Teachers Corner

Biostatistics @ Distance: A Model for Successful Multi-Institutional Delivery

Gillian Z. HELLER, Andrew B. FORBES,
Keith B.G. DEAR, and Erica JOBLING, for the BCA writing group

The Biostatistics Collaboration of Australia was formed to address the shortage of biostatisticians in that country. Academic biostatisticians are geographically spread out, with no single university department having the capacity to offer a graduate program in biostatistics. Eight universities have formed a consortium to mount such a program, with all instruction being in distance mode. Students choose to enroll at one of the institutions, and the courses are each delivered by one of the institutions. Extensive use is made of an online learning environment, as well as more traditional course notes and textbooks. The program has been running successfully since 2001.

KEY WORDS: Consortium; Distance learning; e-learning; Online instruction.

1. INTRODUCTION

There is a worldwide shortage of statisticians with expertise in the health industry, including medical research (Carlin 1998). The Biostatistics Collaboration of Australia (BCA) was formed in 2001 to meet this need within Australia. The collaboration was composed of initially seven, and now eight, universities around the country. Its mission is to meet Australia's need for well-qualified biostatisticians. In this article we describe the BCA consortium model and how it functions as a provider of distance education in biostatistics.

The academic base of biostatistics lies in the mathematical sciences, but those areas of Australian universities have not succeeded in producing enough biostatistics graduates to meet the needs of the health sector. This has limited developments in public health and the pharmaceutical industry in Australia (DeMets et al. 2006). Although biostatistical work is threaded throughout health research, the health and medical sectors of higher education have not historically provided sufficient support to professional biostatistical training. Many graduates of Master of Public Health programs and Master's or Graduate Diploma courses in epidemiology acquire the skills to perform a range of statistical analysis, but these skills are necessarily limited to a basic level. In an era of ever-growing complexity of data and of modeling approaches, these generic skills need to be backed up by professional biostatistical expertise.

Although there are well-recognized academic biostatisticians in many Australian universities, no single university has sufficient depth and breadth to mount a world-class graduate program in biostatistics on its own. Distances between major cities and hence between universities in Australia, together with a tradition of students not moving to attend universities, exacerbates the problem. A consortium model has been developed as a solution to the need for workforce and academic capacity building in biostatistics. In an age of intense competition between universities, the BCA consortium is unusual. The model involves multiple universities collaborating to develop and deliver a single specialist program. Partner universities fully recognize courses taught by other member universities.

Those who envisaged the concept, and then went on to make it happen, were in the first instance the academic biostatisticians in universities, who are personally committed to developing their discipline and are, by the nature of their profession, accustomed to collaboration as their usual mode of working. This culture of collaboration characterizes the BCA.

Distance education is the only feasible delivery mode for this consortium model. The program is composed of a number of courses, offered via distance education enhanced by e-learning support, together with a work-based project. The program has been designed to be studied part-time, which enables concurrent work and study. Many students are working in health care professions and are looking to enhance their skills; others are studying in order to change careers.

Each consortium university (with the exception of the Australian National University, which delivers a course but does not offer a biostatistics award) has established a Master's level coursework award in biostatistics, as well as a Graduate Diploma and Graduate Certificate for students who do not undertake the full Master's program. The consortium universities are listed in Appendix B. Each course is delivered by one of the BCA universities and each consortium university has approved all BCA courses as its own offerings, even though course delivery is essentially subcontracted to the university responsible for

Gillian Heller (corresponding author) is Associate Professor, Department of Statistics, Macquarie University, Sydney, Australia (E-mail: *gillian.heller@mq.edu.au*). Andrew Forbes is Professor, Department of Epidemiology & Preventive Medicine, Monash University, Melbourne, Australia. Keith Dear is Senior Fellow (Biostatistics), National Centre for Epidemiology & Population Health, Australian National University, Canberra, Australia. Erica Jobling is BCA Executive Officer, Biostatistics Collaboration of Australia, c/-NHMRC Clinical Trials Centre, Sydney, Australia. The BCA Writing Group is listed in Appendix D.

 DOI: 10.1198/000313008X368251

delivering the course. A student enrolls at the university of his or her choice, pays fees to that university and receives a transcript and eventually an award from that university. However, he or she will receive instruction from academics from up to eight universities during the course of their studies.

The program is coordinated administratively by staff at a central BCA office. Teaching and other academic issues are handled by a Steering Committee and Teaching Subcommittee, which have regular teleconferences and bi-annual face-to-face meetings. An external Advisory Board, consisting of senior representatives from health and medical research, government agencies and the statistical profession, provides advice to the Steering Committee on workforce issues, marketing, and communication avenues with external bodies such as government departments and industry boards.

2. THE ACADEMIC PROGRAM

The program has been devised with two streams of students in mind: medical or health sciences graduates, with little statistical background; and graduates who majored in statistics with little or no health sciences background. Thus far the first stream has supplied by far the majority of students, with a large number being clinicians. Because of the minimal requirement for statistical background for entry to the program (an introductory statistics course), the first-year courses cover requisite mathematics and statistics. Students coming from a statistics background gain exemption from these courses, and are able to do more of the advanced elective courses as a result. A fairly extensive system of prerequisites effectively forces part-time study because of the structured sequencing of courses. Options for accelerated study are currently being investigated, including offering of some compulsory courses in both semesters. The Master's, Graduate Diploma, and Graduate Certificate comprise 12, 8, and 4 courses, respectively. A practical project, usually originating from the student's workplace, and worth either one or two courses, is a compulsory component of the Master's degree. A list of the courses is given in Appendix C.

3. MODES OF DELIVERY

Learning in distance mode involves two kinds of activity: (1) studying the material by reading and attempting exercises, and (2) communicating with the course coordinator and other students. The BCA model uses the print medium for the first kind of activity, and the e-learning environment for the second.

The emphasis on printed materials has worked well. The avoidance of synchronous online interaction for instruction allows each student to work at his or her own pace. This is important for our students, who come from heterogeneous backgrounds and often have demanding work and family commitments. Study notes and other materials are sent by mail, to avoid devolving the cost of printing to the students. Apart from the course fees, students bear only the costs of textbooks and software licenses.

While distance delivery has been chosen out of necessity, face-to-face contact has in fact been found, in the main, to be neither necessary nor welcome. In the early years in some courses, an attempt to create a blended learning environment (Muirhead 2005) was made by trialing tutorials, teleconferences, synchronous activities within the e-learning environment, and drop-in clinics. These opportunities were not widely taken up by students. Residentials are infeasible because of budgetary constraints, bearing in mind the national reach of the program, and work commitments of students. In contrast, students do make heavy reliance on Internet communications. Each course hosts discussion boards within the e-learning system, and even when contributions are not assessed these tend to be well used for discussion of course material. Although one-to-one discussions with course coordinators are in some cases handled through e-mail or telephone, issues that are considered to be of general relevance are fed back to the class by the coordinator via online postings.

Our experience suggests that distance teaching of biostatistics at the postgraduate level need not be very different from traditional classroom delivery. In both formats, students do most of their study in their own time outside class. In both, discussions between students can take place through their own initiative, with no input from the lecturer. There is perhaps little difference in either substance or convenience nowadays, between classmates chatting in a corridor or over a coffee, and distance students conversing by Internet chat or e-mail. The place of formal tutorials is taken by online discussions. In fact, having class discussion laid out in writing has proved to be a strength. Coordinators can e-moderate, that is monitor discussions without necessarily personally contributing. Problems are often resolved in discussion between students. If contributions begin to go off-target or subject, the coordinator can identify the problem and intercede. Regardless of whether the method of delivery is face-to-face or by distance, this level of discussion benefits the cohesion of the group and the robustness of the overall study regime. However, if it is not carefully managed, it can add a substantial amount of time to the coordinator's teaching load. Clearly identified timetabling of coordinator time, outlined in Study Guides, is a solution.

The one aspect where our program differs from traditional on-campus programs is in the feasibility of various modes of assessment. We have found it unworkable to hold traditional invigilated examinations: the overheads of organizing a venue and invigilator at locations accessible to all students are prohibitive. Instead, each course uses a combination of assignments and at-home final examinations. As is the case at each university, students are required to submit, with each assessment item, a signed statement that the work is entirely their own. Authentication is, however, an ongoing issue. We have examined a number of examples of courses in other programs that contain online assessable components. In most cases plagiarism software is used. We have found that these programs do not deal well with submissions that contain mathematics. To date our observation is that the overall program is very challenging and that students who do not cope adequately with the mathematical components tend to withdraw. The effort entailed in plagiarizing in every course within the program, while probably not impossible, would be very difficult to sustain.

4. COMPUTING ISSUES

All courses make extensive use of the statistical software packages Stata and/or SAS. This choice has been made in the interests of teaching efficiency and industry standards.

In traditional on-campus delivery, computing laboratory sessions are typically provided for students to gain confidence and competency with statistical software. This involves instruction in person, immediate response to questions or problems, and an interactive social atmosphere of group learning. Students are not required to purchase their own copies of the software.

Our model for delivery of computing instruction by distance learning attempts to create, as much as possible, the environment of a "virtual" computing lab.

Students who have no prior exposure to either software package are required to do the course "Data Management and Statistical Computing" (DMC). The aims of DMC are to extend the range of statistical methods available to the student, prepare them for relevant data analyses (using Stata and SAS) and enable the interpretation of results using material from the modules and textbook. Some students have no previous experience with statistical software packages, while others have used packages other than SAS and Stata in the workplace. In each course, detailed syntactical guidance and annotated output is given. Due to the potential for frustration and loneliness when studying by distance, particularly in relation to computing, the course coordinator is mandated with the tasks of providing prompt responses to student questions posted online and encouraging interaction between students. However, we have found that this interaction occurs naturally with little prompting in our group of motivated mature learners, with students willing to freely assist others—or to commiserate on common areas of difficulty! Reports of feeling isolated and/or frustrated with the computing learning tasks have been rare in courses where prompt coordinator response has been provided. Even students without any prior statistical computing experience have generally been able to cope well with this distance mode of acquiring computing skills, although of course there is substantial variability in the attained skills in each course.

The software purchasing problem is remedied via educational licensing that has been organized specifically for students in the BCA program and provides inexpensive access to the required packages.

5. ONLINE ENVIRONMENT

E-learning facilities and helpdesk support are provided by the University of Sydney via the offices of the e-learning project team. Staff at this office and the BCA office coordinate online administration. When e-learning was initiated in 2001, online facilities were relatively new at the university. Training was available to staff within the University of Sydney but not across the other consortium universities. We have found that the services of a professional, teaching and learning-oriented online management team, backed up by IT expertise, have been essential in order to provide an efficient technical platform, communicate user knowledge to academic staff and students, and ongoing helpdesk support. Our experience is that, with a few exceptions, postgraduate students have very little difficulty grasping the basic technical requirements and the elements of meaningful participation. The transition to online delivery for students who have had no previous experience with this delivery mode has been remarkably seamless.

A significant factor in the success of the BCA program is the online aspect of the delivery and the interaction that this facilitates, between students and teaching staff, and student-to-student. Participation in online discussions is a key element in all BCA courses. A feature of the online discussions that has been consistent since the program's inception is the culture of collaboration and camaraderie that exists among the students, which we believe is linked to the fact that all of the students are studying in distance mode. Students have embraced this aspect of the technology enthusiastically, with only a small minority electing not to participate. Discussions take place on the subject matter in general, specific exercises or tasks, and computing; discussions relating to significant assessment tasks are disallowed. Course coordinators and teaching assistants follow the usual practices of e-moderation. The incorporation of mathematical symbols in discussions is achieved either by using the equation editor in the e-learning software, or by attaching a document containing the mathematics. Our experience is that the equation editor is awkward to use, and suitable only for small amounts of mathematics.

Other uses of the online environment vary from course to course. Most course coordinators encourage students to submit their assignments online, although electronic submission by e-mail, or hard copies sent by mail, are also accepted. A variety of grading techniques are used, according to the preference of the coordinator. Some choose to add comments to documents electronically, and return them to students online; others grade hard copies and return the annotated paper by mail or e-mail a scanned copy.

Relatively low use of technology is made, in that no use is made of Java applets, wikis, blogs, or podcasts. Student reaction to the level of technology used is positive, as material can be studied without their being at a computer screen. Nevertheless, the benefits of emerging technologies in encouraging student engagement (Beldarrain 2006) are constantly being reassessed, particularly in the light of what is feasible in the multi-institutional environment.

Students need to have the use of a computer capable of running SAS and Stata, and Internet access. Although a high-speed broadband connection is desirable, we have had students successfully working on dial-up connections. As the bulk of printed material is supplied in hard copy, there is no need to download large volumes of notes. Discussions are not in real time, so speed is not critical for those; solutions and datasets are the only items that need to be downloaded. This lack of reliance on high bandwidth allows greater accessibility and a broader audience for the program.

6. MULTI-UNIVERSITY ARRANGEMENTS: A SHARED RESPONSIBILITY FOR STUDENT LEARNING

The arrangement for delivery of the program goes well beyond that of a series of individual courses delivered by different

universities. That the academics involved are committed to the same ultimate goal of an increased national biostatistics workforce carries over into a multi-university culture of shared responsibility for student learning and continual quality improvement. Each course is regularly reviewed by academics of other universities participating in the program and, where relevant, representatives from workforce end users. Ideas for enhancements of, or problems encountered with, the distance learning experience are readily shared. All academics are granted access to the online discussions and materials of all courses, and are free to comment on these at any time.

The pastoral care of students is also a shared responsibility. Early identification and intervention for students experiencing difficulty with a particular course's material can be problematic in a multi-university delivery arrangement, in particular for students not enrolled through the university of the course coordinator. This has been remedied, to a large extent, by adopting a process in which the course coordinator notifies the student's enrolling coordinator at the first sign of inadequate performance, which may be a failed major assignment or a failure to submit a consecutive series of assessed exercises. Feedback from the ensuing student counseling by the enrolling coordinator is then provided to the course coordinator and the monitoring continued. We believe that the checks and balances inherent in this system, functioning as it does at an inter-collegial level, deliver service to the student that is at least as good as, and often more successful than, many internal university procedures.

7. DEVELOPMENT OF MATERIALS AND CURRICULUM

Development of the entire program was financed by a contract with the Australian Government. The grant provided start-up costs and funds for central organization by a full-time executive office, plus a fixed amount per course, payable to each developer's university department for the development. This permitted the development of entirely new teaching materials for all courses, designed for distance learning. For about half the courses, no suitable textbook has been found, so these are taught almost entirely from course notes developed for this program. The four required introductory courses (on mathematics, probability, epidemiology, and data management), and also a minority of more advanced courses, require students to purchase a textbook. Nevertheless these courses too are supported by purpose-written course notes, which add material on biostatistical applications of the theoretical topics and computing instructions, together with extensive relevant exercises.

The pedagogical style of these notes falls between what is appropriate for conventional lecture notes and what is appropriate for a published textbook. Because they must be adequate in themselves to convey new material to students, they are far more comprehensive than the "handouts" that typically accompany lectures; but a more relaxed, personal style is possible in this setting than would be acceptable in a formal text.

The development of the courses involved extensive peer review both within the consortium and through a formal external review. The funds earmarked for the development of each course were paid only following a satisfactory response to peer review of the course, generally by one external reviewer and one colleague from the program who had not been involved in its development. In most cases, these reviews resulted in modest changes to content, usually in the form of changed emphasis and occasionally additional topics to be included. The reviews also paid careful attention to the intended assessment tools.

A particularly important challenge for the teaching of biostatistics in distance mode is the issue of practical application of the methods under study. Learning about consulting and collaborative communication is a crucial part of the training of any applied statistician, but is an area in which it is difficult for distance delivery to achieve the compelling immediacy that a teacher with personal experience of consulting can convey. Therefore we have not attempted to develop a course on "Statistical consulting" as such.

As much as possible, this learning objective has been embedded in the course material. The program encourages students to make the leap from theory to practice in two ways. In many courses, exercises and assessment items are presented as "clinical scenarios," asking the student to see themselves in the role of biostatistical consultant. Having performed a statistical analysis, using the techniques taught in that course, students are asked, for example, to "write a report for the investigator in plain language." Second, students enrolled for a Master's degree must compile a "workplace project portfolio." In this they work with both a real-world client, perhaps a clinician working in medical research, and also a statistical supervisor from their local BCA consortium university. The student is required to prepare, under the close supervision of the BCA academic, a written report of real value to the workplace client that demonstrates substantial mastery of biostatistical methods. The project takes either one or two semesters, and is assessed as equivalent to one or two courses, respectively.

8. EVALUATION

In each semester of delivery, students' evaluations are sought for each course offered in that semester. These evaluations are presented to the BCA Steering and Teaching Committees for discussion and, where necessary, remedial action. Individual student comments contained in this report are, of course, de-identified. While the response rate has typically been low (around one third), this has nevertheless been a useful means of detecting student satisfaction or dissatisfaction with aspects of the program. A student representative on the Teaching Committee is asked to survey students for feedback about the program as a whole. This report is also presented to the Teaching and Steering Committees

The program has received uniformly positive external reviews. In 2004 an external review of the BCA was undertaken and concluded that:

> The BCA has been successfully established as an outstanding multi-university system for developing, strengthening, and sustaining Australia's workforce of career biostatisticians. Through intensive coordination of expertise in seven universities and the use of

Table 1. Student numbers.

Year	Commenced program	Still studying	Withdrew	Graduated	Graduate Certificate	Graduate Diploma	Master's
2001	5	0	1	4	0	1	3
2002	52	15	18	19	3	3	13
2003	53	14	17	22	3	5	14
2004	80	24	25	31	11	5	15
2005	69	48	8	13	4	4	5
2006	83	61	11	11	8	3	0
2007	93	85	8	0	0	0	0
2008	59	59	0	0	0	0	0
Total	494	306	88	100	29	21	50

> distance education, the BCA is able to offer an educational program in biostatistics that is unique throughout Australia, and indeed the world, in terms of its depth and scope. The multi-university collaboration appears to be working very well, given the challenges associated with such a model. Its effectiveness is attributed to the commitment and dedication of the people involved in running and supporting it .... The BCA offers a more comprehensive range of courses in biostatistics than any other Australian educational institution, and the breadth and depth of its curriculum is comparable with many traditional residential master's degree-level training programs in biostatistics around the world.

Some suggestions for improvement of the program were made, in particular the introduction of a course in probability, which has since been implemented.

The 2005 Review of the Public Health Education and Research Program (PHERP Phase 3) stated that "...the BCA is the best example of PHERP ...strengthening the basis for high-level and consistent quality education programs," and that "PHERP ...has some stunning examples of successful collaborations, such as the BCA."

Student and graduate numbers have been growing healthily, as is shown in Table 1. Note that figures for 2008 cover one half year only.

Courses are reviewed on a three- to five-year cycle. Generally one reviewer is internal to the BCA and one is external. As a result of unfavorable external reviews and consistently poor student evaluations, two courses have been substantially revised, and their course coordinators changed. Some modification to the contents of some other courses has occurred as a result of reviews. These changes have been achieved in a spirit of cooperation within the group.

9. CONCLUSION

The BCA program is a pragmatic solution to the shortage of adequately trained biostatisticians in a country where academic expertise in the discipline is geographically sparse. While there are several successful biostatistics programs in large institutions in countries such as the U.S. and UK, the BCA may serve as a model for smaller institutions which do not have the expertise individually to mount a graduate program. The BCA's achievements have been made possible by a climate of collaboration between academics and administrators at the participating institutions, and we see no reason why our experience would not translate successfully to other countries, as long as academics and university administrators have the will to make it work.

Distance education was chosen as the only feasible mode of delivery, but this has in fact proved to be a strength of the program in enabling wide access, not only in a geographical sense, but also to students in the workforce who could not have attended an on-campus program. While we are not suggesting that distance instruction replace face-to-face teaching, our experience suggests that aspects of distance instruction may be used to enhance students' learning in the face-to-face mode. Our students benefit enormously from online discussions with their fellow students, and develop the ability to learn independently. Fusion of distance and face-to-face instruction in a blended learning approach is being increasingly recognized as a worthwhile approach and "...growing numbers of educators and influential policymakers are discovering not only the advantages but also the lack of threat in combining the advantages of teaching and learning in the two different environments: classroom and home or workplace" (Bonk and Graham 2006). The success of the program in teaching statistical concepts and their application in distance learning mode, at a graduate level, bodes well for the discipline in a future in which traditional learning avenues are being replaced or augmented by distance learning.

APPENDICES

A. GLOSSARY OF TERMS

In a multi-university environment, nomenclature differs between institutions. In order to avoid confusion on the part of students, and academic and administrative staff, a particular set of terms are used in BCA documentation (Table A.1).

Table A.1. Glossary of terms.

BCA name	Description
award course	a program of study formally approved/accredited by a university, which leads to an academic award by that university, abbreviated to course in BCA documentation. This applies to any of the three tiers of the Program: (Post)Graduate Certificate, (Post)Graduate Diploma, and Master's Degree.
consortium university	a university that delivers courses within the program and offers award courses in biostatistics
delivering university	a BCA-affiliated university developing and/or delivering a course within the program
e-learning	online learning management system
home university	the awarding university at which a student is enrolled
program	the postgraduate awards in biostatistics developed and delivered by the BCA. This encompasses awards: (Post)Graduate Certificate; (Post)Graduate Diploma; and Master's Degree.
course	a self-contained quantity of educational instruction developed specifically to deal with subject matter, referred to as a subject or unit of study at some universities, and abbreviated to unit in BCA documentation.

B. BCA CONSORTIUM UNIVERSITIES

- Australian National University (ANU). ANU is a delivering university. Academic staff at this university deliver a course within the program (Mathematical Background for Biostatistics), but the university does not offer award courses in biostatistics.
- Macquarie University
- Monash University
- University of Adelaide
- University of Melbourne
- University of Newcastle
- University of Queensland
- University of Sydney

C. COURSES AND DELIVERING INSTITUTIONS

A list of courses and delivering institutions is shown in Table C.1 on the following page.

Table C.1. Courses and delivering institutions.

Semester	BCA Code	Course	Tier	Prerequisites	Grad Cert	Grad Dip	Master's	Delivering university
1 & 2	EPI	Epidemiology	1	–	√	√	√	UQueensland
1 & 2	MBB	Mathematical Background for Biostatistics	1	–		√	√	ANU, Macquarie
1 & 2	PDT	Probability and Distribution Theory	1	MBB		√	√	Monash
1	HIS	Health Indicators & Health Surveys	elective	*MBB				USydney
1 & 2	DMC	Data Management & Statistical Computing	1	–		√	√	UNewcastle
1 & 2	PSI	Principles of Statistical Inference	1	MBB, PDT		√	√	USydney
1	CLB	Clinical Biostatistics	elective	EPI, MBB, PDT, *PSI				UQueensland
2	DES	Design of Randomized Controlled Trials	1	EPI, MBB		√	√	UAdelaide
2	LMR	Linear Models	2	EPI, MBB, PDT, PSI		√	√	UMelbourne & Monash
2	CDA	Categorical Data & Generalized Linear Models	2	EPI, MBB, PDT, PSI, *LMR		√	√	UQueensland
1	SVA	Survival Analysis	2	EPI, MBB, PDT, PSI, LMR			√	Macquarie
1& or 2	WPP	Workplace Project Portfolio	3	minimum of 4 units, including LMR & DMC			√	all
1	LCD	Longitudinal & Correlated Data	elective	EPI, MBB, PDT, PSI, LMR, CDA				Monash & UMelbourne
2	BAY	Bayesian Statistical Methods	elective	EPI, MBB, PDT, PSI, LMR, CDA				UMelbourne
2	BIF	Bioinformatics	elective	EPI, MBB, PSI, LMR, CDA				Macquarie
2	ACT	Advanced Clinical Trials	elective	EPI, MBB, PDT, PSI, DES, LMR				USydney

Tier equivalent to years 1, 2, and 3 of full-time study
√ course is compulsory
* co-requisite, may be taken concurrently

D. BCA WRITING GROUP

- John Carlin, Murdoch Childrens Research Institute, and School of Population Health, The University of Melbourne, Melbourne, Australia
- Keith Dear, National Centre for Epidemiology & Population Health, Australian National University, Canberra, Australia
- Cate D'Este, Centre for Clinical Epidemiology and Biostatistics, The University of Newcastle, Newcastle, Australia
- Annette Dobson, School of Population Health, The University of Queensland, Brisbane, Australia
- Andrew Forbes, Department of Epidemiology & Preventive Medicine, Monash University, Melbourne, Australia
- Lyle Gurrin, School of Population Health, The University of Melbourne, Melbourne, Australia
- Gillian Heller, Department of Statistics, Macquarie University, Sydney, Australia
- Erica Jobling, Biostatistics Collaboration of Australia, c/-NHMRC Clinical Trials Centre, Sydney, Australia
- Ian Marschner, Pfizer Pty Ltd; and NHMRC Clinical Trials Centre, The University of Sydney, Sydney, Australia
- Helen Moore, NSW Department of Health, Sydney, Australia
- Philip Ryan, Discipline of Public Health, The University of Adelaide, Adelaide, Australia
- Judy Simpson, School of Public Health, The University of Sydney, Sydney, Australia

[Received November 2007. Revised June 2008.]

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