-Development Tools was identified and encompassed responses related to decision-making, reflection, feedback, and creative thinking competencies (Table 4). After careful consideration, examples of creativity and out-of-the-box thinking were assigned to both Self-Development Tools and Process Innovator and Systems Thinker because of the context of the data, illustrative of the complexity of competency-based training and assessment. The coding process underwent multiple rounds of systematic checks by the first author for reliability using a test-retest coding process. Additionally, the second author reviewed and confirmed the accuracy and consistency of the coding process. The coded data was then placed into Excel divided by student and expert responses per capstone project and category.

Table 4. The adapted TS Competency Framework.

Adapted TS Competency Framework
Skilled Communicator
Process Innovator & Systems Thinker
Boundary Crosser
Team Player
Domain Expert & Rigorous Researcher
Self-Development Tools

Both quantitative and qualitative student survey data on translational competencies was placed into Excel and made into three figures showing the students' answers from Q2 (Figure 2&3) and Q4 (Figure 4). These findings were then further explained in the text divided into the adapted TS Competency Framework's six categories according to Table 4, showing both student and expert responses per category. To protect the anonymity of the study participants, their qualitative contributions were described as a group and not separated per capstone project. Additionally, the expert interviews were each given a number and quoted accordingly.

The quantitative student survey data on the influence of the TLS course was placed into Excel and made into one figure showing the students' answers from Q6 and Q7 (Figure 5). These findings were then further explained in the text. The qualitative student survey answers from Q8 were summarized and used to elaborate on the quantitative results in the text. These answers were also grouped together to protect anonymity.

RESULTS

Qualitative Student Survey Results on Translational Competencies

According to the qualitative student survey data, the most listed competency category by all ten students from all five capstone projects combined was Skilled Communicator (Figure 2). When looking at the data for each capstone project separately, Skilled Communicator and Process Innovator & Systems Thinker were each listed four times within the RF capstone project, and Self-Development Tools was listed four times within the PD capstone project (Figure 3). These findings add some nuances on competencies within the context of the different capstone projects, however, the small sample size does not allow for overall conclusions.

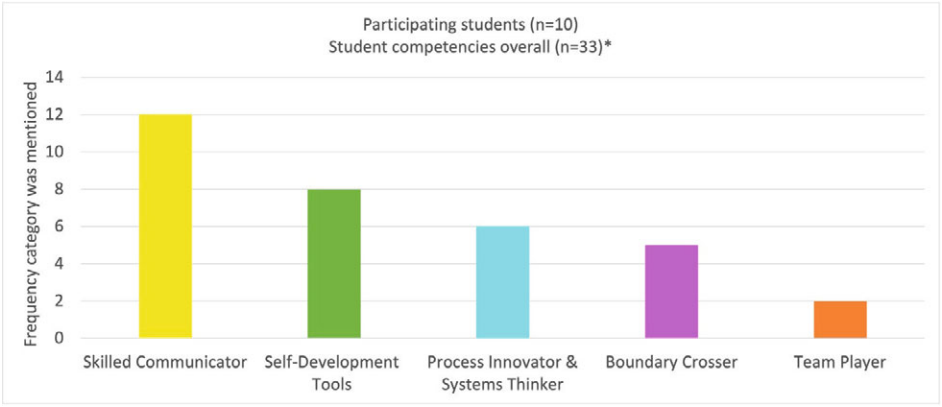

*Figure 2. Competencies listed by students divided into five categories aggregated for all capstone projects. Each student was asked to name three competencies. *On three occasions a student's answer was split between two different categories.*

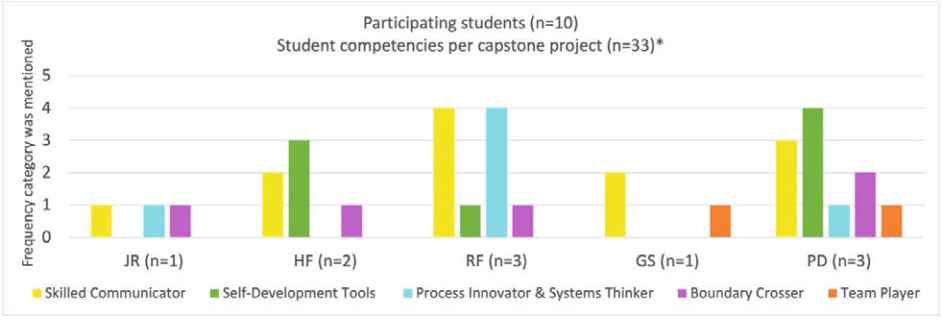

*Figure 3. Competencies listed by students divided into five categories shown per capstone project. Each student was asked to name three competencies. *On three occasions a student's answer was split between two different categories.*

In addition to listing three competencies that were developed during the TLS course, students were asked if they had expected these competencies to be important. Almost all students answered yes, followed by maybe, and two students answered no (Figure 4).

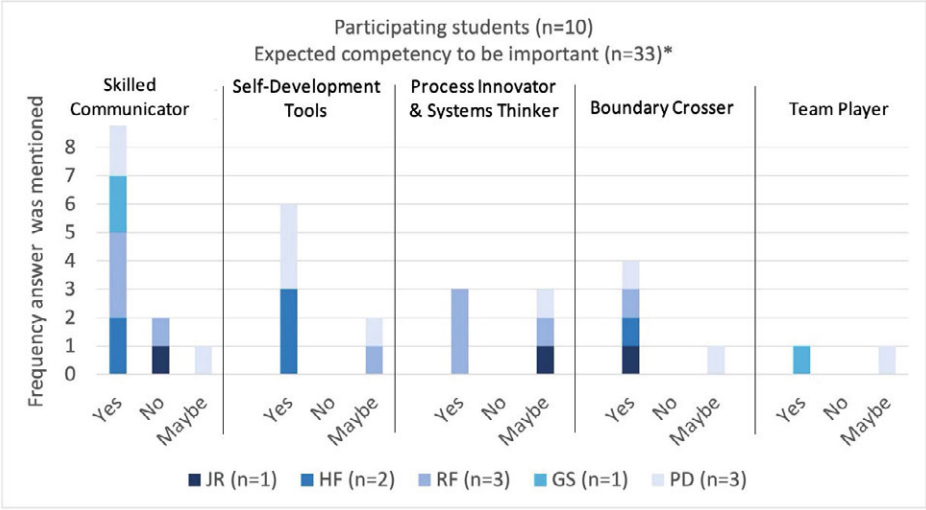

*Figure 4. Student answers to the question if they had expected the three competencies that they listed to be important divided per capstone project. *On three occasions a student's answer was split between two different categories.*

Qualitative Student Survey and Expert Interview Results on Translational Competencies

Skilled Communicator

Students from all five capstone projects listed competencies within this category (n=12). They emphasized the importance of tailoring their communication to different stakeholder groups, including experts and laymen, using various modes of communication. The students elaborated by giving examples of different situations during the TLS course. These included switching the language and tone of conversations to fit specific stakeholder groups by approaching subjects from their perspective. For instance, they chose to use different formats such as presentations for their client and videos or information letters for the general public. The students also described having to adapt their language during the interview process with different stakeholders (e.g., patients, researchers, and policymakers) to help make each interviewee feel comfortable while collecting as much information as possible. They acknowledged sometimes struggling to obtain case specific information from each stakeholder (e.g., patients, parents of patients, and experts in the field), and having to adjust and prepare specific questions for each target group. Lastly, the students highlighted that in conversations with certain stakeholders (e.g., patients) they needed to be very transparent about not presenting certain assumptions as facts when discussing the progress of their capstone project.

When asked if they had expected these competencies to be important, most students answered yes, two responded no, and one maybe. The students who answered yes explained that since they were translating their ideas into real solutions, stakeholder communication was crucial to gain support and reach a broad audience. They added that effective communication was essential in any profession but especially in translational research, where understanding different stakeholders' perspectives plays an important role in reaching their translational goals. These students reiterated the point about tailoring communication to help form a bridge between researchers, policymakers, and the public, and the need for transparency as not to state assumptions as facts. In contrast, the students who answered no admitted underestimating how important stakeholder communication was when involving others in their research. They elaborated that when they thought of translational work they had focused mainly on the scientific aspects and had not anticipated the need for stakeholder interviews. However, they acknowledged the essential nature of engaging stakeholders in this way to ensure the translationability of their work. Finally, the student who answered maybe explained they had not expected to learn so much about interviewing techniques.

All four experts listed communication as a key competency. They emphasized the ability to effectively communicate with peers, patients, and (patient) organizations. The experts highlighted the importance of active listening and using language the patient understands, such as laymen's terms and shorter sentences when appropriate. They gave the example that during their capstone project, students interviewed patients, family members, and health care professionals, adapting their communication to suit each group. This allowed them to pinpoint several important aspects about their research topic. The experts also emphasized the students' ability to communicate their ideas both to experts and to the general public using modern tools. They stressed the importance of both oral and written communication, stating that team discussions, brainstorms, client updates, formal presentations, written reports, and emails with stakeholders needed to be well-structured and effectively communicated. Additionally, the experts noted that due to the COVID-19 pandemic, many meetings were conducted online and required strong communication skills. Lastly, they mentioned that during their capstone projects, a student-team had designated one student as their primary point of contact, which proved to be an effective way of organizing their communication.

> *"While they were interviewing the patients and family members and health care professionals, I think they've done a great job. From the many interviews and questionnaires that they had, they were able to come up with several aspects that are relevant for this specific issue."*
> *(Expert 2)*

"We had regular meetings, I think every two weeks, and there was one person from the three who was basically my point of contact. So, every time a meeting was rescheduled, or I had to read something, this person was communicating with me. So, everything was not coming from three different directions from three different people, but they organized it in a way of communicating that was easy for me. And I think that that is a good way of developing the communication process." (Expert 1)

Self-Development Tools

The students who listed competencies within this category (n=8) wrote about four distinct skills: decision making, reflection, providing and receiving feedback, and creative thinking. Regarding the development of decision-making skills during the TLS course, they explained how by the end of their capstone project, they had learned to incorporate the end-goal in their decision-making process and make faster decisions. Regarding reflection, the students explained that throughout their capstone project they participated in regular reflection to evaluate their progress in each phase of the TLS course. For example, this included reflecting on their own personal development as well as the development of their peers during weekly team meetings focused on discussing acquired and improved competencies. Regarding feedback, the students elaborated on learning how to effectively provide and receive feedback during workshops, team meetings, and feedback sessions. Finally, regarding creative thinking, they listed this as a competency needed in finding solutions to their challenge using the CBL method.

When asked if they had expected these competencies to be important, most students answered yes and two responded maybe. The students who answered yes explained that they had anticipated the importance of decision-making in product development and collaborating with stakeholders. They also recognized the value of reflection and feedback, both in their personal development and in improving their work and the work of others. Regarding creative thinking, the students acknowledged that it was necessary for developing new ideas and solutions for solving societal problems. The students who answered maybe noted that while they recognized reflection as a generally essential skill, they had underestimated its value. Additionally, they had not expected providing and receiving feedback to the extent of what they experienced during the TLS course.

All four experts listed competencies within self-development tools. They used the COVID-19 pandemic as an example of the need for flexibility, pointing out that students had to adapt to working in various environments. They also listed creative

out-of-the-box thinking in the context of *"the sky is the limit"* underpinned, however, by a certain level of content knowledge. Lastly, the experts added empathy for patients and their families, providing an example of how one patient representative had reached out after their student interview praising them on how well prepared and respectful they had been.

> *"Flexibility is also important, but I think especially in COVID times." (Expert 4)*

> *"You have to be able to imagine how it is to be a patient or how it is to be a family member of a patient." (Expert 2)*

Process Innovator and Systems Thinker

The students who listed competencies within this category (n=6) described recognizing and integrating their stakeholders' needs when coming up with suitable deliverables for their capstone project. They explained that during the design process, they encountered stakeholders with different needs and had to ensure all parties felt heard and satisfied with the end-product. Out-of-the-box thinking was mentioned and defined by the students as a necessary competency for designing a product that met the identified societal need while considering the entrepreneurial perspective of the deliverable. The students described engaging in idea-generating sessions within their team, where they were challenged to surpass existing literature and generate entirely novel ideas. They also emphasized the importance of analyzing stakeholders' priorities through interviews and evolving their deliverables from theoretical small-scale concepts to comprehensive research proposals. Additionally, the students mentioned employing a problem-solving approach that involved thoroughly analyzing a problem before thinking about a solution. They explained that prior to joining the TLS course, they tended to jump straight into proposing solutions without adequately analyzing the problem first. Finally, the students shared an experience where they noticed a lack of interest from their target group in their initial design. They then engaged in team-brainstorming to refine their deliverable and better tailor it to the future adopter's needs.

When asked if they had expected these competencies to be important, the students' responses were divided with three answering yes and three maybe. The students who answered yes explained that they recognized the application of their underlying knowledge in solving real-world problems involving multiple stakeholders. They emphasized the significant role of creativity since their assigned problem did not have a known solution, requiring them to come up with something new. On the other hand, the students who responded maybe explained that while they expected to

gain a deeper understanding of their capstone project's problem, they were unaware of the substantial role the stakeholders would play. They noted that they did not initially associate translational science with a design-thinking or problem-solving approach, which they learned during the TLS course. These students also highlighted the importance of a critical and analytical approach in translational work, given its multidisciplinary nature and the multitude of factors to consider. Lastly, they added that they had not always realized that a newly developed product required a paying customer before implementation, and that this customer was not always the end user.

Three experts listed competencies within this category. They mentioned that it was interesting to see how the student-teams grasped the challenge of their capstone project and were able to come up with relevant and novel ideas. The experts explained that during the capstone projects, students had to synthesize information from patients and family members, understand the bigger societal problem, and translate these insights into viable solutions. They commended the students for their fitting and modern ideas. The experts also emphasized that a structured approach and strategic thinking were necessary for developing long-term solutions to societal problems, and that they observed the students demonstrating this ability to assess and prioritize core issues before selecting a focus area and developing a problem-solving strategy.

> *"I think they have listened very carefully and translated what they picked up from the families into something that fits very well into how people are nowadays." (Expert 2)*

> *"I think having a vision is the most difficult, someone with the capability of looking a little bit further than the next day or the next week in terms of what you have to do for your project. What is the dot on the horizon? And the strategy how to get there? I think that is in general quite important in this type of research." (Expert 1)*

Boundary Crosser

The students who listed competencies within this category (n=5) highlighted the importance of collaboration with stakeholders from different fields, including patients, researchers, and policymakers. They emphasized the use of boundary crossing competencies in preparing and conducting interviews with these different stakeholder groups. In their explanation of boundary crossing, the students described the need to adapt their approach to topics based on the specific stakeholder they were engaging with. They also mentioned becoming more proactive in reaching out to experts in the field. Initially, some students expressed hesitancy in approaching experts, concerned about inconveniencing them or taking up their valuable time. However, during the

TLS course, they discovered that experts responded with enthusiasm and were eager to assist with their capstone projects. Finally, the students emphasized the importance of engaging with individuals from various backgrounds, not only researchers but e.g., financial advisors, to initiate collaboration within their capstone projects.

When asked if they had expected these competencies to be important, most students answered yes, while one answered maybe. The students who answered yes highlighted the interdisciplinary nature of translational work, emphasizing the need to engage with professionals from diverse fields and adapt to their needs in order to foster effective collaboration. They recognized that reaching out to stakeholders and boundary crossing were integral aspects of their capstone projects. The student who answered maybe explained that at first they believed that the primary responsibility of a translational scientist was to conduct research benefitting society, and that they had not anticipated the significant role of boundary crossing and connecting with stakeholders from different fields, which became a central part of their capstone project.

Three experts listed boundary crossing competencies. They emphasized that in their respective fields, interdisciplinary collaboration was a key competency. This involved working together across different clinical fields in various hospitals and bridging the gap between research and the clinical setting. The experts highlighted the importance of collaboration not only among themselves but also with patients, general practitioners, and different patient organizations. They listed incorporating both clinical and industrial (pharma- and nutraceutical) needs and being able to collaborate with different parties and people with different expertise as competencies needed for boundary crossing. They further stressed that when addressing a broad problem, it is advantageous to consider different perspectives, involve individuals with a variety of expertise, and remain open to their input.

> *"For my work, I think the most important skill is working together with other disciplines." (Expert 4)*

> *"You need to be open to other people, to other knowledge, and to make the best out of it together." (Expert 1)*

Team Player

The students who listed competencies within this category (n=2) discussed their experiences with learning to delegate tasks more effectively within their teams. They initially expressed stress and discomfort in asking others to take on responsibilities

during their capstone projects, considering the numerous tasks that needed to be completed. However, during the TLS course, they started delegating tasks more frequently and were actively working on becoming more comfortable with this approach. Additionally, the students found it helpful to adhere to the team's established rules, which facilitated smoother teamwork.

When asked if they had expected these competencies to be important, one student answered yes and one maybe. The student who answered yes anticipated that leadership and delegation were essential aspects, particularly within a team dynamic. The other student also expected teamwork to be involved in translational work, however, not to the extent they experienced during the TLS course.

All four experts listed competencies within this category. They expressed positive feedback about the efficient structure and consistency demonstrated by the student-teams working on their capstone projects. The experts noted that the students had different backgrounds, ranging from chemistry and biology to more clinical backgrounds, and that within each student-team there were clearly defined roles for each student, avoiding conflicts. They emphasized the significance of collaboration among the students, highlighting their ability to share the workload, work together harmoniously, and assign relevant tasks to the appropriate team member, thereby overcoming potential barriers such as language. The experts underscored the importance of teamwork in addressing large societal issues and recognized the value of having team members with diverse strengths and flexibility to adapt to various circumstances.

> *"Collaboration with the students themselves is also a very important topic and I had the impression that there were no big issues, and they all took their share and worked on it together." (Expert 2)*

> *"You also need to be able to work together. I think that's really required. You cannot solve these large issues all by yourself." (Expert 1)*

Domain Expert and Rigorous Researcher

Although no students listed competencies within this category, all four experts did. The experts emphasized the importance of skills related to structuring and focusing research questions. They explained that the students encountered an immense amount of information and various viable approaches during their capstone projects, necessitating the ability to narrow down and formulate a single attainable research question. The experts noted that acquiring a solid foundation of basic knowledge was necessary before

students could effectively consider potential solutions. They highlighted the significance of grasping basic science knowledge, particularly in biology and molecular science, to successfully engage with their capstone projects. Lastly, the experts highlighted that the students were tasked with identifying a specific problem within a broad and extensive problem statement, transforming it into a tangible and feasible project.

> *"It was very difficult to structure and to come to one research question. That's one of the skills that they developed." (Expert 4)*

> *"The most complex [part of the project] for students was that they had to make a decision on what specific problem they were focusing on. If I speak about the capstone project that I was the client for, I think that was the most challenging part for students: to go from very broad to a much smaller and achievable, feasible [research question] within the time frame of the project." (Expert 1)*

Quantitative and Qualitative Student Survey Results on the Influence of the TLS Course

When asked if students were planning on choosing a translational career path after graduation, three students answered yes, one responded no, and six maybe (Figure 5). Subsequently, they were asked if their answer had been influenced by their participation in the TLS course. Nine students answered yes, and one maybe (Figure 5).

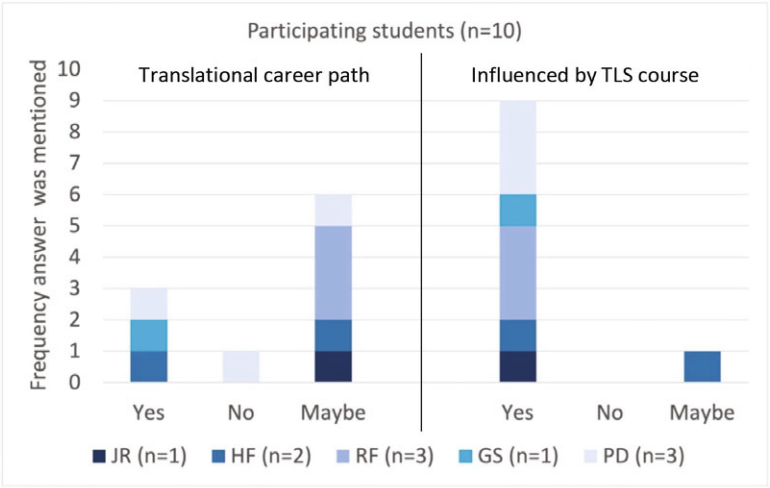

Figure 5. Student answers to the questions if they were planning on choosing a translational career path after graduation and if this decision was influenced by their participation in the TLS course divided per capstone project.

The three students who answered yes to the first question explained that their decision to pursue a translational career path had been made prior to starting the TLS course. However, they all acknowledged that the course had potentially helped confirm their choice. These students expressed that they had enjoyed working in a team to solve societal issues, collaborating with clients, and involving other stakeholders. They also mentioned that the course had highlighted the gap between research and end-users, leading them to consider focusing on e.g., science communication in their future careers. The student who answered no to the first question, expressed dissatisfaction with their capstone project and uncertainty about whether a different project would have been more enjoyable. The six students who answered maybe to the first question shared their appreciation for the course and its translational aspects. They reported to have gained valuable insights into translational work, which opened up potential career paths for them. While unsure about their specific career plans after graduation, the students expressed a strong affinity for collaborating with individuals from diverse professional backgrounds. They added that the TLS course had a significant influence on them and exceeded their initial expectations, resulting in a highly enjoyable experience.

DISCUSSION

This convergent parallel mixed method study aimed to monitor the development of translational competencies from student and expert perspectives. By using both quantitative and qualitative student survey data, as well as semi-structured expert interview data, competencies developed during the six-month GSLS challenge-based TLS course were highlighted. The most listed competency category overall was Skilled Communicator. Almost all students reported that they thought this to be important, and all interviewed experts indicated its importance. In addition to the existing competency categories, this study resulted in a new category named Self-Development Tools. This category consisted of student and expert responses related to decision-making, reflection, feedback, and creative thinking. Finally, the influence of the TLS course on students' choices in pursuing a translational career path after graduation was apparent, all students answered that the challenge-based course did or may have influenced their next career steps.

While the used competency frameworks from literature do not indicate any hierarchy amongst categories, our study showed that the category of Skilled Communicator was most listed overall. In fact, some students reported that they had underestimated how important stakeholder communication was. Communication is explained in both TR and TS Competency Frameworks as playing a crucial role because it facilitates effective collaboration, stakeholder communication, the securing of funding, and ethical research

practices (5).[6] Furthermore, Lotrecchiano et al. (2020) found that competencies within collaboration and interdisciplinary teamwork are commonly required in the translational domain and identified that effective communication is necessary to help exchange and integrate knowledge and expertise towards achieving translational research goals (2). Skilled communication has also been reported as essential for effectively engaging various stakeholders such as patients, healthcare providers, industry partners, policymakers, and the public in a manner that is suitable to each audience (5).[6] In an interview study, LeClair et al. (2020) reported that stakeholder engagement can play an important role in increasing public trust and the understanding of scientific research and its impact (19). Similarly, in a review article Meissner et al. (2020) acknowledged stakeholder engagement as central to dissemination and implementation of translational research (20). They also reported that proper engagement of stakeholders can significantly improve research prioritization and design, yielding more useful research results (20). However, they cautioned that improper engagement with stakeholders can adversely impact the research process and damage trust (20). Additionally, the dissemination of research findings to both scientific and non-scientific audiences enhances the likelihood of adoption and implementation of research (21). Communication is also paramount for grant writing and funding acquisition as funding agencies, to a certain extent, control what research is carried out (22). Finally, the communication of ethical considerations such as transparent informed consent regarding the purpose, risks, benefits, and procedures involved in research participation, is an essential part of the translational research pipeline (23–25).

Several categories from the TR Competency Framework were not found in our study. This could be due to the extensiveness of the framework, interpretation of competencies that fall within these categories, or due to the nature of the challenge-based TLS course being geared more towards competencies for translational scientists. The fact that some competency categories were left unnamed does not diminish their significance. However, a unique finding from our study was the Self-Development Tools category. This category, not found in the TR or TS Competency Frameworks, was identified in both the student survey data and expert interview data and encompassed competencies related to decision-making, reflection, feedback, and creative thinking. According to their article on implications for training translational researchers, Rubio et al. (2010) stated that these competencies help enhance problem-solving skills and refine research approaches, which in turn drives innovation towards more effective, adaptable, and impactful translational research endeavors (26). More specifically, decision-making competencies can enhance the ability to analyze information, evaluate options, consider

6 https://clic-ctsa.org/education/competencies

potential outcomes, and make informed decisions that have significant impact on research projects and translational outcomes (26). In a perspective, Clay et al. (2019) argued that reflection allowed for critical evaluation of one's work creating opportunities for strategy adjustment to enhance research effectiveness, the identification of one's strengths, and areas for growth (27). Additionally, by actively seeking and receiving feedback, research quality and rigor can be improved by gaining different perspectives and identifying blind spots as demonstrated by an article by Searles et al. (2016) on measuring and encouraging research translation and research impact (28). Finally, Rubio et al. (2010) also listed creative thinking as essential for out-of-the-box hypothesis and methodology generation, overcoming research challenges, and generating innovative solutions that contribute to advancements in translational research (26). Skills that were promoted with the challenge-based design of the TLS course.

Although student answers were split between yes, no, and maybe about whether they were planning on choosing a translational path after graduation, all students answered that partaking in the challenge-based TLS course had or may have influenced their answer. By making use of CBL, the TLS course aimed to introduce students to what it would be like working in the translational domain. This was confirmed by the students from our study who emphasized that the TLS course helped them realize they wanted to pursue a translational career, or that the course helped them to better define their future career interests. One of the main benefits of using CBL in the TLS course is its focus on solving real-world problems through interdisciplinary collaboration, engaging stakeholders, and fostering skill development, which both our students and experts alluded to in their answers (15). This finding was corroborated in a study by Radberg et al. (2018) who found that students perceived the development of skills associated with sustainable development, problem formulation, and multidisciplinary collaboration, including engagement with different stakeholders during CBL experiences (16). The collaborative environment of the TLS course fostered innovation, encouraged knowledge sharing, and facilitated the integration of multiple disciplines, which is crucial for successful translation (2). By incorporating stakeholder perspectives and feedback, the TLS course helped students gain insights into the needs, priorities, and constraints of translational work (19,20). These hands-on experiences and active engagement in solving societal challenges are vital for effectively identifying societal needs, and translating research findings into practical applications (26).

Limitations

This study collected student and expert perspectives on which translational competencies were developed during the first edition of the six-month GSLS challenge-based TLS course. While this investigation provides valuable insights, it is essential to acknowledge certain limitations that should be taken into account.

First, the study focused on the development of translational competencies and not on how these competencies were developed. Understanding the approaches that contributed to the development of these competencies could provide insights into the TLS course's learning efficacy.

The design of the TLS course may have also led to the new Self-Development Tools category, as feedback and reflection were integral parts of the curriculum design. However, student and expert answers within this category highlighted their importance for translational work, which was also supported in the literature (10,27).

Data collection included input from ten out of a possible seventeen students and four out of a possible five experts. Furthermore, all five capstone projects differed in subject, and while the results yielded valuable insights for future iterations of the TLS course for the GSLS, the small sample size limits the generalizability of the findings and conclusions on possible subject-specific competency requirements. Discretion should therefore be exercised when interpreting the findings of this study, and further research with a larger and more diverse sample may be necessary to confirm and expand upon these findings.

Notwithstanding these limitations, our findings align with the TR and TS Competency Frameworks, affirming the relevance of the identified competencies. Despite the challenges presented, the results remain valuable, offering a foundational basis for future research on translational competencies.

CONCLUSIONS

This study sheds light on the competencies developed during a six-month challenge-based graduate-level course from the perspectives of both students and experts. The most significant finding was the importance of skilled communication. Additionally, the study identified a new competency category named Self-Development Tools that encompasses competencies related to decision-making, reflection, feedback, and creative thinking. Overall, the study contributes to the understanding of the competencies needed for success in the field of translation and the importance of

tailoring training programs to prepare future professionals. The findings from this study highlight the value CBL can have on helping develop future translational professionals. It also assists with educating the translational workforce and enriches existing literature on translational competencies from both student and expert perspectives.

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Appendix I

Translational Researcher Competency Framework: Core Competencies in Clinical and Translational Research from CTSA (2009).

Core Competencies in Clinical and Translational Research	
Core Thematic Areas	**Competencies**
I. CLINICAL AND TRANSLATIONAL RESEARCH QUESTIONS	1. Identify basic and preclinical studies that are potential testable clinical research hypotheses. 2. Identify research observations that could be the bases of large clinical trials. 3. Define the data that formulate research hypotheses. 4. Derive translational questions from clinical research data. 5. Prepare the background and significance sections of a research proposal. 6. Critique clinical and translational research questions using data-based literature searches. 7. Extract information from the scientific literature that yields scientific insight for research innovation.
II. LITERATURE CRITIQUE	1. Conduct a comprehensive and systematic search of the literature using informatics techniques. 2. Summarize evidence from the literature on a clinical problem. 3. Describe the mechanism of a clinical problem reviewed in a manuscript. 4. Use evidence as the basis of the critique and interpretation of results of published studies. 5. Identify potential sources of bias and variations in published studies. 6. Interpret published literature in a causal framework. 7. Identify gaps in knowledge within a research problem.
III. STUDY DESIGN	1. Formulate a well-defined clinical or translational research question to be studied in human or animal models. 2. Propose study designs for addressing a clinical or translational research question. 3. Assess the strengths and weaknesses of possible study designs for a given clinical or translational research question. 4. Design a research study protocol. 5. Identify a target population for a clinical or translational research project. 6. Identify measures to be applied to a clinical or translational research project. 7. Design a research data analysis plan. 8. Determine resources needed to implement a clinical or translational research plan. 9. Prepare an application to an IRB.
IV. RESEARCH IMPLEMENTATION	1. Compare the feasibility, efficiency, and ability to derive unbiased inferences from different clinical and translational research study designs. 2. Assess threats to internal validity in any planned or completed clinical or translational study, including selection bias, misclassification, and confounding. 3. Incorporate regulatory precepts into the design of any clinical or translational study. 4. Integrate elements of translational research into given study designs that could provide the bases for future research, such as the collection of biological specimens nested studies and the development of community-based interventions.
V. SOURCES OF ERROR	1. Describe the concepts and implications of reliability and validity of study measurements. 2. Evaluate the reliability and validity of measures. 3. Assess threats to study validity (bias) including problems with sampling, recruitment, randomization, and comparability of study groups. 4. Differentiate between the analytic problems that can be addressed with standard methods and those requiring input from biostatisticians and other scientific experts. 5. Implement quality assurance systems with control procedures for data intake, management, and monitoring for different study designs. 6. Assess data sources and data quality to answer specific clinical or translational research questions. 7. Implement quality assurance and control procedures for different study designs and analysis.

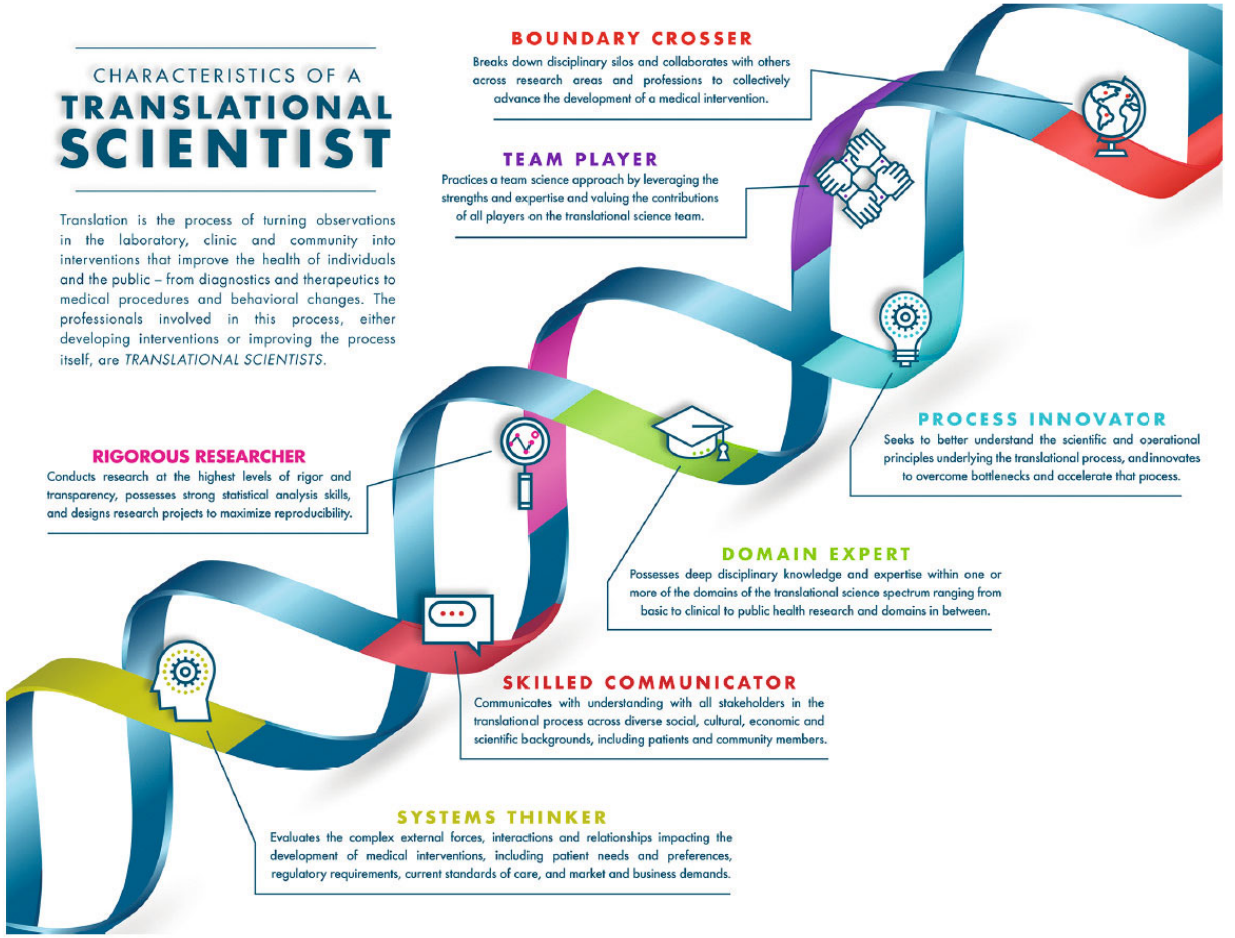
Core Competencies in Clinical and Translational Research

Core Thematic Areas	Competencies
VI. STATISTICAL APPROACHES	1. Describe the role that biostatistics serves in biomedical and public health research. 2. Describe the basic principles and practical importance of random variation, systematic error, sampling error, measurement error, hypothesis testing, type I and type II errors, and confidence limits. 3. Scrutinize the assumptions behind different statistical methods and their corresponding limitations. 4. Generate simple descriptive and inferential statistics that fit the study design chosen and answer research question. 5. Compute sample size, power, and precision for comparisons of two independent samples with respect to continuous and binary outcomes. 6. Describe the uses of meta-analytic methods. 7. Defend the significance of data and safety monitoring plans. 8. Collaborate with biostatisticians in the design, conduct, and analyses of clinical and translational research. 9. Evaluate computer output containing the results of statistical procedures and graphics. 10. Explain the uses, importance, and limitations of early stopping rules in clinical trials.
VII. BIOMEDICAL INFORMATICS	1. Describe trends and best practices in informatics for the organization of biomedical and health information. 2. Develop protocols utilizing management of information using computer technology. 3. Describe the effects of technology on medical research, education, and patient care. 4. Describe the essential functions of the electronic health record (EHR) and the barriers to its use. 5. Explain the role that health information technology standards have on the interoperability of clinical systems, including health IT messaging. 6. Access patient information using quality checks via electronic health record systems. 7. Retrieve medical knowledge through literature searches using advanced electronic techniques. 8. Discuss the role of bioinformatics in the study design and analyses of high dimensional data in areas, such as genotypic and phenotypic genomics. 9. Collaborate with bioinformatics specialists in the design, development, and implementation of research projects.
VIII. CLINICAL RESEARCH INTERACTIONS	A. REGULATORY SUPPORT AND KNOWLEDGE COMPETENCIES 1. Describe the fundamental principles of the protection of human subjects, the main authoritative bodies, key codes, and scope of enforcement. 2. Describe the Food and Drug Administration requirements for drug biologic products 3. Prepare an application for IRB approval. 4. Critique a proposal for risks to human subjects and protections of vulnerable populations. 5. Describe the essential elements of voluntary informed consent. 6. Describe the principles of research documentation, validation and audit. B. RESPONSIBLE CONDUCT OF RESEARCH COMPETENCIES 1. Explain the ways in which the principles of research ethics are integrated into the design, conduct, oversight and dissemination of research. 2. Describe the authority for and professional standards for the responsible conduct o research. 3. Explain the procedures for reporting and investigating misconduct in research. 4. Explain conflict of interest management in research. 5. Outline criteria for determination of authorship. 6. Describe the role of peer review in funding and publication. 7. Explain the purpose, policies and procedures to ensure ethical use, care, and animal safety in research.

Core Competencies in Clinical and Translational Research	
Core Thematic Areas	**Competencies**
IX. SCIENTIFIC COMMUNICATION	1. Communicate clinical and translational research findings to different groups of individuals, including colleagues, students, the lay public, and the media. 2. Translate the implications of clinical and translational research findings for clinical practice, advocacy, and governmental groups. 3. Write summaries of scientific information for use in the development of clinical health care policy. 4. Translate clinical and translational research findings into national health strategies or guidelines for use by the general public. 5. Explain the utility and mechanism of commercialization for clinical and translational research findings, the patent process, and technology transfer.
X. CULTURAL DIVERSITY	1. Differentiate between cultural competency and cultural sensitivity principles. 2. Recognize the demographic, geographic, and ethnographic features within communities and populations when designing a clinical study. 3. Describe the relevance of cultural and population diversity in clinical research design. 4. Describe cultural and social variation in standards of research integrity. 5. Critique studies for evidence of health disparities, such as disproportional health effects on select populations (e.g., gender, age, ethnicity, race).
XI. TRANSLATIONAL TEAMWORK	1. Build an interdisciplinary/ intradisciplinary/ multidisciplinary team that matches the objectives of the research problem. 2. Manage an interdisciplinary team of scientists. 3. Advocate for multiple points of view. 4. Clarify language differences across disciplines. 5. Demonstrate group decision-making techniques. 6. Manage conflict. 7. Manage a clinical and/or translational research study.
XII. LEADERSHIP	1. Work as a leader of a multidisciplinary research team. 2. Manage a multidisciplinary team across its fiscal, personnel, regulatory compliance and problem solving requirements. 3. Maintain skills as mentor and mentee. 4. Validate others as a mentor. 5. Foster innovation and creativity.
XIII. CROSS DISCIPLINARY TRAINING	1. Apply principles of adult learning and competency-based instruction to educational activities. 2. Provide clinical and translational science instruction to beginning scientists. 3. Incorporate adult learning principles and mentoring strategies into interactions with beginning scientists and scholars in order to engage them in clinical and translational research. 4. Develop strategies for overcoming the unique curricular challenges associated with merging scholars from diverse backgrounds.
XIV. COMMUNITY ENGAGEMENT	1. Examine the characteristics that bind people together as a community, including social ties, common perspectives or interests, and geography. 2. Appraise the role of community engagement as a strategy for identifying community health issues, translating health research to communities and reducing health disparities. 3. Summarize the principles and practices of the spectrum of community-engaged research. 4. Analyze the ethical complexities of conducting community-engaged research. 5. Specify how cultural and linguistic competence and health literacy have an impact on the conduct of community engaged research.

Appendix II

Translational Scientist Competency Framework: Characteristics of a Translational Scientist from Gilliland et al. (2019).



Appendix III

Survey questions for the Translational Life Sciences course students.

1. Which Capstone Project were you a part of?
   - Dampening the side effects of Methotrexate in Juvenile Rheumatism
   - Diagnosing heart failure with preserved ejection fraction
   - Differentiation in the measurement of renal function
   - Genetic screening of the family members of patients with genetic disorders
   - Preventing Parkinson's Disease as a result of pesticide use in agriculture

2. While working on your capstone project and personal development, you applied competencies (skills) that are needed as a translational professional. For the purpose of this survey, please state the top three competencies you developed during the TLS course. For example, think of competencies within the categories: translational competencies, boundary crossing competencies, communication, collaboration, and reflection. Feel free to fill in any competency that comes to mind, just try to be as detailed as possible.

3. Please provide one detailed example per above mentioned competency by describing a specific situation during the TLS course in which you used each competency. For example, "I used .. by ..".

4. Did you expect your top three competencies to be an important part of the working life of a translational professional? Yes, No, or Maybe

5. Please explain per competency why you did or did not expect it to be an important part of the working life of a translational professional.

6. Are you planning on choosing a translational path after graduation? Yes, No, or Maybe

7. Was your answer to the previous question influenced by your participation in the TLS course? Yes, No, or Maybe

8. Please explain your answer to question six and the potential influence the TLS course had in this decision. If you answered maybe, please explain what your doubts are.

Appendix IV

Semi-structured interview questions for the Translational Life Sciences course experts.

1. You were one of the clients of the TLS course this past year. Please explain your position in the translational pipeline, to what extent do you see yourself as a translational professional in your line of work?

2. The list of competencies (skills) that are considered a part of the working life for a translational professional is widening. Which competencies do you think are needed for a career in translational research in general?

3. Now focusing on the case you brought to the TLS course. Please give a short summary of the "problem", why it is important, and explain how your capstone project fits into the field of translational research?

4. What would you consider the top three competencies that are needed to work on your specific capstone project?

5. How did you observe these top three competencies in the TLS students that worked on your capstone project? Please provide examples of specific situations during the course.

6. One of the missions of the GSLS is to prepare students for a career in translational research through the TLS course. What would your advice be to them, is there anything missing in your opinion, or can some things only be learned after graduation? Please explain.

7. Lastly a hypothetical question this is just between us, would you consider hiring any of the students you worked with and in what capacity? Why or why not? What did you see in them or what was missing?

8. Do you have anything you would like to add?

CHAPTER 5.2

Practical Tips for Organizing Challenge-Based Learning in Biomedical Education

Publication Status

An adapted version of this study has been accepted for publication as "Kools FRW and van Ravenswaaij H. Practical Tips for Organizing Challenge-Based Learning in Biomedical Education. MedEdPublish. 2023;13:271. https://mededpublish.org/articles/13-271/v1."

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ABSTRACT

Challenge-Based Learning (CBL) in biomedical education can prepare health professionals to handle complex challenges in their work environments through the development and practice of problem-solving skills. This paper provides twelve practical tips for biomedical educators to implement CBL in their education. The intricacies of CBL are explained together with organizational tips, and multiple levels of student support to help students achieve CBL learning goals. Our aim is to promote CBL in biomedical education and to help students acquire valuable skills for post-graduation while working towards solving real societal needs.

INTRODUCTION

Health professionals face complex problems and challenges in their work environments, for which adequate preparation is required during their biomedical education (1). To provide this preparation, Challenge-Based Learning (CBL) can be implemented in biomedical curricula, giving students opportunities to practice and reflect on solving real-world problems (2). CBL is relatively new and is defined by Gallagher and Savage (2023) as a flexible approach that*: "[...] frames learning with challenges using multidisciplinary actors, technology enhanced learning, multi-stakeholder collaboration and an authentic, real-world focus.*". Although CBL resembles Problem-Based Learning (PBL), there are important differences: 1) PBL starts with a given problem, whereas in CBL students formulate the exact problem, 2) PBL uses a product context and customer perspective, whereas CBL uses a transdisciplinary approach within a social context driven by value, and 3) PBL emphasizes team development, whereas CBL focuses on both team and individual development (3,4).

In their international literature review, Gallagher and Savage (2023) provide a summary of the commonly agreed upon characteristics, challenges, and benefits of CBL. Benefits for students include the opportunities to network, apply skills in a real-world environment, practice multidisciplinary teamwork, tolerate ambiguity and uncertainty, and improve their problem-solving and technical skills, as well as deepening their knowledge. Additionally, working partnerships between academia and university are mentioned. However, in their review the authors also highlight the difficulties of reaching a consensus on a single CBL approach (5).

This paper aims to offer practical suggestions for organizing CBL in biomedical education, drawing from our five years of experience with developing, executing, and evaluating CBL at a Dutch graduate school. Given the possible variations of CBL approaches, we describe different implementation choices that could be considered and adapted to local context and learning goals. These suggestions are intended to assist other biomedical educators in effectively incorporating CBL into their educational settings.

TWELVE TIPS

1. Choose a CBL Framework

A framework provides structure for the design and execution of all CBL activities. When designing our CBL activities, we used the "Apple Classrooms of Tomorrow" framework from Nichols, Cator, & Torres (2016) (6). In this framework there are three

distinct phases: 1) engage; students identify a complex real-world problem and define an actionable challenge, 2) investigate; students research their challenge to gain in-depth understanding, and 3) act; solutions are designed and tested (6). Additionally, we integrated design thinking into this CBL framework, which has previously been used in healthcare challenges (see the twelve tips by Wolcott et al. (2020) (7)). Design thinking consists of a series of steps: 1) invest time to understand the problem extensively (divergent thinking), 2) define a specific challenge within the problem (convergent thinking), 3) explore possible solutions (divergent thinking), and 4) prototype and test the chosen solution (convergent thinking), otherwise known as the Double Diamond model.[1] We supported students during both divergent and convergent steps by providing them with tools and exercises. Divergent thinking requires being open and creative. Brainstorming techniques such as the "Six Thinking Hats"[2] or "Wishful Thinking"[3] can be used to encourage this. Convergent thinking involves narrowing down options and making logical decisions. Strategies such as combining similar ideas and voting for the best one or using an impact-effort matrix can aid in this process.[4] During both divergent and convergent phases, we found that stimulating students to include stakeholder perspectives was highly motivating and ensured that creative directions remained on-topic and feasible.

2. Select a Complex Real-World Problem

A real-world problem serves as the starting point for CBL and is in our experience the reason many of our students choose to participate. Gallagher and Savage (2023) identified three CBL characteristics in relation to this: 1) choose a global theme, 2) define the challenge (either by students or educators), and 3) focus on a real-world need (5). Global themes encompass significant topics such as sustainability or health. Complex problems within these themes are inconsistent, influenced by changing variables, open-ended, and include stakeholders with different values and perspectives (8,9). When students define their own specific challenge within a global theme that aims to solve part of a complex problem, ample time is needed for the divergent phase during which students explore the problem in-depth. This approach allows students to a choose a challenge aligned with their own interests, however, faculty supervision is crucial to prevent overwhelming situations due to the enormity of such an assignment. In our education, students tackled the global theme "Healthy Urban Living", specifically the problem of loneliness, and were tasked to formulate

1 https://www.innovationtraining.org/design-thinking-double-diamond-framework-training
2 https://www.debonogroup.com/services/core-programs/six-thinking-hats
3 https://geniusrevive.com/en/wishful-thinking-creativity-technique-for-breakthrough-innovation
4 https://modelthinkers.com/mental-model/impact-effort-matrix

an actionable challenge themselves. When faculty define the challenge, students can spend more time on problem-definition and solutions, resulting in a more action-based design of CBL. However, this approach limits students' freedom, potentially affecting their engagement and motivation. For example, within the "Healthy Urban Living" theme, a pre-defined challenge was to motivate the population to walk or cycle more.

The choice between student- or faculty-defined challenges depends on the design thinking process or the client's preference. A prerequisite of CBL, however, is that students have a certain level of creative freedom, while faculty emphasize the nature of the challenge and guide students towards developing a tangible solution within the given timeframe.

3. Include an Involved Societal Client

Using a real-world problem in CBL involves addressing genuine societal needs rather than fictional scenarios created solely for educational purposes (5,10). Involving one or multiple clients from the community who possess a complex problem requiring a solution is advantageous for CBL. This aspect closely relates to community-engaged learning (see the twelve tips by Marjadi et al. (2022) (11)). Based on our experience, we emphasize the importance of managing the client relationship and establishing agreements regarding their level of involvement, including time investment and level of facilitation. We found that a higher level of client engagement facilitates smoother collaboration. At the very least, the client should be available to provide students with feedback and possess sufficient knowledge about CBL to understand the process, its objectives, and added value. Intellectual property and creative rights should also be agreed upon.

During our CBL program, students were given the opportunity to conduct an initial interview with their client, seek feedback while defining the problem, and after brainstorming sessions about potential solutions. We recommend designating one individual as the client, even if multiple people are involved, to ensure continuity. As CBL is an iterative process that emphasizes student agency, briefing the client about the varying project stages of student-teams helps manage expectations during client-student meetings. Collaboratively designing the conclusion of CBL with the client is also helpful. Possibilities include organizing an event with an external jury and award for the winning team or conducting presentations at the client's workplace. It is crucial for students to understand if this concluding event will be included in their final assessment and how this pertains to the learning objectives of CBL.

4. Offer a Variety of Educational Activities

A variety of educational activities will help to meet different goals of CBL. A not exhaustive overview of educational activities with their purpose, format options, and examples is shown in Table 1. Activities should be chosen based on learning goals, e.g., interviewing the client requires interviewing skills, therefore, a workshop that allows practice is more suitable compared to a lecture.

Table 1. Overview of educational activities with their purpose, format options, and examples.

Educational activity	Purpose	Format options	Examples
Lectures	Provide information	Offline plenary Online content clip	Introducing the global problem
Workshops	Practice CBL skills	Offline Blended	Stakeholder interviewing skills
Inspiration sessions	Inspire students	Short presentation Intro and Q&A	Personal story about a surprising or challenging experience
Team assignments	Define challenge, problem, and solution	Document Video	Contact stakeholders Brainstorm possible solutions
Individual assignments	Stimulate personal development	Document Video	Formulating self-development goals
Coaching	Guide students through CBL and individual development	Flexible and scheduled group and individual sessions Offline or online	Reflecting on subjects such as teamwork and project management

Purposeful scheduling decisions enhance students' workflow and effectivity. Examples include offering activities at consistent times, grouping them by content or type, and scheduling uninterrupted time for team and individual assignments. In our experience, students appreciated a structured approach at the beginning of the challenge, which gradually tapered off as their projects diverged, giving them increased independence and agency. Moreover, we found that using inspiration sessions to spark students' creativity and curiosity stimulated them to proactively seek relevant context related to their challenge, rather than relying on scheduled lectures with predetermined content. This freedom and investigatory approach enhanced students' boundary crossing motivation. Lastly, it is important to offer CBL opportunities throughout the academic year to ensure equal access for students from various disciplines. This creates a diverse student population and promotes interdisciplinary collaboration.

5. Provide an Online Learning Environment and Versatile Physical Location

CBL provides opportunities for learning activities and community building to take place online and offline. Even in completely offline education, an online learning environment is helpful for communication and information sharing. An online CBL learning environment should include: 1) a general channel for announcements and information, 2) an updatable schedule, 3) chat and video conferencing options for plenary, team, and coaching meetings, 4) educational materials (e.g., brainstorming tools, content clips, etc.) with file storage and collaborative functions, and 5) options for uploading assignments for assessment and peer-feedback.

When offline activities are scheduled, having a reserved space for the entire duration of the CBL activities provides continuity, a communal space, share of creative materials, and storing project-related items. Additionally, having a versatile location with movable and adjustable tables and chairs plus technology such as digital whiteboards or screens, facilitates the different educational activities and creative nature of CBL.

6. Train a Diverse Faculty Team

Given the unpredictable nature of CBL, where students can take different directions while trying to solve complex real-world problems, we found that an involved and diverse faculty team is helpful in the design and execution of education. Faculty members should be open to embracing non-traditional ways of teaching where they do not hold all the answers but facilitate students' search for solutions instead. Training faculty in coaching skills and enhancing their understanding of CBL fosters a community mindset and a continuous learning journey alongside the students.

The composition of the faculty team should ideally consist of members with different backgrounds and expertise, supplemented by guest faculty when specific knowledge is required. During our CBL, inspiration sessions were provided by guests from inside academia (e.g., professors), outside academia (e.g., municipality policymakers), and different disciplines (e.g., biomedical sciences and social sciences). Effective teamwork can be cultivated through reflection and feedback (12). Therefore, we recommend organizing faculty meetings to exchange experiences and conducting feedback sessions with students to gather valuable suggestions for improvements.

7. Emphasize Interdisciplinary Collaboration

Interdisciplinary collaboration is one of the key features of CBL and necessary for solving complex (health) problems (5,13). Team formation can play an important role in this process and can be approached in two ways. Students can be given the opportunity to form their own teams, or teams can be formed by faculty. It is recommended that teams consist of a minimum of four members, although the number can be adjusted based on the timeframe and complexity of the challenge, and teams can consist of students from different academic levels (e.g., undergraduates, graduates, and lifelong learners). Given the demanding nature of CBL, teams should aim to be diverse (e.g., mixing educational backgrounds, personality traits, generic skills, and preferred team roles). This will ensure a variety of perspectives and expertise and give students the opportunity to practice interdisciplinary collaboration in preparation for post-graduation work environments.

The interdependency among team members during CBL is high. Therefore, sufficient attention and time should be dedicated to team building. Incorporating team building activities, such as competing with other teams in short challenges where communication is key or getting to know each other games, helps with creating trust between team members (14).

8. Create a Community

In addition to interdisciplinary collaboration within student-teams, it is beneficial to foster a sense of community under all participants in the CBL process, including faculty and coaches. Building a community provides students with a supportive environment and a safe space for reflection, knowledge sharing, learning, and collective growth. Both formal and informal meetings, scheduled during and outside of educational hours, can contribute to community building. Ramani et al. (2021) outlined three phases for developing a community of practice: 1) establish, 2) grow, and 3) sustain (15). Including communal activities such as joint breaks, lunch walks, and energizers in the schedule and encouraging faculty involvement can foster a sense of togetherness. Moreover, students can be encouraged to contribute to community building by suggesting and organizing activities, such as seminars, sports tournaments, or other social gatherings.

Faculty members can enhance community building by being visible and available for students, e.g., by being present in the physical learning space with the students while they work. Beginning and ending each day together also offers opportunities for faculty to reiterate learning objectives and check in with students to ensure they have everything they need to move forward with their projects.

9. Help Students Deal with Uncertainty

Students engaging in CBL often encounter the unfamiliarity of its open character, where the challenge and its solution are not predetermined, and faculty do not possess all the answers (6). It is important for students to learn how to navigate this uncertainty, and faculty can support them by stimulating control behaviors, task monitoring, and self-monitoring (16). Control behaviors involve actions aimed at achieving a goal, which in CBL refers to problem-solving. Faculty can assist students by providing them with tools and instruction for the CBL process, such as discussing the CBL or design thinking structure, offering skill workshops, and sharing examples from previous student-teams. Task monitoring entails understanding the task, so faculty must provide clear instructions and expectations to students. Acknowledging that uncertainty and making mistakes are part of the innovative and creative character of CBL can also be addressed in instruction, with faculty ensuring that this topic remains open for discussion within the community (5). Self-monitoring involves assessing task progress and the effectiveness of actions. One way to do this is through reflection. Additionally, feedback from others is a useful tool (12). Lastly, faculty should clearly communicate how and to what extent students will be assessed.

10. Coach Students and Provide Feedback on Their Development

Supporting students requires recognizing their diverse backgrounds, experiences, knowledge, and (generic) skills, which makes a one-size-fits-all approach challenging. Coaching plays a vital role in CBL as it allows for individualized support tailored to each student's needs. A coach can provide guidance to students both individually and within teams, asking critical questions and facilitating opportunities for them to work towards their goals and explore different team roles, preparing them for post-graduation. A coach can help students navigate uncertainty by helping them find structure within the fluidity of CBL. Feedback is highlighted as a valuable learning mechanism in CBL, and a coach can provide direct feedback on students' actions or engage in reflective discussions with students regarding feedback from others (17).

11. Stimulate Reflection

Reflection, as defined by Sandars (2009), is a process that enhances understanding of a specific situation and oneself to inform future behavior (18). It has been linked to an increased ability to deal with complex problems (19,20). To introduce reflection to our students, we conducted a workshop where we discussed its importance for personal and professional growth, and shared the experiential learning cycle, consisting of four

phases: 1) describing the experience, 2) reviewing the experience, 3) learning from the experience, and 4) experimenting in a new experience.[5]

Throughout the educational process, students were provided with prompts to start the reflective process, such as reflection topics (e.g., trust, resilience, passion) and scheduled disengagement moments (e.g., guided meditation, physical exercises, walking in silence) (21). Linking these prompts to specific educational activities, such as trust and team brainstorming, helps the integration of reflection and education. Reflection can also be stimulated by others, with coaches playing a role in helping students select relevant situations for reflection, analyzing those situations, and formulating alternative behaviors (18). We incorporated both short reflections throughout CBL process and a more comprehensive reflection exercise at the end, allowing students to process their learning. As research indicates no advantage of one format over the other, students were free to choose their own format for their final reflection, such as a written document or video (21). In addition to individual reflection, we also fostered reflection as a community by organizing general feedback moments.

12. Design Appropriate Assessment

In CBL, it is important to employ appropriate assessment methods for both team and individual development (3). Team development is often assessed through presentations of end results to the community, however, each team's challenge specifics such as problem-definition and proposed solutions can be assessed as well. Individual development includes personal learning goals set throughout the educational process (5).

Tackling complex problems with societal impact requires students to apply their domain-specific knowledge and skills flexibly while employing generic skills in different contexts. CBL, with its diverse challenges, stakeholders, and educational activities, provides an ideal platform for developing professional skills such as collaboration, boundary crossing, and communication. These skills can be assessed in detail. For instance, we used personal development plans in which students reflected on and described their skills development (22). A personal development plan can include students' personal learning goals, structured reflection reports, peer-feedback, and teacher observations. Students are assessed on the depth and clarity of their description and their growth regarding professional skills. For more assessment suggestions, see the twelve tips by van der Vleuten et al. (2015) and the CBL framework by Nicols, Cator, & Torres (2016) (6,23).

5 https://learningfromexperience.com

CONCLUSIONS

Being confronted with complex real-world challenges is part of being a health professional. Developing and practicing complex problem-solving should therefore be part of biomedical education, and CBL is a pedagogy that can support this process. The twelve tips described in this paper are inspired by multiple CBL educational activities within a Dutch graduate school but can be adapted to other biomedical programs, as design considerations are described in a broader context, and practical examples are provided. By integrating CBL in biomedical education, students are challenged to develop their complex problem-solving skills and are given the opportunity to involve many stakeholders from inside and outside academia, such as patients and industry, to become the health professionals of the future.

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CHAPTER 6

General Discussion

KEY FINDINGS

In this action-based dissertation, the four studies and their corresponding supplements each highlight a different aspect of the working lives of translational scientists with the purpose of answering the overall research question: *"How can translational scientists be rewarded and supported in their careers?"*.

The scoping review and interview study in **Chapter 2**, aimed to investigate what has been written about publication pressure in biomedical literature using PubMed and elaborate on the findings with semi-structured expert interviews. Results from both the review and interviews showed that publication pressure was perceived as high and that negative consequences of publication pressure, e.g., increased scientific misconduct and burnout, are among the complex challenges researchers face. Based on these results a set of recommendations was formulated. These recommendations include research institutes and graduate schools recognizing and discussing publication pressure amongst employees and students, and that criteria for hiring, promotion, and funding should be as transparent as possible including qualitative measures for impact aside from publication metrics. The supplementary opinion piece associated with this chapter is a critical extension of these findings and embraces the actionable methodological approach set out in this dissertation with the aim of bringing further awareness to this topic within the broader scientific community not only to educate but to also motivate change.

The exploratory interview study in **Chapter 3** on how translational scientists perceive the current academic reward system, consisted of semi-structured interviews with translational scientists from different countries, subspecialties, and at different career stages with the aim of providing real-life accounts of the current working experiences of translational scientists in addition to gathering their suggestions for an ideal academic reward system. The main finding from this study was that translational scientists often lack comprehensive reward systems recognizing their multidimensional work beyond research activities (e.g., clinical, educational, etc.), but despite this, they remain intrinsically motivated to achieve their translational goals. Reported recommendations for an ideal academic reward system included a cultural shift within institutional and global structures allowing for more qualitative performance measurements. Interviewees also recommended support for different employee tracks that allow individuals to customize combinations of clinical work, (bio)medical teaching, and research within flexible working environments, and to facilitate understanding between them and their non-translational colleagues. Supplementing this chapter, the correspondence piece focusing on clinician-scientists brings to light the unique challenges faced by this subset of translational scientists demonstrating how the broader issues identified in this chapter play out in a more specific context.

The longitudinal exploratory mixed method study in **Chapter 4** on international mentorship for translational scientists, aimed to understand mentees' and mentors' mentorship needs, evaluate if the newly piloted online mentorship program met these needs, and collect recommendations for essential components of an online mentorship program. Results showed that both mentees and mentors wanted to learn mentorship skills, receive and provide career support, and gain or expand an (international) network. Recommended essential online mentorship components included interactive online training, multiple mentee-mentor matching rounds, compatible time zones and professional experience for matched pairs, active program moderation with offline activities, and effective online tools. The practical application pieces supplementing this chapter are instrumental in bridging the gap between theory and practical implementation. They offer tangible guidelines and strategies for initiating and maintaining an online mentorship program. These supplementary materials serve not just as an extension of the research, but as a toolkit for institutions and individuals looking to adopt or refine online mentorship programs in their own settings.

The convergent parallel mixed method study in **Chapter 5**, aimed to monitor the development of translational competencies in a graduate-level challenge-based educational setting from student and expert perspectives using two competency frameworks from literature. The main findings from this study were the self-reported importance of skilled communication by both students and experts, and the emergence of a new self-development competency category not found in either competency framework from literature that housed decision-making, reflection, feedback, and creative thinking competencies. The practical piece supplementing this chapter extends the academic inquiry into actionable guidance for implementing challenge-based learning in biomedical education. It is tailored to address the nuances of organizing such an educational model, considering the unique demands and opportunities it presents, and offers a series of pragmatic tips and strategies to assist educators in effectively organizing challenge-based education within their curricula.

BROADER IMPLICATIONS AND CONTRIBUTION TO THE FIELD

When looking at the dynamics of publication pressure (Chapter 2), perspectives from postgraduates (Chapter 3), support for graduate students (Chapter 4), and opportunities within graduate schools (Chapter 5) combined, the overarching findings of these studies highlight the current challenges translational scientists face, but also where opportunities for support lie.

The exploration of publication pressure within biomedical literature and subsequent expert interviews in **Chapter 2**, revealed an interplay of internal and external forces shaping research behavior. Pressure to publish, predominantly driven by current funding and promotional models, not only impacts the quantity and quality of scientific output but also bears psychological implications for researchers. Similarly, the interview study in **Chapter 3** showed strong intrinsic motivations of translational scientists often in the face of suboptimal academic reward systems, and the need for specialized training and sustainable career pathways. These findings together suggest a need for reform to align more closely with the intrinsic goals of translational scientists and for academic reward systems outside of the research domain that support the potential societal impact of their work.

As put forward in the opinion piece in **Chapter 2**, academic journals can play a role in alleviating publication pressure. This can be achieved through several strategies. Firstly, journals could acknowledge and address the impact of their selection bias towards "popular" research topics and positive research results, which significantly shapes global scientific research (1–3). Secondly, a shift in focus may be essential, moving away from emphasizing individual achievements and publication or citation counts, towards fostering societal impact through collaborative efforts (4–6). For example, open access publishing represents a significant transformation in dissemination and accessibility of research findings, promoting societal impact.[1] However, it also brings challenges, such as the proliferation of predatory publishing entities (7). A third potential strategy would be to revise the peer-review system to incentivize reviewers in coping with the exponential increase in publications and ensure transparency, thereby fostering a healthier research culture (8,9). More recently, there have been discussions to move away from traditional peer-review models (10). Innovations such as interactive publications, interdisciplinary research journals, language-agnostic platforms, and AI in peer-review are emerging (11–15). These trends could significantly reduce the workload of all scientists. Likewise, academic institutions have a crucial role in refocusing priorities

1 https://www.nwo.nl/en/open-science

from publications to societal impact (16). This involves supporting in-house knowledge transfer, fostering partnerships with industry, and actively involving patient organizations in setting research agendas (17–22). In addition to these points, the correspondence piece in **Chapter 3** also argues that translational scientists need career support while pursuing translational objectives (23).

The mentorship study in **Chapter 4** highlighted the diverse expectations and evolving needs within mentee-mentor relationships, emphasizing the importance of tailored approaches to mentorship. Even though a decrease in participation can be expected within online programs (24) it could also potentially point to broader systemic issues, such as time constraints and the need for more engaging and supportive designs. In parallel, the competency study in **Chapter 5** provided insights into crucial competencies for translational scientists. The emergence of "Skilled Communicator" as the predominant competency category, alongside the novel category "Self-Development Tools," underscores the evolving skillset required in this field and suggests educational approaches such as Challenge-Based Learning to foster these competencies.

The supplements in **Chapter 4** (Mentorship Program Implementation Handbook, Handbook for Mentees and Mentors, and Mentee Professional Development Portfolio) and **Chapter 5** (Practical Tips for Organizing Challenge-Based Learning in Biomedical Education) aim to offer concrete steps that can be taken within graduate-level education to support early-career translational scientists. Mentorship has previously been found to aid in this support (25,26). Furthermore, on specific competency development, the emergence of micro credentials in higher education potentially offer translational scientists new pathways to gain or hone specific translational skills.[2] These short-term, skills-focused training programs could not only help translational scientists to gain specific competencies relevant to their field that align with their unique roles, but micro credentials could also potentially provide employers with additional metrics during employee evaluations (7,10–15,27,28).

The overall goal of this dissertation was to help understand how to reward and support translational scientists in their careers. Through a series of methodologically diverse studies, this dissertation sheds light on publication pressure, the shortcomings of current academic reward systems, the evolving dynamics of mentorship, and the development of essential competencies in translational science. This research goes beyond identification of issues, it provides actionable recommendations and practical tools for reform and support. The findings underline the need for systemic change, advocating for more holistic approaches that recognize the diverse contributions of

2 https://www.hanoverresearch.com/insights-blog/top-higher-ed-trends-for-the-2023-24-academic-year

translational scientists to patient-focused biomedical science. While not claiming to revolutionize the field, this dissertation adds to the limited but growing body of knowledge on the topic, and importantly, suggests pathways for real-world application and policy reform. Its action-based approach, combined with empirical research, makes it a valuable resource for academic institutions, policy makers, and translational science professionals, in addition to contributing to ongoing discussions and developments in the broader scientific community.

LIMITATIONS

It is important to address the limitations of the studies in this dissertation, potential implications for the findings, and what was done to mitigate them as much as possible. As each chapter contains study specific limitations, overarching limitations are discussed here.

Because this is an action-based dissertation, first and foremost transparency about possible researcher biases is needed in the context of scientific rigor. The interventions designed and studied are subject to selection, observer, and confirmation bias, as well as cultural bias. To mitigate these, multiple researchers and external collaborators were involved in the research process to strive for transparency and reflexivity. Furthermore, mixed-method approaches were used to enhance validity and reliability of the findings for this specific study population.

Other methodological limitations include generalizability of the findings. The studies carried out in this dissertation concern a particular context, **Chapter 2**, or subset of translational scientists, **Chapter 3**, making the findings context specific while providing potential insights about the larger study population. The limited sample sizes, especially in **Chapters 4 and 5**, limit the scope of conclusions in understanding the full spectrum of experiences and perceptions in the whole translational community. Furthermore, all studies (entirely or in part) rely on self-reported data that can affect accuracy. To mitigate these limitations, full transparency and caution was exercised not to overstate or extrapolating findings outside of specific contexts. Lastly, each study provides a snapshot of a situation at a given time. Especially in **Chapters 4 and 5**, a lack of more longitudinal data limits the understanding of long-term impacts and evolutions of mentorship dynamics and competency development.

The limitations underscore the need for continued investigation in these areas. They also highlight the dynamic landscape of translational science, calling for adaptable and responsive research methodologies.

FUTURE RESEARCH DIRECTIONS

This dissertation lays the groundwork for future investigations into how translational scientists can be rewarded and supported in their careers. It calls for an approach that balances the intrinsic motivations of researchers with the extrinsic demands of current academic reward systems. When considering the gaps identified in each study, areas emerge that warrant further investigation.

In the context of publication pressure:
Studies examining the biomedical research landscape from 2010 onwards could help to identify key elements that caused increased publication pressure. These studies should take into account potential cultural and institutional differences. In addition, studies exploring the scientific impact of innovative publication processes could also provide insights into potential viable solutions aimed at alleviating publication pressure.

In the context of academic reward systems:
Studies exploring and analyzing alternative academic reward systems that consider other measures for impact outside of publication metrics and include activities in other domains (e.g., clinical, educational, outreach, policy, innovation, etc.) could help develop more suitable academic reward systems. This is in line with both global and local Dutch initiatives that are introducing new models for recognition and rewards within institutional structures including efforts in collaboration and leadership.[3]

In the context of online mentorship for translational scientists:
Further evaluative and longitudinal studies could help trace the evolutions of mentorship dynamics between matched mentee-mentor pairs over time and study the impact of online mentorship on career development for mentees as well as mentors.

In the context of translational competency development:
Studies that assess the effectiveness of courses designed to contribute to translational competency development could help support the education of early-career translational scientists. These studies should also evaluate the relevancy of these competencies in real-world settings.

3 https://www.uu.nl/en/news/from-merit-to-triple

FINAL CONCLUSION AND RECOMMENDATIONS

The final takeaways from all chapters combined speak to the dynamic and multifaceted nature of the translational medicine landscape, highlighting the intricate interplay between individual motivations, institutional structures, and broader societal impact.

The multifaceted effects of publication pressure on translational scientists can be seen at a systemic and individual level. Because of this complexity, any intervention must be multi-pronged encompassing policy changes, institutional reforms, and a shift in academic culture.

There is a misalignment between current academic reward systems and the goals of translational scientists. To correct this, more holistic, diverse, and equitable systems are needed that recognize a broader range of societal contributions and achievements, beyond traditional publication metrics.

The mentorship study highlights the evolving needs and expectations of mentee-mentor relationships, stressing the importance of adaptable and supportive program designs. This aligns with the competency study, which points to the growing significance of competencies like communication and self-development, underscoring the need for innovative educational approaches.

This dissertation is a call to action from a translational medicine standpoint. It urges a re-evaluation and redesign of current academic reward systems, advocating for an approach that is more aligned with the intrinsic motivations of these researchers to impact patient care. Developments must be culturally relevant taking into account geographical and institutional differences and responsive to current challenges but also future proof, considering the evolving landscape of biomedical research, technological advancements, and changing societal needs. Policy initiatives should aim to fostering a more sustainable, equitable, and impactful research environment. The development of supportive, flexible, and innovative educational programs can serve as a catalyst for change, fostering a new generation of researchers equipped with the skills and motivations to navigate and shape the future of translational science.

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EPILOGUE

As we conclude, the narrative of our postdoctoral researcher from the prologue serves as a reminder of the common struggles faced by translational scientists. Her experiences illuminate a critical need for a paradigm shift in how success is measured in this field. The prevailing dominance of publications as the primary metric overshadows the broader societal impact that lies at the heart of translational medicine.

It is evident that we must redefine the current academic reward system to reward not only scholarly output, but also other contributions to patient care, education, policy, innovation, etc. Furthermore, mentorship tailored to the unique needs and stages of translational scientists' careers and hands-on, problem-solving educational courses geared towards translational competency development, equip aspiring translational scientists with knowledge that textbooks cannot provide.

Let us strive to alleviate the conflict of interest between career progression and achieving patient impact that translational scientists face, and work towards finding more suitable rewards and support.

APPENDIX

ENGLISH SUMMARY

Introduction

Translational medicine is a subfield of the life sciences that aims to solve clinical problems with biomedical research. Unmet patient needs are translated into research questions and research results are then translated into clinical solutions. For this long and complex pipeline to progress, multi- and interdisciplinary collaboration is needed between scientists, clinicians, patient organizations, industry partners, and other stakeholders. Several challenges have been identified along the translational research pipeline, these include financial challenges, regulatory hurdles, uncertain scientific outcomes, and commercial viability that hinder the translational process. Various initiatives have arisen to combat these challenges, however, due to their complexity hurdles still remain.

Within translational medicine, translational scientists hold many different professional identities. For instance, they can be biomedical, bioinformatics, pharmacology, epidemiology researchers with a clear interest in clinical research, clinician-scientists who combine clinical practice with clinical research, or can possess another scientific expertise from in- or outside academia that contributes to the advancement of the translational field while often also being involved in education. Because of this diverse nature, there is no singular path to become a translational scientist and their day-to-day working lives can differ greatly. Additionally, because translational scientists usually balance responsibilities within two or three working domains, i.e., research, education, and healthcare, they face specific challenges in each domain. Pressure to publish scientific articles within the research domain for career advancement or securing funding must be balanced with educational commitments, and if also involved in clinical care, seeing to patient needs.

Publication pressure in the context of scientific research refers to the expectation or demand placed upon researchers to publish their findings in prestigious peer-reviewed journals in order to advance their scientific careers. This includes pressure to publish to obtain funding opportunities and to build scientific reputation amongst peers and academic institutions. Publication pressure can be motivating, and publications remain the main mode of communication within the scientific community. However, when publication pressure turns negative, unintended side-effects arise and can push scientists towards questionable research practices, scientific misconduct, and burnout. In the context of translational medicine where research is meant to serve patient needs, an additional layer of complexity is added because it distracts from the rest of the research pipeline. To counteract the negative effects of publication pressure,

several initiatives have been put forward that aim for more open and collaborative research and re-evaluation of the current academic reward system within research for career advancement, placing greater emphasis on evaluating someone based on impact and real-world outcomes. For translational scientists, this could alleviate the pressure to prioritize publications over focusing on clinical implementation.

The overarching goal of this dissertation is to use an action-based approach to provide evidence-based practical solutions for the challenges that translational scientists face. Specifically, to gain insight into the dynamics of publication pressure in this patient-driven field, to explore options for recognition that are less publication-focused, and to find ways to support and educate its workforce. Action-based research, or action research, is a research methodology that focuses on solving complex real-world problems through an iterative and collaborative process between researchers and stakeholders in the field. It emphasizes the importance of bridging the gap between theory and practice to create meaningful change. The overarching research question for this dissertation is: *"How can translational scientists be rewarded and supported in their careers?"*. This action-based dissertation integrates an empirical study with a supplementary piece for each chapter.

The Dynamics of Publication Pressure

Literature regarding publication pressure in the biomedical sciences was investigated through a scoping review and interview study. The scoping review addressed the ongoing debate within the academic community about publication pressure, specifically its nuances for biomedical sciences. The semi-structured interview component added further understanding of the literature by discussing the review findings from different points of view with professionals working in the field. Results from both the review and interviews showed that publication pressure was perceived as high and that negative consequences of publication pressure, e.g., increased scientific misconduct and burnout, are among the complex challenges researchers face. Based on these results, a set of recommendations was formulated. These recommendations include research institutes and graduate schools recognizing and discussing publication pressure amongst employees and students, and that criteria for hiring, promotion, and funding should be as transparent as possible including qualitative measures for impact aside from publication metrics. This chapter is supplemented by an opinion piece discussing the societal impact of publications. The piece is a critical extension of the study results and embraces the actionable methodological approach set out in this dissertation with the aim of bringing further awareness to this topic within the broader scientific community not only to educate but to also motivate change.

Perspectives From Postgraduates

In an exploratory interview study, perspectives of postgraduate translational scientists from varying countries, subspecialties, and career stages were collected on publication pressure, potential solutions, and how they navigate the current academic reward system. Additionally, light was shed on how they managed their working lives, as many translational scientists balance clinical, educational, and research duties simultaneously in varying settings. The main finding from this study was that translational scientists often lack comprehensive reward systems recognizing their multidimensional work beyond research activities (e.g., clinical, educational, etc.), but despite this, they remain intrinsically motivated to achieve their translational goals. Reported recommendations for an ideal academic reward system included a cultural shift within institutional and global structures allowing for more qualitative performance measurements. Interviewees also recommended support for different employee tracks that allow individuals to customize combinations of clinical work, (bio)medical teaching, and research within flexible working environments, and to facilitate understanding between them and their non-translational colleagues. This chapter is supplemented by a correspondence piece on clinician-scientists, which sheds light on the unique challenges faced by this subset of translational scientists demonstrating how the broader issues identified in this chapter play out in a more specific context.

Support For Graduate Students

A longitudinal exploratory mixed method study was conducted into online mentorship. The aim of the newly developed online mentorship program was to support early-career translational scientists and to foster a translational community. By analyzing participant input data over two pilot years, mentee (early-career) and mentor (more senior) mentorship needs, and program evaluations were analyzed. Additionally, participants' thoughts on the program's online aspect were gathered. Results showed that both mentees and mentors wanted to learn mentorship skills, receive and provide career support, and gain or expand an (international) network. Recommended essential online mentorship components included interactive online training, multiple mentee-mentor matching rounds, compatible time zones and professional experience for matched pairs, active program moderation with offline activities, and effective online tools. This chapter is supplemented by several practical application pieces. The pieces are instrumental in bridging the gap between theory and practical implementation. They offer tangible guidelines and strategies for initiating and maintaining an online mentorship program. These supplementary materials serve not just as an extension of the research, but as a toolkit for institutions and individuals looking to adopt or refine online mentorship programs in their own settings.

Opportunities Within Graduate Schools

Potential educational opportunities within graduate schools to prepare students for a translational career were investigated by studying the development of translational competencies during a newly developed graduate-level challenge-based course. In challenge-based learning, students are tasked to provide potential solutions for complex problems that have societal impact. The translational domain lends itself well to this type of educational framework as it strives to create patient impact and requires competencies transcending disciplinary boundaries. A convergent parallel mixed method design was chosen for this study. Using survey and semi-structured interview data, self-reported competency development from both student and biomedical expert perspectives was compared to two existing competency frameworks. The main findings from this study were the self-reported importance of skilled communication by both students and biomedical experts, and the emergence of a new self-development competency category not found in either competency framework. The new category consisted of decision-making, reflection, feedback, and creative thinking competencies. This chapter is supplemented by a practical tips piece that extends the academic inquiry into actionable guidance for implementing challenge-based learning in biomedical education. It is tailored to address the nuances of organizing such an educational model, considering the unique demands and opportunities it presents, and offers a series of pragmatic tips and strategies to assist educators in effectively organizing challenge-based education within their curricula.

Conclusions

The overall goal of this dissertation was to help understand how translational scientists can be rewarded and supported. Through a series of methodologically diverse studies, this dissertation sheds light on publication pressure, the shortcomings of current academic reward systems, the evolving dynamics of mentorship, and the development of essential competencies in translational science. This research goes beyond identification of issues, it provides actionable recommendations and practical tools for reform and support. The findings underline the need for systemic change, advocating for more holistic approaches that recognize the diverse contributions of translational scientists to patient-focused biomedical science. While not claiming to revolutionize the field, this dissertation adds to the limited but growing body of knowledge on the topic, and importantly, suggests pathways for real-world application and policy reform. Its action-based approach, combined with empirical research, makes it a valuable resource for academic institutions, policymakers, and translational science professionals, in addition to contributing to ongoing discussions and developments in the broader scientific community.

The final takeaways from all chapters combined speak to the dynamic and multifaceted nature of the translational science landscape, highlighting the intricate interplay between individual motivations, institutional structures, and broader societal impact. The effects of publication pressure on translational scientists can be seen at a systemic and individual level. Because of this complexity, any intervention must be multifaceted encompassing policy changes, institutional reforms, and a shift in academic culture. There is a misalignment between current academic reward systems and the goals of translational scientists. To correct this, more diverse and equitable systems are needed that recognize a broader range of societal contributions and achievements, beyond traditional publication metrics. The mentorship study highlights the evolving needs and expectations of mentee-mentor relationships, stressing the importance of adaptable and supportive program designs. This aligns with the competency study, which points to the growing significance of competencies like communication and self-development, underscoring the need for innovative educational approaches.

This dissertation is a call to action from a translational science standpoint. It urges a re-evaluation and redesign of current academic reward systems, advocating for an approach that is more aligned with the intrinsic motivations of these researchers to impact patient care. Developments must be culturally relevant, taking into account geographical and institutional differences, and responsive to current challenges but also future proof, considering the evolving landscape of biomedical research, technological advancements, and changing societal needs. Policy initiatives should aim to support a more sustainable and impactful research environment. The development of flexible and innovative educational programs can serve as a catalyst for change, fostering a new generation of researchers equipped with the skills and motivations to navigate and shape the future of translational science.

NEDERLANDSE SAMENVATTING

Inleiding

Translational medicine is een subveld van de life sciences dat als doel heeft klinische problemen op te lossen door middel van biomedisch onderzoek. Klinische problemen worden vertaald naar onderzoeksvragen, en onderzoeksresultaten worden vervolgens omgezet in klinische oplossingen. Om deze lange en complexe pijplijn te doorlopen is inter- en multidisciplinaire samenwerking nodig tussen wetenschappers, clinici, patiëntenorganisaties, industriële partners en andere belanghebbenden. Verschillende uitdagingen die het translationele proces belemmeren zijn geïdentificeerd langs de translationele onderzoekspijplijn, waaronder financiële uitdagingen, obstakels in regelgeving, onzekere wetenschappelijke uitkomsten en commerciële haalbaarheid. Verschillende initiatieven zijn ontstaan om deze uitdagingen aan te pakken, maar vanwege hun complexiteit blijven er obstakels bestaan.

Binnen translational medicine kunnen translationele wetenschappers veel verschillende professionele identiteiten hebben. Ze kunnen biomedische, bio-informatica-, farmacologie-, epidemiologieonderzoekers zijn met een duidelijke interesse in klinisch onderzoek, klinische wetenschappers die klinische praktijk combineren met klinisch onderzoek, of een andere wetenschappelijke expertise bezitten van binnen of buiten de academie die bijdraagt aan de vooruitgang van het translationele subveld, en zijn vaak ook betrokken bij onderwijs. Vanwege deze diverse aard zijn er veel verschillende manieren om een translationele wetenschapper te worden en kunnen hun dagelijkse werkzaamheden sterk verschillen. Bovendien, omdat translationele wetenschappers meestal verantwoordelijkheden balanceren binnen twee of drie werkgebieden (onderzoek, onderwijs en gezondheidszorg) worden ze geconfronteerd met specifieke uitdagingen in elk domein. Druk om wetenschappelijke artikelen te publiceren binnen het onderzoeksdomein voor carrièreontwikkeling of het verkrijgen van onderzoeksfinanciering moet worden gebalanceerd met onderwijsverplichtingen, en als ze ook betrokken zijn bij klinische zorg, het voldoen van patiëntenbehoeften.

Publicatiedruk in de context van wetenschappelijk onderzoek verwijst naar de verwachting of eis die wordt gesteld aan onderzoekers om hun bevindingen te publiceren in prestigieuze peer-reviewed tijdschriften voor hun wetenschappelijke carrière. Dit omvat druk om te publiceren om financieringsmogelijkheden te verkrijgen en om wetenschappelijke reputatie op te bouwen onder vakgenoten en academische instellingen. Publicatiedruk kan motiverend zijn en publicaties zijn nog steeds het belangrijkste communicatiemiddel binnen de wetenschappelijke gemeenschap. Echter, wanneer publicatiedruk negatief wordt, ontstaan onbedoelde neveneffecten

en kan het wetenschappers aanzetten tot twijfelachtige onderzoekspraktijken, wetenschappelijk wangedrag en burn-out. In de context van translational medicine, waar onderzoek bedoeld is om aan de behoeften van patiënten te voldoen, wordt een extra laag complexiteit toegevoegd omdat het afleidt van de rest van de translationele onderzoekspijplijn. Om de negatieve effecten van publicatiedruk tegen te gaan, zijn verschillende initiatieven ontstaan die streven naar meer open en collaboratief onderzoek en om het huidige academische beloningssysteem binnen onderzoek voor carrièreprogressie te heroverwegen en meer nadruk te leggen op het evalueren van iemand op basis van impact en tastbare resultaten. Voor translationele wetenschappers zou dit de druk kunnen verlichten om publicaties te prioriteren boven de focus op klinische implementatie.

Het overkoepelende doel van dit proefschrift is om een op actie gebaseerde benadering te gebruiken om op bewijs gebaseerde praktische oplossingen te bieden voor de uitdagingen waarmee translationele wetenschappers worden geconfronteerd. Specifiek om inzicht te krijgen in de dynamiek van publicatiedruk in dit op patiënten gerichte veld, opties te verkennen voor erkenning die minder op publicaties is gericht, en manieren te vinden om translationele wetenschappers te ondersteunen en op te leiden. Actiegericht onderzoek is een onderzoeksmethodologie die zich richt op het oplossen van complexe problemen door middel van een iteratief en collaboratief proces tussen onderzoekers en belanghebbenden in het veld. Het benadrukt het belang van het overbruggen van de kloof tussen theorie en praktijk om verandering te creëren. De overkoepelende onderzoeksvraag voor dit proefschrift is: *"Hoe kunnen translationele wetenschappers worden beloond en ondersteund?"*. Dit actiegerichte proefschrift integreert een empirische studie met een aanvullend stuk voor elk hoofdstuk.

De Dynamiek van Publicatiedruk

Literatuur over publicatiedruk in de biomedische wetenschappen werd onderzocht via een scoping review en interviewonderzoek. De scoping review verkende het huidige debat binnen de academische gemeenschap over publicatiedruk, met name de nuances voor de biomedische wetenschappen. Het semi-gestructureerde interviewcomponent voegde verder begrip van de literatuur toe door de bevindingen van de review te bespreken vanuit verschillende perspectieven met professionals die werkzaam zijn in het veld. Resultaten uit zowel de review als de interviews toonden aan dat publicatiedruk als hoog werd ervaren en dat negatieve gevolgen van publicatiedruk, zoals verhoogd wetenschappelijk wangedrag en burn-out, tot de complexe uitdagingen behoren waarmee onderzoekers worden geconfronteerd. Op basis van deze resultaten werd een reeks aanbevelingen geformuleerd. Deze aanbevelingen omvatten dat

onderzoeksinstituten en graduate schools publicatiedruk onder medewerkers en studenten moeten erkennen en bespreken, en dat criteria voor in dienst neming, promotie en financiering zo transparant mogelijk moeten zijn, inclusief kwalitatieve maten van impact naast publicatielijsten. Dit hoofdstuk wordt aangevuld met een opiniestuk dat de maatschappelijke impact van publicaties bespreekt. Het stuk is een kritische verlenging van de onderzoeksresultaten en omarmt de actiegerichte methodologische aanpak die in dit proefschrift is uiteengezet met als doel meer bewustwording over dit onderwerp binnen de bredere wetenschappelijke gemeenschap te brengen, niet alleen om te informeren maar ook om verandering te stimuleren.

Perspectieven van Translationele Wetenschappers

In een exploratief interviewonderzoek werden perspectieven van translationele wetenschappers uit verschillende landen, subspecialismen en loopbaanstadia verzameld over publicatiedruk, mogelijke oplossingen en hoe ze omgaan met het huidige academische beloningssysteem. Daarnaast werd bellicht hoe ze hun werkzaamheden beheerden, aangezien veel translationele wetenschappers klinische, educatieve en onderzoeksverplichtingen tegelijkertijd balanceren in verschillende omgevingen. De belangrijkste bevinding uit dit onderzoek was dat translationele wetenschappers vaak een alomvattend beloningssysteem missen dat hun multidimensionale werk erkent buiten onderzoeksactiviteiten (o.m. klinisch, educatief, etc.), maar ondanks dit blijven ze intrinsiek gemotiveerd om hun translationele doelen te bereiken. Aanbevolen essentiële componenten van een ideaal academisch beloningssysteem omvatten een culturele verschuiving binnen institutionele en globale structuren die meer kwalitatieve prestatie-evaluaties toelaten. Geïnterviewden bevolen ook ondersteuning aan voor verschillende medewerkerstracks binnen instituten die individuen in staat stellen combinaties van klinisch werk, (bio) medisch onderwijs en onderzoek binnen flexibele werkomgevingen aan te passen, en om begrip te vergemakkelijken tussen hen en hun niet-translationele collegas. Dit hoofdstuk wordt aangevuld met een correspondentiestuk over klinische wetenschappers, dat licht werpt op de unieke uitdagingen waarmee deze subset van translationele wetenschappers wordt geconfronteerd en aantoont hoe de bredere problemen geïdentificeerd in dit hoofdstuk zich manifesteren in een meer specifieke context.

Ondersteuning Voor Studenten

Een longitudinale exploratieve mixed method studie werd uitgevoerd naar online mentorschap. Het doel van het nieuw ontwikkelde online mentorschapsprogramma was om beginnende translationele wetenschappers te ondersteunen en een translationele gemeenschap te creëren. Door de data van deelnemers gedurende twee

pilotjaren te analyseren, werden behoeften van mentees (beginnende wetenschappers) en mentoren (meer ervaren wetenschappers) en programma evaluaties geanalyseerd. Daarnaast werden de gedachten van deelnemers over de online aspecten van het programma verzameld. Resultaten toonden aan dat zowel mentees als mentoren mentorschapsvaardigheden wilden leren, loopbaanondersteuning wilden ontvangen en aanbieden, en een (internationaal) netwerk wilden opbouwen of uitbreiden. Aanbevolen essentiële componenten van online mentorschap omvatten interactieve online training, meerdere mentee-mentor-matchingrondes, compatibele tijdzones en professionele ervaring voor gematchte paren, actieve programma-moderatie met offline activiteiten en effectieve online tools. Dit hoofdstuk wordt aangevuld met verschillende praktische toepassingsstukken. De stukken zijn instrumenteel bij het overbruggen van de kloof tussen theorie en praktische implementatie. Ze bieden tastbare richtlijnen en strategieën voor het initiëren en onderhouden van een online mentorschapsprogramma. Deze aanvullende materialen dienen niet alleen als een verlengstuk van het onderzoek, maar als een toolkit voor instellingen en individuen die online mentorschapsprogrammas willen inzetten of verfijnen in hun eigen omgevingen.

Kansen Binnen Graduate Schools

Potentiële educatieve mogelijkheden binnen graduate schools om studenten voor te bereiden op een translationele carrière werden onderzocht door de ontwikkeling van translationele competenties te bestuderen tijdens een nieuw ontwikkeld challenge-based cursus op graduate-niveau. Bij challenge-based learning, krijgen studenten de opdracht om mogelijke oplossingen te bieden voor complexe maatschappelijke problemen. Het translationele domein leent zich goed voor dit type educatief kader, omdat het streeft naar het creëren van impact op patiënten en competenties vereist die disciplinaire grenzen overschrijden. Voor deze studie werd een convergente parallel mixed method ontwerp gekozen. Door middel van enquête en semi-gestructureerde interviewgegevens werden gerapporteerde competentieontwikkelingen van zowel studenten als biomedische experts vergeleken met twee bestaande competentiekaders. De belangrijkste bevindingen uit dit onderzoek waren de zelfgerapporteerde relevantie van vaardige communicatie door zowel studenten als biomedische experts, en het ontstaan van een nieuwe competentiecategorie voor zelfontwikkeling die niet werd gevonden in beide bestaande competentiekaders. De nieuwe categorie bestond uit de competenties besluitvorming, reflectie, feedback en creatief denken. Dit hoofdstuk wordt aangevuld met praktische tips dat de academische vraagstelling uitbreidt naar praktische richtlijnen voor het implementeren van challenge-based learning in biomedisch onderwijs. Het is op maat gemaakt om de nuances van het organiseren van een dergelijk educatief model aan te pakken, rekeninghoudend met de unieke eisen en

kansen, en biedt een reeks pragmatische tips en strategieën om docenten te helpen bij het effectief organiseren van challenge-based onderwijs binnen hun curricula.

Conclusies

Het overkoepelende doel van dit proefschrift was om te begrijpen hoe translationele wetenschappers kunnen worden beloond en ondersteund in hun carrière. Via een reeks methodologisch diverse studies belicht dit proefschrift publicatiedruk, tekortkomingen van de huidige academische beloningssystemen, dynamiek van mentorschap en de ontwikkeling van essentiële translationele competenties. De onderzoeken gaan verder dan het identificeren van problemen, ze bieden bruikbare aanbevelingen en praktische hulpmiddelen voor hervorming en ondersteuning. De bevindingen benadrukken de noodzaak van systemische veranderingen en pleiten voor meer holistische benaderingen die de diverse bijdragen van translationele wetenschappers aan op patiënt gericht biomedisch onderzoek erkennen. Dit proefschrift draagt bij aan de nog beperkte maar groeiende kennis over het onderwerp, en belangrijker nog, suggereert paden voor praktische toepassing en beleidshervorming. De op actie gebaseerde benadering, gecombineerd met empirisch onderzoek, maakt het een waardevolle bron voor academische instellingen, beleidsmakers en professionals in translational medicine, naast het bijdragen aan lopende discussies en ontwikkelingen in de bredere wetenschappelijke gemeenschap.

De uiteindelijke conclusies van alle hoofdstukken gezamenlijk benadrukken de dynamische en veelzijdige aard van het landschap van translational medicine, waarbij de ingewikkelde dynamiek tussen individuele motivaties, institutionele structuren en bredere maatschappelijke impact wordt belicht. De effecten van publicatiedruk op translationele wetenschappers zijn waarneembaar op zowel individueel als systemisch niveau. Vanwege deze complexiteit moet elke interventie veelzijdig zijn en moeten beleidsveranderingen en institutionele hervormingen een verschuiving in academische cultuur omvatten. Er is een discrepantie tussen de huidige academische beloningssystemen en de doelen van translationele wetenschappers. Om dit te corrigeren, zijn er diversere en rechtvaardigere systemen nodig die een breder scala aan maatschappelijke bijdragen en prestaties erkennen, naast traditionele publicatielijsten. Het mentorschapsonderzoek benadrukt de zich ontwikkelende behoeften en verwachtingen van mentee-mentor-relaties, waarbij het belang van aanpasbare en ondersteunende programmaontwerpen wordt benadrukt. Dit sluit aan bij het competentieonderzoek, dat wijst op het groeiende belang van competenties zoals communicatie en zelfontwikkeling, waarbij de noodzaak van innovatieve onderwijsbenaderingen wordt onderstreept.

Dit proefschrift is een oproep tot actie vanuit het perspectief van translationele wetenschappers. Het dringt aan op een heroverweging en herontwerp van de huidige academische beloningssystemen en pleit voor een benadering die meer in lijn is met de intrinsieke motivaties van deze onderzoekers om impact te hebben op patiëntenzorg. Ontwikkelingen moeten cultureel relevant zijn, rekening houden met geografische en institutionele verschillen, en responsief voor huidige uitdagingen maar ook toekomstbestendig zijn, gezien het ontwikkelende landschap van biomedisch onderzoek, technologische vooruitgang en veranderende maatschappelijke behoeften. Beleidsinitiatieven moeten streven naar het bevorderen van een duurzamere en impactvollere onderzoeksomgeving. De ontwikkeling van ondersteunende, flexibele en innovatieve onderwijsprogrammas kan dienen als een katalysator voor verandering, waarbij een nieuwe generatie onderzoekers wordt uitgerust met de vaardigheden en motivaties om de toekomst van translational medicine te navigeren en vorm te geven.

PERSONAL REFLECTION

Looking back on the past years, I can clearly see the significant professional and personal transformation I have experienced. Transitioning from a biomedical laboratory-focused background to the multifaceted realm of social sciences was a daunting experience. This shift was more than just trying to grasp new concepts, methodologies, and a new research language. It was about finding my place in between fields. Finding the right mentors and learning to bridge the gaps in my knowledge were key milestones. With each challenge, my resilience grew, shaping not only my academic skills but also my self-confidence as an independent interdisciplinary scientist. Each setback I encountered was a lesson in persistence and gave me the perspective to celebrate the small victories along the way. This dissertation is a reflection of my academic journey and a testament to the need for creativity and adaptability when approaching this complex topic. While it is impossible to ascertain the impact of this dissertation, I am hopeful about its potential value to the academic community. This work was born out of the desire to do better, better for the scientists working in this field, and better for the patients who should ultimately benefit.

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ABOUT THE AUTHOR

Farah R.W. Kools (1990) was born in Singapore and grew up traveling the world with her parents who were passionate about bringing healthcare to underprivileged areas. Her father, a Dutch general surgeon and Utrecht University alum, and mother, a Singaporean nurse, instilled in her a patient-focused perspective from a young age.

Farah has many interests within biomedical research. During her bachelor's degree in biomedical sciences at Utrecht University, she interned at the department of metabolic diseases within the University Medical Center Utrecht researching the potential post-translational modifications of exercise-induced Nur77 in skeletal muscle and its significance for patients suffering from type 2 diabetes. Thereafter, she began her master's degree in biology of disease with a cardiovascular focus at the Graduate School of Life Sciences of Utrecht University where she did her major internship within the department of regenerative medicine of the University Medical Center Utrecht on the role of lysyl oxidase-like 2 in endothelial-to-mesenchymal transition. For her minor internship, she went abroad to the Vaccine and Immunotherapy Center within Massachusetts General Hospital, a teaching hospital of Harvard Medical School in Boston, USA. There she worked on immune-modulating combination therapies for ovarian cancer. Farah seeks to combine her multidisciplinary biomedical interests with her philosophical interests. During her master's degree she wrote her first philosophical thesis "Imagining the further evolved biological form of human beings" and hopes to write many more.

When in search of a PhD topic, Farah embraced the opportunity to combine her biomedical knowledge with a social sciences approach to question the current academic system in which translational scientists face publication pressure for career progression while working towards unmet clinical needs. While publications are the mode of scientific communication and an important step in the research pipeline, the great emphasis on publications records over research implementation in order to reach societal impact fascinates her. To this end, Farah dedicated her doctoral dissertation to studying this contradiction and identifying areas for improvement and support.

Her personal life has led her to emigrate to the Boston area where she hopes to continue her work within the translational domain.

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