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Are Leadership and Management Essential for Good Research? An Interview Study of Genetic Researchers

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Abstract

Principal investigators are responsible for a myriad of leadership and management activities in their work. The practices they employ to navigate these responsibilities ultimately influence the quality and integrity of research. However, leadership and management roles in research have received scant empirical examination. Semi-structured interviews with 32 National Institutes of Health (NIH)-funded genetic researchers revealed that they considered leadership and management essential for effective research, but their scientific training inadequately prepared them. We also report management practices that the researchers described employing in their labs, as well as their perceptions of a proposed intervention to enhance laboratory leadership. These findings suggest best practices for the research community, future directions for scientific training, and implications for research on leadership and management in science.

Keywords

Leadership; management; research integrity; responsible conduct of research; training; leadership development; professional development; researchers; scientists

Introduction

A recent article describes why researchers were referred by their institutions for research compliance or integrity remediation training (DuBois, Chibnall, Tait, & Vander Wal, 2016). The authors, who run the training program, found that most researchers who were referred are successful and never intended to break research rules. The most common reason for referral (49%) was failure to provide adequate oversight of their labs or studies, which in turn led to more serious lapses in compliance or research integrity. These oversight failures were frequently related to deficiencies in managing workloads and setting priorities.

The quality and integrity of scientific work depends largely on the leadership and management practices of investigators. Activities such as cultivating a lab culture, mentoring trainees, assembling teams, training and supervising staff, solving technical problems, and improving work processes are integral to good research (Adamo, Bauer, Berro, Burnette, &

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Hartman, 2012; Arnon, 1989b; Bennett, Gadlin, & Levine-Finley, 2010; Cohen, 2012; Gray, 2008; Nosek et al., 2015; Roberts, Kavussanu, & Sprague, 2001; Sapienza, 2004). Yet, how scientists navigate the numerous social and organizational dimensions of scientific research has received virtually no attention (Hurley, 2003; Robledo, Peterson, & Mumford, 2012). This is notable given the sizeable scientific workforce, the immense investments made in research, and the social consequences of the work (Freedman, Cockburn, & Simcoe, 2015; Hurley, 2003; Ladd, Lappé, McCormick, Boyce, & Cho, 2009; McCormick, Boyce, Ladd, & Cho, 2012). Thus, there is a pressing need to examine the role of leadership in science.

Leadership in science exists at multiple levels (Robledo et al., 2012). Leadership and management activities essential to the scientific enterprise are performed by institutional administrators (Ball, 2007; Billot, 2010; Hansson & Monsted, 2008), project coordinators and lab managers (Pryor, Habermann, & Broome, 2007; Rico-Villademoros et al., 2004), and principal investigators (K. Barker, 2010; Kvaskoff & McKay, 2014). Our focus in the present effort is principal investigators (PIs) and the leadership and management responsibilities they encounter as they lead their research labs.

We explored the perspectives of National Institutes of Health (NIH)-funded genetic researchers regarding leadership and management in their research. Specifically, our intention was to gather evidence to understand whether investigators attribute significance to leadership and management in their performing research. We also sought to understand how prepared investigators felt to perform leadership and management responsibilities after completing their scientific training and to identify practices that they employ.

What Are Leadership and Management?

Leadership may be the most written about phenomenon in human life (Hogan & Kaiser, 2005; Zaccaro, 2014). Indeed, an extensive literature examining leadership and management in organizations exists in the psychology and management disciplines (Bass & Bass, 2008; Day, 2014; DeRue, Nahrgang, Wellman, & Humphrey, 2011; Schein, 2010; Yukl, 1989). In this literature, scholars debate the importance of distinguishing between leadership and management; indeed they are both essential and often overlap (National Research Council, 2015b; Northouse, 2013).

The many models and theories of leadership and management reflect in part their complexity and context-dependent nature (Marion & Uhl-Bien, 2001; National Research Council, 2015b). Some scholars describe leadership as having a longer-term orientation and management a shorter-term focus. Leaders are forward-thinking and change-oriented while managers focus on consistency and efficiency in accomplishing tasks (Kotter, 2008; Maccoby, 2000). Thus, theories of leadership often emphasize mechanisms such as vision, inspiration, and relationships aimed at *influencing people*, and models of management emphasize mechanisms such as planning, directing, and organizing aimed at *overseeing work* (Bass, 1990; Conger, 1999; Maccoby, 2000; Zaleznik, 1977).

Overall, leadership and management may be defined as the social mechanisms and organizational processes by which people achieve success through collective effort (Kaiser, Hogan, & Craig, 2008). Notably, effective leadership may require hierarchical and distributed forms of influence (Pearce, 2004); however, contemporary leadership theories increasingly define leadership as a dynamic, shared social process, rather than a quality of specific individuals per se (Avolio, Walumbwa, & Weber, 2009).

How Are Leadership and Management Germane to Scientific Research?

In the existing small body of empirical evidence, leadership in scientific groups and organizations is associated with research team attitudes and scientific performance outcomes (Andrews & Farris, 1967; Barnowe, 1975; Baumgartel, 1957; Knorr, Mittermeir, Aichholzer, & Waller, 2009). While we know very little about leadership and management in scientific research, it is clear that leadership is particularly critical when the nature of work is complex and creative (Frankel, Leonard, & Denham, 2006; M. Mumford, Gibson, Giorgini, & Mecca, 2014; M. Mumford, Scott, Gaddis, & Strange, 2002). Leaders of creative work identify and coordinate requisite expertise for projects, create shared mindsets about mission direction, define strategies for carrying out the work, and orchestrate an environment characterized by intellectual stimulation, communication, and productive conflict (Gemmill & Wilemon, 1994; M. Mumford & Licuanan, 2004; Robledo et al., 2012).

In performing these key activities, leaders engage in a complex array of behaviors—some more traditionally associated with "management" (e.g., planning, obtaining resources, providing feedback) and others more traditionally associated with "leadership" (e.g., coaching, modeling, building relationships, and providing socio-emotional support, particularly in the face of obstacles and setbacks) (M. Mumford, Scott, & Gaddis, 2003; National Research Council, 2015b). The scientific community describes some interpersonal elements of scientific work (e.g., communication, shared values, and trust) in the mentoring and team science literatures (Adams, 2014; Bird, 2001; Gewin, 2015; Straus, Johnson, Marquez, & Feldman, 2013), but generally the social dynamics of the research context are overlooked. The collective nature of scientific research (Adams, 2014; Binz-Scharf, Kalish, & Paik, 2015; Ledford, 2015) suggests models of shared and distributed leadership may be appropriate in scientific work (Bolden, 2011; Drath et al., 2008; Friedrich, Vessey, Schuelke, Ruark, & Mumford, 2009). These models emphasize the need to draw on requisite expertise at necessary points during projects, and they construe leadership as the collective mindsets and practices that facilitate direction, alignment, and commitment.

Additionally, scientific research is highly project-based. This implies that what constitutes effective leadership may vary at different stages (Buijs, 2007; Robledo et al., 2012). Thus, PIs likely need to be highly adaptive as they manage different projects and teams, particularly as they engage different individuals, from staff to students, post-docs, peers, and superiors (Chi, 2010; Cohen, 2012; Bonetta, 2006). Models of leadership emphasizing pragmatic forms of leadership—employing technical expertise and problem-solving strategies as means to enhance individual and group capacity to perform work effectively—may also be particularly appropriate in the scientific context (M. Mumford et al., 2003; M. Mumford & Van Doorn, 2001).

Finally, considerations about integrity, transparency, and ethics are integral to performing scientific work (Bird, 2014; Buck, 2015; Devereaux, 2014; Macrina, 2014). In orchestrating research, some of the considerations researchers encounter include employing best practices to ensure data integrity, avoiding biases that undermine objective methods and interpretations, executing peer review fairly, complying with research regulations, and managing competition and pressure (De Vries, Anderson, & Martinson, 2006; DuBois, 2004; DuBois et al., 2016; Nuzzo, 2015; Parker, Vermeulen, & Penders, 2011). Furthermore, scientists must model responsible behaviors to those whom they train, mentor, and manage (Bird & Sprague, 2001; Ripley, Markowitz, Nichols-Casebolt, Williams, & Macrina, 2012). Navigating this environment requires leadership and management skills in their highest form. Individuals must engage in self-evaluation and continually scrutinize and improve work processes and practices (Ashford & DeRue, 2012; Unsworth & Mason, 2012). Although moral and positive forms of leadership are not the only viable models of leadership (M. Mumford & Fried, 2014), matters of integrity and ethics are elemental to notions of scientific work (Kalichman, 2014b). Thus, models of leadership in scientific research should consider practices, such as modeling ethical behavior and creating ethical work climates (Barnett & Vaicys, 2000; Brown & Trevino, 2006), associated with rigorous, transparent and ethical research.

Overall, models of leadership in science are in their infancy. Future work must examine leadership in science as its own phenomenon as existing models (which typically focus on corporate and political settings) may be inadequate for explaining leadership in this unique context (Arnon, 1989a; National Research Council, 2015b; Robledo et al., 2012). In the healthcare setting, for example, attempts to adopt Six Sigma management strategies—which have been successful in transforming manufacturing industries—have yielded limited evidence of their effectiveness (DelliFraine, Wang, McCaughey, Langabeer, & Erwin, 2013).

Why Have Leadership and Management in Scientific Research Been Overlooked?

There are several potential reasons that the scientific community has overlooked leadership and management in performing scientific work. These reasons relate primarily to assumptions about the nature of researchers and the nature of scientific work.

Researchers tend to be autonomous, self-driven individuals who are intrinsically motivated by their work (M. Mumford et al., 2003). Thus, the notion that researchers require external motivation, such as motivation provided through the influence of a leader, seems dubious (M. Mumford et al., 2014; Robledo et al., 2012). Indeed, given the self-confident, conscientious, and achievement-oriented nature of scientists, it may be difficult for leaders to engage in influence attempts (M. Mumford et al., 2003; Robledo et al., 2012). But, as outlined above, models of distributed and pragmatic leadership may be appropriate. Furthermore, although tenuous, there may be an assumption that scientific work can advance even in spite of poor leadership (Hogan & Kaiser, 2005; Sapienza, 2004).

The contemporary scientific community recognizes that scientific work is not a sole endeavor (Bennett et al., 2010; Hemlin, Allwood, Martin, & Mumford, 2013). However, the romantic notion of an individual scientist working alone to achieve breakthroughs lingers in thinking about scientific work (M. Mumford et al., 2003). This notion may account at least in part for the neglect of the social nature of the modern scientific enterprise. Additionally, researchers view the scientific process as an objective, dispassionate endeavor—one potentially devoid of significant human and social elements (Markowetz, 2105; McCormick et al., 2012). But, the recent recognition of the fallibilities of the scientific process (Collins & Tabak, 2014; Nuzzo, 2015) have highlighted that science is, in fact, a deeply human endeavor. Nonetheless, these notions may have fostered the sidelining of the social dimensions of science.

Research Questions

In sum, researchers work in a complex professional environment on multi-faceted, high-demand work. This work requires leadership and management. The objective of the present study was to provide initial empirical evidence regarding the importance that genetic researchers attach to leadership and management in their scientific work. Overall, we addressed the questions: Do PIs perceive leadership and management activities as essential to conducting effective research and how prepared did they feel for these activities after completing their scientific training? Additionally, we identified management practices that successful, funded investigators employ in their work, and inquired about their openness to an intervention aimed at fostering effective lab practices.

Methods

Study Design and Sample

We conducted semi-structured interviews with NIH-funded genetic researchers at Washington University School of Medicine in St. Louis, a research-intensive medical center which has one of the four human genome sequencing centers funded by the National Human Genome Research Institute. Our target sample was biomedical researchers conducting diverse types of research (e.g., lab, human, and animal) funded across NIH institutes but sharing a common focus on genetic or genomic science. At this stage, to foster interpretation of our findings we focused within one academic medical center to minimize the potential for differences attributable to varied institutional cultures.

We identified PIs funded through R (research), P (center), U (collaborative), or K (career development) grants using the NIH RePORTER database. We sought investigators diverse in career stage, hence our inclusion of PIs funded on K grants. A keyword search (e.g., gene, genetic, genomic, exome) of project abstracts active as of September 2014 yielded 407 unique project PIs at Washington University. We utilized institutional or lab websites to identify the gender of the investigators so that we could stratify our sample proportionally for gender representation among the funded investigators (70% male, 30% female). We also stratified our sample across the NIH institutes that had funded the research.

We randomly sampled 30–35 investigators at a time across the two strata in each of four rounds of recruitment. To refine the initial RePORTER query, we reviewed the project descriptions to ensure that the projects did involve a primary or secondary aim in genetics or genomics and replaced (at random) those that did not. In total, we emailed 135 investigators inviting them to participate in a 30–45 minute telephone or in-person interview focused on "understanding the challenges and practices of researchers in genetic and genomics." We followed up after one week with a second email and a phone call. We received responses from 7 (5%) declining to participate, 11 (8%) indicating they did not consider themselves genetic researchers, and 32 (24%) agreeing to participate. The Washington University in St. Louis institutional review board approved this study (ID# 201409169). PIs received a consent information sheet via email before participating in the study and had the opportunity to ask questions before the interviews began.

Data Collection

The interview script consisted of open-ended questions with follow-up questions used as needed and as time permitted. The experience of the senior investigator (J.M.D.), and his research on professionalism and responsible conduct in research (DuBois, 2004; DuBois et al., 2016), as well as the first author's familiarity with the leadership literature (Antes & Mumford, 2012; Antes & Schuelke, 2011; M. Mumford, Antes, Caughron, & Friedrich, 2008) guided generation of interview questions. However, questions were intentionally broad in focus to avoid priming participants to discuss leadership and management. Our opening question was simply, "Thinking about what it takes to do your research effectively, in addition to scientific knowledge and technical expertise, what skills have you found that you need?" The overall focus of our interview was to understand whether PIs viewed leadership and management as important to their research and to discover practices they utilize. Additionally, we asked the participants for their reactions to a potential program aimed at providing PIs with guidance in lab leadership and management. A secondary area of focus was PIs' perspectives on ethical and social issues in research. In this manuscript, we report on the primary focus—leadership and management.

A member of our study team (A.M.) conducted the interviews, after training provided by the first author. For the convenience of the PIs, we allowed them to choose whether to participate via telephone (n = 20) or in-person (n = 12). The average length of the interviews was 34 minutes (*SD* = 16). All of the participants gave consent for us to audio-record the interview. To obtain demographics, we asked participants to describe their career stage and type of research. We collected data on their degrees and whether they were originally from the U.S. or an international background via biographical information posted online on institutional or lab websites. We began to achieve saturation of themes at about 20 interviews, but completed 32 to interviews to ensure that the themes remained consistent upon achieving a fuller, more representative sample in terms of gender and career stage. A professional transcriptionist transcribed the interviews verbatim.

Data Analysis

We performed a content analysis of the interview transcripts (Roller & Lavrakas, 2015; Vogt, Vogt, Gardner, & Haeffele, 2014) using an inductive coding scheme developed from the participants' responses. First, one member of the study team (A.L.A.), an organizational psychologist, read the transcripts to identify themes and subthemes present in the responses and to develop a coding guide consisting of the themes and their descriptions. The senior author (J.M.D.) reviewed the coding guide. Next, A.L.A. and A.M. met to discuss the coding scheme before applying it to 10% of the interviews. Both coders read the transcripts and indicated whether each theme was present or not present by entering 1 (*present*) or 0 (*not present*) in a Microsoft Excel spreadsheet used to manage the data. After independent coding, the coders met to discuss issues that had arisen in applying the coding scheme and reached consensus about any differences in interpretation. Before A.M. proceeded to code the remaining transcripts, we established that the guide could be applied with satisfactory inter-rater agreement (Kappa = 0.74). We report frequencies and percentages for the themes that emerged in the interviews and provide quotes to illustrate the PIs' responses.

Results

As shown in Table 1, the participants consisted of 32 NIH-funded investigators who described their career stage as very junior (16%), somewhat junior (25%), mid-career (41%), or senior (19%); 69% where male and 31% female. Their research included human (41%), animal (63%), bench (59%), and computational/statistical (28%) research; many investigators (66%) indicated that their research involved multiple types. The majority of participants (69%) had a PhD degree and 31% had a MD and PhD degree. Approximately 41% were originally from an international location. Nearly all of the investigators reported having multiple ongoing collaborations at the institution and external to the institution. All but a small subgroup of the "very junior" investigators reported having post-docs, graduate students, and/or undergraduates working in their labs.

PIs Spontaneously Reported That Leadership and Management Skills Are Essential

Our first question was general before we probed more specifically about issues related to leadership and management. We began by asking investigators to describe what skills, in addition to scientific knowledge and technical expertise, they have found that they need to do research effectively. As shown in Table 2, leadership and management skills emerged as the dominant theme. Nearly all investigators (97%) indicated one or more leadership or management skill. (The one investigator who did not mention a leadership or management skill was a member of the "very junior" group.)

The most common responses included management skills (56%). Investigators described needing to manage people in particular, but also projects. Next, investigators highlighted the importance of collaboration skills (44%), including being able to bring together multiple people and work well with diverse individuals. Relatedly, investigators reported needing interpersonal skills (41%)—skills that foster their ability to interact well with people and communicate with them.

A small sub-group of investigators (16%) specifically mentioned leadership skills, or activities related to leadership, such as motivating or inspiring people and creating a caring environment. Overall, investigators utilized "management" more commonly in their terminology to describe their work-related tasks. Notably, just 9% of investigators mentioned "mentoring," or mentoring activities, such as developing the skills of others, teaching, supporting, or guiding. This is interesting considering that, of the terms used in scientific research, mentoring is more common than management or leadership.

PIs Described Learning Necessary Skills through Trial-and-Error

We asked researchers how they learned the skills that they need that are not scientific in nature. As shown in Table 3, the most common response, provided by 73% of the investigators, was that they learned to navigate management and leadership responsibilities "on-the-job" through "trial-and-error." Investigators described a process of making mistakes and then trying something new, and they portrayed the learning process as occurring "on the fly," through "osmosis," through "trial by fire," or by "playing it totally by ear."

Several PIs specifically noted the lack of formal training on these issues, and many emphasized the need to learn these skills earlier. Additionally, several described their lack of skills and the slow learning process as "haphazard and hazardous" and "high-stakes." One described worrying about having detrimental effects on the careers of individuals in the lab stating, "You hope that you don't ruin someone's life in the process. It's pretty high stakes to be learning on-the-job."

Many of the investigators specifically noted that their graduate or post-doctoral experience did not adequately prepare them; however, 33% reported that their graduate training or post-doctoral experience provided some development in this regard. Another 40% mentioned learning some of these skills from mentors or other models. However, a sub-set of these individuals reported learning practices to avoid by working with poor models. Finally, 30% of the researchers who were also physicians (those with MD/PhD degrees) mentioned that their medical residency assisted in learning skills necessary for interacting well with others.

PIs Reported Being Unprepared for Lab Management Responsibilities

We asked PIs how well prepared they felt when they started their careers to navigate issues in research that are not scientific in nature or to mentor trainees and manage staff. Most were forthcoming about lacking preparation. Overall, 50% felt that they were inadequately prepared, and 40% described being modestly prepared. Notably, just 10% stated that they were prepared (N = 30, two responses were un-codeable due to unclear answers). Several mentioned that they had been overly confident, and others noted that training for science is different than the skills needed for running a lab. A couple speculated that they might be further ahead in their careers if they had been better prepared. As illustrated in the following quotes, the PIs described the early stages of their careers, in particular, as challenging. One researcher noted, "I would say that's [management] something that I wasn't prepared for, it was sort of like jumping into the deep end as far as that goes." Another described the transition to running a lab as follows, "[It's] shocking the dramatic transition that occurs, the type of responsibilities and time management from going from post-doc to running a lab ... you go from doing the work to managing the work and redefine what works means."

PIs Described Key Leadership and Management Practices

We asked the PIs to describe their mentoring practices or management style at this point in their careers. With the exception of a couple "very junior" investigators, most PIs were able to articulate their approach to managing their labs. Overall, the themes included a constructive set of practices (shown in Table 4). Although most of the mid-career and senior PIs reported feeling fairly confident in their approach at this stage, some noted the need for continual refinement, feedback, and adjustment. Additionally, a couple noted that they recognized that they may need to change practices such as being rigid about deadlines, too "hands off," or "micro-managing."

Of the themes reported, the top responses included fostering open communication (41%) and meeting regularly (38%). The underlying theme of these responses was problem-solving. Open communication and regular meetings allowed the lab to address problems immediately and move projects forward. Several PIs also noted being available daily for ad-hoc meetings. Some (28%) emphasized the critical importance of finding a balance between guiding people while also encouraging them to be independent. Additionally, one-third (31%) noted the importance of personalizing one's management or mentoring style to individual needs. Other themes included creating a positive environment (28%) and setting clear deadlines (25%).

PIs Welcomed a Proposed Management Intervention

We wanted to ascertain whether investigators would welcome programs intended to assist them with lab leadership and management. Rather than asking them about their general interest, we contextualized this question by asking the PIs about their reactions to a specific hypothetical intervention—one that would be intensive in terms of the commitment required of a PI. We described a feedback and coaching intervention that would utilize a lab climate survey to obtain feedback about lab practices and culture from members of the lab and the PIs own self-assessment. Subsequently, PIs would receive aggregated results and coaching in areas of desired change in lab practices. After developing an initial plan for change, coaching would take place quarterly via telephone to assist PIs with following through on their plans.

A majority of PIs (74%) strongly supported the program and described it as valuable (N = 31, one response was missing due to running out of time). A small group (19%) was unsure about the proposed intervention or thought it could be potentially useful. Only 2 individuals (6%) stated that it was not a good idea, citing that it may be time-consuming or difficult to get anonymous feedback from members of the lab. Several of the PIs' statements illustrated their openness to improving their management practices and reiterated their recognition of the importance of lab management. One researcher indicated, "I would welcome it. I would always like to improve my lab, improve the culture in the lab, and any advice or help that I can get from the outside I would welcome." Our question prompted another researcher to note, "As I said, you're not taught management.... Am I managing most efficiently? I don't know.... I would be open to hearing about ideas ... I'd be flexible to change; it would be good to have feedback." Finally, another investigator stated:

> If I look back ... and I look at the single thing that I've screwed up the most it would be management ... management and management practices, and execution. Anything that helps that game would be better, and especially if people are like, you know, particularly focused on science.

Although what we proposed was intensive, several of the PIs stressed that they liked the tailored nature of the program, and that there is a need generally for leadership and management resources tailored to scientists. About half of those who supported the proposed program emphasized that PIs at early career stages in particular might benefit. However, one PI's comment highlighted the importance of the timing of interventions, noting that something like this might be most appropriate once one's research team started to get particularly complicated.

> I would say I wouldn't have felt much value for it maybe five years ago. It's kind of at a point where there's enough going on in a lab where it starts to get complicated personnel wise; then that would start to be really useful. In a small lab with junior faculty, I wouldn't necessarily find value in it, but at this point I would.... You don't even know what your issues are going to be until you're kind of in the middle of it.

Discussion

Our interviews with NIH-funded genetic researchers revealed that researchers consider leadership and management essential for performing research effectively. However, PIs reported that they were inadequately prepared to navigate the social and organizational elements of their scientific careers based solely on their scientific training. They emphasized that they learned the necessary leadership and management skills on-the-job through trial-and-error. Notably, the traditional means employed to impart scientists with requisite knowledge and skills—namely mentoring and graduate training—did not appear to be significant sources for learning to perform leadership and management activities central to research. Certainly, scientific training affords trainees with problem-solving skills that may facilitate acquiring such expertise through experience (K. Barker, 2010), but this study reinforces the proposal that the scientific community must better prepare scientists to navigate these aspects of their careers (Evans, 2012; Hede, 2007; Kvaskoff & McKay, 2014; Laursen, 2014; Leiserson & McVinney, 2015; Seeliger, 2012). The present effort provides some recommendations for how to approach such an effort. However, we need additional research on approaches for developing scientists' leadership and management skills and basic research on leadership and management in research.

Best Practices

Our findings suggest several best practices for researchers. Overall, it is important to be intentional about leadership and management practices that one employs and to refine these practices continually across one's career. Elemental to this effort is openness to feedback from lab members and advice from peers and colleagues. Additionally, one must be mindful of the outcomes of different approaches to coordinating and monitoring the work of research team members. Important practices include fostering open communication and meeting regularly, particularly to serve the interest of troubleshooting problems. It is also important to be attentive to the individual needs of those whom one manages or mentors, and to balance providing appropriate guidance while also allowing independence. Finally, it is prudent to gauge and monitor the workgroup climate or culture within a lab, working towards fostering one conducive to creativity, integrity, and productivity. Our findings also suggest that scientists, particularly those early in their careers, should seek out available resources and training opportunities. Finally, it is important for researchers to be mindful that their behaviors and practices as lab directors and research mentors have a lasting impact on those within their labs.

These points imply broader practical recommendations for leaders of research institutions. In the academic setting studied in the present effort, investigators desired access to leadership and management resources and training opportunities tailored to scientists. Institutional leaders should assess whether such a need exists in their organizations. Additionally, if extant resources and programs are available, leaders should ensure that they are sufficiently advertised, particularly when onboarding new investigators. Not only could such efforts improve practices in performing scientific work and enhance the quality of training and mentoring of junior scientists, but support from administrative officials may also influence the broader institutional culture. Finally, institutions should assess the outcomes of such programs and share their findings with others in the scientific community.

Educational Implications

Of course, a major issue moving forward is what should be the nature of training and development efforts for scientists. A set of established approaches for leadership and management development and education exist in the organizational psychology and business disciplines (Day, Fleenor, Atwater, Sturm, & McKee, 2014; DeRue & Myers, 2014; Doh, 2003; Snook, Nohria, & Khurana, 2011), which may provide best practices to guide future work. However, it is unclear which techniques and topics translate to the scientific context, reinforcing the importance of defining learning objectives and assessing the outcomes of training and developmental interventions (Antes & Schuelke, 2011; Arthur, Bennett, Edens, & Bell, 2003; Riggio, 2008).

In addition to traditional training models, we should also explore other potentially viable developmental techniques, such as providing investigators feedback from lab climate surveys and coaching (Ely et al., 2010; Feldman & Lankau, 2005; M. Mumford, Peterson, & Robledo, 2013). Notably, new measures of leader effectiveness tailored to the scientific enterprise may be necessary to assess training and developmental interventions (and such measures would facilitate research efforts as well). Furthermore, future discussion about leadership and management training and development for investigators should also consider educational practices in undergraduate and graduate education in the sciences (National Research Council, 2015a).

Although more basic research on scientific leadership and management must guide appropriate content, existing evidence suggests that social judgment and interpersonal skills, in addition to problem-solving skills and technical expertise, underlie leadership in professional settings. Such competencies include the ability to build and maintain relationships, present oneself well, communicate effectively, build teams, and support others (R. A. Barker, 1997; Hogan & Kaiser, 2005; M. Mumford et al., 2003; M. Mumford, Zaccaro, Harding, & Jacobs, 2000). Indeed, the PIs in our interviews emphasized the importance of these skills, and they appear to be emphasized in existing, albeit limited, leadership training programs offered for scientists (Laursen, 2014). Coupled with scientists' existing problem-solving skills and technical expertise, enhanced social and interpersonal skills would likely better equip investigators for responsibilities such as fostering an open, innovative, high-integrity work environment, engaging others in participatory decision-making, and effectively distributing leadership among lab members or research team members (Salazar, Lant, Fiore, & Salas, 2012). However, to be effective and credible, leadership development programs, particularly those focusing on emotional and interpersonal competencies, must be grounded in research (Riggio & Lee, 2007).

Additionally, business skills, such as planning, budgeting, staffing, monitoring progress, and setting priorities, are imperative (Hogan & Kaiser, 2005; T. Mumford, Campion, & Morgeson, 2007). Indeed, the investigators we interviewed raised this point. Such skills assist researchers with tasks such as hiring and training staff, planning project timelines and milestones, and overseeing work. In designing training and development interventions, it may also be necessary to consider the relative priority of different competencies at different stages in a scientist's career (M. Mumford, Marks, Connelly, Zaccaro, & Reiter-Palmon, 2000). Additionally, developmental efforts should consider the dynamic needs of investigators across the stages of scientific projects (Antes & Schuelke, 2011; National Research Council, 2015b), including how investigators simultaneously manage multiple projects in multiple stages. Moreover, the skills investigators need may also vary depending on the level of support provided by institutions such as support in budget development and management.

Another model for training and development efforts would prepare researchers to be reflective and adaptive in their approach to leading and managing in their labs and across their careers (Ashford & DeRue, 2012; Nesbit, 2012). Such an approach would encourage investigators to recognize leadership and management responsibilities and roles in scientific work and foster a leader self-identity (Day & Harrison, 2007; Pearce, 2007). A reflective, adaptive approach allows individuals to change and tailor their leadership style and practices appropriately for a given context, project, or career stage, and it facilitates self-directed learning and growth by encouraging individuals to extract lessons from their experience (Ashford & DeRue, 2012; Cohen, 2012; Puccio, Mance, & Zacko-Smith, 2013). The comments of the participants in our study suggest that they engage in this reflective approach to some extent intuitively, and formal training could provide support and knowledge to accelerate this natural approach to developing leadership skills.

Several practical considerations emerge from these points. First, investigators already juggle many duties and responsibilities (James, 2011; National Science Board, 2014). Thus, it may seem unreasonable to suggest that they participate in leadership training. Theoretically, well-executed training would *save* investigators time by helping them to address issues before they emerge and being more mindful about practices that foster successful research. Indeed, some of the PIs in this study reported learning things the "hard way" and speculated that this had slowed them down; others have reinforced the hazards of learning to lead "on-the-fly" (Kreeger, 1997). Overall, this potential critique reinforces the need to utilize best practices and assess leadership development and training efforts to demonstrate their value. Additionally, offering support and services on-demand, for instance through consultation services or access to online resources, might allow investigators to obtain the right kind of information and assistance at the right times.

Second, engaging issues related to "soft skills" and asking for assistance to improve one's practices may be unfamiliar to researchers who tend to be analytic, self-reliant, and self-confident (Feist, 1998). Moreover, those trained in the life and physical sciences may be skeptical of the insights about leadership and management practices offered by the social sciences (Sapienza, 2004). However, researchers are naturally open-minded, which many mitigate these concerns (Robledo et al., 2012). It is important, however, to consider how to best frame such efforts. It is unclear to what extent investigators find different terminology appealing—for example, career development, professional development, leadership development, or management training.

Finally, although leadership training and development are certainly not a panacea, future work might consider whether a leadership and management framework provides an umbrella for integrating the currently disparate conversations about topics such as mentoring, responsible conduct in research, professionalism, mentoring, research rigor and transparency, and team science. These topics all highlight social and organizational dimensions in designing, performing, and communicating scientific work. Such an approach might answer calls to make responsible conduct of research training more relevant to the daily work of scientists and to explore ways to foster engagement of ethical issues in research through connecting them directly to the practice of science (Devereaux, 2014; Kalichman, 2014a; Smith, 2001).

Research Agenda

Notably, the basis for effective leadership development interventions is an understanding of the practice of leadership and management in science. Thus, there is an urgent need for empirical research examining the social and organizational elements of scientific research. This research should examine the mechanisms and processes proposed in the existing, although scarce, literature on scientific leadership (Hemlin et al., 2013; M. Mumford et al., 2003; National Research Council, 2015b; Robledo et al., 2012). For instance, this work might examine processes in team alignment and knowledge integration (Drath et al., 2008; Salazar et al., 2012). Other issues such as conflict resolution, project management, building a lab culture, cross-cultural communication, and interacting with difficult colleagues may also be fruitful directions (K. Barker, 2010; Cohen, 2012). There is an existing, expansive base of related research in the workplace psychology and organizational behavior disciplines, but future research must take into account the unique qualities of scientific work and the distinct qualities of staff and collaborators engaged in it.

Future work must also examine explicit connections between leadership and management practices and the ethics, integrity, and transparency of research. With a few notable exceptions—for instance, an investigator recounted realizing that inadequate oversight of a graduate student had comprised the integrity of data generated during the student's tenure in the lab—investigators in our study generally did not raise such connections. Two opposing explanations may account for this. Investigators may implicitly acknowledge the connection between practices they employ to manage their research and the effectiveness and integrity of the research. Alternatively, PIs may lack awareness of the significance of ethical issues in their work (McCormick et al., 2012). It is also important to understand connections between management practices and the productivity of scientific labs and teams—what practices yield scientific productivity while also supporting the quality and integrity of the work?

The present study focused primarily on management issues in the lab setting, but future work should also consider the multiple levels at which investigators may lead in their careers and the multiple types of scientific organizations (M. Mumford et al., 2003). For example, leadership takes place in collaborative, even multi-site and international, teams, in scientific disciplines (e.g., leadership roles in a professional society), in communities and among the public, and in administrative roles (e.g., a division chief or department chair). Additionally, leadership across multiple levels must be considered; for instance, how administrative leadership at the organizational or departmental level influences leadership within labs (Bland & Ruffin, 1992; Robledo et al., 2012). Future research on leadership and management in science will also need to consider differences and commonalities across academic, industry, and entrepreneurial organizational contexts (M. Mumford et al., 2003).

To address these research questions about scientific leadership, we must consider several significant practical issues that emerge. Notably, who should study, fund, and publish "metascience" (Hu, 2016) on leadership and management in research? Interdisciplinary teams comprised of social scientists and those from specific social, life, or physical science disciplines may be best equipped to employ social science methods to test research questions while also appreciating unique features of specific scientific disciplines. But, funding agencies and journals typically focus on specific diseases or disciplines. Research issues that span all scientific research do not have clear funding or publication outlets (Ioannidis, Fanelli, Dunne, & Goodman, 2015). Often this work is published in a wide range of disciplines, making it difficult for scholars studying similar issues to locate each other's work (Ioannidis et al., 2015). Additionally, these efforts are likely to be unfunded secondary projects of interest to individual researchers, and as such, potentially funded inadequately to address the necessary large and complex questions.

Limitations

These findings provide some useful future directions for research, training, and development regarding leadership and management in science, but they are not without limitations. The first limitation relates to the generalizability of the findings because the PIs were at one academic institution. However, this allowed us to hold constant the potential influence of institutional culture, which was not of interest in this particular study. Additionally, we ensured that our sample was diverse and representative of biomedical researchers conducting NIH-funded genetic research. They were diverse in terms of nation of origin (i.e., international or U.S.), and they conducted varied types of research (e.g., human, animal, computational) funded by a variety of NIH institutes. They were also diverse in career stage, and our sample was representative of the NIH-funded population in terms of gender.

Another potential limitation includes that the investigators self-selected as volunteers for the interview study. Therefore, they may be those most interested in issues related to operating a lab or leading a research team. Indeed, their responses suggested that they were reflective about their lab management practices. Overall, it is unclear whether our findings would generalize to other groups of scientists in other settings.

Finally, all of our participants could be considered highly successful: they are PIs at a leading medical research center with NIH funding. While this is a limitation in terms of the generalizability of findings, it is also a strength in terms of learning about the management practices of successful researchers.

Conclusion

In conclusion, the NIH-funded principal investigators that we interviewed at a top-tier US academic medical center decidedly indicated that leadership and management are essential to performing effective research. Moreover, they observed that scientific training does not prepare researchers for these activities, and they encouraged the development of programs to better train investigators. Ultimately, equipping investigators to navigate the social and organizational dimensions of scientific work serves to foster the quality, integrity, and societal impact of scientific research. But, efforts must follow best practices in leadership development and assessment, and empirical research on leadership and management in science should serve as their basis. Several practical concerns emerge in light of the foregoing observations, such as who should study, fund, and publish such work. We hope that the present study inspires the scientific community to take on this challenge.

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References

Adamo JE, Bauer G, Berro M, Burnette BK, Hartman KA. A roadmap for academic health centers to establish good laboratory practice-compliant infrastructure. Academic Medicine. 2012; 87(3):279–284. [PubMed: 22373618]

Adams LG. Putting together a scientific team: Collaborative science. Trends in Microbiology. 2014; 22(9):483–485. DOI: 10.1016/j.tim.2014.05.001 [PubMed: 24894627]

Andrews FM, Farris GF. Supervisory practices and innovation in scientific teams. Personnel Psychology. 1967; 20(4):497–515. DOI: 10.1111/j.1744-6570.1967.tb02446.x

Antes AL, Mumford MD. Strategies for leader cognition: Viewing the glass "half full" and "half empty". Leadership Quarterly. 2012; 23(3):425–442. DOI: 10.1016/j.leaqua.2011.10.001

Antes AL, Schuelke MJ. Leveraging technology to develop creative leadership capacity. Advances in Developing Human Resources. 2011; 13(3):318–365. DOI: 10.1177/1523422311424710

Arnon, I. Agricultural research and technology transfer. New York, NY: Elsevier Science Publishers Ltd; 1989a. Principles of research management; p. 585-599.

Arnon, I. Agricultural research and technology transfer. New York, NY: Elsevier Science Publishers Ltd; 1989b. The scientist as research administrator; p. 599-611.

Arthur W, Bennett W, Edens PS, Bell ST. Effectiveness of training in organizations: A meta-analysis of design and evaluation features. Journal of Applied Psychology. 2003; 88(2):234–245. DOI: 10.1037/0021-9010.88.2.234 [PubMed: 12731707]

Ashford SJ, DeRue DS. Developing as a leader: The power of mindful engagement. Organizational Dynamics. 2012; 41(2):146–154. DOI: 10.1016/j.orgdyn.2012.01.008

Avolio B, Walumbwa F, Weber TJ. Leadership: Current theories, research, and future directions. Annual Review of Psychology. 2009; 60:421–449. DOI: 10.1146/annurev.psych.60.110707.163621

Ball S. Leadership of academics in research. Educational Management Administration & Leadership. 2007; 35(4):449–477.

Barker, K. At the helm: Leading your laboratory. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press; 2010.

Barker RA. How can we train leaders if we do not know what leadership is? Human Relations. 1997; 50(4):343–362.

Barnett T, Vaicys C. The moderating effect of individuals' perceptions of ethical work climate on ethical judgments and behavioral intentions. Journal of Business Ethics. 2000; 27(4):351–362.

Barnowe JT. Leadership and performance outcomes in research organizations: The supervisor of scientists as a source of assistance. Organizational Behavior and Human Performance. 1975; 14(2):264–280. DOI: 10.1016/0030-5073(75)90029-X

Bass BM. From transactional to transformational leadership: Learning to share the vision. Organizational Dynamics. 1990; 18(3):19–31. DOI: 10.1016/0090-2616(90)90061-S

Bass, BM.; Bass, R. The Bass handbook of leadership: Theory, research, and managerial applications. 4. New York, NY: Simon and Schuster; 2008.

Baumgartel H. Leadership style as a variable in research administration. Administrative Science Quarterly. 1957; 2(3):344–360. DOI: 10.2307/2391003

Bennett, LM.; Gadlin, H.; Levine-Finley, S. Collaboration and team science: A field guide. Bethesda, MD: National Institutes of Health; 2010.

Billot J. The changing research context: Implications for leadership. Journal of Higher Education Policy and Management. 2010; 33(1):37–46. DOI: 10.1080/1360080X.2011.537010

Binz-Scharf MC, Kalish Y, Paik L. Making science: New generations of collaborative knowledge production. American Behavioral Scientist. 2015; 59(5):531–547. DOI: 10.1177/0002764214556805

Bird SJ. Mentors, advisors and supervisors: Their role in teaching responsible research conduct. Science and Engineering Ethics. 2001; 7(4):455–468. [PubMed: 11697001]

Bird SJ. Socially responsible science is more than "good science". Journal of Microbiology & Biology Education. 2014; 15(2):169–172. DOI: 10.1128/jmbe.v15i2.870 [PubMed: 25574272]

Bird SJ, Sprague R. Mentoring and the responsible conduct of research: Reflections and future. Science and Engineering Ethics. 2001; 7(4):451–453. DOI: 10.1007/s11948-001-0001-2 [PubMed: 11697000]

Bland CJ, Ruffin MT IV. Characteristics of a productive research environment: Literature review. Academic Medicine. 1992; 67(6):385–397. [PubMed: 1596337]

Bolden R. Distributed leadership in organizations: A review of theory and research. International Journal of Management Reviews. 2011; 13:251–269. DOI: 10.1111/j.1468-2370.2011.00306.x

Bonetta, L., editor. Making the right moves: A practical guide to scientific management for postdocs and new faculty. Chevy Chase, MD and Research Triangle Park, NC: Howard Hughes Medical Institute and Burroughs Wellcome Fund; 2006.

Brown ME, Trevino LK. Ethical leadership: A review and future directions. Leadership Quarterly. 2006; 17(6):595–616. DOI: 10.1016/j.leaqua.2006.10.004

Buck S. Solving reproducibility. Science. 2015; 348(6242):1403–1403. DOI: 10.1126/science.aac8041 [PubMed: 26113692]

Buijs J. Innovation leaders should be controlled schizophrenics. Creativity and Innovation Management. 2007; 16(2):203–210.

Chi KR. Running the Show. Nature. 2010; doi: 10.1038/nj7312-240a

Cohen, CC.; SL. Lab dynamics: Management and leadership skills for scientists. 2. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press; 2012.

Collins FS, Tabak LA. NIH plans to enhance reproducibility. Nature. 2014; 505(7485):612. [PubMed: 24482835]

Conger JA. Charismatic and transformational leadership in organizations: An insider's perspective on these developing streams of research. Leadership Quarterly. 1999; 10(2):145–179.

Day, DV., editor. The Oxford Handbook of Leadership in Organizations. New York, NY: Oxford University Press; 2014.

Day DV, Fleenor JW, Atwater LE, Sturm RE, McKee RA. Advances in leader and leadership development: A review of 25 years of research and theory. Leadership Quarterly. 2014; 25(1):63–82. DOI: 10.1016/j.leaqua.2013.11.004

Day DV, Harrison MM. A multilevel, identity-based approach to leadership development. Human Resource Management Review. 2007; 17(4):360–373. DOI: 10.1016/j.hrmr.2007.08.007

De Vries R, Anderson MS, Martinson BC. Normal Misbehavior: Scientists talk about the ethics of research. Journal of Empirical Research on Human Research Ethics. 2006; 1(1):43–50. DOI: 10.1525/jer.2006.1.1.43 [PubMed: 16810336]

DelliFraine JL, Wang Z, McCaughey D, Langabeer JR, Erwin CO. The use of six sigma in health care management: Are we using it to its full potential? Quality Management in Healthcare. 2013; 22(3): 210–223.

DeRue, DS.; Myers, CG. Leadership development: A review and agenda for future research. In: Day, DV., editor. The Oxford handbook of leadership and organizations. New York, NY: Oxford University Press; 2014. p. 832-855.

DeRue DS, Nahrgang JD, Wellman N, Humphrey SE. Trait and behavioral theories of leadership: An integration and meta-analytic test of their relative validity. Personnel Psychology. 2011; 64(1):7–52.

Devereaux ML. Rethinking the meaning of ethics in RCR education. Journal of Microbiology & Biology Education. 2014; 15(2):165–168. DOI: 10.1128/jmbe.v15i2.857 [PubMed: 25574271]

Doh JP. Can leadership be taught? Perspectives from management educators. Academy of Management Learning & Education. 2003; 2(1):54–67.

Drath WH, McCauley CD, Palus CJ, Van Velsor E, O'Connor PM, McGuire JB. Direction, alignment, commitment: Toward a more integrative ontology of leadership. Leadership Quarterly. 2008; 19(6):635–653.

DuBois JM. Is compliance a professional virtue of researchers? Reflections on promoting the responsible conduct of research. Ethics and Behavior. 2004; 14(4):383–395. DOI: 10.1207/s15327019eb1404_8 [PubMed: 16625734]

DuBois JM, Chibnall JT, Tait RC, Vander Wal JS. Lessons from Researcher Rehab. Nature. 2016; 534:173–175. [PubMed: 27279195]

DuBois JM, Chibnall JT, Tait RC, Vander Wal JS, Baldwin KA, Antes AL, Mumford MD. Professional Decision-Making in Research (PDR): The validity of a new measure. Science and Engineering Ethics. 2016; 22:391–416. DOI: 10.1007/s11948-015-9667-8 [PubMed: 26071940]

Ely K, Boyce LA, Nelson JK, Zaccaro SJ, Hernez-Broome G, Whyman W. Evaluating leadership coaching: A review and integrated framework. Leadership Quarterly. 2010; 21(4):585–599.

Evans L. Leadership for researcher development: What research leaders need to know and understand. Educational Management Administration & Leadership. 2012; 40(4):423–435. DOI: 10.1177/1741143212438218

Feist GJ. A meta-analysis of personality in scientific and artistic creativity. Personality and Social Psychology Review. 1998; 2(4):290–309. [PubMed: 15647135]

Feldman DC, Lankau MJ. Executive coaching: A review and agenda for future research. Journal of Management. 2005; 31(6):829–848. DOI: 10.1177/0149206305279599

Frankel AS, Leonard MW, Denham CR. Fair and just culture, team behavior, and leadership engagement: The tools to achieve high reliability. Health Services Research. 2006; 41(4):1690–1709. DOI: 10.1111/j.1475-6773.2006.00572.x [PubMed: 16898986]

Freedman LP, Cockburn IM, Simcoe TS. The economics of reproducibility in preclinical research. PLoS Biology. 2015; 13(6):e1002165.doi: 10.1371/journal.pbio.1002165 [PubMed: 26057340]

Friedrich TL, Vessey WB, Schuelke MJ, Ruark GA, Mumford MD. A framework for understanding collective leadership: The selective utilization of leader and team expertise within networks. Leadership Quarterly. 2009; 20(6):933–958.

Gemmill G, Wilemon D. The hidden side of leadership in technical team management. Research Technology Management. 1994; 37(6):25.

Gewin V. Recipe for a team. Nature. 2015; 523:245–247. DOI: 10.1038/nj7558-245a [PubMed: 26161446]

Gray B. Enhancing transdisciplinary research through collaborative leadership. American Journal of Preventive Medicine. 2008; 35(2):S124–S132. [PubMed: 18619392]

Hansson F, Monsted M. Research leadership as entrepreneurial organizing for research. Higher Education. 2008; 55(6):651–670. DOI: 10.1007/s10734-007-9081-5

Hede K. Managing scientists. Science. 2007; 318(5852):993–995. DOI: 10.1126/science.318.5852.993

Hemlin, S.; Allwood, CM.; Martin, B.; Mumford, MD. Introduction: Why is leadership important for creativity in science, technology and innovation?. In: Hemlin, S.; Allwood, CM.; Martin, B.; Mumford, MD., editors. Creativity and leadership in science, technology, and innovation. New York, NY: Routledge; 2013. p. 1-26.

Hogan R, Kaiser RB. What we know about leadership. Review of General Psychology. 2005; 9(2): 169–180. DOI: 10.1037/1089-2680.9.2.169

Hu JC. Studying the science of science. Science. 2016; doi: 10.1126/science.caredit.a1600051

Hurley, J. Scientific research effectiveness: The organisational dimension. Dordrecht, The Netherlands: Kluwer Academic Publishers; 2003.

Ioannidis JPA, Fanelli D, Dunne DD, Goodman SN. Meta-research: Evaluation and improvement of research methods and practices. PLoS Biology. 2015; 13(10):e1002264.doi: 10.1371/journal.pbio. 1002264 [PubMed: 26431313]

James A. Too many tasks. Nature. 2011; 475:257.doi: 10.1038/nj7355-257a

Kaiser RB, Hogan R, Craig SB. Leadership and the fate of organizations. American Psychologist. 2008; 63(2):96–110. DOI: 10.1037/0003-066X.63.2.96 [PubMed: 18284278]

Kalichman MW. A modest proposal to move RCR education out of the classroom and into research. Journal of Microbiology & Biology Education. 2014a; 15(2):93–95. DOI: 10.1128/jmbe.v15i2.866 [PubMed: 25574254]

Kalichman MW. Rescuing Responsible Conduct of Research (RCR) education. Accountability in Research. 2014b; 21(1):68–83. DOI: 10.1080/08989621.2013.822271 [PubMed: 24073608]

Knorr, K.; Mittermeir, R.; Aichholzer, G.; Waller, G. Leadership and group performance: A positive relationship in academic research units. In: Andrews, FM., editor. Science productivity: The effectiveness of research groups in six countries. 2009. p. 95-120.

Kotter, JP. Force for change: How leadership differs from management. New York, NY: Simon and Schuster; 2008.

Kreeger, KY. Researchers setting up labs must learn skills on the fly. The Scientist. 1997. Retrieved from http://www.the-scientist.com/?articles.view/articleNo/18333/title/Researchers-Setting-Up-Labs-Must-Learn-Skills-On-The-Fly/

Kvaskoff M, McKay SD. Education: Scientists need leadership training. Nature. 2014; 506:159.doi: 10.1038/506159c

Ladd JM, Lappé MD, McCormick JB, Boyce AM, Cho MK. The "how" and "whys" of research: Life scientists' views of accountability. Journal of Medical Ethics. 2009; 35(12):762–767. DOI: 10.1136/jme.2009.031781 [PubMed: 19948933]

Laursen, L. Learning to Lead a Lab. Science. 2014. Retrieved from http://www.sciencemag.org/careers/2014/02/learning-lead-lab

Ledford H. Team science: Interdisciplinarity has become all the rage as scientists tackle society's biggest problems. But there is still strong resistance to crossing borders. Nature. 2015; 525:308–311. DOI: 10.1038/525308a [PubMed: 26381968]

Leiserson CE, McVinney C. Lifelong learning: Science professors need leadership training. Nature. 2015; 523(7560):279–281. DOI: 10.1038/523279a [PubMed: 26178950]

Maccoby M. Understanding the difference between management and leadership. Research Technology Management. 2000; 43(1):57–59.

Macrina, FL. Scientific integrity: Text and cases in responsible conduct of research. 4. Washington, DC: ASM Press; 2014.

Marion R, Uhl-Bien M. Leadership in complex organizations. Leadership Quarterly. 2001; 12:389–418.

Markowetz F. You are not working for me; I am working with you. PLoS Computational Biology. 2015; 11(9):e1004387.doi: 10.1371/journal.pcbi.1004387 [PubMed: 26402330]

McCormick JB, Boyce AM, Ladd JM, Cho MK. Barriers to considering ethical and societal implications of research: Perceptions of life scientists. AJOB Primary Research. 2012; 3(3):40–50. DOI: 10.1080/21507716.2012.680651 [PubMed: 22866239]

Mumford MD, Antes AL, Caughron JJ, Friedrich TL. Charismatic, ideological, and pragmatic leadership: Multi-level influences on emergence and performance. Leadership Quarterly. 2008; 19(2):144–160. DOI: 10.1016/j.leaqua.2008.01.002

Mumford MD, Fried Y. Give them what they want or give them what they need? Ideology in the study of leadership. Journal of Organizational Behavior. 2014; 35(5):622–634. DOI: 10.1002/Job.1921

Mumford, MD.; Gibson, C.; Giorgini, V.; Mecca, J. Leading for creativitiy: People, products and systems. In: Day, DV., editor. The Oxford handbook of leadership and organizations. New York, NY: Oxford University Press; 2014. p. 757-782.

Mumford MD, Licuanan B. Leading for innovation: Conclusions, issues, and directions. Leadership Quarterly. 2004; 15:163–171.

Mumford MD, Marks MA, Connelly MS, Zaccaro SJ, Reiter-Palmon R. Development of leadership skills: Experience and timing. Leadership Quarterly. 2000; 11(1):87–114. DOI: 10.1016/S1048-9843(99)00044-2

Mumford, MD.; Peterson, D.; Robledo, I. Leading scientists and engineers: Cognition in a socio-technical context. In: Hemlin, S.; Allwood, CM.; Martin, B.; Mumford, MD., editors. Creativity and leadership in science, technology, and innovation. New York, NY: Routledge; 2013. p. 29-57.

Mumford, MD.; Scott, GM.; Gaddis, B. Leadership in scientific organizations. In: Hurley, J., editor. Scientific research effectiveness: The organisational dimension. Dordrecht, The Netherlands: Kluwer Academic Publishers; 2003. p. 69-99.

Mumford MD, Scott GM, Gaddis B, Strange JM. Leading creative people: Orchestrating expertise and relationships. Leadership Quarterly. 2002; 13(6):705–750. DOI: 10.1016/S1048-9843(02)00158-3

Mumford MD, Van Doorn JR. The leadership of pragmatism reconsidering Franklin in the age of charisma. Leadership Quarterly. 2001; 12:279–309.

Mumford MD, Zaccaro SJ, Harding FD, Jacobs TO. Leadership skills for a changing world: Solving complex social problems. Leadership Quarterly. 2000; 11(1):11–35.

Mumford TV, Campion MA, Morgeson FP. The leadership skills strataplex: Leadership skill requirements across organizational levels. Leadership Quarterly. 2007; 18:154–166.

National Research Council. Committee on the Science of Team Science. Board on Behavioral, Cognitive, and Sensory Sciences, Division of Behavioral and Social Sciences and Education. Professional development and education for team science. In: Cooke, NJ.; Hilton, ML., editors. Enhancing the effectiveness of team science. Washington, DC: National Academies Press; 2015a. p. 97-124.

National Research Council. Committee on the Science of Team Science, Board on Behavioral, Cognitive, and Sensory Sciences, Division of Behavioral and Social Sciences and Education. Team science leadership. In: Cooke, NJ.; Hilton, ML., editors. Enhancing the effectiveness of team science. Washington, DC: National Academies Press; 2015b. p. 125-148.

National Science Board. Reducing investigators' administrative workload for federally funded research. Arlington, VA: National Science Foundation; 2014.

Nesbit PL. The role of self-reflection, emotional management of feedback, and self-regulation processes in self-directed leadership development. Human Resource Development Review. 2012; 11(2):203–226. DOI: 10.1177/1534484312439196

Northouse, PG. Leadership: Theory and practice. 6. Thousand Oaks, CA: Sage Publications; 2013.

Nosek B, Alter G, Banks G, Borsboom D, Bowman S, Breckler S, … Yarkoni T. Promoting an open research culture: Author guidelines for journals could help to promote transparency, openness, and reproducibility. Science. 2015; 348(6242):1422–1425. DOI: 10.1126/science.aab2374 [PubMed: 26113702]

Nuzzo R. Fooling ourselves. Nature. 2015; 526:182–185. DOI: 10.1038/526182a [PubMed: 26450039]

Parker JN, Vermeulen N, Penders B. Admin burden is part of the job. Nature. 2011; 476:33.doi: 10.1038/476033c

Pearce CL. The future of leadership: Combining vertical and shared leadership to transform knowledge work. Academy of Management Executive. 2004; 18(1):47–57.

Pearce CL. The future of leadership development: The importance of identity, multilevel approaches, self-leadership, physical fitness, shared leadership, networking, creativity, emotions, spirituality and on-boarding processess. Human Resource Management Review. 2007; 17:355–359.

Pryor ER, Habermann B, Broome ME. Scientific misconduct from the perspective of research coordinators: A national survey. Journal of Medical Ethics. 2007; 33(6):365–369. DOI: 10.1136/jme.2006.016394 [PubMed: 17526690]

Puccio, GJ.; Mance, M.; Zacko-Smith, J. Leadership and followership in science and technology. In: Hemlin, S.; Allwood, CM.; Martin, B.; Mumford, MD., editors. Creativity and leadership in science, technology, and innovation. New York, NY: Routledge; 2013. p. 287-315.

Rico-Villademoros F, Hernando T, Sanz JL, López-Alonso A, Salamanca O, Camps C, Rosell R. The role of the clinical research coordinator – data manager – in oncology clinical trials. BMC Medical Research Methodology. 2004; 4(6):1–9.

Riggio RE. Leadership development: The current state and future expectations. Consulting Psychology Journal: Practice and Research. 2008; 60(4):383–392. DOI: 10.1037/1065-9293.60.4.383

Riggio RE, Lee J. Emotional and interpersonal competencies and leader development. Human Resource Management Review. 2007; 17:418–426.

Ripley E, Markowitz M, Nichols-Casebolt A, Williams L, Macrina F. Guiding the next generation of NIH investigators in responsible conduct of research: The role of the mentor. Accountability in Research. 2012; 19(4):209–219. DOI: 10.1080/08989621.2012.700880 [PubMed: 22861178]

Roberts GC, Kavussanu M, Sprague RL. Mentoring and the impact of the research climate. Science and Engineering Ethics. 2001; 7(4):525–537. DOI: 10.1007/s11948-001-0010-1 [PubMed: 11697009]

Robledo IC, Peterson DR, Mumford MD. Leadership of scientists and engineers: A three-vector model. Journal of Organizational Behavior. 2012; 33(1):140–147.

Roller, MR.; Lavrakas, PJ. Applied qualitative research design: A total quality framework approach. New York, NY: Guilford Press; 2015.

Salazar MR, Lant TK, Fiore SM, Salas E. Facilitating innovation in diverse science teams through integrative capacity. Small Group Research. 2012; 43(5):527–558.

Sapienza, AM. Managing scientists: Leadership strategies in scientific research. 2. Hoboken, NJ: John Wiley & Sons; 2004.

Schein, EH. Organizational culture and leadership. 4. San Francisco, CA: Jossey-Bass; 2010.

Seeliger J. Scientists must be taught to manage. Nature. 2012; 483(7391):511.doi: 10.1038/483511a [PubMed: 22460862]

Smith DH. Notes on pilgrimage to science: A fly on the wall. Science and Engineering Ethics. 2001; 7(4):615–634. [PubMed: 11697016]

Snook, SA.; Nohria, N.; Khurana, R., editors. The handbook for teaching leadership: Knowing, doing, and being. Thousand Oaks, CA: Sage Publications; 2011.

Straus SE, Johnson MO, Marquez C, Feldman MD. Characteristics of successful and failed mentoring relationships: A qualitative study across two academic health centers. Academic Medicine. 2013; 88(1)

Unsworth KL, Mason CM. Help yourself: The mechanisms through which a self-leadership intervention influences strain. Journal of Occupational Health Psychology. 2012; 17(2):235–245. [PubMed: 22308967]

Vogt, PW.; Vogt, ER.; Gardner, DC.; Haeffele, LM. Selecting the right analyses for your data. Quantitative, qualitative, and mixed methods. New York, NY: Guilford Press; 2014.

Yukl G. Managerial leadership: A review of theory and research. Journal of Management. 1989; 15(2): 251–289. DOI: 10.1177/014920638901500207

Zaccaro, SJ. Leadership memes: From ancient history and literature to Twenty-First Century theory and research. In: Day, DV., editor. The Oxford handbook of leadership and organizations. New York, NY: Oxford University Press; 2014. p. 13-39.

Zaleznik A. Managers and leaders. Harvard Business Review. 1977; 55:67–78.

Table 1

Sample Demographics

	# of researchers	% of researchers
Type of Research[a]		
Human	13	41%
Animal	20	63%
Bench	19	59%
Computational/Statistical	9	28%
Level of Experience		
Very Junior/Early Career	5	16%
Somewhat Junior	8	25%
Mid-Career	13	41%
Senior	6	19%
Type of Degree		
PhD only	22	69%
MD/PhD both	10	31%
Gender		
Male	22	69%
Female	10	31%
Nation of Origin		
U.S.	18	56%
International	13	41%
Unknown	1	3%

[a]Many PIs (66%) indicated multiple types; accordingly percentages equal more than 100%.

Table 2

Leadership and Management Skills Needed for Effective Research

	Illustrative Quotes	# of times addressed	% of researchers
Management skills	"One big thing is management, and that's the thing that I kind of wasn't quite expecting when I started, but it is a pretty big responsibility ... that is a component in my career." "Managing people, and every PI I've ever talked to, this is where we have no idea what we're doing."	18	56%
Collaboration skills	"You need to be able to negotiate and collaborate well with multiple people from multiple different backgrounds." "Being able to rely on other people, and to be able to bring lots of different groups together is a skill that I definitely rely on."	14	44%
Interpersonal skills	"Being able to communicate with people in my lab that are coming from all sorts of different diverse areas and backgrounds, both domestic and foreign researchers." "Interact in a productive way with other people ... communicating with them ... and listening to them."	13	41%
Business skills	"Figuring out budget issues and how much to pay people, how to you know, write job ads, interview people" "How to budget a lab, I've never learned that, I sort of really have to learn on the fly."	11	34%
Intellectual qualities	"Curiosity and perseverance are the most important things." "Organization, logical thinking, reasoning, and perseverance, these are all important characteristics."	10	31%
Leadership skills	"Being an effective leader to motivate them for what needs to be done for the lab." "In terms of environment ... it's critical for me that people who come to the lab ... demonstrate an innate ability to care about each other. Most of science is failure ... so you need people who will care for you."	5	16%
Mentoring skills	"A PI is also a mentor, so we really need to train students in the science the right way. They're not just coming to the lab to work for the lab, they came here for their training"	3	9%

Note. N = 32. The only additional response provided was writing skills, which 12 (38%) PIs mentioned.

Table 3

Methods for Learning Necessary Skills

	Illustrative Quotes	# of times addressed	% of researchers
On-the-job, trial- and-error	"When you start your own lab it's sort of the ultimate on the job training because before that you're taught how to be a scientist, you're not taught how to be a lab manager." "I set up my own lab, and so there were a lot of mistakes made right away, but I think I always look back on myself and reflect on myself and the situations and learn through those mistakes." "Navigating that is totally by trial and error. I'm not even sure, I'm getting better, I'm probably better now over time, but you know, it needs constant refinement."	22	73%
Mentors or other models	"I think I learned by observing my former advisor. I was very lucky to be a student and a post doc with two fantastic mentors." "Seeing what's worked in other labs and doing those things, and what hasn't worked in other labs, and trying not to do those things."	12	40%
Graduate or post-doctoral experience	"I trained a grad student before, especially when I was a post-doc, so it's not a total shock to me." "I was very fortunate to be in a really large, well-funded lab in my post doc where I was allowed to do a fair amount of mentoring there."	10	33%
Natural ability	"I'm a people person; I like to interact with people." "Some of it, I think, comes from temperament."	4	13%
Medical residency	"Being a resident and running resident teams or being a fellow and running a clinical team, kind of helped translate into how do you get everybody to work together towards a common goal." "For the people aspect of it, the residency actually was really a great training ... it involved a lot of interaction with people."	3	30%[a]

Note. N = 30 (2 un-codeable responses).

[a]10 PIs were MD/PhDs; therefore, the denominator for this statistic was 10.

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Table 4

Mentoring and Management Practices

	Illustrative Quotes	# of times addressed	% of researchers
Foster open communication	"If something isn't working out, there's a communication that occurs; how do we try to fix that?" "I really encourage the people in the lab to speak their mind, I listen to them, I consult with them on many, many things before I make a decision."	13	41%
Meet regularly	"Meet with everybody on a regular basis, at least once a week, to have them update me with what's going on." "Review everybody's work at least once a week pretty thoroughly to go through all of the technical details ... usually I talk with them briefly [on a daily basis]"	12	38%
Personalize approach to each individual	"I take time to get to know people, trying to understand their level of expertise, their strengths ... maybe gaps exist in their training ... I establish a relationship... then try to be attentive to different styles and different individual needs." "I tend to adapt my management style to individual needs."	10	31%
Guide while encouraging independence	"They're supposed to be learning how to be independent, so I try to encourage that I give advice and they comment, but I try to give them opportunity to really shape their own research." "I think on one hand, to be really close to my trainees and trying to understand what they are doing, advising them, and at the same time giving them significant freedom in what they are doing from day to day."	9	28%
Create positive environment	"I want everyone in this lab to be happy I want to make sure this is an environment I provide. I try very hard to make everybody comfortable and happy." "Research is never going to be a very smooth process ... people in my lab deal with that very well For my part, you have to have patience ... we always stick together and try to find the solution for the problems."	9	28%
Set clear deadlines	"I set pretty firm guidelines in terms of what I expectI don't tell them how to get them done, I just kind of set the bar." "We usually discuss what the projects for the week are, and what our goals are for when those projects are complete ... and how to adjust plans if things aren't going according to the plan."	8	25%
Expect self-motivation	"My expectation is you drive yourself You need to be self-driven." "I expect people to be self-motivated, and to generate their own thoughts I work well with people who are kind of self-driven."	5	16%

Note. N = 32.