Research

Implementation and outcome evaluation of the Medical Education Partnership Initiative biostatistical reasoning workshops for faculty and postgraduate students at the University of KwaZulu-Natal, Durban, South Africa

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Background. There is a shortage of biostatistics expertise at the University of KwaZulu-Natal (UKZN), Durban, South Africa and in the African region. This constrains the ability to carry out high-quality health research in the region.

Objectives. To quantitatively and qualitatively evaluate a programme designed to improve the conceptual and critical understanding of biostatistical concepts of UKZN health researchers.

Methods. A 40-hour workshop in biostatistical reasoning was conducted annually between 2012 and 2015. The workshops were structured around interpretation and critical assessment of nine articles from the medical literature, with a mix of in-class sessions and small group discussions. Quantitative evaluation of the knowledge gained from the workshops was carried out using a pre- and post-workshop quiz, and qualitative evaluation of the workshop process was done using a mid-workshop questionnaire and focus group discussions.

Results. For each year that the workshop was conducted, post-workshop quiz scores were significantly higher than pre-workshop scores. When quiz assessments from all 4 years of training were combined, the pretest median score was 55% (interquartile range (IQR) 40 - 62%) and the post-test median score was 68% (IQR 62 - 76%), with $p<0.0001$ for the overall comparison of pre- v. post-scores. There was a general consensus among participants that the workshop improved their reasoning skills in biostatistics. Participants also recognised the value of the workshop in building biostatical capacity at UKZN.

Conclusion. The workshops were well received and improved the critical and conceptual understanding of the participants. This education mode offers the opportunity for health researchers to advance their knowledge in settings where there are few professional biostatistician collaborators.

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The University of KwaZulu-Natal (UKZN), Durban, South Africa (SA) was formed in January 2004 as a result of a merger of the former universities of Natal and Durban-Westville.[1] It has ~44 000 students, which makes it the largest residential university in SA; 26% of the students are in postgraduate programmes.[2] The university sees its research enterprise as fundamental to the initiative of significantly increasing its output of doctoral graduates.

Biostatistics is the application of statistics to questions about human health.[3] Biostatistical considerations inform the design of medical research studies, their analysis and the interpretation of the conclusions. It is an inherently collaborative discipline that is essential in advancing and integrating biomedical, genomic and clinical research. In the KwaZulu-Natal region of SA there is a wide and growing range of medical research activities, the majority of which have a biostatistical component. There is, however, a serious shortage of biostatisticians in SA and in the broader African region.[4] The shortage of expertise manifests itself not only in concrete problems

such as difficulty in recruiting suitable biostatisticians for medical research collaboration, but also in less tangible ways affecting quality of research.[5]

In an effort to build research capacity in the College of Health Sciences (CHS) at UKZN, a research methodology project (REMETH) was developed by UKZN in partnership with the Medical Education Partnership Initiative (MEPI). The goal of REMETH was to improve the research methodology skills of faculties from the schools of medicine, nursing, pharmacy and pharmacology. The MEPI Biostatistics Initiative was conceived in 2011 to support the development of the discipline of biostatistics at UKZN and to strengthen biostatistics skills among researchers and postgraduate students in the CHS. The initiative arose over several years of stakeholder engagement and is a collaborative effort between the Department of Biostatistics at the University of Washington, Seattle, USA and the UKZN Discipline of Statistics (in the College of Agriculture, Engineering and Science), as well as Disciplines in the CHS, including Public Health Medicine and Occupational and Environmental Health.

In this article, we describe one component of that strategy, a workshop in biostatistical reasoning, and we present an assessment of the workshop over the 4 years of its implementation. As part of the project description, we present the context and rationale of the project, describe the project structure and delivery mechanism, and outline the implementation process. The outcomes evaluation assessed the actual and perceived knowledge gain in biostatistical reasoning among workshop attendees. The process evaluation focused on the perceptions of the workshop attendees regarding the implementation and value of the workshops.

Project description

Context and rationale

The majority of PhD candidates in the UKZN CHS have not had any formal biostatistics training during their under- and postgraduate years. They are reliant on the few biostatisticians in the CHS, who, in addition to being few in number, have many competing demands on their time. This places these candidates at a disadvantage when conducting their research, particularly in critically reading the relevant literature, developing their study design, assessing its validity and generalisability and developing an appropriate statistical analysis plan.

While recognising the need for a greater number of professional biostatisticians at UKZN, it was concluded by the Biostatistics Initiative that one approach to advancing research capacity in a setting with limited biostatistics expertise would be to offer workshops in biostatistical reasoning to CHS researchers themselves to improve their understanding of biostatistics concepts. Complementary approaches, also undertaken as part of the initiative, include the development of online asynchronous biostatistics modules, which offer the opportunity for hands-on acquisition of biostatistics analysis skills, biostatistics software tutorials, protocol development workshops and one-on-one consultations with REMETH candidates.

Workshop structure and delivery

As part of the MEPI Biostatistics Initiative, a 40-hour biostatistical reasoning workshop was offered annually to UKZN CHS researchers from 2012 to 2015. This workshop was intended to provide a broad overview of biostatistics methods relevant to the health sciences, emphasising interpretation and concepts rather than computation or mathematical details. Topics covered include data description, study design, sampling variability, statistical inference and regression (linear, logistic, Poisson and Cox).

The workshop was built around nine articles from the medical literature. Consequently, the material development was not linear, but addressed topics as they arose in each of the articles, with each article advancing the complexity of the concepts covered. This may be considered a variant of case-based learning, which has been shown to overcome many of the limitations of a traditional lecture-based mode of instruction.[6] After the material necessary to understand a particular article had been covered in class, participants broke into small groups to review the article, with a list of questions aimed at guiding the discussion. Each group then reported back to the class as a whole and there was further discussion. The in-class sessions were designed to be participatory, with ample opportunity for participants to raise questions or discussion points. Upon completion of the workshop, participants should have been able to recognise relevant study design features and explain how they affect interpretation of results, interpret key data displays and statistical results commonly found in medical research reports, and judge whether the conclusions drawn from a study are justified.

The workshop learning objectives are outlined below:
- Interpret and critique graphical displays of data (e.g. box plots, scatter plots, Kaplan-Meier curves).
- Interpret and critique numerical summaries of data.
- Translate scientific questions into measurable outcomes and associated statistical goals.
- Explain the difference between observational and experimental studies.
- Identify and describe the key features of different study designs (e.g. randomised trials, cohort, case-control and cross-sectional studies).
- Explain the concept of bias and how a given study design does or does not control for types of bias.
- Identify sources of random variation for a given study.
- Explain how sample size, variability and effect size interact to determine the power of a study.
- Explain the concepts of confounding and effect modification.
- Explain the distinction between association and causation.
- Explain the key elements of statistical hypothesis testing.
- Identify common statistical tests that might be applied to specific research questions.
- Explain and interpret p-values and confidence intervals and their implications for the research question under consideration.
- Explain the distinction between statistical significance and practical significance.
- Identify questions that can be addressed with regression models and interpret regression coefficients in different settings (linear, logistic, Cox proportional hazards).
- Identify common abuses of statistical methods in the literature.

Workshop implementation

The workshop was held for the first time in 2012, over 14 successive 3-hour afternoon sessions. It was found that this scheduling made it difficult for clinicians among the participants to attend regularly, as they often had clinics and patients to attend to. Irregular attendance then possibly contributed towards difficulty in grasping all the material. From 2013, the workshop was offered over 8 full days, which improved attendance, but with disadvantages in terms of participant ability to absorb and process the material. The in-class sessions were a few hours' duration each, with breaks between sessions. After requests from 2012 participants, supplementary exercises, which participants could work on in their own time, were also provided, with further questions relating to interpretation of biostatistics concepts that had been covered in the workshop in-class sessions.

The 2012 workshop was conducted by a faculty member (MLT) from the Department of Biostatistics at the University of Washington in Seattle, USA. With a view to sustainability, from 2013 there was increasing participation in facilitating the small group discussions from the three biostatisticians in CHS and two members of the UKZN Discipline of Statistics, and in 2014 and 2015 they participated as co-instructors.

Project evaluation

An evaluation was conducted to assess whether participants' understanding of biostatistical concepts improved following the training. This also explored participant expectations of the workshop before attending and the extent to which these expectations had been met throughout the workshop. Of additional interest were the participants' perceptions of the strengths and limitations of the workshop, the perceived effectiveness of the workshop in increasing know-

ledge and skills in biostatistics, and the value of the workshop in increasing biostatistics capacity at faculty and postgraduate levels. The evaluation was approved by the UKZN Biomedical Research Ethics Committee (Ethics Ref. No. BE035/15).

Methods

Evaluation components
The objective of the evaluation was to assess the knowledge gained as well as workshop process and included both quantitative and qualitative components: *(i)* quantitative pre- and post-workshop assessments; *(ii)* a brief qualitative mid-workshop questionnaire; and *(iii)* focus group discussions (FGDs).

Population and sampling
The target population comprised current and future health researchers at UKZN. For the quantitative evaluation of post- v. preworkshop knowledge gain, and the mid-workshop qualitative evaluation, the sample comprised all 2012 - 2015 workshop participants. These participants were regarded as representative of current and future UKZN health researchers who require skills in biostatistical reasoning. Participants for the FGDs were randomly selected from the 2014 and 2015 workshop participants. Each FGD comprised seven to eight participants and, in total, three FGDs were conducted.

Data collection
The same knowledge assessment quiz was used with all available participants in each annual cohort, before and after the workshop, to quantify participants' change in knowledge following the training. Box 1 provides an example of one of the questions used for pre- and post-test assessments. The anonymous mid-workshop questionnaire enquired about the pace of the workshop and participants were asked to describe in one sentence something that they really liked about the workshop and to make a constructive suggestion to improve it. FGDs were conducted by a single interviewer (MM), during which information about the objectives of the FGD and the overall study was provided. Each participant was asked to provide informed consent to participate and to be recorded using a tape recorder. A structured discussion guide was used to facilitate the FGDs. Saturation was allowed to be reached during the three FGDs conducted.

Data analysis
Quantitative data were cleaned and analysed using Microsoft Excel and Stata version 13 (Statacorp LP,

USA). The distribution of pre- and post-scores by cohort was graphically assessed using box plots, and the change in knowledge based on the pre- and post-test scores was assessed for each year of training using the Wilcoxon signed-rank test.

The raw audio data from FGDs were first carefully reviewed and then transcribed verbatim into Microsoft Word in English, the language of the interview. The audio transcriber (MM) was familiar with the theoretical perspectives of the study and was able to ensure that these were reflected in the approach to transcriptions, which was interpretative, to ensure that the views and representations of the participants in the FGDs were fully conveyed.[7] The Framework Analysis Technique[8] was then used to analyse the transcribed data. This technique was chosen as it has been shown to preserve the integrity of individual responses throughout the analytical process, thereby providing a platform for reconsidering and reworking of ideas where more clarity is needed.

To ensure trustworthiness of the qualitative data, respondent validation (cross-checking interim findings) was conducted by means of reflection to ensure that information reported by participants had been accurately understood. The data were collected and transcribed by one interviewer (MM), thereby minimising inter-investigator bias. The same interviewer also carried out the coding and analysis to ensure internal consistency. Furthermore, a peer-review process was undertaken whereby a fellow senior researcher reviewed the steps taken to analyse and interpret data as a way of improving the inter-rater reliability of the study findings.[9]

Results

Quantitative findings
The number of workshop participants in each year was 20, 17, 22 and 19 for 2012 - 2015, respec-

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Researchers obtained birth weights for a random sample of 1 500 infants. The mean birth weight was 3 250 g and the standard deviation was 550 g. The 95% confidence interval (CI) for the mean was 3 221 - 3 278 g. Which one of the following statements best describes the information given by the 95% CI?

(i) 95% of babies in the sample had a birth weight between 3 221 and 3 278 g
(ii) There was a probability of 0.95 that the sample mean birth weight would be between 3 221 and 3 278 g
(iii) There was a probability of 0.95 that the 95% CI will contain the mean birth weight for infants in this population
(iv) 95% of babies in this population had a birth weight between 3 221 and 3 278 g.
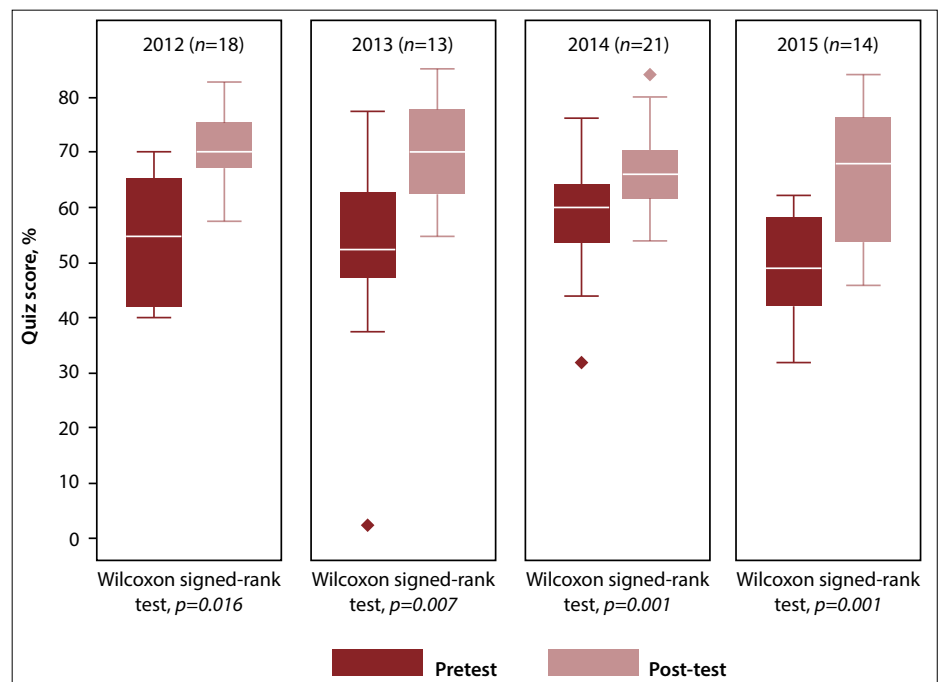
Box 1. Sample quiz question.

Fig. 1. Box plots of the participants' quiz scores before and after the workshop.

tively. In total, 78 postgraduate students and faculty members were trained over this period, the majority of whom were from the School of Clinical Medicine (33%), with the remainder from the School of Nursing and Public Health (27%), Laboratory Medicine and Medical Sciences (13%) and other disciplines in Health Sciences (13%).

The pre- and post-workshop assessment achieved a response rate of 84.6% (n=66). The 15.4% non-respondents included participants who were not available at either time of testing as well as those who only took part in one test and not the other. Fig. 1 shows, for each year, box plots of the participants' quiz scores (%) before and after the workshop and whether there was a statistically significant change in score, pre- v. post-workshop. The median post-test scores were higher than the median pretest scores across all 4 years of training; these differences were statistically significant, based on the Wilcoxon signed-rank test. When data from all 4 years of training were combined, the results were as follows: pretest median score 55%, interquartile range (IQR) 40 - 62%; post-test median score 68%, IQR 62 - 76%; and p<0.0001, for the pre- v. post-workshop comparison.

Qualitative findings
Feedback on the mid-workshop questionnaire regarding the workshop process was generally positive. With very few exceptions, participants found the pace 'about right'. Comments regarding aspects of the workshop that participants really liked included 'good technique re. learning concepts rather than calculations', and 'the fact that it emphasises intuitive understanding of concepts'. Comments regarding possible improvement often included requests for consideration of the biostatistics regarding participants' own research studies.

Prior expectations v. actual satisfaction
Participants attended with many expectations about the workshop and it was encouraging to learn from the FGD analysis that the majority were satisfied with the material delivered:

'Generally the pre-course expectations were quite high … but I felt the course has met those expectations in terms of practically understanding biostatistics. It has taken our interpretation of medical literature to another level.'

'We are not exposed to basic [statistics] stats on a regular basis. Our training too hasn't equipped us with this knowledge. Our knowledge is limited by what we read. Coming here, my expectation was to attain the skills to do equations and how to do stats and I have achieved more than what I have expected.'

'I have come here to get to know how to do statistical testing for my research purposes. But what we got was more than that, which increased my understanding … .'

Perceptions about course delivery
Participants were also particularly impressed with the way the course was delivered and the approach used by the workshop facilitator:

'When I first did stats 30 years ago it was manually done. I had various attempts to gain this knowledge and this is the first time we had a person like [name of facilitator] who made it easy to understand the concepts … the effectiveness of this method of teaching made us understand the concepts. That is what we found as beneficial … .'

'So she has a nice way of breaking it down to useable chunks, so that you can get a good grasp. She takes you from where you are and your level and builds on that potential.'

'The way she brings the message home she is a very good teacher. We had people here like he said … people who are intelligent don't know how to transfer knowledge to other people [and] that becomes a problem. You ask her a question and she will be able to bring it down to the level of your understanding. That makes it wonderful.'

Perceived improvement in the subject matter
The workshop also boosted the participants' ability to engage with the literature. The general sense from those who took part in FGDs was that the biostatistical aspect of the literature had been a no-go area and they were grateful for the opportunity to learn how to critically interpret the statistics reported in biomedical and public health literature:

'It has broadened our understanding because I didn't have a background in statistics, for example when reading articles I would just rely on the discussion to understand but now I have a clue on how to interpret it.'

'I often skip over the stats-based concepts and proceed to the discussion, not knowing whether the study was reliable and valid. This has given me the tools to understand study design, the terminology and the concepts that we use.'

'… personally I also feel the same way, my knowledge has gone up by 50 to 60 percent … .'

Value of the workshop
Participants also recommended that the workshop continues as it holds the promise of narrowing the skills gap in biostatistics in the school:

'Personally I think it's a course that should continue, I think it actually is increasing our appetites in terms of how we look at papers, and the advice it gives to students is incredible … .'

'I think most of us are teachers and supervisors so when we are supervising we can also consider this as a master trainer kind of course, where this information is just not going to remain among the participants. We are supervising other students at different levels, so obviously the level and intensity of supervision will also improve as opposed to sending the student to the biostatistician to be assisted.'

' … we are just Masters students, it is a good course and maybe more of the students should have an opportunity to be a part of this, because we don't know anything about statistics so we rely on the supervisor who will refer us to someone else.'

Nevertheless, some respondents felt that the workshop was too compressed and could benefit from a more extended timetable to accommodate busy candidates:

'I think this is a valuable course. However, I think [in] its current form, where it is compressed over 2 weeks, we have difficulty in keeping the commitment of being here the whole day over the 2 weeks. It's going to be difficult. Also this is intensive information which you need some time to process and to practise. They have provided all the building blocks,

they provide us with articles to read, they ask us questions to ensure we understand the concepts being taught, and they also provide us with supplementary exercises to go over. All of these resources are very helpful but at the same time it is very tiring. I think it needs to be changed from the current format and perhaps done over a longer period of time.'

Discussion

This article was written to share a possible model for improving biostatistical reasoning capacity among health researchers in academic institutions with a shortage of biostatistical expertise, and to demonstrate some of the lessons learned and the outcomes realised during a 4-year implementation period.

There are unique needs for health research in the African region, but the ability to carry out this research is limited by the shortage of biostatistical expertise.[4] Consequently, Africa is often a source of data collection, but studies are designed and analysed elsewhere.[4] The UKZN Biostatistics Initiative envisaged a range of strategies to address this problem, one of which was a workshop in biostatistical reasoning for UKZN health researchers. The intention of the workshop was to improve the ability of participants to critically interpret the biostatistical components of the literature in their field and for them to be better able to assess the reports and proposals that they are responsible for reviewing. It was also hoped that the knowledge gained by individual participants would be shared with others within their own disciplines.

A case-discussion approach to teaching biostatistics has been found to be successful with medical students in terms of both learning and student evaluation,[10] which is consistent with our experience with these workshops. The workshops were well received and there was both quantitative and qualitative evidence of participants achieving some level of learning. The evaluation of pre- and post-test scores demonstrated quantitative improvement in understanding, and in the FGDs the participants indicated that they felt that they had indeed gained knowledge. The opportunity for small group discussions and in-class participation was considered by both instructors and participants to be an important component towards this success. This type of learning platform has been shown to lead to positive perceptions about knowledge gain.[11]

Some education researchers have advanced a view that to maximise learning outcomes, there is a need to consider group composition, to ensure homogeneity of expertise and seniority.[12] In this project, there was considerable heterogeneity in the seniority and experience of participants. The senior faculty among the participants often raised insightful points for discussion in class, arising from their own experience in their area of specialisation. The challenge for the facilitators was then to address these questions in a way that made them relevant for the broader workshop audience. Another challenge for the facilitators was the diverse backgrounds of the participants, ranging from junior researchers, working on Master's-level projects, to heads of departments. However, it was felt that this diversity allowed the opportunity for improvement in biostatistical understanding throughout the spectrum of CHS researchers and hence possibly longer-term effect. These pedagogic challenges are most readily met by biostatisticians with a depth of experience in the field, which, of course, presents a 'Catch-22' challenge in a setting where this expertise is uncommon and, when present, often newly acquired. Leading a workshop such as this is very different from teaching a more conventional biostatistics course and, as has been observed in other comparable settings, the choice of instructors is crucial to its success.[13]

It is noteworthy that the biostatistical understanding of participants in the 2012 - 2015 workshops was typically poor to modest before the workshops. This is not surprising, as the dearth of biostatistical expertise in the sub-Saharan region has been widely recognised,[4,14] but it confirms the need for educational initiatives such as this. While the workshops increased quiz scores by an average of 13% overall, the understanding of many participants, post workshop, was still modest. Scheduling the workshop over 8 full days improved participation, but was not ideal from a knowledge-processing perspective. This constraint is reflected in some of the comments from the FGDs.

This study does not assess to what extent the knowledge of biostatistical concepts was retained in the longer term. Refresher sessions might be one way of maintaining and improving knowledge. It is further hoped that the knowledge gained from the workshops would better enable participants to engage with the hands-on online material which has also been developed as part of the Biostatistics Initiative.

Conclusion

While the workshops were successful, there were limitations. The full-day condensed format, while improving attendance, was not ideal for learning. The concepts covered were increasingly complex and a gestation time to process the ideas would have been preferable. There is clearly a need for UKZN health researchers to also develop some analytic biostatistics skills, given the local shortage of professional biostatisticians for collaboration.

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