The mentor's role in fostering research integrity standards among new generations of researchers: A review of empirical studies.

Abstract

Promoting research integrity practices among doctoral candidates and early career researchers is important for creating a stable and healthy research environment. In addition to teaching specific technical skills and knowledge, research supervisors and mentors inevitably convey research practices, both directly and indirectly. We conducted a scoping review to summarise the role of mentors in fostering research integrity practices, mentors' responsibilities and the role that institutions have in supporting good mentorship. We searched five different databases and included studies that used an empirical methodology. After searching, a total of 1199 articles were retrieved, of which 24 were eligible for analysis. After snowballing, a total of 35 empirical articles were selected. The review discusses various themes such as the importance of good mentorship, poor mentorship practices, virtues and qualities of mentors, responsibilities and activities of mentors, group mentoring and responsibilities of the institution in supporting good mentorship. This review demonstrates the importance of mentors instilling responsible research practices and attitudes, and promoting research integrity among their mentees. Mentors are responsible for providing explicit guidance and for acting as good role models. The review highlights how poor mentorship can have a bad impact on the research climate. In addition, the review highlights the important influence that institutions can have in supporting mentorship.

Keywords: Mentoring, role model, RI awareness, professional virtues, mentor, research supervisors, institutional responsibilities, research integrity

Introduction

Promoting research integrity (RI) and good research practices (GRPs) is crucial to maintaining a healthy research environment and to countering research malpractice and questionable research practices (QRPs). RI means conducting research according to responsible research practices that meet high professional, methodological and ethical standards (Science Europe Working Group on Research Integrity 2016). In the research environment, QRPs and research misconduct are widespread. Fanelli (2009) already confirmed this in his study, reporting that 2% of researchers admitted serious misbehaviour and that 34% of them reported having been involved in QRPs. No researcher is immune from making research-related mistakes during their career. Poor research practices are not necessarily a matter of bad intentions, but can also be due to a lack of research integrity (RI) awareness and education about responsible research practices (Antes & Dubois 2014; Bouter 2015; Kalichman 2006). RI experts and research administrators have stressed over the years the need to strengthen RI education and awareness (EARMA 2020; Forsberg et al. 2018; Steneck 2013).

In addition to emphasising the role of formal and institutionalised RI education in fostering RI and preventing QRPs and misconduct, various codes and advice from RI experts have accentuated the role of mentors in the education of students, doctoral candidates, and junior researchers (ALLEA 2017; Danish code of conduct for research integrity 2014; Forsberg et al. 2018; Working group of the Austrian Higher Education Group 2020). In addition, mentoring has been identified as one of the core topics highlighted by the Office of Research Integrity (ORI- https://ori.hhs.gov/mentorship). More recently, responsible mentorship has been pinpointed as one of the nine cardinal topics that research performing organisations must tackle to promote RI and good research practices (GRPs) (Mejlgaard et al. 2020).

Mentors are described as gatekeepers of knowledge and professional expertise, as experienced people who serve as career models, who impart technical skills and provide guidance and advice (Smith 2001; Vance 1982). In addition to providing scientific skills and career guidance, mentors can play a critical role in transferring a clear understanding of the values, norms, and behaviour that form the basis for responsible research practices and a healthy research climate (Bell 2015; Bird 2001; Whitbeck 2001). Resnik argues that established scientists should educate and train junior researchers to do good science and promote GRPs (2005). However, there are no specific rules, guidelines or requirements for good mentoring (Sawatzky & Enns 2009; Titus & Ballou 2014).

The European Code of Conduct for research integrity emphasises the role of senior researchers, research leaders, and supervisors in mentoring their younger colleagues and students, by also paying particular attention to fostering a culture of RI (ALLEA 2017). However, it is not clear how mentors are responsible for this and what activities they need to undertake with their mentees to foster RI. Before investigating the role and the responsibilities of mentors in fostering a RI culture and discussing new strategies, policies and initiatives, a review of published empirical studies on the topic is needed to identify gaps and new opportunities for enquiry.

This study focuses on performing a scoping review of empirical studies on the role of mentors in transmitting RI competencies to mentees and promoting good research practices among junior researchers and doctoral students. The analysis provides a comprehensive overview of the role and responsibilities of the mentor, and the virtues and characteristics associated with a good role model. In addition, the study aims to provide an overview of the role that institutions play in supporting good

mentorship practices and in recognising the role of mentors in fostering a positive RI climate.

Methods

Design

We conducted a scoping review of empirical studies with the aim of mapping existing literature on the role of mentors in transmitting RI competencies and fostering GRPs in their mentees, and on the role of institutions in supporting good mentorship. Conducting a scoping review permits one to identify key concepts and lacunae of existing studies on this topic (Arksey & O'Malley 2005; Peters et al. 2015). Moreover, a scoping review permits us to have a first assessment of the size of the literature, focusing on identifying research evidence, and providing a characterization of the quantity and quality of the literature (E.g. study design, stakeholders involved and other key features) (Grant & Booth 2009). We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Liberati et al. 2009; Page et al. 2021). PRISMA guidelines provide a reporting system to help researchers organise and transparently report a review study.

Search strategy

We searched five different databases: PubMed, Embase, Web of Science, Scopus and Science Direct. The search strings were developed using two different groups of keywords. Strings referring to the role of mentors and the topic of RI were merged in a single search string (Table 1 – Search strategy).

The results from the different databases were merged and duplicates were deleted. Screenings of titles, abstracts and full-texts were conducted to determine if the retrieved

papers met the inclusion criteria. After selecting the final 24 manuscripts, a snowballing[1] process was performed to enrich the pool of selected papers (Greenhalgh & Peacock 2005) (Figure 1 – PRISMA extraction chart). This snowballing process added 11 more articles, giving us a total number of 35 manuscripts to analyse.

Inclusion and exclusion criteria

In the review, we included only empirical papers published in English in peer-reviewed journals. The search was first conducted in June 2020, double-checked in October 2020, and in October 2021. Educational resources, training materials, books, monographs, newspaper articles and other types of academic products on the subject were excluded. We included only peer-reviewed empirical literature to have high-quality empirical evidence on the topic. In selecting the papers, we did not make any philosophical or semantic distinction between terms such as mentor, supervisor, and advisor, but considered them interchangeable (Titus & Ballou 2013). Titus and Ballou reported that institutions and students have various ways (e.g., mentor, advisor, supervisor) to describe the role. Therefore, we wanted to be sure not to exclude certain studies by not including one of the terms. We included publications describing the role of mentors in transmitting RI competencies and fostering GRPs in their mentees and research team. Although scientific rigour is key to replicability and thereby valid and credible studies, we focused on RI-related studies and did not include articles describing the role of mentors in the development of scientific and technical skills. In other words, we acknowledge that the development of technical skills (e.g., laboratory skills, statistical skills, empirical research-related skills) also play a role in maintaining RI (NASEM 2017- Chapter 9).

[1] "Snowballing" refers to a specific practice used in literature review in which references listed on a paper and citations to the paper are used to enrich the pool of papers retrieved in the primary search (Greenhalgh & Peacock 2005).

In this review, we included only studies that address the role of mentors as trainers and in fostering GRPs in the context of RI. Although we acknowledge that the concept of RI can have a broad understanding (e.g., addressing diversity, inclusion and other ethical aspects), we considered RI in a narrow sense, taking into consideration only the issues highlighted by the ORI (the Office of Research Integrity). The review focuses on mentorship practices "to maximise the quality and robustness of research, and to respond adequately to threats to, or violations of research integrity" (ALLEA 2017).

Analysis of the selected manuscripts

At first, we analysed empirical studies alongside theoretical ones, in order to better analyse and structure the findings from empirical studies. This was also done to overcome preliminary problems we had in defining specific themes to be analysed. These problems were related to the difficulties in defining clear themes, due to several overlaps, only from the empirical literature. Through a preliminary analysis of the empirical literature selected for the review (Supplement 1 & 2) and the theoretical literature on the topic (Alfredo & Hart 2011; Bird 2001; Bukusi, Manabe & Zunt 2019; Eisen & Berry 2002; Faden et al. 2002; Heitman 2000; Pascal 2006; Roland 2007; Weil 2001; Whitbeck 2001), we identified six distinct thematic groups, namely: 1) the importance of good mentorship, 2) poor mentorship practices, 3) virtues and qualities of mentors, 4) mentor's responsibilities and activities, 5) group mentoring and 6) responsibilities of institutions in supporting good mentorship. The purpose of this phase was to provide an initial idea for a framework to better categorise the empirical findings. In a second phase, we re-analysed the empirical studies selected for this review. In order to better organise and structure the findings, we felt that the six thematic groups were appropriate for the scope of our work. Therefore, to make the organisation of the findings simple and clear, we assigned a colour to each of the six thematic groups. When organising the findings, we colour-coded the

different contents according to the thematic group we wanted to assign them to. For example, content related to the first thematic group, the importance of good mentorship, was similarly colour-coded. The preliminary analysis of the empirical and theoretical papers only served to better organise the findings and not to select *a priori* empirical studies for re-analysis. In the analysis, we only considered empirical data described in the Results section below without considering opinions, justifications or hypotheses made by the authors in the discussion of the results.

In addition to the content analysis, we analysed the Methods and Results sections of each empirical study, looking for information on how the studies were performed. First, we sought information about the study approach (e.g., qualitative, quantitative, multiple or mixed approaches). Second, we identified whether the study was conducted in a specific academic field (e.g., life sciences, social sciences, engineering and physics, humanities). Finally, we sought information on the profile of the actors involved in the study (e.g., PhD students, senior faculty members, mentors, professors, etc.) (Supplement 1 – Characterisation of the articles).

Results

The systematic search retrieved 1199 articles (Figure 1- PRISMA extraction chart). Of those, 24 were eligible for inclusion. We identified 11 additional articles through snowballing for a total of 35 publications (Table 2 – Methodology of the selected studies; Supplement 1 – Characterisation of the articles).

Among the empirical papers, 18 studies used a quantitative approach, 12 used a qualitative approach, three used multiple qualitative and quantitative methods, and two were analyses of case studies (Table 2 – Methodology of the selected studies). Quantitative studies took into consideration the perspective of mentors (6), mentees (8)

and both groups (3). Qualitative studies also took into consideration the perspectives of mentors (6), mentees (4) and both groups (3) (Supplement 1 – Characterisation of the articles).

About half of the studies were conducted exclusively in the life sciences[2] (19/35-54%) (Supplement 1 – Characterisation of the articles). However, studies conducted within the social sciences and other fields also contributed to the topic. When analysing empirical studies that involved multiple disciplines (not just the life sciences), the opinions of people from the social sciences and engineering provided additional information for the development of the topic.

In analysing the research papers, we identified content belonging to all six thematic groups mentioned above. No other recurring theme related to the role of mentors in fostering RI practices was found. Eighteen articles addressed the importance of mentorship, eleven articles addressed poor mentorship, nine addressed the virtues and qualities of mentors, sixteen addressed the mentor's responsibilities and activities, four addressed group mentoring, and eight addressed institution's responsibilities related to mentorship (Supplement 2- Publications for specific thematic group).

The importance of good mentorship

The importance of good mentorship in RI is emphasised in 18 publications (18/35; 51.5%). This section summarises information on the importance of good mentorship practices in influencing the behaviour and attitude of mentees towards responsible research practices.

[2] For this paper, we included the biomedical sciences in the life sciences as used by the European Research Council. (ERC- https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/wp-call/2022/wp_horizonerc-2022_en.pdf).

Empirical studies reported the importance of mentors in providing ongoing guidance and engaging in informal discussions about research integrity and responsible practices. By providing RI-related information and engaging in RI-related discussions, mentors can raise mentees' awareness of responsible conduct in all stages of the research process (Abedin et al. 2012; Antes, Kuykendall & DuBois 2019a; Eastwood et al. 1996; Haven et al. 2020; House & Seeman 2010; Huybers, Greene & Rohr 2020; Lenz & Ketefian 1995; Peiffer, Hugenschmidt & Laurienti 2011; Ripley et al. 2012). Good mentorship is valuable not only for mentees' development into responsible researchers, but also for their development into future responsible mentors (Straus, Chatur & Taylor 2009). In addition, other studies have reported the importance of mentors being responsible for the process of socialisation of mentees with the norms and values related to the research environment and RI practice (Abedin et al. 2012; Gray & Jordan 2012; Lenz & Ketefian 1995).

Mentors can influence the attitude of mentees towards responsible research by providing explicit and direct instructions on both general and more discipline-specific research practices and responsible conduct of research (RCR). Fisher and colleagues showed in their survey that mentors, by providing mentees with explicit instructions on RI, help to increase the awareness of mentees about responsible research practices (Fisher, Fried & Feldman 2009). According to Anderson and colleagues, good mentorship practices can influence the behaviour of mentees and their understanding related to RI issues when done formally and directly (Anderson et al. 2007). Explicit practices are meant to train mentees to do science in the right way (Antes, Mart & DuBois 2016). In addition, direct mentorship seems to be more effective when mentors can demonstrate RI with their own daily research activities. Direct mentoring allows mentors to provide general and more discipline-specific RI training (Gray & Jordan 2012).

In addition to providing direct instructions, mentors promote RI practices among their mentees by acting as role models and setting examples for responsible research. Empirical studies report that by acting responsibly, mentors provide concrete role modelling and shape the attitudes and the behaviour of their mentees (Abedin et al. 2012; Antes, Mart & DuBois 2016; Fisher, Fried & Feldman 2009; Gray & Jordan 2012; Ketefian & Lenz 1995; Krishna & Peter 2018; Plemmons & Kalichman 2018). Furthermore, good mentorship is important to address the values and morality of academic integrity and implicitly set standards of integrity (Löfström et al. 2015).

Poor mentorship practices

Poor and inappropriate mentorship has been highlighted in 11 publications (11/35; 31.5%). The following section summarises information related to the negative influence and impact that poor mentorship can have on the attitude of mentees towards RI. Moreover, the section shows how poor mentorship practices can lead to misconduct and questionable practices.

Different typologies of poor mentorship practices related to RCR are highlighted in diverse empirical studies. First, poor mentorship practices include mentors not being good role models in terms of responsible research attitude. According to two different studies, mentees' attitudes and behaviour can be negatively influenced by research supervisors when acting irresponsibly and setting a bad example (Gray & Jordan 2012; Krishna & Peter 2018). Research supervisors who take RI-related issues lightly can give their mentees the wrong impression regarding the importance of respecting certain good practices. Haven and colleagues reported that mentees and students know when a mentor does not pay attention to transferring RI-related competencies (Haven et al. 2019; Straus, Chatur & Taylor 2009). It has been reported that mentors often feel more comfortable

serving as role models for developing knowledge and expertise rather than modelling ethical behaviour (Ripley et al. 2012).

Second, poor mentorship practices concern mentors not giving importance to directly transferring RI-related information. The study conducted by Ripley and colleagues (2012) stated that the frequency of RI-related communications between mentors and mentees only occurred once every four months rather than weekly. This low frequency and contact time is insufficient for students to learn to solve significant problems (Ripley et al. 2012). The idea that research supervisors might have little interest in the moral development of their mentees has been considered by another study. Senior academics have been reported to be more interested in producing results rather than teaching and mentoring their students. The authors argue that an outcome-oriented climate might produce "corner-cutting, ethically insensitive future researchers" (Roberts, Kavussanu & Sprague 2001, p.536).

Third, poor mentorship practices refer to mentors being completely absent. Redman and colleagues analysed cases involving allegations of research misconduct made by individual clinical trials staff members. The authors summarised their analysis, stating, "because of lax supervision and poor quality control methods, the respondent (the defendant) had been able to produce fraudulent data over an extended period of time" (Redman, Tempelin & Merz 2006, p.485). In another publication, it has been highlighted how deficient mentoring contributed to increased malpractice. In 71% of the cases, mentors rarely reviewed raw data and in 47% of the cases, mentors failed to set standards for RCR and created a stressful environment (Wright, Titus & Cornelison 2008).

Finally, poor mentorship practices are related to mentors taking advantage of the mentees' work. For example, research supervisors have been known to take credit for the

work of mentees, or even steal their research (Jackson et al. 2003; Seeman & House 2010; Straus, Chatur & Taylor 2009).

Virtues and qualities of mentors

Virtues and qualities of mentors are discussed in nine publications (9/35; 25.7%). This section summarises information on the virtues and qualities that mentors should possess and express in order to act as good mentors and role models.

A number of publications listed virtues and qualities that mentors should have or develop during their careers (Table 3 – List of virtues). All publications listed in Table 3 emphasised that it is important for mentors to embody certain virtues and qualities in order to be positive role models. Trustworthiness and honesty are the most frequently cited virtues (Hauer et al. 2005 ; Leslie, Lingard & White 2005; Rabatin et al. 2004; Sawatzky & Enns 2009; Straus, Chatur & Taylor 2009). Furthermore, good communication skills are described as an essential quality of good role models (Antes, Kuykendall & DuBois 2019b; Pennanen, Heikkinen & Tynjälä 2020; Rose 2003; Sawatzky & Enns 2009; Williams et al. 2004). In their empirical work, Antes and colleagues reported that mentors consider it important to express certain virtues such as transparency and honesty in their daily research-related activities in order to be exemplars for the entire team (Antes, Kuykendall & DuBois 2019b). Pennanen and colleagues stated that virtuous mentors, or mentors who exhibit virtuous characteristics, generally display the qualities in their daily lives outside mentoring or research-related activities (Pennanen, Heikkinen & Tynjälä 2020).

Mentor's responsibilities and activities

The responsibilities of mentors and the activities they undertake to foster RI are highlighted in 16 publications (16/35; 45%). The following section summarises the

information on mentor responsibilities and the activities mentors must perform to promote RI (Table 4 – Mentor's responsibilities and activities).

Empirical studies report that organising regular meetings between mentors and mentees is considered one of the most important activities to foster responsible practices (Antes, Mart & DuBois 2016; Antes, Kuykendall & DuBois 2019a; Antes, Kuykendall & DuBois 2019b; Leslie, Lingard & White 2005; Plemmons & Kalichman 2018; Rabatin et al. 2004; Rose 2003). Such meetings serve to review the different research steps of the mentee's progress and discuss responsible practices and other activities focusing on preventing possible misbehaviour.

Another responsibility reported in empirical publications is related to checking, discussing, and interpreting data and findings. Mentors are responsible for supporting their mentees in the analysis of data and helping them to understand how to interpret data and results (Antes, Kuykendall & DuBois 2019a; Antes, Kuykendall & DuBois 2019b; Lenz & Ketefian 1995; Rabatin et al. 2004; Titus & Ballou 2014). In addition, research supervisors and mentors are responsible for providing writing support, dealing with authorship and peer review issues, for ensuring sufficient training for all novices, holding regular meetings, fostering good attitudes towards compliance, integrity and standard operating procedures, reviewing data, and providing emotional and psychological support as needed (Abedin et al. 2012; Anderson et al. 2007; Antes, Kuykendall & DuBois 2019b; House & Seeman 2010; Ripley at al. 2012; Seeman & House 2010; Titus & Ballou 2014).

Group mentoring

The concept of group mentoring is discussed in four publications (4/35; 11.4%). This section presents information on the added value of group mentoring activities in fostering RI and responsible research practices.

A small number of empirical studies report that although it is the most common mentor-mentee relationship, not limiting mentees to only one mentor can help promote greater awareness and knowledge of the topic of RI (Haven et al. 2020; Peiffer, Hugenschmidt & Laurienti 2011; Pennanen, Heikkinen & Tynjälä 2020; Plemmons & Kalichman 2018). In particular, it has been documented that it is important to have more than one mentor to avoid getting a single worldview of the research environment and research practices (Haven et al 2020). Plemmons and Kalichman reported the importance of more formal group discussions to concretely engage mentees in discussions about RI and responsible practices (Plemmons & Kalichman 2018). Pennanen and colleagues reported that group mentoring activities helped the promotion of a sense of equality and fairness within the group. The added value of group mentoring is that different mentors and mentees can participate in a discussion that offers diverse experiences and perspectives to promote reflection (Pennanen, Heikkinen & Tynjälä 2020).

Peiffer and colleagues developed a weekly programme to meet the need for continuous professional development on RCR. Their goal was to foster open discussion among lab members about the integrity of science and daily research activities involving senior researchers as mentors. After analysing the survey results on perspectives of lab members concerning the program, the authors reported that the weekly promotion of RCR has changed the culture in the laboratory and that the discussion about RI are a regular activity during weekly meetings and at other times (Peiffer, Hugenschmidt & Laurienti 2011).

Institution's responsibilities in supporting good mentorship

Institutional responsibilities in supporting good mentorship are highlighted in eight publications (8/35; 22,8%). Here, we have summarised various recommendations in which institutions are called upon to take responsibility for supporting and helping

mentors. In addition, information on institutions that recognise the role of mentors is also reported.

Both qualitative and quantitative studies have highlighted the responsibility of institutions to emphasise the importance of the role of mentors and to improve mentoring practices (Hauer et al. 2005; Ketefian & Lenz 1995). However, there is little guidance regarding good mentorship practices and a lack of supportive infrastructures (Sawatzky & Enns 2009; Titus & Ballou 2014). Mentors have also been reported to lack concrete preparation and competence on the topic of RI (Ripley et al. 2012; Straus, Chatur & Taylor 2009). Moreover, a lack of academic recognition has also been mentioned (Straus, Chatur & Taylor 2009).

Quantitative and qualitative studies point out that institutions need to support and help research mentors by providing training, seminars and workshops on mentoring practices and RI (Hauer et al. 2005; Haven et al. 2020; Ripley et al. 2012; Titus & Ballou 2014; Williams et al. 2004). In addition, institutions should foster peer discussion groups and provide dedicated spaces for interaction between mentors to share advice and experiences.

Discussion

In analysing the methods section of the selected studies, we became aware that most empirical research on RI-related mentoring has been conducted exclusively in the life sciences. However, in studies with participants from different fields, the social sciences and engineering are well-represented, while the humanities are only marginally involved. This could be due to different factors. First, concerning the humanities, our review excludes publications such as books and monographs, which are more common in this field. Second, some specific mentorship-related activities such as group mentoring,

reviewing raw data and developing standard operating procedures are less prevalent in the humanities. Third, this could be due to different understandings of the mentor's role in fostering RI culture across disciplines. Finally, it could be due to the fact that the topic of RI is generally more addressed, taught and discussed more in the life sciences than in other fields. For example, looking at the freely available educational resources on RI and documents referring to RI practices, only a few of them focus on disciplines other than the life sciences and outside medical research (Pizzolato, Abdi & Dierickx 2020; Ščepanović et al. 2021). Therefore, the fact that most studies on the role of mentors in fostering RI are conducted within the life sciences is probably not an artefact of the selected databases. Even though two of them (PubMed and Embase) are specific to the biomedical sciences, we made sure to cover all the other disciplines by including three additional multidisciplinary databases (Scopus, Web of Science and Science Direct). Another important point is that empirical studies investigating the role of mentors in fostering RI are very recent. The fact that 19 studies (19/35; 54%) were performed after 2010 shows that the interest in this topic is growing.

Most empirical studies investigate the role of mentors in fostering RI only as part of the research, and do not focus solely on RI. Moreover, the role of institutions in supporting good mentorship practices was only marginally addressed in most of the studies that we found. These gaps in the literature may provide further opportunities for exploration.

In analysing the manuscripts, we encountered some difficulties related to the interchangeable use of the terms 'mentor', 'supervisor', 'advisor' and 'leader'. In the majority of the publications, these terms seem to be used inconsistently. There is often no demarcation between these roles and no understanding of what the authors mean when using these specific terms. However, we do recognise that all of these different profiles

can include the role of the mentor. To be clear, none of these other roles are completely synonymous with that of the mentor though some may include the responsibilities of a mentor. The fact that there is no a clear definition of the terms ‘mentor’, ‘supervisor’, ‘advisor’ and ‘leader’ can be problematic in defining one’s activities and clear expectations for mentees. In this way, ”we lose the opportunity to assess and discuss standards to achieve the ultimate objective of promoting and improving the research ethics education and training of doctoral students to prevent scientific misconduct (Steneck 2006).

The role that mentors play in fostering RI practices and transmitting RI competencies is considered an essential duty and also emphasised in theoretical articles on the subject, and in international and national codes of conduct (ALLEA 2017; Bell 2015; Bird 2001; Danish Code of Conduct for Research Integrity 2014; Netherlands Code of Conduct for Research Integrity 2018; Whitbeck 2001; Weil 2001). Good mentorship can shape mentees' ethical conduct, encourage good research practices, and produce ethical researchers (Daku 2018). In addition, besides being responsible for their mentees’ development as responsible researchers, mentors also hold an overarching responsibility for the general research climate. For instance, this role is also highlighted by KU Leuven in its Charter of the PhD researchers and supervisors (https://www.kuleuven.be/english/research/phd/charter). In discussing the importance of good mentorship in fostering RI and responsible research practices, we focused mainly on the direct impact that mentors can have on their mentees. However, this impact can be extended to a larger scale. Good mentorship and responsible research practices by mentors could lead mentees to follow in their mentors’ footsteps, as mentors and as researchers. This ‘mimetic’ effect could have a long term impact on the research climate.

In addition, good mentorship and responsible research practices may spread across and/or beyond institutional or national boundaries due to the high mobility of researchers.

In contrast to institutionalised RI training, mentorship has the advantage in that it can be personalised according to the need. This customisation may depend on the nature of the particular relationship and the discipline-specific RI issues. The unique mentor/mentee relationship might be more successful in transferring RI-related awareness and knowledge than formal lectures on RI, and can result in well-supported colleagues based on a well-established trust-based working relationship (Lee, Dennis & Campbell 2007). In relying too much on formal trainings, mentors can miss the opportunity to provide a first-hand real-life training to translate into practice what mentees learn from institutional RI training sessions (Muthanna & Alduais 2020).

Being absent as a mentor is not only a missed opportunity to promote responsible research, but it is also considered malpractice (Roland 2007; Whitbeck 2001). Poor mentorship can also be related to a lack of interest in addressing and discussing RI-related issues (Bird 2001; Lee, Dennis & Campbell 2007; Roland 2007; Weil 2001; Whitbeck 2001). The latter may be due to a voluntary lack of attention towards these practices, but it can also be caused by mentors being busy with teaching, academic and administrative obligations, and not having enough time for RI-related activities. In this case, institutional support is crucial to ensure that students receive the right mentoring. Although the review focuses on the role of the mentor in fostering RI, poor mentorship practices concern mentoring broadly.

The role of mentors in transferring RI knowledge and high ethical standards should be acknowledged and supported by institutions (Bird 2001; Kornfeld 2012; Rose 2003; Weil 2001). This could be especially important for junior supervisors. In order to continue their academic career, junior mentors, especially senior post-doctoral

researchers, have to dedicate the majority of their time to research and publishing (Rawat & Meena 2014). For this reason, junior mentors who devote a considerable amount of time to supervising or mentoring their mentees instead of doing research and publishing might be penalised in the appointment or promotion process.

The quality of guidance and modelling of mentees' theoretical attitudes and practical behaviour in relation to ethical research is difficult to assess. Poor ethical behaviour of mentees could be due to dubious or even bad mentorship practices but could also be due to the incapacity or unwillingness of mentees to receive and accept RI-related instructions from mentors. Although mentees and junior researchers are knowledgeable and skilled in terms of RI and able to distinguish between what can be done or not (theoretical attitude), they may be willing to take shortcuts and engage in QRPs and sloppy science (practical behaviour). Although it is not always easy to identify the culprit in case of misconduct, empirical studies show how poor mentoring can lead to misbehaviour of junior researchers (House & Seeman 2010; Kornfeld 2012; Redman, Tempelin & Merz 2006; Seeman & House 2010; Wright, Titus & Cornelison 2008).

Being a bad mentor in terms of providing RI support should not imply that one is a bad mentor overall. One can be a good mentor in providing instruction about research procedures but lack adequate RI-related expertise. In this case, a more team-based approach provided by multiple mentors can be useful to fill possible gaps in delivering RI standards (Abedin et al. 2012; Haven et al. 2020).

Mentors are expected to spend regular time with their mentees to engage in preparatory activities that lead to mentee’s independence, but also to discuss RI-related issues (Faden et al. 2002; Pascal 2006; Roland 2007). In addition to this, mentors have a special responsibility to the scientific community and society (Bird 2001; Löfstrom et al. 2015). Mentors are responsible for making their mentees aware of the social function,

expectations, and scientific standards of their profession as researchers and scientists (Motta 2002). Furthermore, mentors are in part responsible for maintaining the level of trust that society has in science and scientists (Eisen & Berry 2020). In addition, providing emotional and psychological support when needed can be crucial for limiting a mentee's level of stress, thereby helping them to resist taking shortcuts or engaging in QRPs.

Specific virtues and qualities of mentors are highlighted in our review. In the results section, we decided to list all the virtues we found in the analysis to avoid possible misinterpretations, as the same virtue can be understood in different ways. To be more effective, we decided to group similar virtues together. The most important virtues that emerged in this way are honesty, openness, respect, trust, responsibility, empathy and commitment. These virtues are not just related to the role of mentors in fostering RI, but they concern mentorship broadly. Virtues such as honesty and respect are also cited as important virtues in national and international European codes of conduct (ALLEA 2017; Desmond & Dierickx 2021; Netherlands Code of Conduct for Research Integrity 2018). It has been argued that the virtue-based teaching approach is more useful in informal training practices through mentorship than in institutional education (Resnik 2012). Pennock and colleagues have already proposed the virtue-based approach for ethics training (Berling et al. 2018; Pennock & O'Rourke 2017). In addition, within the EU framework, the same approach is currently used in the RI related Train-the-Trainer program developed by the EU-funded project VIRT^{2}UE (VIRT^{2}UE-project).

While the quality of being a good mentor can be innate in some people, others need training to learn how to act as a mentor and how to develop specific skills (e.g., communication, social skills, and non-verbal communication). Institutions should develop, document, and promote specific training to educate faculty members to be effective mentors and avoid misinterpretation of some RI-related issues (Bird 2001;

Lerouge & Hol 2020; Mejlgaard et al. 2020; Rose 2003; Whitbeck 2001). Institutional responsibility to provide adequate training sessions for all senior academics involved in mentorship activities is also required by different European codes (ALLEA 2017; Danish Code of Conduct for Research Integrity 2014). In this regard, some initiatives are already taking place Europe, in which universities encourage supervisors to follow training on mentorship and responsible supervision (Haven et al. 2022; Lerouge & Hol 2020). In addition, the National Science Foundation (NSF), in the U.S., has recently enlarged requirements for institutions by adding the necessity to provide mentor training (https://resdev.gmu.edu/research-development-resources/nsf-mentoring-requirements-for-new-proposals/).

Strengths and limitations

This review provides an overview of the mentor's role in transmitting RI core values and good research practices to doctoral students and junior researchers. Its main strength lies in its transdisciplinarity, focusing on the role of mentors in promoting RI culture and good research practices without making distinctions among disciplines or academic fields. Raising awareness of this topic goes beyond differences between disciplines or research typologies. Not only did we search databases related to the life sciences, where RI seems to be more commonly addressed, but we expanded the search to three general databases in the hope of finding publications in other fields (e.g., social sciences, humanities, and engineering). As mentioned earlier, this could be due to several factors and the fact that the topic of RI and RI-related mentoring practices are likely to be more prevalent in the life sciences than in other academic fields. Although we did not limit our search to a specific time period, it was not possible to find empirical articles on this topic before 1996. This may be due to the fact that the search for empirical evidence

on the role of mentors in promoting RI has only recently begun. For example, when searching for the term "research integrity" in PubMed, we found that the oldest article dates back to 1986 (https://pubmed.ncbi.nlm.nih.gov/?term=%22research%20integrity%22&sort=pubdate&sort_order=asc).

One of the major limitations of this review is due to the methodology used and the exclusion and inclusion criteria. We only included empirical evidence from peer-reviewed publications in the review to ensure high quality. However, not including books, monographs, teaching materials, and newspaper articles on the topic could have limited the number of reflections on the role of mentors in promoting RI and influenced the results and discussion section. Another limitation of this review is that there are few qualitative publications that ask mentors and mentees separately: mentors about their perceptions of their role in promoting RI and mentees about their experiences.

Conclusion

This review highlights the literature that addresses how mentors play a fundamental role in educating mature students and young researchers to act responsibly in doing science. By both providing explicit instructions and acting as virtuous exemplars, mentors can guide new generations of researchers towards a greater awareness of RI. Although many have acknowledged the importance of the role of mentors, institutions seem reluctant to formally recognise and reward mentors for their contribution to fostering a climate of RI. Rewards and recognition are essential for improving mentorship practices, but first, the academic environment needs to recognise the key role that good mentorship plays in maintaining high RI standards and awareness of the topic. In addition, institutions should

work more actively to train research supervisors and mentors so that they are able to effectively teach RI competencies and foster a responsible research climate.

Although this review provides an overview of best practices (e.g., regular meeting, review of data, discussion of results, psychological support) further empirical studies are needed. Further investigation of real-life mentorship practice in different academic disciplines can clarify differences in mentors' understanding of their role as RI trainers. Furthermore, exploring also differences in gender, seniority and country could facilitate the development of more general, as well as detailed, guidelines. This can help research institutions develop ad-hoc guidelines to support responsible mentorship.

List of abbreviations

GRPs: Good research practices

ORI: Office of research integrity

QRP: questionable research practice

RCR: Responsible conduct of research

RI: Research integrity

SOP: Standard operating procedure

Reference

Abedin, Z., Biskup, E., Silet, K., Garbutt, J. M., Kroenke, K., Feldman, M. D., … Pincus, H. A. (2012). Deriving competencies for mentors of clinical and translational scholars. *Clinical and Translational Science*, *5*(3), 273–280. https://doi.org/10.1111/j.1752-8062.2011.00366.x

Alfredo, K., & Hart, H. (2011). The university and the responsible conduct of research: Who is responsible for what? *Science and Engineering Ethics*, *17*(3), 447–457. https://doi.org/10.1007/s11948-010-9217-3

ALLEA. 2017. *The European Code of Conduct for Research Integrity* (revised edition)

Anderson, M. S., Horn, A. S., Risbey, K. R., Ronning, E. A., De Vries, R., & Martinson, B. C. (2007). What do mentoring and training in the responsible conduct of research have to do with scientists' misbehaviour? Findings from a national survey of NIH-funded scientists. *Academic Medicine*, *82*(9), 853–860. https://doi.org/10.1097/ACM.0b013e31812f764c

Antes, A. L., & Dubois, J. M. (2014). Aligning objectives and assessment in responsible conduct of research instruction. *Journal of microbiology & biology education*, *15*, 12. https://doi.org/10.1128/jmbe.v15i2.852

Antes, A. L., Kuykendall, A., & DuBois, J.M. (2019) (a). Leading for research excellence and integrity: A qualitative investigation of the relationship-building practices of exemplary principal investigators. *Accountability in Research 26*(3): 198–226. https://doi.org/10.1080/08989621.2019.1611429.

Antes, A. L., Kuykendall, A., & DuBois, J.M. (2019) (b). The lab management practices of 'research exemplars' that foster research rigor and regulatory compliance: A qualitative study of successful principal investigators. *PLoS ONE 14*(4): 1–29. https://doi.org/10.1371/journal.pone.0214595.

Antes, A. L., Mart, A., & DuBois, J. M. (2016). Are leadership and management essential for good research? An interview study of genetic researchers. *Journal of Empirical Research on Human Research Ethics*, *11*(5), 408–423. https://doi.org/10.1177/1556264616668775

Arksey, H., & O'Malley, L. (2005). Scoping studies: Towards a methodological framework. *International Journal of Social Research Methodology: Theory and Practice*, *8*(1), 19–32. https://doi.org/10.1080/1364557032000119616

Bell, E. (2015). A room with a view of integrity and professionalism: Personal reflections on teaching responsible conduct of research in the neurosciences. *Science and Engineering Ethics*, *21*(2), 461–469. https://doi.org/10.1007/s11948-014-9545-9

Berling, E., McLeskey, C., O'Rourke, M., & Pennock, R. T. (2019). A new method for a virtue-based responsible conduct of research curriculum: Pilot test results. *Science and Engineering Ethics*, *25*(3), 899–910. https://doi.org/10.1007/s11948-017-9991-2

Bird, S. J. (2001). Mentors, advisors and supervisors: Their role in teaching responsible research conduct. *Science and Engineering Ethics*, *7*(4), 455–468. https://doi.org/10.1007/s11948-001-0002-1

Bouter, L. M. (2015). Commentary: Perverse incentives or rotten apples? *Accountability in Research*, *22*(3), 148–161. https://doi.org/10.1080/08989621.2014.950253

Bukusi, E. A., Manabe, Y. C., & Zunt, J. R. (2019). Mentorship and ethics in global health: Fostering scientific integrity and responsible conduct of research. *American Journal of Tropical Medicine and Hygiene*, *100*(Suppl 1), 42–47. https://doi.org/10.4269/ajtmh.18-0562

Buljan, I., Barać, L., & Marušić, A. (2018). How researchers perceive research misconduct in biomedicine and how they would prevent it: A qualitative study in a small scientific community. *Accountability in Research 25*(4): 220–38. https://doi.org/10.1080/08989621.2018.1463162.

Character traits: Scientific virtue. *Nature 532***,** 139 (2016). https://doi.org/10.1038/nj7597-139a

Charter of the PhD researchers and the supervisors- KU Leuven. https://www.kuleuven.be/english/research/phd/charter

Danish Code of Conduct for Research Integrity. 2014. https://ufm.dk/en/publications/2014/the-danish-code-of-conduct-for-research-integrity

Daku, M. (2018). Ethics beyond ethics: the need for virtuous researchers. *Bmc Medical Ethics*, *19*. https://doi.org/10.1186/s12910-018-0281-6

Desmond, H. (2019). Professionalism in science: competence, autonomy, and service. *Science and Engineering Ethics*, *26*(3), 1287–1313.. https://doi.org/10.1007/s11948-019-00143-x

EARMA. 2020. Guidance for implementation of ethics and integrity training. https://www.earma.org/wp-content/uploads/2020/10/EARMA-ERION-Training-Report-2020_v20.10.pdf

Eastwood, S., Derish, P., Leash, E., & Ordway, S. (1996). Ethical issues in biomedical research: Perceptions and practices of postdoctoral research fellows responding to a survey. *Science and Engineering Ethics*, *2*(1), 89–114. https://doi.org/10.1007/BF02639320

Eisen, A., & Berry, R. M. (2002). The absent professor: Why we don't teach research ethics and what to do about it. *American Journal of Bioethics*, *2*(4), 38–49. https://doi.org/10.1162/152651602320957556

Faden, R. R., Klag, M. J., Kass, N. E., & Krag, S. S. (2002). On the importance of research ethics and mentoring. *American Journal of Bioethics*, *2*(4), 50–51. https://doi.org/10.1162/152651602320957565

Fanelli, D. (2009). How many scientists fabricate and falsify research? A systematic review and meta-analysis of survey data. *PLoS ONE*, *4*(5). https://doi.org/10.1371/journal.pone.0005738

Fisher, C. B., Fried, A. L., & Feldman, L. G. (2009). Graduate socialisation in the responsible conduct of research: A national survey on the research ethics training experiences of psychology doctoral students. *Ethics & Behaviour*, *19*(6), 496–518. https://doi.org/10.1080/10508420903275283

Forsberg, E. M., Anthun, F. O., Bailey, S., Birchley, G., Bout, H., Casonato, C., … Zoller, M. (2018). Working with research integrity-guidance for research

performing organisations: The Bonn PRINTEGER statement. *Science and Engineering Ethics*, *24*(4), 1023–1034. https://doi.org/10.1007/s11948-018-0034-4

Grant, M. J., & Booth, A. (2009). A typology of reviews: an analysis of 14 review types and associated methodologies. Health information and libraries journal, 26(2), 91–108. https://doi.org/10.1111/j.1471-1842.2009.00848.x

Gray, P. W., & Jordan, S. R. (2012). Supervisors and academic integrity: Supervisors as exemplars and mentors. *Journal of Academic Ethics*, *10*(4), 299–311. https://doi.org/10.1007/s10805-012-9155-6

Greenhalgh, T., & Peacock, R. (2005). Effectiveness and efficiency of search methods in systematic reviews of complex evidence: Audit of primary sources. *British Medical Journal*, *331*(7524), 1064–1065. https://doi.org/10.1136/bmj.38636.593461.68

Hauer, K. E., Teherani, A., Dechet, A., & Aagaard, E. M. (2005). Medical students' perceptions of mentoring: A focus-group analysis. *Medical Teacher*, *27*(8), 732–734. https://doi.org/10.1080/01421590500271316

Haven, T., Bouter, L., Mennen, L., & Tijdink, J. (2022). Superb supervision: A pilot study on training supervisors to convey responsible research practices onto their PhD candidates. Accountability in research, 1–18. Advance online publication. https://doi.org/10.1080/08989621.2022.2071153

Haven, T. L., Tijdink, J. K., Martinson, B. C., & Bouter, L. M. (2019). Perceptions of research integrity climate differ between academic ranks and disciplinary fields: Results from a survey among academic researchers in Amsterdam. *PLoS ONE*, *14*(1), 1–17. https://doi.org/10.1371/journal.pone.0210599

Haven, T., Pasman, H. R., Widdershoven, G., Bouter, L., & Tijdink, J. (2020). Researchers' perceptions of a responsible research climate: A multi focus group study. *Science and Engineering Ethics*, *26*(6), 3017–3036. https://doi.org/10.1007/s11948-020-00256-8

Heitman, E. (2000). Ethical values in the education of biomedical researchers. *The Hastings Center Report*, *30*(4), S40. https://doi.org/10.2307/3527665

House, M. C., & Seeman, J. I. (2010). Credit and authorship practices: Educational and environmental influences. *Accountability in Research*, *17*(5), 223–256. https://doi.org/10.1080/08989621.2010.512857

Huybers, T., Greene, B., & Rohr, D. H. (2020). Academic research integrity: Exploring researchers' perceptions of responsibilities and enablers. *Accountability in Research*, *27*(3), 146–177. https://doi.org/10.1080/08989621.2020.1732824

Jackson, V. A., Palepu, A., Szalacha, L., Caswell, C., Carr, P. L., & Inui, T. (2003). '"Having the Right Chemistry"': A qualitative study of mentoring in academic medicine. *Academic Medicine*, *78*(3), 328–334. https://doi.org/10.1016/s1359-6128(17)30424-x

Kalichman, M. (2006). Ethics and science:A 0.1% solution. *Issues in Science*, *23*(1), 34–36. https://doi.org/10.1016/j.coldregions.2009.07.004.Calonne

Ketefian, S., & Lenz, E. R. (1995). Promoting scientific integrity in nursing research .2. Strategies. *Journal of Professional Nursing*, *11*(5), 263–269. https://doi.org/10.1016/s8755-7223(05)80006-7

Kornfeld, D. S. (2012). Perspective: Research misconduct: The search for a remedy. *Academic Medicine*, *87*(7), 877–882. https://doi.org/10.1097/ACM.0b013e318257ee6a

Krishna, A., & Peter, S. M. (2018). Questionable research practices in student final theses – Prevalence, attitudes, and the role of the supervisor's perceived attitudes. *PLoS ONE*, *13*(8). https://doi.org/10.1371/journal.pone.0203470

Lee, A., Dennis, C., & Campbell, P. (2007). Nature's guide for mentors. *Nature*, *447*(7146), 791–797. https://doi.org/10.1038/447791a

Lenz, E. R., & Ketefian, S. (1995). Promoting scientific integrity in nursing research, part I: Current Approach in Doctoral Programs. *Journal of Professional Nursing*, *11*(4), 213–219. https://doi.org/10.1016/S8755-7223(05)80006-7

Lerouge, I., & Hol, A. (2020). Towards a research integrity culture at universities : From recommendations to implementation, LERU, 48. https://www.leru.org/publications/towards-a-research-integrity-culture-at-universities-from-recommendations-to-implementation

Leslie, K., Lingard, L., & Whyte, S. (2005). Junior faculty experiences with informal mentoring. *Medical Teacher*, *27*(8), 693–698. https://doi.org/10.1080/01421590500271217

Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P. A., … Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: Explanation and elaboration. *PLoS Medicine*, *6*(7), 1-28. https://doi.org/10.1371/journal.pmed.1000100

Löfström, E., Trotman, T., Furnari, M., & Shephard, K. (2015). Who teaches academic integrity and how do they teach it? *Higher Education*, *69*(3), 435–448. https://doi.org/10.1007/s10734-014-9784-3

Mejlgaard, N., Bouter. L.M., Gaskell, G., Kavouras, P., Allum, N., Bendtsen, A-K.,… Veltri, G.. (2020). Research integrity: nine ways to move from talk to walk. *Nature*, *586*, 358–360.

Muthanna, A., & Alduais, A. (2021). A thematic review on research integrity and research supervision : Relationships , crises and critical messages. *Journal of Academic Ethics*, (19), 95–113.

National Academies of Sciences, Engineering, and Medicine (NASEM). (2017). Fostering integrity in research. Washington, DC: The National Academies Press. 10.17226/21896.Netherland Code of Conduct For Research Integrity . 2018 https://www.vsnu.nl/files/documents/Netherlands%20Code%20of%20Conduct%20for%20Research%20Integrity%202018.pdf

Office of Research Integrity. https://ori.hhs.gov/mentorship

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C.D., …Moher, D. (2021). The PRISMA 2020 statement: An update guideline for reporting systematic review. *PLoS Medicine, 18*(3), 1-15. https://doi.org/10.1371/JOURNAL.PMED.1003583

Pascal, C. B. (2006). Managing data for integrity: Policies and procedures for ensuring the accuracy and quality of the data in the laboratory. *Science and Engineering Ethics, 12*(1), 23–39. https://doi.org/10.1007/s11948-006-0004-0

Peiffer, A. M., Hugenschmidt, C. E., & Laurienti, P. J. (2011). Ethics in 15 min per week. *Science and Engineering Ethics*, *17*(2), 289–297. https://doi.org/10.1007/s11948-010-9197-3

Pennanen, M., Heikkinen, H. L. T., & Tynjälä, P. (2020). Virtues of mentors and mentees in the finnish model of teachers' peer-group mentoring. *Scandinavian Journal of Educational Research*, *64*(3), 355–371. https://doi.org/10.1080/00313831.2018.1554601

Pennock, R. T., & O'Rourke, M. (2017). Developing a scientific virtue-based approach to science ethics training. *Science and Engineering Ethics*, *23*(1), 243–262. https://doi.org/10.1007/s11948-016-9757-2

Peters, M. D. J., Godfrey, C. M., Khalil, H., McInerney, P., Parker, D., & Soares, C. B. (2015). Guidance for conducting systematic scoping reviews. *International Journal of Evidence-Based Healthcare*, *13*(3), 141–146. https://doi.org/10.1097/XEB.0000000000000050

Pizzolato, D., Abdi, S., & Dierickx, K. (2020). Collecting and characterising existing and freely accessible research integrity educational resources. Accountability in research, *27*(4), 195–211. https://doi.org/10.1080/08989621.2020.1736571

Plemmons, D. K., & Kalichman, M. W. (2018). Mentoring for responsible research: The creation of a curriculum for faculty to teach RCR in the research environment.

Science and Engineering Ethics, *24*(1), 207–226. https://doi.org/10.1007/s11948-017-9897-z

Rawat, S., & Meena, S. (2014). Publish or perish: Where are we heading? *Journal of research in medical sciences : the official journal of Isfahan University of Medical Sciences*, *19*(2), 87–89.

Rabatin, J. S., Lipkin, M., Rubin, A. S., Schachter, A., Nathan, M., & Kalet, A. (2004). A year of mentoring in academic medicine. *Journal of General Internal Medicine*, *19*(5), 569–573. https://doi.org/10.1111/j.1525-1497.2004.30137.x

Redman, B. K., Templin, T. N., & Merz, J. F. (2006). Research misconduct among clinical trial staff. *Engineering*, *12*(3), 481–489.

Resnik, D. B. (2005). *The Ethics of Science: An Introduction*. New York: Routledge

Resnik, D. B. (2012). Ethical virtues in scientific research. *Accountability in Research* *19*(6): 329–43. https://doi.org/10.1080/08989621.2012.728908.

Ripley, E., Markowitz, M., Nichols-Casebolt, A., Williams, L., & Macrina, F. (2012). Guiding the next generation of NIH investigators in responsible conduct of research: The role of the mentor. *Accountability in Research*, *19*(4), 209–219. https://doi.org/10.1080/08989621.2012.700880

Roberts, G. C., Kavussanu, M., & Sprague, R. L. (2001). Mentoring and the impact of the research climate. *Science and Engineering Ethics*, *7*(4), 525–537. https://doi.org/10.1007/s11948-001-0010-1

Roland, M. (2007). Who is responsible? *EMBO Reports*, *8*(8), 706–711.

Rose, G. L. (2003). Enhancement of mentor selection using the ideal mentor scale. *Research in Higher Education*, *44*(4), 473–494. https://doi.org/10.1023/A

Sawatzky, J. A. V., & Enns, C. L. (2009). A mentoring needs assessment: Validating mentorship in nursing education. *Journal of Professional Nursing*, *25*(3), 145–150. https://doi.org/10.1016/j.profnurs.2009.01.003

Ščepanović, R., Labib, K., Buljan, I., Tijdink, J., & Marušić, A. (2021). Practices for Research Integrity Promotion in Research Performing Organisations and Research Funding Organisations: A Scoping Review. *Science and engineering ethics, 27*(1), 4. https://doi.org/10.1007/s11948-021-00281-1

Science Europe working group on research integrity. (2016). Research integrity practices in Science Europe member organisations. *Science Europe.* https://www.scienceeurope.org/media/onrlh1tf/science-_europe_integrity_survey_report_july_2016_final.pdf

Seeman, J. I., & House, M. C. (2010). Influences on authorship issues: An evaluation of receiving, not receiving, and rejecting credit. *Accountability in Research, 17*(4), 176–197. https://doi.org/10.1080/08989621.2010.493094

Smith, P. (2001). Mentors as gate-keepers: An exploration of professional formation. *Educational Review, 53*(3), 313–324. https://doi.org/10.1080/00131910120085900

Steneck, N. (2006). Fostering integrity in research: Definitions, current knowledge, and future directions. Science and Engineering Ethics, 12, 53–74.

Steneck, N. H. (2013). Global research integrity training. *Science*, *340*(6132), 552–553. https://doi.org/10.1126/science.1236373

Straus, S. E., Chatur, F., & Taylor, M. (2009). Issues in the mentor-mentee relationship in academic medicine: A qualitative study. *Academic Medicine, 84*(1), 135–139. https://doi.org/10.1097/ACM.0b013e31819301ab

Titus, S. L., & Ballou, J. M. (2013). Faculty members' perceptions of advising versus mentoring: Does the name matter? *Science and Engineering Ethics*, *19*(3), 1267–1281. https://doi.org/10.1007/s11948-012-9366-7

Titus, S. L., & Ballou, J. M. (2014). Ensuring PhD development of responsible Conduct of research behaviours: Who's responsible? *Science and Engineering Ethics, 20*(1), 221–235. https://doi.org/10.1007/s11948-013-9437-4

Vance C.N. (1982). The mentor connection. *The Journal of Nursing Administration*. Apr;12(4):7-13. PMID: 6917880.

VIRT^{2}UE project. https://cordis.europa.eu/project/rcn/214892/factsheet/en

Weil, V. (2001). Mentoring: Some ethical considerations. *Science and Engineering Ethics*, *7*(4), 471–482. https://doi.org/10.1007/s11948-001-0004-z

Whitbeck, C. (2001). Group mentoring to foster the responsible conduct of research. *Science and Engineering Ethics*, *7*(4), 541–558. https://doi.org/10.1007/s11948-001-0012-z

Working group of the Austrian Higher Education Group. 2020. Best practice guide for research integrity and ethics. https://oeawi.at/wp-content/uploads/2020/12/2020-10-20_Praxisleitfaden-fuer-Integritaet-und-Ethik-in-der-Wissenschaft_engl_.pdf

Williams, L. L., Levine, J. B., Malhotra, S., & Holtzheimer, P. (2004). The good-enough mentoring relationship. *Academic Psychiatry*, *28*(2), 111–115. https://doi.org/10.1176/appi.ap.28.2.111

Wright, D. E., Titus, S. L., & Cornelison, J. B. (2008). Mentoring and research misconduct: Analysis of research mentoring in closed ORI cases. *Science and Eng*, *14*, 323–336. https://doi.org/10.1007/s11948-008-9074-5

Table 1 - Search strategy

Table 2 – Methodology of the selected studies

Table 3 – List of virtues

Table 4 – Mentors' responsibilities and activities

Figure 1 - Prisma extraction chart

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Figure

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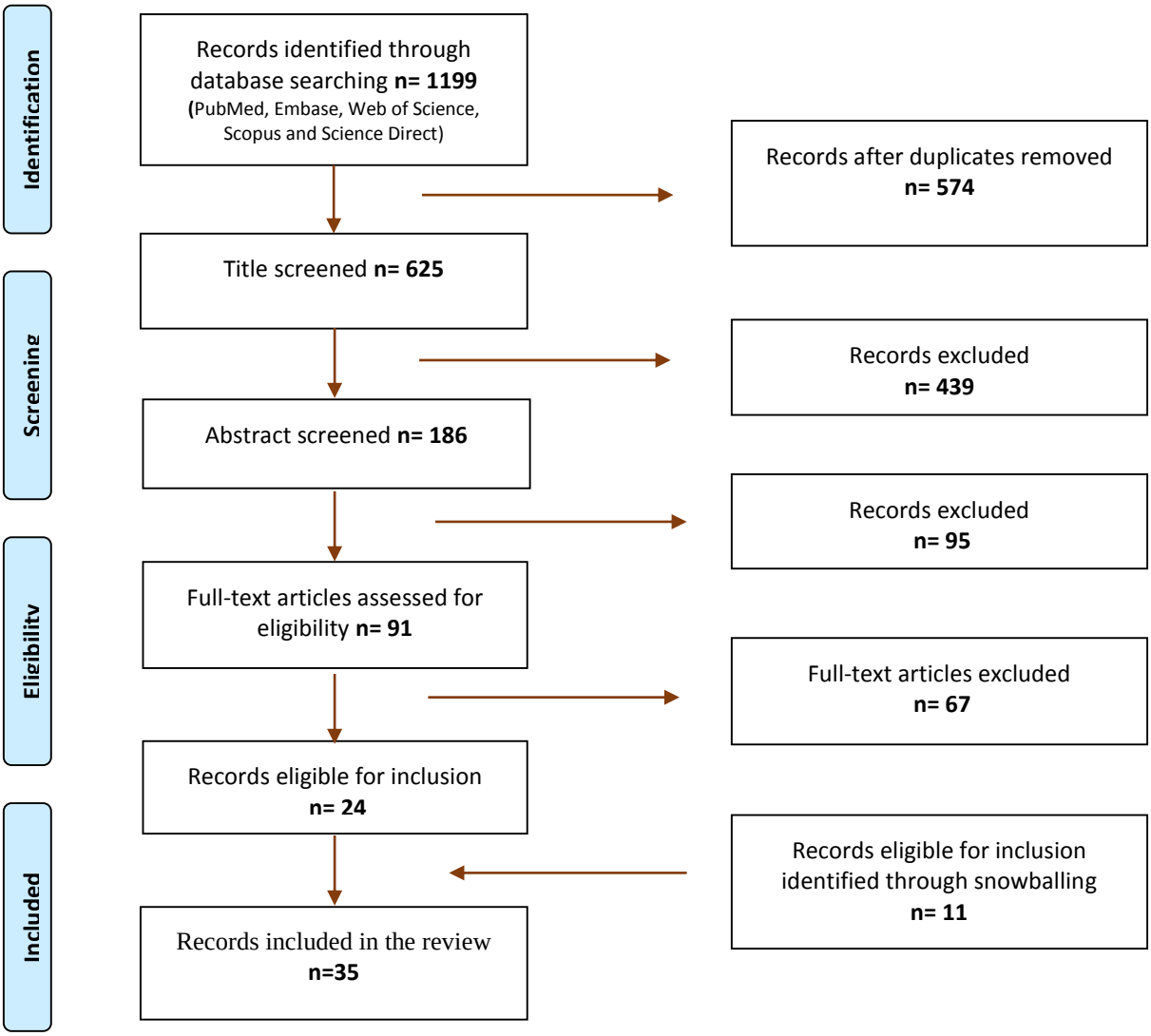

Figure 1: PRISMA extraction chart (The figure represents the selection process of empirical studies)

Table 1 Click here to download table Table 1 - Search strategy.docx

Databased	Mentor-related	RI-related
PubMed	((((((mentor*[Title/Abstract]) OR supervis*[Title/Abstract]) OR leader*[Title/Abstract]) OR leadership[Title/Abstract]) OR role model[Title/Abstract]) OR promotor*[Title/Abstract])	((((((research integrity[Title/Abstract]) OR responsible conduct of research[Title/Abstract]) OR RI[Title/Abstract]) OR RCR[Title/Abstract]) OR scientific integrity[Title]))
Web of Science	**TOPIC:** (mentor*) *OR* **TOPIC:** (supervis*) *OR* **TOPIC:** (leader*) *OR* **TOPIC:** (leadership) *OR* **TOPIC:** (promotor*) *OR* **TOPIC:** ("role model")	**TOPIC:** ("research integrity") *OR* **TOPIC:** ("responsible conduct of research") *OR* **TOPIC:** (RI) *OR* **TOPIC:** (RCR) *OR* **TOPIC:** ("scientific integrity")
Embase	**mentor***:ti,ab,kw OR **supervis***:ti,ab,kw OR **leader***:ti,ab,kw OR **leadership**:ti,ab,kw OR **'role model'**:ti,ab,kw OR **promotor***:ti,ab,kw	**'research integrity'**:ti,ab,kw OR **'responsible conduct of research'**:ti,ab,kw OR **ri**:ti,ab,kw OR **rcr**:ti,ab,kw OR **'scientific integrity'**:ti,ab,kw
Scopus	((TITLE-ABS-KEY (*mentor**) OR TITLE-ABS-KEY (*supervis**) OR TITLE-ABS-KEY (*leader**) OR TITLE-ABS-KEY (*leadership*) OR TITLE-ABS-KEY (*promotor**) OR TITLE-ABS-KEY (*"role model"*)))	((TITLE-ABS-KEY (*"research integrity"*) OR TITLE-ABS-KEY (*"responsible conduct of research"*) OR TITLE-ABS-KEY (*ri*) OR TITLE-ABS-KEY (*rcr*) OR TITLE-ABS-KEY (*"scientific integrity"*)))
ScienceDirect	Title, abstract, keywords: (mentor OR mentorship OR supervisor OR supervision OR leadership)	Title, abstract, keywords: ('research integrity' OR 'responsible conduct of research')

Table 1: Search strategy (Two search strategies focusing on RI and mentoring were merged and used in five different databases)

Quantitative studies (18)	Lenz & Ketefian 1995; Ketefian & Lenz 1995; Eastwood et al. 1996; Roberts, Kavussanu & Sprague 2001; Rose 2003; Anderson et al 2007; Sawatzky & Enns 2009; Fisher, Fried & Feldman 2009; Seeman & House 2010; House and Seeman 2010; Peiffer, Hugenschmidt & Laurienti 2011; Gray & Jordan 2012; Ripley et al. 2012; Titus & Ballou 2014; Krstić 2015, Krishna & Peter 2018; Haven et al. 2019; Huybers, Greene & Rohr 2020
Qualitative studies (12)	Jackson et al. 2003; Williams et al. 2004; Rabatin et al. 2004; Hauer et al. 2005 ; Leslie, Lingard & White 2005 ; Straus, Chatur & Taylor 2009 ; Antes, Mart & DuBois 2016 ; Buljan, Barać & Marušić 2018 ; Antes, Kuykendall & DuBois 2019A ; Antes, Kuykendall & DuBois 2019B; Pennanen Heikkinen & Tynjälä 2020; Haven et al. 2020
Multiple approaches (3)	Abedin et al. 2012; Löfström et al. 2015; Plemmons & Kalichman 2018
Analyses of case studies (2)	Redman, Templin & Merz 2006; Wright, Titus & Cornelison 2008

Table 2: Methodology of the selected studies

Virtues and qualities	Publications
Trustworthiness (4)	Hauer et al. 2005 ; Leslie, Lingard & White 2005; Rabatin et al. 2004; Sawatzky & Enns 2009
Honesty (3)	Rabatin et al. 2004; Sawatzky & Enns 2009 ; Straus, Chatur & Taylor 2009
Able to communicate openly, clearly and effectively (3)	Antes, Kuykendall & DuBois 2019b ; Pennanen, Heikkinen & Tynjälä 2020; Rose 2003
Respectfulness (3)	Rabatin et al. 2004 ; Rose 2003; Sawatzky & Enns 2009
Integrity (2)	Antes, Kuykendall & DuBois 2019b; Rose 2003
Active listener (2)	Sawatzky & Enns 2009; Williams et al. 2004
Courage(2)	Pennanen, Heikkinen & Tynjälä 2020; Rabatin et al. 2004
Accessibility (2)	Leslie, Lingard & White 2005; Straus, Chatur & Taylor 2009
Non-judgmental (2)	Leslie, Lingard & White 2005; Sawatzky & Enns 2009
Approachable (2)	Sawatzky & Enns 2009; Straus, Chatur & Taylor 2009
Fairness	Rose 2003
Able to provide honest feedback	Rose 2003
Openness	Rose 2003
Agreeableness	Rose 2003
Conscientiousness	Rose 2003
Supportive	Hauer et al. 2005
Sincerity	Hauer et al. 2005
Friendship	Hauer et al. 2005
Open-mindedness	Hauer et al. 2005
Reliability	Leslie, Lingard & White 2005
Positive-attitude	Sawatzky & Enns 2009
Caring	Sawatzky & Enns 2009
Altruism	Straus, Chatur & Taylor 2009
Patience	Straus, Chatur & Taylor 2009
Understanding	Straus, Chatur & Taylor 2009
Transparency	Antes, Kuykendall & DuBois 2019b
Meticulousness	Antes, Kuykendall & DuBois 2019b
Accuracy	Antes, Kuykendall & DuBois 2019b
Attentiveness	Pennanen, Heikkinen & Tynjälä 2020
Reflexivity	Pennanen, Heikkinen & Tynjälä 2020
Empathy	Pennanen, Heikkinen & Tynjälä 2020
Calm	Pennanen, Heikkinen & Tynjälä 2020
Commitment	Pennanen, Heikkinen & Tynjälä 2020
Peerness	Pennanen, Heikkinen & Tynjälä 2020
Motivation	Pennanen, Heikkinen & Tynjälä 2020
Preparedness	Pennanen, Heikkinen & Tynjälä 2020

Table 3: List of virtues

Responsibilities and activities	Publications
Organize regular meetings	Antes, Mart & DuBois 2016; Antes, Kuykendall & DuBois 2019a ; Antes, Kuykendall & DuBois 2019b; Plemmons & Kalichman 2018 ; Leslie, Lingard & White 2005 ; Rabatin et al. 2004; Rose 2003
Discussion and interpretation of data and findings	Antes, Kuykendall & DuBois 2019a; Antes, Kuykendall & DuBois 2019b ; Lenz & Ketefian 1995; Rabatin et al. 2004; Titus & Ballou 2014
Reframe failure as a learning activity	Abedin et al. 2012 ; Rabatin et al. 2004;
Discussion of good research practices	Plemmons & Kalichman 2018 ; Titus & Ballou 2014
Establish and follow standard operating procedures	Antes, Kuykendall & DuBois 2019a; Antes, Kuykendall & DuBois 2019b
Encourage shared ownership and decision-making	Antes, Kuykendall & DuBois 2019a; Antes, Kuykendall & DuBois 2019b
Ensure sufficient training	Antes, Kuykendall & DuBois 2019a; Antes, Kuykendall & DuBois 2019b
Foster a positive attitude about compliance	Antes, Kuykendall & DuBois 2019a; Antes, Kuykendall & DuBois 2019b
Authorship practices	House & Seeman 2010 ; Seeman & House 2010
Emotional support	Abedin et al. 2012 ; Anderson et al. 2007
Prevent sloppy science and fraudulent practices	Lenz & Ketefian 1995
Review of mentees' manuscript	Lenz & Ketefian 1995
Communication of norms and practices of responsible research	Lenz & Ketefian 1995
Respect intellectual property of others	Rose 2003
Give proper credits to PhD candidates	Rose 2003
Have day-to-day conversations with mentees	Leslie, Lingard & White 2005
Guidance against data fabrication	Fisher Fried & Feldman 2009
Establish rules and guidelines to uphold the integrity of mentee's data	Abedin et al. 2012
Teach ethical conduct in research	Abedin et al. 2012
Discussion of misconduct policies	Titus & Ballou 2014
Setting standards for data collection	Titus & Ballou 2014
Setting boundaries about what one can do or cannot	Buljan, Barać & Marušić 2018
Peer-review practices	Ripley et al. 2012
Assistance in writing for publication and presentation	Anderson et al. 2007

Table 4: List of mentor's responsibilities and activities specifically highlighted in the empirical literature

Supplement

Click here to download table Supplement 1 - Characterisation of the articles.xlsx

Title	Author(s)/year	Typology of the study	Stakeholders	Field	Thematic group
Promoting scientific integrity in nursing research, part I: Current Approach in Doctoral Programs	Lenz, E. R., & Ketefian, S. (1995). Promoting scientific integrity in nursing research, part I: Current Approach in Doctoral Programs. *Journal of Professional Nursing* , *11* (4), 213–219. https://doi.org/10.1016/S8755-7223(05)80006-7	Quantitative (open-ended 21-item questionnaire)	Deans and administrat	Life Sciences	Importance of mentorship /Mentors' responsibilities
PROMOTING SCIENTIFIC INTEGRITY IN NURSING RESEARCH .2. STRATEGIES	Ketefian, S., & Lenz, E. R. (1995). PROMOTING SCIENTIFIC INTEGRITY IN NURSING RESEARCH .2. STRATEGIES. *Journal of Professional Nursing* , *11* (5), 263–269. https://doi.org/10.1016/s8755-7223(05)80006-7	Quantitative (open-ended 21-item questionnaire)	Deans and administrat	Life Sciences	Importance of mentorship/ Institutions' responsibilities
Ethical issues in biomedical research: Perceptions and practices of postdoctoral research fellows responding to a survey	Eastwood, S., Derish, P., Leash, E., & Ordway, S. (1996). Ethical issues in biomedical research: Perceptions and practices of postdoctoral research fellows responding to a survey. *Science and Engineering Ethics* , *2* (1), 89–114. https://doi.org/10.1007/BF02639320	Quantitative (survey)	Postdocs (mentees)	Life Sciences	Importance of mentorship
Mentoring and the Impact of the Research Climate	Roberts, G. C., Kavussanu, M., & Sprague, R. L. (2001). Mentoring and the Impact of the Research Climate. Science and Engineering Ethics, 7(4), 525–537. https://doi.org/10.1007/s11948-001-0010-1	Quantitative (questionnaire)	Professors	Life Sciences/ Physics and Engineering/ Social sciences	poor mentoring
‘‘Having the Right Chemistry’’: A Qualitative Study of Mentoring in Academic Medicine	Jackson, V. A., Palepu, A., Szalacha, L., Caswell, C., Carr, P. L., & Inui, T. (2003). ‘‘Having the Right Chemistry’’: A Qualitative Study of Mentoring in Academic Medicine. *Academic Medicine* , *78* (3), 328–334. https://doi.org/10.1016/s1359-6128(17)30424-x	Qualitative (interviews)	Faculty members'experiences as mentees	Life science	Poor mentorship
Enhancement of Mentor Selection Using the Ideal Mentor Scale	Rose, G. L. (2003). Enhancement of Mentor Selection Using the Ideal Mentor Scale. *Research in Higher Education* , *44* (4), 473–494. https://doi.org/10.1023/A	Quantitative (survey)	Doctoral students	Life Sciences/ Social sciences	Virtues and Characteristics/ Mentors' responsibilities

The good-enough mentoring relationship	Williams, L. L., Levine, J. B., Malhotra, S., & Holtzheimer, P. (2004). The good-enough mentoring relationship. *Academic Psychiatry* , *28* (2), 111–115. https://doi.org/10.1176/appi.ap.28.2.111	Qualitative (Focus groups)	Psychiatric residents and Faculty	Social Sciences	Virtues and Characteristics/ Institutions' responsibilities
A year of mentoring in academic medicine	Rabatin, J. S., Lipkin, M., Rubin, A. S., Schachter, A., Nathan, M., & Kalet, A. (2004). A year of mentoring in academic medicine. *Journal of General Internal Medicine* , *19* (5), 569–573. https://doi.org/10.1111/j.1525-1497.2004.30137.x	Qualitative	Mentor and Mentee	Life Sciences	Mentors' responsibilities/ Virtues and Characteristics
Medical students' perceptions of mentoring: a focus-group analysis	Hauer, K. E., Teherani, A., Dechet, A., & Aagaard, E. M. (2005). Medical students' perceptions of mentoring: A focus-group analysis. *Medical Teacher* , *27* (8), 732–734. https://doi.org/10.1080/01421590500271316	Qualitative (Focus groups)	Medical students	Life Sciences	Virtues and Characteristics/ Institutions' responsibilities
Junior faculty experiences with informal mentoring	Leslie, K., Lingard, L., & Whyte, S. (2005). Junior faculty experiences with informal mentoring. *Medical Teacher* , *27* (8), 693–698. https://doi.org/10.1080/01421590500271217	Qualitative (interviews)	Junior phisicians	Life sciences	Virtues and Characheristics/ Mentors' responsibilities
Research Misconduct Among Clinical Trial Staff	Redman, B. K., Templin, T. N., & Merz, J. F. (2006). Research Misconduct Among Clinical Trial Staff. *Engineering* , *12* (3), 481–489.	Case studies analysis	N/A	Life Sciences	Poor mentoring
What Do Mentoring and Training in the Responsible Conduct of Research Have To Do with Scientists' Misbehavior? Findings from a National Survey of NIH-Funded Scientists	Anderson, M. S., Horn, A. S., Risbey, K. R., Ronning, E. A., De Vries, R., & Martinson, B. C. (2007). What do mentoring and training in the responsible conduct of research have to do with scientists' misbehavior? Findings from a national survey of NIH-funded scientists. Academic Medicine, 82(9), 853–860. https://doi.org/10.1097/ACM.0b013e31812f764c	Quantitative (survey)	NIH grantee	Life Sciences	Importance of mentorship/ Mentors' responsibilities

Mentoring and research misconduct: Analysis of research mentoring in closed ORI cases	Wright, D. E., Titus, S. L., & Cornelison, J. B. (2008). Mentoring and research misconduct: Analysis of research mentoring in closed ORI cases. *Science and Eng* , *14* , 323–336. https://doi.org/10.1007/s11948-008-9074-5	Case studies analysis	N/A	Broad audience (not specified)	Poor mentorship
A Mentoring Needs Assessment: Validating Mentorship in Nursing Education	Sawatzky, J. A. V., & Enns, C. L. (2009). A Mentoring Needs Assessment: Validating Mentorship in Nursing Education. Journal of Professional Nursing, 25(3), 145–150. https://doi.org/10.1016/j.profnurs.2009.01.003	Quantitative (questionnaire)	Faculty members	Life Sciences	Virtues and Characteristics/ Institutions responsibilities
Issues in the mentor-mentee relationship in academic medicine: A qualitative study	Straus, S. E., Chatur, F., & Taylor, M. (2009). Issues in the mentor-mentee relationship in academic medicine: A qualitative study. *Academic Medicine* , *84* (1), 135–139. https://doi.org/10.1097/ACM.0b013e31819301ab	Qualitative (interviews)	Mentees and mentors	Life Sciences	Importance of mentorship/ Poor mentorship/ Virtues and Characteristics/ Institutions' responsibilities
Graduate Socialization in the Responsible Conduct of Research: A National Survey on the Research Ethics Training Experiences of Psychology Doctoral Students	Fisher, C. B., Fried, A. L., & Feldman, L. G. (2009). Graduate Socialization in the Responsible Conduct of Research: A National Survey on the Research Ethics Training Experiences of Psychology Doctoral Students. Ethics & Behavior, 19(6), 496–518. https://doi.org/10.1080/10508420903275283	Quantitative (survey)	Students and mentors	Social Sciences (Psycology)	Importance of mentorship/ mentors' responsibilities
Influences on authorship issues: An evaluation of receiving, not receiving, and rejecting credit	Seeman, J. I., & House, M. C. (2010). Influences on authorship issues: An evaluation of receiving, not receiving, and rejecting credit. *Accountability in Research* , *17* (4), 176–197. https://doi.org/10.1080/08989621.2010.493094	Quantitative (survey)	PhD students	Life Science	Poor mentorship/ Mentors' responsibilities
Credit and authorship practices: Educational and environmental influences	House, M. C., & Seeman, J. I. (2010). Credit and authorship practices: Educational and environmental influences. *Accountability in Research* , *17* (5), 223–256. https://doi.org/10.1080/08989621.2010.512857	Quantitative (survey)	PhD students	Life Science	Importance of mentorship/ Mentors' responsibilities

	Peiffer, A. M., Hugenschmidt, C. E., & Laurienti, P. J. (2011). Ethics in 15 min per Week. *Science and Engineering Ethics* , *17* (2), 289–297. https://doi.org/10.1007/s11948-010-9197-3	Quantitative (survey)	Lab members	Life Science	Importance of mentorship/ Group mentoring
Ethics in 15 min per Week					
Deriving Competencies for Mentors of Clinical and Translational Scholars	Abedin, Z., Biskup, E., Silet, K., Garbutt, J. M., Kroenke, K., Feldman, M. D., … Pincus, H. A. (2012). Deriving Competencies for Mentors of Clinical and Translational Scholars. *Clinical and Translational Science* , *5* (3), 273–280. https://doi.org/10.1111/j.1752-8062.2011.00366.x	Qualitative (multiple approaches)	Mentors and PIs	Broad audience (not specified)	Importance of mentorship/ Mentors' responsibilities
Supervisors and Academic Integrity: Supervisors as Exemplars and Mentors	Gray, P. W., & Jordan, S. R. (2012). Supervisors and Academic Integrity: Supervisors as Exemplars and Mentors. *Journal of Academic Ethics* , *10* (4), 299–311. https://doi.org/10.1007/s10805-012-9155-6	Quantitative (survey)	Mentees	Life Sciences	Importance of mentorship/ poor mentorship
Guiding the Next Generation of NIH Investigators in Responsible Conduct of Research: The Role of the Mentor	Ripley, E., Markowitz, M., Nichols-Casebolt, A., Williams, L., & Macrina, F. (2012). Guiding the Next Generation of NIH Investigators in Responsible Conduct of Research: The Role of the Mentor. *Accountability in Research* , *19* (4), 209–219. https://doi.org/10.1080/08989621.2012.700880	Quantitative (survey)	Mentors and mentees	Life Sciences/ Social sciences	Importance of mentorship/ poor mentorship/ Institutions' responsibilities
Ensuring PhD Development of Responsible Conduct of Research Behaviors: Who's Responsible?	Titus, S. L., & Ballou, J. M. (2014). Ensuring PhD Development of Responsible Conduct of Research Behaviors: Who's Responsible? *Science and Engineering Ethics* , *20* (1), 221–235. https://doi.org/10.1007/s11948-013-9437-4	Quantitative (survey)	Faculty members	Life Sciences	Mentors' responsibilities/ Institutions' responsibilities
Research Integrity Practices from the Perspective of Early-Career Researchers	Krstić, S. B. (2015). Research Integrity Practices from the Perspective of Early-Career Researchers. *Science and Engineering Ethics* , *21* (5), 1181–1196. https://doi.org/10.1007/s11948-014-9607-z	Quantitative (survey)	PhD students	Broad audience (not specified)	Poor mentorship

Who teaches academic integrity and how do they teach it?	Löfström, E., Trotman, T., Furnari, M., & Shephard, K. (2015). Who teaches academic integrity and how do they teach it? *Higher Education* , *69* (3), 435–448. https://doi.org/10.1007/s10734-014-9784-3	Quantitative+ qualitative	Mentors	Broad audience (not specified)	Importance of mentorship
Are Leadership and Management Essential for Good Research? An Interview Study of Genetic Researchers	Antes, A. L., Mart, A., & DuBois, J. M. (2016). Are Leadership and Management Essential for Good Research? An Interview Study of Genetic Researchers. *Journal of Empirical Research on Human Research Ethics* , *11* (5), 408–423. https://doi.org/10.1177/1556264616668775	Qualitative (interviews)	PIs (NIH funded resea	Life Sciences	Importance of mentroship/ mentors' responsibilities
Mentoring for Responsible Research: The Creation of a Curriculum for Faculty to Teach RCR in the Research Environment	Plemmons, D. K., & Kalichman, M. W. (2018). Mentoring for Responsible Research: The Creation of a Curriculum for Faculty to Teach RCR in the Research Environment. *Science and Engineering Ethics* , *24* (1), 207–226. https://doi.org/10.1007/s11948-017-9897-z	Qualitative (multiple approaches)	Multiple stakeholders	Broad audience (not specified)	Importance of mentorship /Mentors' responsibilities/ Group mentoring/
How researchers perceive research misconduct in biomedicine and how they would prevent it: A qualitative study in a small scientific community	Buljan, I., Barać, L., & Marušić, A. (2018). How researchers perceive research misconduct in biomedicine and how they would prevent it: A qualitative study in a small scientific community. *Accountability in Research* , *25* (4), 220–238. https://doi.org/10.1080/08989621.2018.1463162	Qualitative (Focus groups)	PhD students	Life Sciences	Mentors' responsibilities
Questionable research practices in student final theses – Prevalence, attitudes, and the role of the supervisor's perceived attitudes	Krishna, A., & Peter, S. M. (2018). Questionable research practices in student final theses – Prevalence, attitudes, and the role of the supervisor's perceived attitudes. *PLoS ONE* , *13* (8). https://doi.org/10.1371/journal.pone.0203470	Quantitative (survey)	Students	Social sciences	Importance of mentorship/ poor mentorship

Perceptions of research integrity climate differ between academic ranks and disciplinary fields: Results from a survey among academic researchers in Amsterdam	Haven, T. L., Tijdink, J. K., Martinson, B. C., & Bouter, L. M. (2019). Perceptions of research integrity climate differ between academic ranks and disciplinary fields: Results from a survey among academic researchers in Amsterdam. *PLoS ONE* , *14* (1), 1–17. https://doi.org/10.1371/journal.pone.0210599	Quantitative (survey)	PhDs and researchers	Broad audience (not specified)	Poor mentorship
Leading for research excellence and integrity: A qualitative investigation of the relationship-building practices of exemplary principal investigators	Antes, A. L., Kuykendall, A., & DuBois, J. M. (2019)a. Leading for research excellence and integrity: A qualitative investigation of the relationship-building practices of exemplary principal investigators. *Accountability in Research* , *26* (3), 198–226. https://doi.org/10.1080/08989621.2019.1611429	Qualitative (interviews)	PIs / Mentors	Life sciences, Social sciences/ Applied sciences	Mentors' responsibilities
The lab management practices of "Research Exemplars" that foster research rigor and regulatory compliance: A qualitative study of successful principal investigators	Antes, A. L., Kuykendall, A., & DuBois, J. M. (2019)b. *The lab management practices of "Research Exemplars" that foster research rigor and regulatory compliance: A qualitative study of successful principal investigators . PLoS ONE* (Vol. 14). https://doi.org/10.1371/journal.pone.0214595	Qualitative (interviews)	PIs	Life sciences	Importance on mentorship/ Mentors' responsibilities/ Virtues and charactristics
Virtues of Mentors and Mentees in the Finnish Model of Teachers' Peer-group Mentoring	Pennanen, M., Heikkinen, H. L. T., & Tynjälä, P. (2020). Virtues of Mentors and Mentees in the Finnish Model of Teachers' Peer-group Mentoring. *Scandinavian Journal of Educational Research* , *64* (3), 355–371. https://doi.org/10.1080/00313831.2018.1554601	Qualitative (interviews)	Mentors	Broad audience (not specified)	Virtues and characteristics/ Group mentoring
Researchers' Perceptions of a Responsible Research Climate: A Multi Focus Group Study	Haven, T., Pasman, H. R., Widdershoven, G., Bouter, L., & Tijdink, J. (2020). Researchers' Perceptions of a Responsible Research Climate: A Multi Focus Group Study. *Science and Engineering Ethics* , *26* (6), 3017–3036. https://doi.org/10.1007/s11948-020-00256-8	Qualitative (Focus groups)	PhDs, researchers and professors	Broad audience (not specified)	Importance of mentorship / group mentoring/ Institutions' responsibilities

Academic research integrity: Exploring researchers' perceptions of responsibilities and enablers	Huybers, T., Greene, B., & Rohr, D. H. (2020). Academic research integrity: Exploring researchers' perceptions of responsibilities and enablers. *Accountability in Research* , *27* (3), 146–177. https://doi.org/10.1080/08989621.2020.1732824	Quantitative (survey)	Academic researchers	Broad audience (not specified)	Importance of mentorship

CLUSTER	REFERENCES
Importance of mentorship (18)	Lenz & Ketefian 1995; Ketefian & Lenz 1995; Eastwood et al. 1996; Anderson et al. 2007; Straus, Chatur & Taylor 2009; Fisher, Fried & Feldman 2009; House & Seeman 2010; Peiffer, Hugenschmidt & Laurienti 2011; Abedin et al. 2012; Gray & Jordan 2012; Ripley et al .2012; Löfström et al. 2015; Antes, Mart & DuBois 2016; Plemmons & Kalichman 2018; Krishna & Peter 2018; Antes, Kuykendall & DuBois 2019a; Haven et al. 2020; Huybers Greene & Rohr 2020
Poor mentorship practices (11)	Roberts, Kavussanu & Sprague 2001; Jackson et al. 2003; Redman, Templin & Merz 2006; Wright, Titus & Cornelison 2008; Straus, Chatur & Taylor 2009; Seeman & House 2010; Gray & Jordan 2012; Ripley et al. 2012; Krstić 2015; Krishna & Peter 2018; Haven et al. 2019;
Virtues and qualities of mentors (9)	Rose 2003; Williams et al. 2004; Rabatin et al. 2004; Hauer et al. 2005; Leslie, Lingard & Whyte 2005; Sawatzky & Enns 2009; Straus, Chatur & Taylor 2009; Antes, Kuykendall & DuBois 2019b; Pennanen, Heikkinen & Tynjälä 2020
Mentor's responsibilities and activities (16);	Lenz & Ketefian 1995; Rose 2003; Rabatin et al. 2004; Leslie, Lingard & Whyte 2005; Anderson et al. 2007; Fisher, Fried & Feldman 2009; House & Seeman 2010; Seeman & House 2010; Abedin et al. 2012; Ripley et al. 2012; Titus & Ballou 2014; Antes, Mart & DuBois 2016; Plemmons & Kalichman 2018; Buljan Barać & Marušić 2018; Antes, Kuykendall & DuBois 2019a; Antes, Kuykendall & DuBois 2019b
Group mentoring (4)	Peiffer, Hugenschmidt & Laurienti 2011; Plemmons & Kalichman 2018; Pennanen, Heikkinen & Tynjälä 2020; Haven et al. 2020
Institution's responsibilities in supporting good mentorship (8)	Ketefian & Lenz 1995; Williams et a. 2004; Hauer et al. 2005; Sawatzky & Enns 2009; Straus, Chatur & Taylor 2009; Ripley et al 2012; Titus & Ballou 2014; Haven et al. 2020

Supplement 2 - Publications for specific thematic group