MORE THAN JUST NUMBERS: CHALLENGES FOR PROFESSIONAL STATISTICIANS

CLAIRE CAMERON
Department of Preventive and Social Medicine
Dunedin School of Medicine, University of Otago
claire.cameron@otago.ac.nz

ELLA IOSUA
Department of Preventive and Social Medicine
Dunedin School of Medicine, University of Otago
ella.iosua@otago.ac.nz

MATTHEW PARRY
Department of Mathematics and Statistics
University of Otago
mparry@maths.otago.ac.nz

ROSALINA RICHARDS
Cancer Society Social and Behavioural Research Unit
Department of Preventive and Social Medicine
Dunedin School of Medicine, University of Otago
rose.richards@otago.ac.nz

CHRYSTAL JAYE
Department of General Practice and Rural Health
Dunedin School of Medicine, University of Otago
chrystal.jaye@otago.ac.nz

ABSTRACT

This paper describes a qualitative survey of professional statisticians carried out in New Zealand in 2014. The aim of the study was to find out if the issues this group faced were consistent with those identified in the literature. The issues identified were integrity, legitimacy, isolation, workforce shortage, communication, and marginalisation. They represent points of frustration for statisticians that may impact on the future of the profession as it responds to increasing demands and higher expectations. We found that these issues resonated for many of the statisticians included in our study and we have discussed a number of strategies to address them. They include raising our profile, attracting a broader range of people to the profession, increasing our communication skills, raising the statistical literacy of the people we work with, and a commitment to making it easy to engage with our colleagues.

Keywords: *Statistics education research; Statistics profession; Workplace perceptions; Workplace issues; Qualitative research*

Statistics Education Research Journal, 16(2), 362-375, http://iase-web.org/Publications.php?p=SERJ

1. INTRODUCTION

Professional statistical expertise is in demand in diverse and ever-expanding fields across academia and industry. Advances in statistical theory and computational power, the collection and availability of extensive data sets, and the increasing complexity of data have generated unparalleled opportunities, and provide an exciting and dynamic context for statisticians. The environment of government, academic, and industry sectors is increasingly data dependent, and the professional future of statistics is potentially unlimited (Brown & Kass, 2009; Fox, 2010; Hurwitz & Gardenier, 2012; Rodriguez, 2013).

These developments mean that careers in statistics can be challenging and dynamic in an unprecedented fashion. There are increasing opportunities in many fields to apply statistical expertise, and statisticians can take on many kinds of roles: teachers, consultants, researchers, advisors, and public servants. Often, within those roles, statisticians get to work with a wide variety of people on a wide variety of problems. The potential exists for a fantastic professional life as the demand for statistical expertise will be ongoing. However, the literature identifies a number of issues that confront the statistical profession. In this article, we investigate the salience of these issues in the New Zealand context where there is a relatively small but diverse community of professional statisticians.

2. LITERATURE REVIEW

The literature reveals five prevailing themes pertinent to professional statisticians, including legitimacy and integrity, workforce shortage, communication with non-statisticians, professional isolation, and marginalisation.

The first and predominant theme concerns the *legitimacy and integrity* of the profession itself, epitomised by the well known quote, “There are three kinds of lies: lies, damned lies, and statistics" (an unverified attribution by Mark Twain to Benjamin Disraeli) (Best, 2012; Imrey, 1994a). It is clear that the specialised analytic skillset and professional values essential for competent statistical practice are not widely recognised by non-statisticians (Best, 2012; Fox, 2010; Imrey, 1994a; Meng, 2009; Minton, 1983; Pfannkuch & Wild, 2000). There is a public misperception that statistics is simple number crunching, which overlooks the expertise implicit in statistical thinking, discounts the statistician's focus on inferential processes, and unjustifiably limits the statistician to a subsidiary technical role (Brown & Kass, 2009; Imrey, 1994a; Minton, 1983; Pfannkuch & Wild, 2000; Turner & Turner, 2012).

Another related misperception attributes professional statistical inference to both inexpert analysis of quantitative data and intentional “sleazy numerical advocacy" (Imrey, 1994b, p. 83). Some of these misrepresentations are unintentional and inadvertent mistakes made by amateur statisticians who do not appreciate the statistical complexity of the research problem or overestimate their statistical competence (Fox, 2010; Gelfond, Heitman, Pollock, & Klugman, 2011; Meng, 2009). Others, however, could be construed as deliberate manipulations of the data expressly adopted to promote a personal agenda. According to several authors, such exemplars violate the profession's ethical responsibility to promote diligent and valid statistical data analysis (Best, 2012; Finney, 1991; Hurwitz & Gardenier, 2012; Imrey, 1994a).

The second theme is *workforce shortage* where the notable increase in demand for statistical expertise has resulted in a shortfall of professional statisticians with demand exceeding supply (Brown & Kass, 2009; Fox, 2010; Lindsay, Kettenring, & Siegmund, 2004; Meng, 2009; Minton, 1983; Rodriguez, 2013; Wild, 2006). Unfortunately, this has led to a proliferation of naïve statistical analyses and inference that lack professional

credibility. To counter this situation, Minton in 1983 stressed the need to increase academic and public recognition of statistics as a professional discipline by promoting its existence as a bachelor's degree, and to promote the intellectual, rather than supportive, contribution of statistics in research. This is still relevant in 2016. Conventionally, statistics has attracted students from mathematical backgrounds (Wild, 2006). In order for the discipline of statistics to succeed in the future, we need to entice undergraduates from a more diverse disciplinary background. According to some, the key to this is to provide more appetising curricula that shift the focus from the mathematical calculations and statistical tools to a focus on competence in statistical practice (Brown & Kass, 2009; David & Brown, 2012; Fox, 2010; Meng, 2009). Specifically, "targeted, relevant, and stimulating courses in *statistical science* will be critical" (Fox, 2010, p. 7) to the future health of the statistics profession.

The third and fourth themes involve *communication with non-statisticians* and *professional isolation*. The relational aspect of statistical collaborations is complex (Kirk, 1991; Thabane, Thabane, & Goldsmith, 2007; Unwin, 2007). Alongside statistical expertise, effective communication and good interpersonal skills are essential in providing quality statistical advice (Gibbons & MacGillivray, 2010; Hahn & Doganaksoy, 2012; Kirk, 1991; Pfannkuch & Wild, 2000; Rodriguez, 2013; Unwin, 2007). Statisticians often engage with people from other disciplines who have limited statistical knowledge and may not understand the important contribution statisticians make to valid and compelling research (Hahn & Doganaksoy, 2012). To improve collaborations, it is therefore essential to promote the value of statistics (Hahn & Doganaksoy, 2012), negotiate "client" expectations (Kirk, 1991; Pfannkuch & Wild, 2000), and clearly explain statistical concepts, methods and inferences (Gibbons & MacGillivray, 2010; Hahn & Doganaksoy, 2012; Jolliffe, 2003; Pfannkuch & Wild, 2000). The last involves understanding the collaborator's statistical experience and adjusting technical language to suit. Effective collaboration requires an integration of both statistics and specialist fields (Brown & Kass, 2009; Gibbons & MacGillivray, 2010; Jolliffe, 2003; Pfannkuch & Wild, 2000; Unwin, 2007). This demands statisticians' commitment and receptivity to cross-disciplinary learning. In addition to including communication and collaboration skills in statistical training (David & Brown, 2012; Gibbons & MacGillivray, 2010; Kirk, 1991; Meng, 2009), a structured mentoring process for young statisticians by experienced professionals might also promote cross-disciplinary collaboration (Gibbons & MacGillivray, 2010; Odueyungbo & Thabane, 2012; Pantula, 2010; Thabane et al., 2007). A related issue is that professional isolation has been identified as a particular challenge for statisticians (Hahn & Doganaksoy, 2012). Individuals, especially those who are not part of a large statistics unit, often have limited peer contact and are susceptible to social and intellectual isolation.

Marginalisation, the fifth theme, has also recently been identified as an issue for statisticians. At a plenary talk at the World Statistics Congress in 2013, incoming President of the International Statistics Institute, Vijay Nair, asked whether statisticians are losing out to computer scientists in the big data revolution (Nair, 2013). Around the same time, the then President of the American Statistical Association, Marie Davidian, wrote a column for the association newsletter asking, "Aren't *We* Data Science?" In the column she discusses the National Consortium for Data Science in the United States, whose founding members include computer scientists and engineers, but no statisticians (Davidian, 2013). There have been further discussions on this issue (Bartlett, 2013; Jones, 2015), clearly showing that there is a growing sense in the statistical community that statisticians could be left behind or left out.

We view data science as an emerging discipline centered on statistics and machine learning, but that fundamentally incorporates database management and distributed

systems (American Statistical Association, 2015). Although statisticians are data scientists in a literal sense, experts identifying as data scientists are typically found in professional communities such as computer and information science, marketing and business analytics, and engineering.

3. BACKGROUND TO RESEARCH STUDY

The University of Otago employs many statisticians, the majority of whom work within the Department of Mathematics and Statistics (part of the Division of Sciences) and the Division of Health Sciences over three campuses: Dunedin, Christchurch, and Wellington. The other main employer of statisticians in the region is AgResearch, which is located at Invermay near Dunedin. There are also a number of self-employed, and independent statisticians working in the region. Because of their geographical dispersion, it has been difficult for them to get to know one another. Consequently, two of the authors (CC and MP) initiated a social network of statisticians called Box Plot that regularly meets. We have hosted two one-day symposia (Box Plot I and Box Plot II in 2013 and 2014, respectively), which were non-technical meetings and had the purpose of allowing professional statisticians from the Dunedin area and those working at the University of Otago to meet in a relaxed environment. There are more than 50 people in this group and they all work as statisticians in the region or the university.

At these symposia, participants talked about their professional lives and some of the issues they faced. This stimulated our interest in how professional statisticians in our network regard their career. Did issues of legitimacy and integrity of the profession affect them? Did they perceive a workforce shortage of statisticians? Did they feel professionally isolated? Was communication with non-statisticians an issue? Did they view the growth of data science as a threat?

To examine these issues, we invited members of the network to participate in a qualitative study. We chose a qualitative research design because this is the more appropriate design when the purpose of the study is to understand people's experiences and perspectives within the scope of those issues identified. The advantage it offered was the ability to canvas a broad range of opinions from participants in the form of free text and de novo responses.

The study was approved by the University of Otago Human Ethics Committee (Category B) in May 2014 and the Ngāi Tahu Research Consultation Committee.

4. METHOD

Because our aim was to investigate a group of New Zealand statisticians' perspectives on the issues identified in overseas contexts, we used a structured template approach that would also allow for the identification of novel and de novo responses (see Appendix). We prepared a questionnaire with seven sections (see Appendix) developed from each of the key topics identified in the literature and discussions held at the inaugural Box Plot Symposium. Each section begins with a brief summary of relevant literature followed by a series of open ended questions asking if this has been an issue thus far in the participants' careers, and if so, how they have dealt with it, what initiatives they would like to address further on this issue and any other comments they would like to make. We also requested demographic data on ethnicity, gender, and work experience. The questionnaire was piloted with three (non-sample) statisticians and revised. We attempted to contact 57 people that we believed worked as statisticians in Otago or at Otago University (Dunedin, Christchurch, or Wellington Campus). Thirty people responded to the survey. Six people

declined to take part. Twenty-one people did not respond. Of these, we were uncertain of the contact details for 12 people and it is possible that they never received our communications.

Over May and June 2014 each member of the sample was emailed a questionnaire and an information sheet and followed up at least once (by email) after approximately a week. Completion of the form was taken as implied consent to participate in the survey Of the 30 respondents, 27 reported how many years they had been working as a statistician and the mean was 18 years. The minimum was 1 year and the maximum was 53. There were 22 men and 8 women in the group. We have not provided job descriptions of participants in order to protect anonymity although participants from the university would be likely to be involved in a combination of teaching, research, and consultancy work.

Responses were collated and analysed using a template organising thematic approach (Crabtree & Miller, 1999). Sections of the questionnaire were divided among the research team, with each taking a lead role in development of themes for that question, with the others reading a smaller portion of the responses. For the purposes of concordance, a series of meetings was held for the full research team to discuss and confirm themes from each question and for the survey as a whole.

5. FINDINGS

We present the results under several thematic headings based on the literature, which informed the questionnaire. Overall, many participants noted positive aspects to being a professional statistician. These included being supported by their employers and colleagues, enjoying diversity and challenge in their everyday work, and feeling valued by their institutions. The following themes represent points of frustration in their professional experience that might impact on the development of the profession as it responds to increasing demand and higher expectations from many sectors within New Zealand.

5.1. LEGITIMACY AND INTEGRITY

For many respondents, lack of legitimacy was not an issue in their current workplace.

> I work in an organisation and at a location within that organisation that has a long history of valuing input from statisticians, both analytically and from a more general scientific perspective.

However, many of our participants commented that the legitimacy and integrity of the profession is threatened by people's misperceptions of what statisticians actually do as an occupation. Specifically, our data indicate that there are colleagues and collaborators, who sometimes perceive statisticians' contributions as basic number crunching.

> Many clients are apologetic about asking you to do something and say they would do it themselves if they had time. I ask them if they know of any weekend course in a particular type of surgery, as I would like to be able to earn some extra money as a locum. They seem to get the point.

Participants also commented that the statistician's role is varied and they are involved in many different areas of application. Although that makes statistics an appealing profession, a consequence is that involvement in projects can be uneven in the depth of engagement required.

Those falsely regarding themselves as statisticians also threaten the profession's integrity.

> It is not very hard to find misleading information of a statistical nature in the newspaper almost every day. It is also prevalent in lots of scientific papers. As with prostitutes our greatest competition is from enthusiastic amateurs.

Respondents suggested that one way to address this might be to educate non-statistical colleagues on the skills and expertise characteristic of professional statistics and to emphasise the importance of engaging a statistician from the outset of project planning. This would also ensure appropriate recognition of statisticians' contributions to research projects. Improving the practice of statistical peer review (in terms of frequency and quality) of submissions to scientific journals could also emphasise the imperative of valid statistical inference. As one person said, statisticians should "continue to highlight the importance of statistical principles in scientific enquiry."

5.2. STATISTICIAN WORKFORCE SHORTAGE

Responses suggest that the shortage of statisticians is a worsening problem. This may encourage unqualified people to conduct amateur statistical analyses in the absence of qualified statisticians. Also, the shortage of trained statisticians means applicants for statistics positions may not have the mix of skills required for a professional statistical role.

> There doesn't appear to be any shortage of people with an interest in biostatistics, but the number who have the combination of skills required to perform in a consulting role is much lower than that required to meet demand, even if funding was not an issue.

Ideas suggested by participants for addressing the shortfall included encouraging school students to think of statistics as a career and admitting non-statisticians into postgraduate statistics courses, as well as including more statistics in basic science degrees. Opportunities for advancement, higher salaries and increased support for statisticians in the form of peer support, and mentoring and professional development were identified as strategies for retaining professional statisticians.

5.3. COMMUNICATION WITH NON-STATISTICIANS

Some participants commented that there could be difficulties in communicating technical details to non-statisticians because of the jargon used by some statisticians or a lack of statistical knowledge by their clients. These amount to translational issues.

> [It can be] difficult to understand what they want from us, they also do not understand what we say.

When asked about initiatives to improve communication between statisticians and non-statisticians, the responses emphasised training statisticians to be more effective communicators and increasing the statistical literacy of those who work with statisticians. Several participants suggested that communication skills should be part of statistics courses.

> Good communication is essential, and it is something statisticians as a whole are not noted for. When working in an applied area it is up to the statistician to be the one that has to work at their communication skills. There should be some teaching of these in statistics courses.

5.4. PROFESSIONAL ISOLATION

Almost half of the respondents said that isolation was a problem, however many of those who indicated it was not, acknowledged that it might be their particular work situation that prevents isolation and recognised it could be an issue for others. When asked

what steps they have taken to ameliorate their isolation, many participants spoke of seeking out statistical colleagues or joining local peer groups where they could participate in technical discussions. Attending regular meetings, seminars, and conferences were also seen as helpful activities in mitigating professional isolation. One statistician mentioned that it was difficult to find the time to participate in activities. Other initiatives to reduce isolation included journal clubs, web discussions, and social events.

> [I] joined [a] biostatistics group where biostatisticians from the university meet. Joined Box Plot. Meet regularly with statisticians from other departments about technical issues and also informally. Created a support group within my department of statistics-enthusiasts.

A few respondents made the point that, ideally, statisticians should not be employed to work alone. One person suggested mentoring:

> I have been lucky that statistical mentors have made themselves available to me and if it had not been for them isolation would have been a huge problem. I wonder if this type of collegiality could be formalised and prioritised by the university, or even by an outside group?

5.5. MARGINALISATION

There was a range of opinions on marginalisation. Some respondents had felt marginalised by data science and associated techniques, with one seeing a potential danger: "Statisticians must make sure they are involved with big data wherever it is taught." Another respondent mentioned difficulty in accessing a big dataset from IT specialists within their own department.

Half of the respondents expressed a view on the question of whether classical statistics and data science were complementary or in competition. Only one respondent felt the approaches were in competition; the rest saw them as complementary. The word "overlap" was used by several respondents. Several felt the approaches were the same under different names; several felt the approaches were different but the results were equivalent.

There was considerable ambivalence among participants over big data. One respondent felt data scientists were better at exploratory analysis. Another felt data scientists were better at finding patterns in the data but were not good at inference or quantifying uncertainty. Two respondents felt that data scientists could be rather naïve in their analysis and statisticians were trained to look beyond the obvious.

> The techniques being applied by many data science practitioners frequently fail to address the question: "is this result real?" (i.e., "what is the probability that I could have observed this result by chance?"). Often such individuals lack the skills necessary to answer this question, which falls squarely in the realm of statistics. Understanding how to use standard statistical techniques to answer "big data" questions is an important skill to develop.

Respondents did not seem threatened by data science; indeed most were open to new approaches. Around half of those who responded to this question saw value in statisticians developing data science skills. One respondent felt it was important to know what skills our students were going to need and another said it was easy to be "seduced" by big data. A third commented:

> I think the most important skills of a statistician aren't the number crunching ones, but thinking critically about how to collect the data required to answer certain questions, or to critically assess the usefulness of the data that is available.

5.6.OTHER ISSUES

A third of respondents chose to make a comment when asked if there were other issues that they felt needed to be discussed or addressed. Performance Based Research Funding (PBRF) was mentioned as a particular source of problems for New Zealand statisticians. This is because consulting statisticians rarely have the opportunity to be first author on a paper. Also, statisticians often become involved in cross-disciplinary research, which is hard to place in the PBRF categorisation.

> Being the main PI [Principal Investigator] on a small-scale project is likely viewed as more worthy than being an integral researcher (and major contributor) to really vital work that is being done in a collaborative setting.

Other matters raised were a shortage of competent postgraduate students. Our diverse discipline should be able to attract students as we have "many roles in many disciplines." Also mentioned was a lack of options for continuing professional development in New Zealand (e.g., short courses), with many statisticians attending workshops in Australia.

6. DISCUSSION

The aim of the study was to find out if issues faced by this group of professional statisticians were consistent with the issues identified in the literature. There is certainly evidence from the statisticians we questioned that many of the issues raised in the literature for professional statisticians (Best, 2012; Brown & Kass, 2009; Fox, 2010; Imrey, 1994a; Lindsay et al., 2004; Meng, 2009; Minton, 1983; Pfannkuch & Wild, 2000; Turner & Turner, 2012) are pertinent for those who work in the Otago region or are working for the University of Otago. These included legitimacy and integrity of the profession, workforce shortages, communication with non-statisticians, professional isolation, and to a lesser extent marginalisation. It is likely that these findings are also relevant to other regions of New Zealand, given similarities in work roles and expectations, although we acknowledge that there may be cultural and societal distinctions from other countries. Hence we recommend similar surveys be conducted in other countries in order to allow international comparisons.

The themes identified in our New Zealand study represent existing challenges that we can address as the requirements of our profession increase. We acknowledge that effecting changes in the work lives of statisticians might be easier said than done. One significant barrier to implementing our own and other's recommendations is institutional confusion around the role of the statistician. For example, academic statisticians at Otago University can be employed on conventional confirmation (tenure) path positions involving teaching statistics and researching in a pure or applied setting; research only positions that are highly reliant upon collaborative "client" relationships; and fixed term (usually soft-funded) positions over the life of a specific project. In research only roles, it is likely that statisticians have little opportunity to develop and lead their own research projects, however their roles as a specialist consultants are essential to the success of their clients' research projects. Within the consultancy research only positions, there can be lack of clarity around statisticians' affiliated roles in thesis supervision and organisational service requirements, and the typical rhizomatic or horizontal networking associated with consultancy can result in an uneasy fit within existing organisational teams and management structures.

The theme of workforce shortages raises the question about how to address the demand for statisticians. Within the University of Otago, statistician positions have been difficult to fill with qualified specialist statisticians. Could the current shortage of statisticians be

attributed to lack of marketing to high school students, or to failure in encouraging graduate students into postgraduate programmes in statistics? How do we attract students to a major in Statistics? Perhaps, it is due to the relative invisibility of statistics as a profession or to the profession attracting students mainly from a mathematical background as Minton (1983) and Wild (2006), respectively, suggest. Raising our profile in high schools and tertiary education providers might be one way to address the issue of the workforce shortage of statisticians.

Strengthening the profile of professional statisticians (Minton, 1983) could positively influence many of the issues raised here. How can statisticians and the profession assist colleagues and collaborators to appreciate the complexity of the work we do, and understand the skills and expertise that are required for statistical enquiry? Our data suggest that statisticians could have greater input into project planning, at the same time improving statistical scientific peer review and actively seeking opportunities to educate non-statisticians about the value of statistics.

Further questions raised by this study include the following: What is the purpose of a university education for future statisticians? In particular, what is the purpose of postgraduate study in statistics? What makes a good consultant? Could communication skills be included in more statistics courses to improve the statisticians' ability to communicate with non-statisticians? In recent guidelines for undergraduate programs in statistical science the American Statistical Association (2014, p. 10) claimed that "[g]raduates should be expected to write clearly, speak fluently, and construct effective visual displays and compelling written summaries." As Cameron (2009) noted, statistics students should be trained in consulting methods and in addition, take "a reading course on the history, successes and pitfalls of statistics" (p. 13). Our findings indicate that learning the technical toolkits of statistics may not adequately prepare graduates for unsupervised work in the real world. Statisticians need to be able to explore what Cameron describes as the "essence of the problem" (p. 15).

Although we as statisticians can work on our ability to communicate effectively with our non-statistical collaborators, how can we increase the statistical literacy of those we work with? Professionally, it would be beneficial if our collaborators understood why we are reluctant to provide just a *p*-value, or pick up data at short notice to analyse. It would also be advantageous if our collaborators knew that a competent statistician would provide a credible analysis that can be relied on. As an example, medical undergraduate education at the University of Otago no longer includes introductory statistics in the curriculum and this, it could be argued, results in decreased statistical literacy in the medical profession. Research methods courses in health and sciences would ideally include a credible statistical component. There is much thought given to "service" teaching, which is statistics teaching aimed at people who are working in other fields. Are there enough of these courses? How much teaching of statistics goes on in non-statistics courses? Who would teach these courses and what preparation would people attending them need? Do universities recognise their importance?

We identified a strong need for statisticians to be able to engage with their colleagues and participate in a network. Although the vagaries of soft funding and lack of job security can compound isolation, statisticians who work alone should be given opportunities to meet with their statistical colleagues. Like other professionals, employers need to support their statisticians to attend professional development and networking forums. Having strong networks of statisticians who have good working relationships with one another might also help raise our profile, improve communications, and, in the long-term, help create a working space for professionals that is welcoming and inclusive. This, in turn, would make the profession more attractive to people and improve the working lives of many of us.

Many employers want to have their own statistician, and statisticians are sometimes employed on their own to work on a specific project. This creates tensions between the employment of statisticians in groups within a large institution and their accessibility, or as individuals working in a fragmented way on one or other projects within a specific unit or centre. The networks we form should provide a base to help advise on employment practices so that statisticians are either not employed in isolation or else given every opportunity to engage with other statisticians if they are employed as a sole statistician. To retain professional statisticians we could improve the availability of peer support, mentoring, and career development.

Our regional attempt to address many of these issues is our local network, Box Plot, based on the need to provide a friendly, non-competitive environment for statisticians to meet and form connections and collaborations—and to ameliorate the isolation that some statisticians can feel. It also allows younger members of the profession to meet others easily and form their own professional support networks. In conclusion, although this study is a local example, we feel that the results will likely resonate with other statisticians elsewhere. We should be taking an opportunity to advertise our profession, raise our profile, and educate collaborators on the specialised skills we have. The discussion in this paper has raised more questions than it has answered but it does provide a direction for future research. Through these means, statistics can be seen as the wonderful and interesting career that it is.

ACKNOWLEDGEMENTS

We are especially grateful to the many statisticians from the Box Plot network who provided us with their thoughtful, valuable, and insightful responses to our questionnaire. Many thanks to Aaron Bryant, Marti McCracken, and Will Probert for kindly piloting our questionnaire. Thanks also to Sheila Williams and Lindsay Robertson for thoughtfully reviewing drafts of this paper. The journal reviewers have also provided valuable feedback that has allowed us to improve the paper, thank you.

REFERENCES

American Statistical Association. (2014). *Curriculum guidelines for undergraduate programs in statistical science*. Washington, DC: Author. Retrieved from http://www.amstat.org/asa/files/pdfs/EDU-guidelines2014-11-15.pdf

American Statistical Association. (2015). ASA Statement on the role of statistics in data Science. *Promoting the practice and profession of statistics.* Washington, DC: Author. Retrieved from http://ww2.amstat.org/misc/DataScienceStatement.pdf

Bartlett, R. (2013). We are data science. *AMSTATNEWS*, *433*, 3-5.

Best, J. (2012). *Damned lies and statistics: Untangling numbers from the media, politicians, and activists*. Berkeley and Los Angeles, CA: University of California Press.

Brown, E. N., & Kass, R. E. (2009). What is statistics? *The American Statistician, 63*(2), 105–110.

Cameron, M. (2009). Training statisticians for a research organisation. *Proceedings of the International Statistical Institute 57th Session*. Durban, South Africa: ISI. Retrieved from https://www.researchgate.net/profile/Murray_Cameron2/publication/228376035_Training_Statisticians_for_a_Research_Organisation/links/02e7e51955a26da94f000000.pdf

Crabtree, B., & Miller, W. (1999). *Using codes and code manuals: A template organising style of interpretation* (2nd ed.). Thousand Oaks, CA: Sage.

David, I., & Brown, J. A. (2012). Beyond statistical methods: Teaching critical thinking to first-year university students. *International Journal of Mathematical Education in Science and Technology, 43*(8), 1057–1065.

Davidian, M. (2013). Aren't *we* data science? *AMSTATNEWS*, *436*, 27.

Finney, D. J. (1991). Ethical aspects of statistical practice. *Biometrics, 47*, 331-339.

Fox, D. R. (2010). Desired and feared—*quo vadis* or *quid agis*? *The American Statistician, 64*(1), 6-9.

Gelfond, J. A,. Heitman, E., Pollock, B. H., & Klugman, C. M. (2011). Principles for the ethical analysis of clinical and translational research. *Statistics in Medicine, 30*(23), 2785-2792.

Gibbons, K., & MacGillivray, H. (2010). Training for statistical communication in the workplace. In H. MacGillivray & B. Philips (Eds.), *Proceedings of the 7th Australian Conference on Teaching Statistics (OZCOTS 2010)*. Fremantle, Australia. Retrieved from http://opax.swin.edu.au/~3420701/Springer/Gibbons_OZCOTS2010_paper.pdf

Hahn, G. J., & Doganaksoy, N. (2012). *A career in statistics: Beyond the numbers*. Hoboken, NJ: John Wiley and Sons.

Hurwitz, S., & Gardenier, J. S. (2012). Ethical guidelines for statistical practice: The first 60 years and beyond. *The American Statistician, 66*(2), 99-103.

Imrey, P. B. (1994a). Statistical values, quality, and certification. *The American Statistician, 48*(2), 65-70.

Imrey, P. B. (1994b). Reply. *The American Statistician, 48*(2), 82-87.

Jolliffe, F. (2003). Communication, collaboration, and consulting. *Proceedings of Bulletin of the International Statistical Institute, 54th Session*. Berlin, Germany: ISI. Retrieved from http://isi.cbs.nl/iamamember/CD3/abstracts/papers/3084.pdf

Jones, T. (2015). The identity of statistics in data science. *AMSTATNEWS*, *461*, 25-26.

Kirk, R. E. (1991). Statistical consulting in a university: Dealing with people and other challenges. *The American Statistician, 45*(1), 28-34.

Lindsay, B. G., Kettenring, J., & Siegmund, D. O. (2004). A report on the future of statistics. *Statistical Science, 19*(3), 387-413.

Meng, X.-L. (2009). Desired and feared—What do we do now and over the next 50 years? *The American Statistician, 63*(3), 202-210.

Minton, P. D. (1983). The visibility of statistics as a discipline. *The American Statistician, 37*(4a), 284-289.

Nair, V. (2013). What's the big deal about big data? Paper presented at the *59th ISI World Statistics Congress of the International Statistical Institute*. Hong Kong, China: ISI. Abstract retrieved from http://2013.isiproceedings.org/Files/IPS106-P1-A.pdf

Odueyungbo, A., & Thabane, L. (2012). Mentoring in biostatistics: Some suggestions for reform. *Journal of Multidisciplinary Healthcare, 5*, 265-272.

Pantula, S. (2010). Mentor a statistician today. *AMSTATNEWS*, *392*, 3-4.

Pfannkuch, M., & Wild, C. J. (2000). Statistical thinking and statistical practice: Themes gleaned from professional statisticians. *Statistical Science*, 132-152.

Rodriguez, R. N. (2013). Building the big tent for statistics. *Journal of the American Statistical Association, 108*(501), 1-6.

Thabane, L., Thabane, M., & Goldsmith, C. H. (2007). Mentoring young statisticians: Facilitating the acquisition of important career skills. *The African Statistical Journal, 4*, 123-136.

Turner, J. R., & Turner, J. R. (2012). *Key statistical concepts in clinical trials for Pharma*. New York: Springer.

Unwin, A. (2007). Statistical consulting interactions: A personal view. *AStA Advances in Statistical Analysis, 91*(4), 349-359.

Wild, C. (2006). On cooperation and competition. In A. Rossman & B. Chance (Eds.), *Working cooperatively in statistics education* (Proceedings of the 7th International Conference on Teaching of Statistics, Salvador, Bahai, Brazil). Voorburg, The Netherlands: International Statistical Institute. Retrieved from http://iase-web.org/documents/papers/icots7/PL7_WILD.pdf

CLAIRE CAMERON
Department of Preventive and Social Medicine
Dunedin School of Medicine
University of Otago
PO Box 913
Dunedin 9054
New Zealand

APPENDIX

Section 1: Legitimacy of the profession

It has been suggested in the literature that one of the issues for statisticians is that the specialist analytical capabilities intrinsic in competent statistical practice are not widely appreciated. This may lead to statistical input as being viewed as simple number crunching and, in turn, limit the view of a statistician to having a subsidiary technical role in the research process.

a) Has this issue ever been, or threatened to be, an issue for you?
b) If so, what steps have you taken to mitigate or avoid this being an issue?
c) What other initiatives do you think could be developed, either individually or collectively, to address issues of professional legitimacy?
d) Do you have any other thoughts or comments about this issue?

Section 2: Integrity of the profession

Another challenge identified for the profession is perceptions that statisticians are involved in the generation of misleading information. This is epitomised in the popularised axiom "There are three kinds of lies: lies, damned lies, and statistics" and involves a lack of understanding of the statistical profession's ethical responsibility to promote diligent and valid statistical analysis.

a) Has professional integrity ever been, or threatened to be, an issue for you?
b) If so, what steps have you taken to mitigate or avoid this being an issue?
c) What other initiatives do you think could be developed, either individually or collectively, to address misconceptions about professional integrity?
d) Do you have any other thoughts or comments about this issue?

Section 3: Shortage of Statisticians

Difficulty in recruiting and retaining statisticians is also an issue identified in the research literature, despite statistical proficiency being a critical and influential skill in the current and future workplace.

a) Have issues of recruitment or retention ever been, or threatened to be, an issue for you?
b) If so, what steps have you taken or experienced which support recruitment and retention of statisticians?
c) What other initiatives do you think could be developed, either individually or collectively, to address issues of recruitment and retention?
d) Do you have any other thoughts or comments about this issue?

Section 4: Communication with non-statisticians

The human side of statistical collaborations is complex, and varies alongside client expectations and knowledge. Effective communication skills are an important complement to sound knowledge of statistical methodology.

a) Has communication with non-statisticians ever been, or threatened to be, an issue for you?
b) If so, what steps have you taken to support or enhance good communication with non-statisticians?

c) What other initiatives do you think could be developed, either individually or collectively, to address communication issues?

d) Do you have any other thoughts or comments about this issue?

Section 5: Isolation

Isolation is another issue for statisticians. Individuals may find themselves as the only statistician in a workplace or team. Challenges of professional isolation include loneliness and a lack of colleagues to have technical discussions with.

a) Has isolation ever been, or threatened to be, an issue for you?

b) If so, what steps have you taken to mitigate or avoid isolation?

c) What other initiatives do you think could be developed, either individually or collectively, to address issues of isolation?

d) Do you have any other thoughts or comments about this issue?

Section 6: Marginalisation of the statistics profession

A recent issue for statisticians is the rise of data scientists in other disciplines such as computer science and information science. The questions they have and techniques they use can be the same or quite different to those of classical statistics. In either case, data scientists are making great progress without the direct involvement of statisticians.

a) Has marginalisation ever been, or threatened to be, an issue for you?

b) If so, were these other approaches better or worse than a classical statistical approach?

c) Do you think classic statistics and other approaches compete with each other or are complementary? Should statisticians be developing skills in these other approaches?

d) Do you have any other thoughts or comments about this issue?

Section 7: Other issues

Are there any other issues for professional statisticians that you would like to see discussed or addressed?