

Evidence-based Practice

'Double symposium' proceedings on problems, possibilities and politics

SYMPOSIUM 1

Is evidence overrated? – An international symposium on the nature, purposes, ethics and politics of evidence in a democracy

SYMPOSIUM 2

Evidence-based advice: How can governments and the nation at large best draw on the knowledge and skills of the science community?

Edited by

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September 2006

CSIR Convention Centre, Tshwane/Pretoria, South Africa

Published by the Academy of Science of South Africa

ISBN 0-620-37188-9

September 2006

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The Academy of Science of South Africa (ASSAf) was inaugurated in May 1996 in the presence of then President Nelson Mandela, the Patron of the launch of the Academy. It was formed in response to the need for an Academy of Science consonant with the dawn of democracy in South Africa: activist in its mission of using science for the benefit of society, with a mandate encompassing all fields of scientific enquiry in a seamless way, and including in its ranks the full diversity of South Africa's distinguished scientists.

The Parliament of South Africa passed the Academy of Science of South Africa Act, Act 67 in 2001, and the Act came into operation on 15 May 2002.

This has made ASSAf the official Academy of Science of South Africa, recognised by Government and representing South Africa in the international community of science academies.

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Preface

The Academy's Double Symposium, that was admirably arranged by Prof. Jonathan Jansen and executed by the staff of the Academy, had objectives that were concisely captured by the Minister of Science and Technology in his address that intervened between the two symposia:

"This Double Symposium on the 'Nature of Evidence' and 'Science-based Advice for the Nation' has an important contribution to make in exploring the urgency and growing importance of evidence as the basis for making informed policy and practical decisions across the world. It also offers the Academy of Science of South Africa (ASSAf), which is an independent and authoritative provider of evidence-based advice on a broad range of nationally significant topics and issues, an opportunity to examine its own role in the national science system" Mr M. Mangena, Minister of Science and Technology

Robust debate in a democracy can be fostered through the use of evidence where the participants share a common understanding of the nature of evidence. The participants in the first symposium showed that the nature and use of evidence is often divergent in different domains, with the particularly stark contrast being represented by the views of the natural sciences and the law. The discussion during this symposium indicated that a much more nuanced approach to the use of evidence is required, as well as explicit discussion of divergent understandings of the uses of evidence if productive debate and effective decision making is to be achieved.

The use of evidence based advice to address topics and issues that affect the well-being of the nation is a significant and daunting role that the Academy wishes to fill. In this respect, it will be following the example of other international academies of Science and Arts that have mobilized the intellectual capacity of their membership to perform this function. The second symposium considered the results of studies that had been undertaken by the National Academies of Science of the United States and the Royal Society of London so that the lessons that they have learned may be applied in our context. What was clear from these discussions was that giving advice tends to be nationally embedded. The nature of advice structures in different countries requires that Academies determine their mode of operation and role in relation to these. In this respect the National Academies of Sciences of the US generally have their reports commissioned by government or other organisations, while the Royal Society studies are almost exclusively self-generated. We need to determine in our own context what judicious mixture of commissioned and self-generated reports we need to develop, taking into account our relationships with other advice giving organisations in South Africa.

Participants in the symposia came from a range and diversity of organisations, indicating that the Academy was addressing a topical subject with particular resonance in our context at the moment. It is clear that the Academy has at its disposal a resource that can be effectively

used to play the role envisaged both in the Minister of Science and Technology's speech and encapsulated by Mark Orkin in the discussion at the end of the Double Symposium:

"ASSAf by contrast has a major role to play in acting as a professional body drawing judiciously on the large pool of intellectual resources at the universities, at the highest level of expertise and in a multi-disciplinary way, to generate advice on big national issues."

The presentations and discussions that are recorded in this volume, show that the Academy has accepted the challenge implicit in the deliberations of the two symposia and wishes to engage actively in its advice giving role.

Robin Crewe

President

September 2006

Acknowledgements

The editors would like to acknowledge the role the presenters and participants have played in contributing to the success of the ‘Double Symposium’ and also of this Report.

The organisers would like to thank the ASSAf Council for its decision to hold a major symposium on evidence-based advice to government and the nation. The symposium was divided into two carefully planned sessions called Symposium 1 and 2, hence the word ‘Double Symposium’.

Invitations to participate were sent to senior officials in government and other policy-makers, in addition to representatives of academia, business, non-governmental organisations, delegates from other African Academies within the African Science Academies Development Initiative (ASADI), and as well as the media and the general public. We would like to thank the Honourable Minister of Science and Technology, Mr Mosibudi Mangena, for officially opening the ‘Double Symposium’ and the Deputy Minister of Health Ms Nozizwe Madlala-Routledge who attended and participated in the deliberations.

The symposium was sponsored by the US National Academies, through the African Academies Development Initiative (ASADI), a partnership collaboration programme between the US National Academies and seven African national science academies.

We are indebted to Ms. Robyn Arnold, the scribe and editor of this Proceedings Report, who took notes throughout the symposium proceedings, transcribed the presentations, and finally proofread and edited the draft Report. Responsibility for the final content of this Report, however, rests with the presenters who did the initial and final proofreading of their individual presentations as submitted, captured and recorded by the scribe and editor.

We would like to thank Ms Christina Scott, an award-winning science journalist and author who wrote a press/media campaign to disseminate information about the ASSAf ‘Double Symposium’ on the best ways to generate evidence-based advice to government and the nation at large. The organisers would also like to acknowledge the London-based Science and Development Network, the Cape Times, Natal Witness, Pretoria News and the SABC News for publishing the symposium press/media campaign.

Finally, the organisers would like to thank the ASSAf staff, Ms Rudzani Ramaite who has been an essential player throughout the logistical planning of the event, supported by Ms Fundiswa Kanise, Ms Boitumelo Mabina, Ms Khanya Ledwaba and Mr Morakeng Malatji. Thanks are due also to everyone else who contributed towards the success of the Symposium and of this Report.

Jonathan Jansen

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Society of London (GSL). He has been chair of the Board of Directors of the State Mining Corporation (STAMICO) and was Head of Geology at the University of Dar Es Salaam in 1997-2000.

- **Olive Shisana**, is the President and CEO of the South African Human Sciences Research Council (HSRC). She was Executive Director of the Social Aspects of HIV/AIDS and Health at the HSRC; Professor and Head of Department of Health Systems Management and Policy at MEDUNSA; Professor and Head of the WHO's Family and Community Health and Director-General of South African Department of Health, the first woman to head the national health services. She coordinated the establishment of the School of Public Health at the University of the Western Cape.
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SYMPOSIUM 1

Is evidence overrated?

An international symposium on the nature,
purposes, ethics and politics of
evidence in a democracy

Introduction

James Volmink*

The symposium deals with evidence-based practice. The evidence-based movement had its roots in France in the 19th century. The evidence-based movement has resurfaced quite forcibly in recent years as the result of many factors, including the shift towards a knowledge economy, as well as changes in the balance of power between the creators of policies and services and those that receive them.

The central argument of evidence-based practice is hard to refute. In essence, it says that policy-makers and practitioners take it upon themselves to intervene in the lives of others, intending to do good, but sometimes they do more harm than good.

To minimise the risk of harm, it is argued that interventions should be informed by reliable research evidence, and that evidence-based or evidence-informed decision-making should always be undertaken whenever possible. Not to do so would be to act irresponsibly.

However, not everyone is persuaded by this argument. Questions have been raised about factors such as the privileging of some forms of evidence, the accessibility of evidence that may be context sensitive, and there have also been arguments for a greater role for judgement in decision-making and concerns about the roles played by values and cultural insights into the use of evidence.

Given the vision to promote excellence in the application of science for the benefit of society, it is therefore appropriate for the Academy of Science of South Africa to convene this national symposium on evidence-based practice. The purpose of this meeting is both to raise awareness and to generate discussion and debate. We hope by the end of the day to have deepened our insights into the claims, assumptions and value of evidence-based approaches to government policy and professional practice in South Africa and in developing countries in general.

* James Volmink, ASSAf Council, University of Stellenbosch and MRC

Keynote Address

Les Irwig*

What we mean and understand by knowledge and evidence is culturally determined and will depend on our perspectives and background.

I will talk about the framework for thinking through evidence, which we have found useful within health. A simple planning cycle begins with defining a health problem for which a range of research is required, including qualitative research, how common the condition is, and what happens to the health problem if left untreated. The next stage is that of basic research, which is often laboratory based. One of the things flowing from that will be potential treatment and diagnostic tests, which may be useful and have beneficial effects, and which will hopefully do so with minimal harm. Potential treatments and tests then have to be assessed to determine whether they deliver their promise and actually do good in practice, and whether they do so without avoidable harm. Effective treatments can then be selected and built into health care, importantly not without consideration of other issues such as the preferences of patients and of communities, as well as judgement to balance what needs to be done. Finally, there would be a reassessment and audit of how the health problem is being dealt with and quality improvement where possible. Add refs: Henderson-Smart et al Clinics in Perinatology. 2003, 30:333-342, Irwig and Zwarenstein

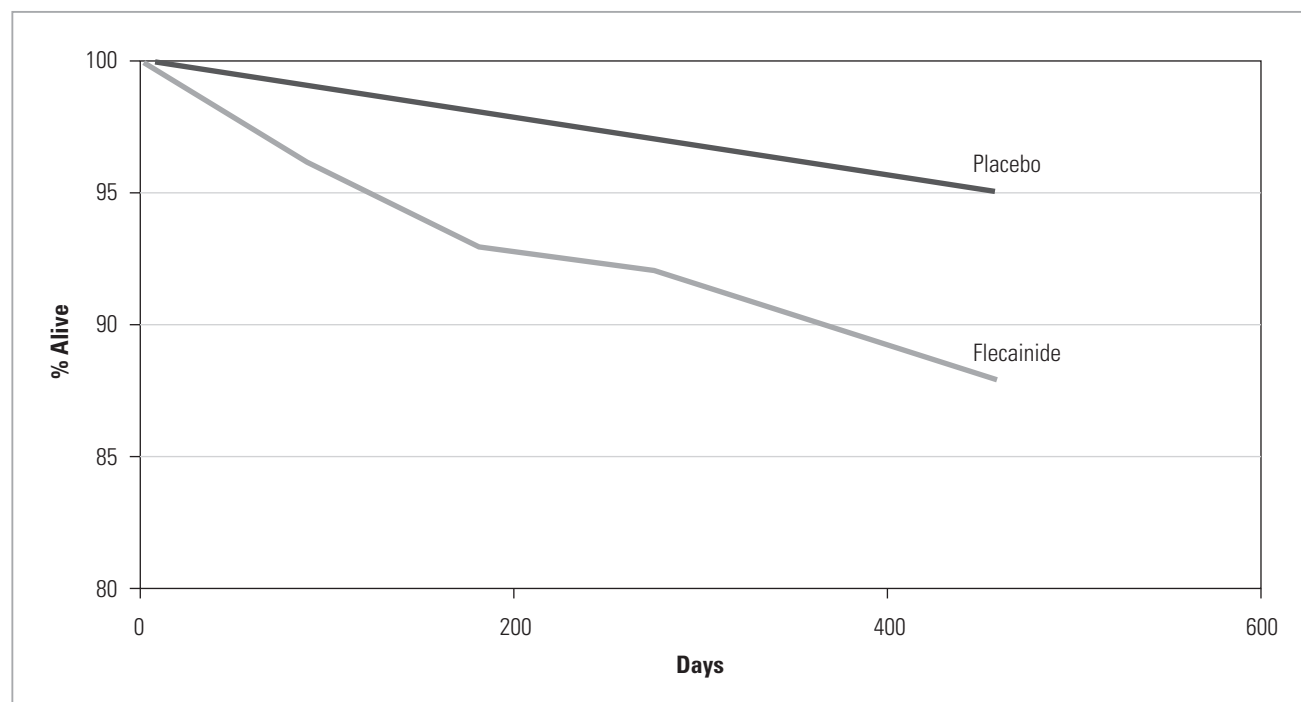
[I suggest this next section is omitted – it interferes with the flow and is not that important: if you leave it in, please get back to me as it will need to be amended. The ‘best’ applied evidence depends on the type of question. Different questions will be examined in different ways, for example:

- Measuring the frequency of a problem may be done by means of a random (or consecutive) sample.
- Identity of the sufferer from the problem will depend on the prognosis.
- The nature of the phenomena/problems may be established by means of observation (for example, qualitative research) and follow-up of the inception cohort.
- Diagnosis may be used to determine whether a particular person has the problem using a random (or consecutive) sample with the Gold Standard.
- Intervention or therapy to alleviate the problem would be developed by means of randomised controlled trials (RCT).

I will focus mostly on applied research and issues related to preferences and judgements. I will begin by using the specific example of arrhythmia that occurs in people after a heart attack. The outcome that we are interested in is preventing sudden death after a heart attack. People with rhythm disturbances are four times as likely to die. The drug Flecainide has been found to stop the rhythm disturbances, and one would therefore expect Flecainide to prevent death.

* Les Irwig, Screening and Test Evaluation Program, School of Public Health, University of Sydney, Australia

Figure 1: The cardiac arrhythmia suppression trial



A randomised controlled trial was carried out to test the effectiveness of Flecainide in treating patients with rhythm disturbances compared with a placebo. The percentage alive after 400 days after administration with the placebo was 95%, but fewer than 90% survived among the group treated with the Flecainide drug, which was expected to be effective (see Figure 1).

Numerous deaths were caused through the use of Flecainide before the trial was carried out. Moore (*Deadly Medicine* 1995) reported:

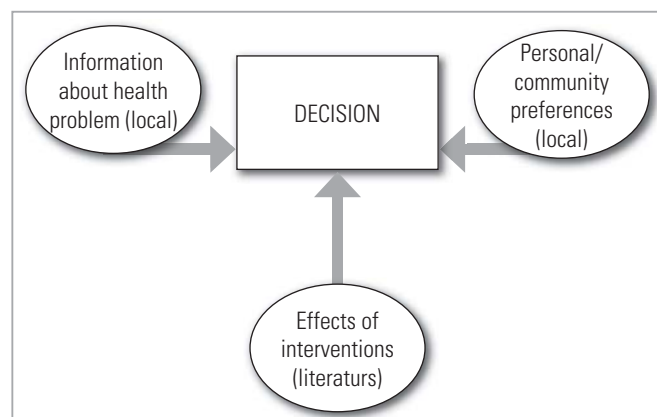
At the peak of their use in the late 1980s, it has been estimated that anti-arrhythmic drugs were causing between 20 000 and 70 000 premature deaths every year in the United States alone. This annual death total is of the same order of magnitude as the total number of Americans who died in the Vietnam war.

We need to examine the effects of interventions on person-centred outcomes that matter to people, such as survival and quality of life. This is a lesson that it seems we have to keep relearning. Richard Asher, writing in the *Lancet* in 1961, noted:

The question to which we must always find the answer is not 'should it work' but 'does it work'.

We cannot rely directly on basic science results. They will generate opportunities and possibilities, but the selection of useful and effective interventions requires the stage of

Figure 2: Evidence-based decision-making



applied research, which must consider the effect on person-centred outcomes. Another important issue in looking at person-centred outcomes is that they make it easier for non-scientists to understand the evidence, since they do not depend on grasping complex scientific measurements. Evidence that focuses on person-centred outcomes will generally be acceptable to people without the need for specialised insight into the results.

EVIDENCE-BASED DECISION-MAKING

In taking decisions based on scientific evidence, we would need to know the effect of the intervention (which could

usually be gleaned from the research literature), as well as information about the health problem (which often depends on local data on an individual patient or on the health profile of a community). Personal and community preferences will also affect the decision, since there will often be trade-offs, in that very few interventions provide only benefits without drawbacks, and consideration has to be given to whether the tradeoffs are worthwhile (see Figure 2).

Studies of interventions or policies must take account of the complexity of the situation, in that evidence cannot necessarily be readily transferred from one situation to another, as well as the complexity of the intervention or policy. We need to think about the applicability of results from studies elsewhere. We also need to think through the ethical principles in terms of beneficence, non-maleficence and respect for autonomy and justice.

ESTIMATING THE BENEFITS FROM RCTS

We know with breast cancer that there is a reduction in breast cancer mortality in women who are regularly screened by means of mammograms. The mortality reduction is about 40% in women aged 50–74 and about 20% in women aged 40–49. Considerable effort has gone into making this information available to communities with the purpose of recommending screening. If the issue is looked at in more depth, however, considering how to use the information, we have to look at benefit–harm balance sheets (that is, what benefit is obtained, and at the risk of what harm). Table 1 shows that for 1000 women aged 40–49 screened for breast cancer five times over ten years, a quarter would have to be recalled for more tests, which produces anxiety, and 60 would be referred for a biopsy. Without screening, 14 cancers would surface among the group of 1 000. With screening, 21 cases of cancer would be found. Some of the difference is accounted for through cancers that are diagnosed early, but it has been discovered that some of the diagnosed cancers would not have progressed during the lifetime of the patient. This is thus an instance of over-detection. The mortality from breast cancer for the screened group is 2.5 women, as opposed to 2.0 for unscreened women.

Table 1: Benefit–harm balance sheet for 1000 women aged 40–49 screened for breast cancer five times over ten years

	Screened	Not screened
Recalled for more tests	250	–
Biopsy	60	–
Breast cancer diagnosis	21	14
Die from breast cancer	2.5	2.0
Die from other causes	11	11

The results of asking the opinions of women in weighing up the benefits and harms of screening for breast cancer are shown in Table 2.

Table 2: Benefits and harms of screening: Perceptions of women aged 40–49

Benefits outweigh Harms	62%
Harms outweigh Benefits <	12%
Benefits are equal to Harms	25%
Give women all the information so they can decide for themselves	65%

Source: Cockburn J, et al. *ANZ J Public Health* 1999; 23(3):318–321.

The findings point to the need for respect for autonomy in that cancer-screening decisions are preference sensitive. A choice either for or against screening can be rational. We need to give people balanced information about the benefits and harms and let them choose. However, not one of the 57 Australian pamphlets consulted give the necessary information to enable women to take an informed decision on screening for breast cancer (Slaytor & Ward [1998] BMJ)

The questions we need to ask about research in terms of evidence for policy-making include:

- Is the research on the right species (not laboratory animals or in test-tubes but on humans)?
- Were appropriate outcomes considered in terms of being person-centred, in that all the benefits and harms have been considered, whose preferences have been considered, whether all the relevant research was identified, whether the research is of high quality and whether studies can be pooled and considered collectively?

Systematic review of research findings for policy-making entails identifying all the relevant studies, identifying those of adequate quality and summarising the results through a process of meta-analysis.

WHY IDENTIFY ALL THE STUDIES?

A study has recently been published which examines whether liquid-based cytology (LBC) should replace conventional cytology (CC) for Pap smears to detect pre-cancers of the cervix.

The claims for LBC include that slides can be read more quickly, there is a lower rate of unsatisfactory slides and better detection of important cervical pre-cancers, as well as detecting fewer very mild 'nuisance' abnormalities.

LBC has been adopted by screening programmes in the USA, England, Scotland and Wales, but has not been adopted in Europe, Australia and New Zealand, which suggests that people are interpreting the evidence in different ways.

All the studies in the literature comparing liquid-based cytology with conventional cytology were identified. Of the 147 articles in the literature, only 56 fulfilled the inclusion criteria for the study. Of the 56 papers, quality was found to be ideal in none, high in five, medium in 32 and low in 19.

After looking at all the available studies in considering whether liquid-based cytology should replace conventional cytology for pap smears to detect pre-cancers of the cervix, one can conclude as follows with respect to the claims in favour of LBC:

- It is unproven that LBC results in a lower rate of unsatisfactory slides than CC.
- It is unproven that LBC results in better detection of important cervical pre-cancers than CC.
- LBC probably detects more mild 'nuisance' abnormalities than CC.

If a policy decision had been based on a single study, it could have gone either way, depending on which particular study was selected. It is thus important to look at all the evidence and to consider the quality of the various studies before taking policy decisions. If that had been done earlier, it might have prevented the current diversity of policy and the furore now that an analysis of the basis for the policy has been published.

Another policy example is that of banning smoking in public places such as restaurants (except in designated areas). Before the policy decision, there were fears that such a policy would have a negative impact on patronage and revenue of restaurants. These fears held up the introduction of the policy in many countries for a number of years.

Systematic reviews often evaluate more complex policy interventions than simply drug trials. For example, a systematic review of evidence has been done as to whether a smoke-

free policy reduces restaurant income. The review considered the quality of 97 studies on the economic effects of smoke-free policies on restaurants, bars, hotels or tourism. Some of the studies claimed that income was reduced, while others claimed the opposite (Scollo, Lal, Hyland, Glantz, *Tobacco Control* 2003;12:13–20). The quality criteria used in the systematic review included:

- Objective data (such as tax receipts or employment statistics).
- Inclusion of all data points after the law was implemented and several years before.
- Use of regression or other statistical methods that control for secular trends and random fluctuation in the data.
- Appropriate control for overall economic trend.

The researchers used methods to try to infer whether the studies had engaged a long enough time period both before and after the introduction of the policy to disentangle a policy effect from an economic trend (given that all the studies reported on before–after situations).

None of the 21 studies that met all the quality criteria reported a reduction in income after the introduction of the no-smoking policy. In fact, four of the studies reported an increase in income. The studies reporting a reduction in income were all of low quality.

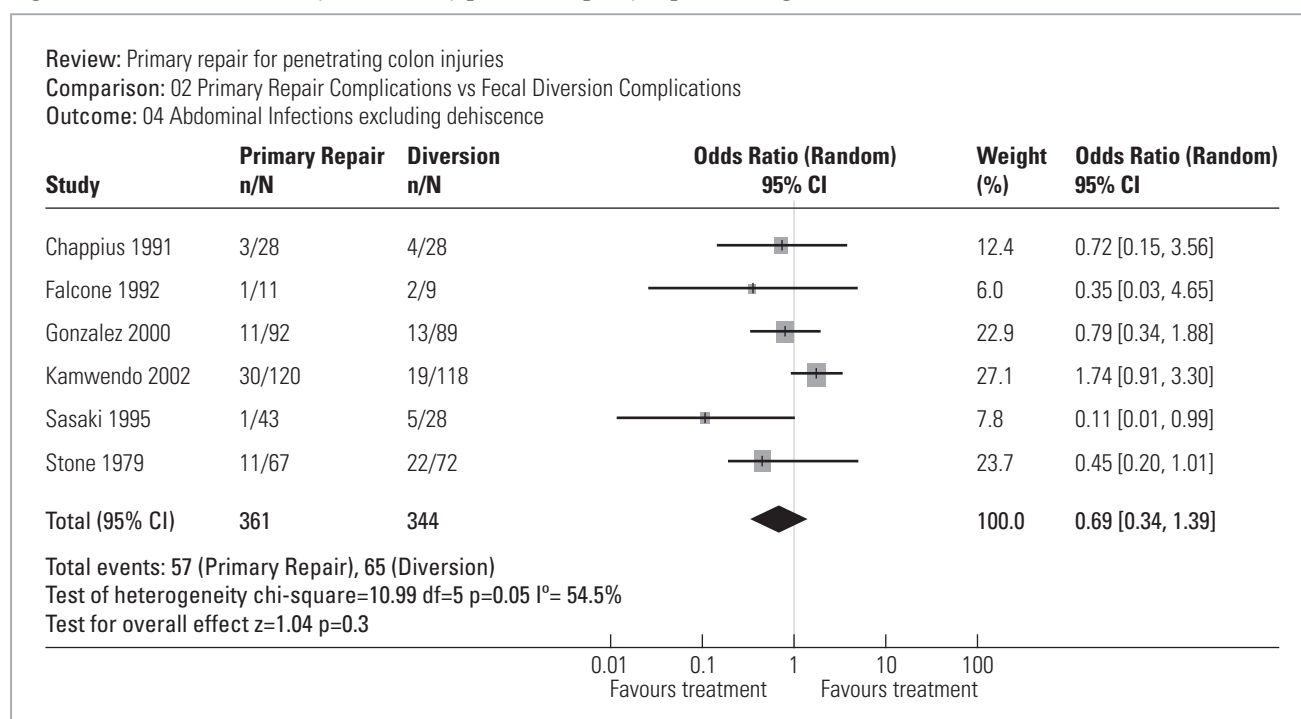
A South African example is the work by Sydney and Emily Kark, who looked at the infant mortality rate at Pholela in 1942–1943 and compared this with the situation in 1950–1951 to evaluate complex interventions with respect to community-oriented primary care (Table 3).

Table 3: Infant mortality rate at Pholela in 1942–1943 and 1950–1951 after interventions

	Number of live births	Number of deaths	Infant mortality rate (IMR)	% decline in IMR	Relative risk
Before intervention	121	34	281	Baseline	Baseline
After intervention	584	58	99	64.8	0.35 (0.24–0.51)
Area not yet intervened (control area)	53	10	189	32.7	0.67 (0.36–1.26)

Source: Kark SAMJ 1952, quoted as a Public Health Classic by Susser, Bull WHO, 1999

Figure 3: Systematic review of advocacy of primary repair for penetrating colon injuries



ARE RESULTS FROM RESEARCH IN OTHER COUNTRIES APPLICABLE IN SOUTH AFRICA?

There are several reasons why results might not be applicable across countries, including the setting, patients, interventions (in terms of skills and resources) and preferences. Applicability is especially an issue for complex interventions, such as changes in policy or health services. There is a need to explore the heterogeneity of effects between countries (Chinnock, Siegfried & Clarke *Plos Med* 2005).

The Cochrane Collaboration is an organisation devoted to systematically reviewing evidence in health and making it available electronically. An example is the review of evidence of the need for primary repair for penetrating colon injuries. All the studies from Western countries are in favour of primary treatment, and a study from South Africa is the only one to advise against primary treatment (Figure 3). It is necessary to consider reasons for variability that might reduce transferability.

ACKNOWLEDGING COMPLEXITY

The work by Lyn Denny at the University of Cape Town shows how things may be considered differently in southern Africa compared with Australia, where liquid-based cytology was compared with conventional cytology. Resources are more limited for cytology in South Africa, and considerable training is required. It might thus be necessary to consider alternatives that may be either less or more sophisticated. A less high-tech method is direct visual inspection (DVI), and a more high-tech method is a test for the virus that is known to be one of the precursor requirements for the development of cervical cancers (HPV DNA [HC II]). Both direct visual inspection and HPV DNA (HC II) are sensitive and detect many of the pre-cancers, but unfortunately they are not unspecific, and also detect many abnormalities that are unimportant. A three-arm randomised trial of the screening methods for cervical cancer was conducted in Cape Town in 2000. It evaluated the effectiveness of screening and immediate treatment of women with positive screening tests. The women were divided into three groups:

- Those that were treated on the basis of positive direct visual inspection.
- Those that were treated on the basis of positive HPV DNA.
- Those in whom treatment was delayed.

The differences between treated and untreated groups were found to be statistically highly significant after six months (Table 4).

Table 4: Advanced pre-cancers at six months after randomisation

	Treat if DVI	Treat if HPV	Control
6 months (n = 5667) CIN 2 or greater	2.2	0.8	3.6

Source: Denny L., *JAMA*, 2005; 294:2173–2181

The two alternative methods also identified a number of false positives, giving rise to over-treatment. The question remains whether over-treatment is an acceptable price for women to pay for the significant but numerically small reduction in the incidence of cervical pre-cancers.

RCTs can be done on complex interventions, for example, a study in Tanzania of whether treatment of sexually transmitted infections (STIs) reduces HIV transmission. The study involved about 10 000 people, with six matched pairs of communities (matched for geography and socio-economic circumstances). One of each pair was randomised to receive clinics providing STI treatment. The results show an overall reduction in HIV transmission over the

period. In each match community, the STI treatment clinic had an impact on reducing HIV transmission (Table 5).

Randomised controlled trials (RCT) are acknowledged as the best evidence to be found in the area of health, and I believe the best evidence in other areas as well. In the field of medicine, there has been a 40% increase in randomised trials reported in *Medline* between 1992–1995 and 2002–2005. However, there has been a 12% decrease in randomised trials in South Africa over the same period (Table 6). South Africa thus appears to be moving in the wrong direction, given the importance of randomised controlled trials in providing evidence and the issue that trials from other countries may not be applicable.

Table 5: Results – HIV seroconversions %

	Intervention	Control
Overall	1.2	1.9
Pair 1	0.9	1.4
Pair 2	0.5	0.8
Pair 3	2.6	3.2
Pair 4	1.8	3.0
Pair 5	0.5	1.5
Pair 6	0.7	1.4

Source: Grosskurth et al. *Lancet* 1995; 346:530–536

Table 6: Growth in medical research (1992–2005)

	1992–1995	2002–2005	% change
World-RCTs	35 730	50 343	40% increase
SA – RCTs	178	157	12% decrease
South Africa – all studies	3 423	4 534	32% increase

RCTs can be designed as part of the roll-out of possible new policies. An example is the recent introduction of bowel cancer screening in Australia. The question was which of two possible tests to use, both of which ranked equally. Rather than making an arbitrary choice, the decision of the Australian government was to design a test based on randomised households.

The advantages of randomising as against alternative tests include that it acknowledges uncertainty, ensures best choice, introduces a process for dealing with new tests in the future, avoids risk of relying on a single test manufacturer and is a fair way of dealing with uncertainty.

HIERARCHY OF EVIDENCE

Systematic review of several high-quality studies would be at the top of a hierarchy of evidence (and RCTs would be at the top of the hierarchy if the question was about intervention), followed by one high quality study, low quality studies and opinion in last position in the hierarchy.

EVIDENCE AND POLICY

Evidence used in formulating policy should be accessible, and there are a number of sources:

- In the health field, the Cochrane Collaboration (Evidence-Aid), which is free to any Internet user in Australia, and used also to be free in South Africa.
- World Health Organisation (Reproductive Health Library, Essential Medicines).
- In the field of education, the Campbell Collaboration.

If the results of studies are valid, they should be applied. An example of failure in this regard is the unavailability of magnesium sulphate in Mozambique and Zimbabwe for treating pregnant women with eclampsia, which is a simple, inexpensive and effective remedy (Sevene et al. BMJ 2005). If the evidence is insufficient for conclusions, or is not applicable, further studies will be required.

From the consumer perspective, randomised trials to assess the effects of an intervention are ethical and feasible (even for complex interventions), if there is uncertainty about the effect of proposed interventions. There should be respect for the autonomy in weighing up the benefits and harms of intervention. If the benefit clearly outweighs harm, on the basis of sound evidence, the recommendation would be that the intervention should be used. If the harm outweighs the benefit, the intervention should not be used. In a situation of equipoise, where benefits and harms appear to be in balance, or where the evidence is poor, authorities might consider carrying out (and communities might consider participating in) randomised controlled trials.

CHALLENGES FOR RESEARCHERS

The challenge for researchers in fields such as health, education and social policy is to:

- Anticipate policy-makers' questions.
- Define alternative policies or interventions.
- Identify outcomes in terms of potential benefits and harms.
- Decide on interventions based on best available evidence from a systematic review, taking into account the community view of how the benefits and harms weigh up.

If uncertainty remains, it becomes necessary to conduct a study, which would be a randomised trial if the question is about the effects of an intervention: Is it ethically justifiable not to conduct randomised controlled trials?

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Panel of South African respondents

From eminence-based to evidence-based: Challenges for judicial decision-making in South Africa

Thea Illsley*

INTRODUCTION

My brief today as part of this panel is to respond to the evidence debate from the vantage point of my own discipline – at first glance a relatively simple task since, as it happens, my discipline is the law of evidence. Closer scrutiny of the materials on the evidence-based movement reveals that quite the opposite may be true. In fact, having ventured into the materials dealing with the evidence-based movement, I have to conclude that, just as the United States of America and the United Kingdom are often said to be two nations divided by a common language, the disciplines of natural sciences and law are also divided by the two very different meanings they attach to the concept of evidence (Eisenberg 2001: 369 – 373).

Although the influence of the evidence-based movement and the debates it has generated may have spilled over into the field of law in countries such as the United States, very few South African lawyers have any idea what the debate is about or, more specifically, how it may have any impact at all on judicial decision-making. In my own case, at least, the exercise has, in fact, left me with a number of uncertainties about the discipline in which I have found myself for 14 years. What follows here, then, is an attempt to begin to explore some of those uncertainties.

This paper considers the divergent meanings of the concept of evidence in the courtroom and makes a number of observations in this context. More specifically, it examines the endeavour of incorporating evidence-based practice into the judicial decision-making process. In the first place, it does so by providing a brief survey of the role of the expert witness. In the second instance, it examines how the adversarial system of adjudication, an essential feature of South African law, has influenced the role of the expert witness in our courtrooms. It also takes a closer look at the view that expert witnesses are nothing more than ‘hired guns’, who provide favourable testimony for the clients who hire them to testify and who are biased in favour of their clients. Finally, this paper considers a number of ways in which law and health care approach the concept of evidence.

EXPERTS IN COURT

The primary function of the medical expert is to guide the court as to a correct decision on questions falling within the expert’s specialised field (Carstens 2002: 430). In this regard, the expert witness constitutes an exception to the general rule of evidence in that a witness who is called upon to testify may only relate facts and not opinions. (Although this is the rule in theory, it may be difficult in practice to distinguish between facts and opinions.) The opinion

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of the expert witness is admissible because, as a result of his/her particular knowledge or training, the expert is better equipped than the court to make inferences from a specific set of facts. As such, he/she can provide information the court does not have to its disposal and will assist the court in coming to a decision (*Ruto Flour Mills v Adelson* (1) 1958 4 SA 235 (T))

Although the need for expert evidence may vary according to changes in public knowledge, the exponential growth in science has resulted in an increase in both the range and the complexity of the issues that form the subject-matter of expert evidence in our courts (Meintjes-Van der Walt 2003). Expert evidence may be received by courts on such a variety of matters that it is impossible to draw up a list of cases in which a court may possibly receive such evidence. Some recent examples from South African case law include expert evidence regarding the Muslim faith (particularly what the requirements are for a person to practise as a Halaal butcher) (*Food and Allied Workers Union (FAWU) and another v Rainbow Chicken Farms* [1999] JOL 5682 (LC)), and expert testimony about the reconstruction of a motor vehicle collision (*GS Fouche Vervoer BK v Intercape Bus Service* [2006] JOL 16651 (C); *Radasi v RAF* [2006] JOL 16725 (EL)).

Concurrently with this growth in the need for expert evidence in courts, lawyers have increasingly been questioning the science underlying the claims of expert testimony, particularly in the field of the health sciences (Pappas 2005: 595 at 598). In order to establish a more reliable and objective framework for assessing the admissibility of expert medical opinion, legal scholars are looking at the possibility of supplementing legal rules of evidence with standards of evidence-based medicine (Pappas 2005: 595 at 598).

One of the reasons why legal scholars are looking towards evidence-based practice is that they have started to lose trust in the reliability of expert testimony and the ability of this type of testimony to settle judicial disputes objectively. At the very root of the problem lies the adversarial nature of the procedure that is followed in order to settle factual disputes in common law.

ADVERSARIAL TRIALS AND EXPERT EVIDENCE

The adversarial model of adjudication is based on the assumption that the truth in any given situation is best attained in a setting resembling an old-fashioned dual. Each party to this dual or contest presents evidence aimed at serving the specific interests of his/her party. Litigants challenge the evidence presented by their opponents and set out to expose the frailties of the opponents' evidence by making use, for instance, of cross-examination. In the midst of all of this, we find the impartial and independent judicial decision-maker (in South African courts, the judge or magistrate in the case) whose task is regarded as that of an objective, neutral 'umpire' or referee.

One of the consequences of the adversarial trial procedure is that, where the evidence of expert witnesses is called for, litigating parties choose those expert witnesses who are prepared to give their evidence the particular slant that would influence the outcome of the case to the benefit of the litigant on whose behalf they are testifying (Pappas 2005: 8 at 616). This development has given rise to the notion that trials where expert witnesses are used by the opposing parties have been turned into 'battles between hired gunslingers with nothing more than a feared reputation and weapons loaded with blanks'.

The 'hired gun' problem is compounded by aspects of the adversarial trial. The first of these is the financial reality that experts, unlike ordinary lay witnesses, are compensated for their services. This aspect of expert testimony clearly makes something of a mockery of the idea that the adversarial trial is a fair contest where parties compete on an equal footing and the playing fields are entirely level. The second aspect that exacerbates the dilemma is the emphasis in judicial decision-making on the qualifications of a specific expert witness and the confidence with which opinions are expressed, rather than the scientific basis of these

opinions. Some scholars refer to this as eminence-based decision-making versus evidence-based decision-making (Eisenberg 2001: 1 at 370).

Legal scholars and judges in the United States, another jurisdiction where the adversarial model operates, have been grappling with the question of how to counteract the effects of the 'hired gun' phenomenon. Initially, litigants bore the burden of persuading the court that an expert's testimony was based on methods or techniques that were 'generally accepted' in the relevant peer community. (The 'general acceptance' standard was originally formulated by the Court of Appeal in the District of Columbia in *Frye v United States* 54 App D C 46 (1923)). As dissatisfaction with the 'hired gun' phenomenon grew, it became necessary to find an alternative method for ensuring the reliability of expert testimony. After decades of debate on the issue (the details of which are beyond the scope of this paper) the Supreme Court attempted to settle the controversy in its decision in *Daubert v Merrel Dow Pharmaceuticals* (509 US 579, 113 S Ct 2786). In *Daubert*, the court established a 'gatekeeping' role for judges with regard to expert testimony. The court held the view that it is the responsibility of the judge in a particular trial to determine whether an expert's methodology and the principles underlying his/her opinion are scientifically valid. Some general guidelines were offered which are to be assessed in order to determine whether the theory or technique is capable of being (or has been) tested; whether it has been subjected to peer review and publication; what its known or potential error rate was, when applied; and whether it has gained general acceptance. (These guidelines were offered to assist judges but are not compulsory in determining the admissibility of the evidence. See *People v Shreck*, 22 P 3d 68, 90 (May 14, 2001), where the Supreme Court of Colorado held that a trial court may, but need not, consider the factors listed in *Daubert* in determining reliability.)

The experience in the United States highlights the valuable contribution of evidence-based practice to ensuring that expert evidence fulfils the purpose for which the law has intended it, namely, reliability and relevance. Unfortunately, it also shows that the exercise is fraught with difficulties. These difficulties, in my view, have as more to do with the differences between law and science than disciplines than with law itself.

LAW AND SCIENCE: DIVIDED BY A COMMON LANGUAGE

An important first step or condition in any endeavour involving the introduction of evidence-based practice into judicial decision-making is acquiring an understanding of the vital differences between law and science. Such an endeavour would have to take cognisance both of the differences in the *methodology* applied in the respective disciplines (Meintjes-Van der Walt 2000), and of the differences in the manner in which *evidence* is used in these two disciplines (Eisenberg 2001: 1).

The first most prominent difference between the use of evidence in the two different contexts relates to the fact that, in law, evidence is largely used to determine whether a particular individual has been harmed by a particular action or has been denied the opportunity to benefit from a particular action. In this way, law is concerned with evidence of the instance. Health care, however, is concerned with evidence of the generalisable (Eisenberg 2001: 1). Although the rules of evidence are standardised so as not to discriminate between differently situated persons, a major tenet of modern legal thought is that it is based on individual rights, obligations and harms. The use of evidence in health care, again, is largely aimed at achieving the greatest possible good for a population of individuals.

Another notable difference is the focus in law on the use of evidence to determine the effects of an action that has already taken place. Health care uses evidence *pre hoc* to inform a decision-making to render improved health; in law, evidence is used *post hoc* to judge responsibility and render justice (Eisenberg 2001: 1).

Finally, it is significant to note the differences between law and health care in the manner in which the two disciplines adjudicate differences. In order to create an evidentiary base for clinical practice, research findings are submitted in the form of articles that are sent out for review and critiqued before being published. Only once the findings have been published is it accepted that such a base has been established. In law, however, lawyers representing the relevant litigants choose which evidence to submit, and the court decides what evidence will be admitted, upon which the ultimate decision of the court will then be based. Judges and magistrates generally do not identify court-appointed experts to review the evidence before taking a decision on whether the evidence should be admitted or not. This clearly differs from the approach in health care where the final decision regarding the publication, or not, of the research findings lies with the editor of the relevant journal.

CONCLUSION

The goal of evidence-based practice parallels that of the legal system in the sense that both are aimed at making decisions based on the best available evidence (Eisenberg 2001: 8 at 623).

Our courts constantly grapple with the question of how to set boundaries for the acceptance of expert testimony in order to ensure that the evidence serves the purposes for which it is allowed by our rules of evidence (that is, reliability and relevance) (Carstens 2002: 2). The incorporation of evidence-based practice into judicial decision-making certainly involves significant challenges, which are the result of both the epistemological differences between law and medicine and the adversarial system of adjudication that is used in South Africa. It is submitted, however, that these challenges are not insurmountable and that evidence-based practice may be used very effectively to turn 'battles between hired gunslingers with nothing more than a feared reputation and weapons loaded with blanks' into 'gunfight(s) where expert marksmen use guns with high calibre ammunition' (Pappas 2005: 8 at 620).

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Should educators be wary of evidence?

Johan Muller*

INTRODUCTION

My principal focus in this presentation will be on technical knowledge produced by education researchers and practitioners. I am interested in innovations. I will not refer here to reflective and hermeneutical approaches to knowledge, valuable as they are. I am interested here in technical knowledge for policy. What is the status of evidence-based policy research in education? Should educational researchers be wary of evidence? For complicated reasons, many of them are indeed wary. Partly for this reason, policy-makers have paradoxically come to be wary about educational researchers and the products of their endeavours; that is, they have come to be wary about the evidence they produce. The internal reservations about evidence on the part of the education research fraternity has, in one of those unintended consequences so often found in the interface between knowledge and policy, come to fashion a stick to beat them with. The upshot is that there is a *very weak bond of trust* between policy-makers and the educational research community. This is an international phenomenon, but is certainly marked in South Africa.

It should go without saying that this is a most undesirable state of affairs. I will make the case in this presentation that if education researchers are to re-establish a strong role for education research in policy, they will have to find ways to construct a rigorous basis for their evidentiary claims. This will be a complicated business, for institutional reasons that I will discuss. I also hope to make it plain, however, that it is achievable; indeed, that there are encouraging signs of progress in this regard.

I will begin this presentation with an analysis of the status and position of education research as a knowledge sector, and compare it to other knowledge sectors. This will reveal some of the inherited possibilities and limits for advance which, I would like to stress, cannot be laid at the door of the present generation of researchers. I will discuss some progress made in buttressing education research in general and with respect to research into effective practices in schools, ending with a practical example with which I have been involved that shows that it is possible to make fairly strong evidentiary claims about education with direct relevance for policy. I will conclude that this is the only way that education researchers will regain the confidence of policy-makers and hence re-establish a productive basis for engagement with policy.

KNOWLEDGE SECTORS, MODES AND SPILLOVERS

Knowledge growth is a profoundly collective enterprise. Even when a single individual achieves a breakthrough, this is almost always on the basis of what has gone before. We stand, as both

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Newton and Google Scholar have said, on the shoulders of giants. It follows that the ways in which knowledge sectors organise this collective accumulation is critical. Knowledge sectors differ as to their rate of knowledge accumulation. Examples at the high accumulation end of the spectrum, are biotechnology, as well as disciplines of medicine and transport. At the low accumulation end of the spectrum, we find management, urban development and education. Low accumulation sectors show a relatively slow rate of production and dissemination as compared with high sectors. The issue is to understand the basis for this difference. Following Dominique Foray & David Hargreaves (2003) I will discuss this difference in terms of their different modes of institutionalisation of knowledge production and transfer, and in terms of their richness in spillover potential.

MODES OF INSTITUTIONALISATION

We can distinguish two modes of institutionalisation of knowledge accumulation, namely: experimental mode and learning-from-practice (See Table 1).

Table 1: Modes of institutionalisation of knowledge accumulation

Experimental mode (science in technology)	Humanistic mode Learning from practice mode
Controlled experimentation	Situated learning by doing
Knowledge-technology link	Embodied practitioner knowledge
Off-line – strong institutions of application (such as R&D labs)	On-line – applications on site (such as classrooms)
Highly codified, hence easily transferred, disseminated and absorbed	Often not codified, hence weak transferability and dissemination
Strong incentives to produce and disseminate	Weak incentives to produce and disseminate

KNOWLEDGE SPILLOVERS

Sectors differ also as to the rate at which knowledge becomes publicly accessible and absorbed by those other than the originator. This is referred to as spillover. Spillover rate is strongly conditioned by competition and cooperation. Competition in the form of incentives to produce new knowledge creates a strong impulse for researchers to raise their game by developing 'absorptive capacities' (that is, processes for monitoring what else is going on in the sector and maximising the possibility of learning from the innovations). Codification and dissemination is clearly critical to this. Competition thus, by increasing spillover, pushes up the general level of activity in the sector. Where competition is weak, as in education, dissemination, at least to practitioners, is largely by way of 'reforms'. Take-up is weak, the dosage of the treatment correspondingly weak (as I will show presently), and growth and innovation also correspondingly weak. Cooperation among researchers is a second means of fostering spillover.

Sectors that are spillover-rich generally combine competition and cooperation.

To sum up so far:

- Sectors differ therefore as to their relative combination of modes, and their spillover-richness or poverty.
- No sector can productively rely on only one mode. This is particularly evident in sectors such as biotechnology and medicine, where learning from practice is an intrinsic part of the innovation system, even though the scientific mode is dominant.

- In low accumulation knowledge sectors, not only does a weak relation between modes occur, but also antagonism between them. In each case, this weakens the sector even further in terms of:
 - Its capacity for growth and accumulation.
 - Its capacity for dissemination and take-up.
 - A consequent further erosion of public trust.
 - A consequent further reduction of money for research.
 - A further impairment of the potential for virtuous impact on policy.

EDUCATION AS A SECTOR

For structural and historical reasons, education has developed an antagonism between its modes, its scientific and practitioner wings. Neither mode is strong in South Africa, either in terms of its evidentiary claims or in terms of innovation. Historically, the scientific mode has, in South Africa, come to be identified with political conservatism, and its practitioner mode with progressivism. Besides being wrong, this creates a further impediment to their rapprochement.

The climate of the knowledge society has placed pressure on low accumulation knowledge sectors to strengthen their basis for evidentiary claims, and in education globally, there have been some signs of definite movement in this regard. I will discuss this further, but first I would like to take a particular sector of educational research as an example, namely, research into effective practices in schools.

EFFECTIVE PRACTICES IN SCHOOLS

School effectiveness research, including in South Africa, is characterised by considerable classroom-based learning from practice innovation, very little of which is formally codified. This is in contrast to other sectors, such as law, engineering and architecture, where specific-case learning from practice success is frequently codified and widely disseminated. Classroom-based innovations tend to remain context-specific, if not site-specific. There is little formal assessment of the innovations, hence little opportunity for assessment of success and the conditions for it. There is consequently a weak spillover and low levels of accumulation and growth.

This latter is further retarded by the small number of trained researchers relative to other sectors (which is changing), the lack of a shared theoretical/technical language, and the paucity of funding. Large-scale randomised designs in naturalistic settings such as schooling are vastly expensive, and large sample studies have until recently been rare partly for this reason. They have also been rare because of the reluctance to conduct formal experiments, as already discussed. There are weak incentives to disseminate learning from practice knowledge compared for example with the incentives for medical researchers to disseminate their innovations.

It is little wonder that Foray and Hargreaves (2003: 13) conclude: 'The system in education for innovation and the rapid spread of ideas and practices is deeply flawed'.

Again it is worth stressing that these researchers are not saying that the research is not good; they are saying that the institutionalisation of innovation and dissemination is weak. As already mentioned, the pressures for rapprochement between the different epistemic cultures have been increasing. This rapprochement will take a different form in education compared with medicine, for example, because in this latter sector there is a dominant mode and a complementary subordinate mode, whereas in education there are two rather weak antagonistic modes. In education, thus, the evidentiary base for both modes requires strengthening. I will discuss the strengthening of the scientific or experimental mode.

THE CLAREMONT DEBATE

In 2003, the US Department of Education’s Institute of Educational Sciences declared its commitment to experimental and some quasi-experimental designs over the plethora of ‘soft’ methods in the sector of evaluation research in education. The American Evaluation Association (AEA) issued a statement, signed i.a. by Michael Scriven, which sharply criticised the move. A group of senior AEA members issued a counter-statement signed i.a. by Mark Lipsey supporting the US Department. Claremont Graduate University in 2004 organised a debate between Scriven and Lipsey, to mediate the standoff, and to find common ground.

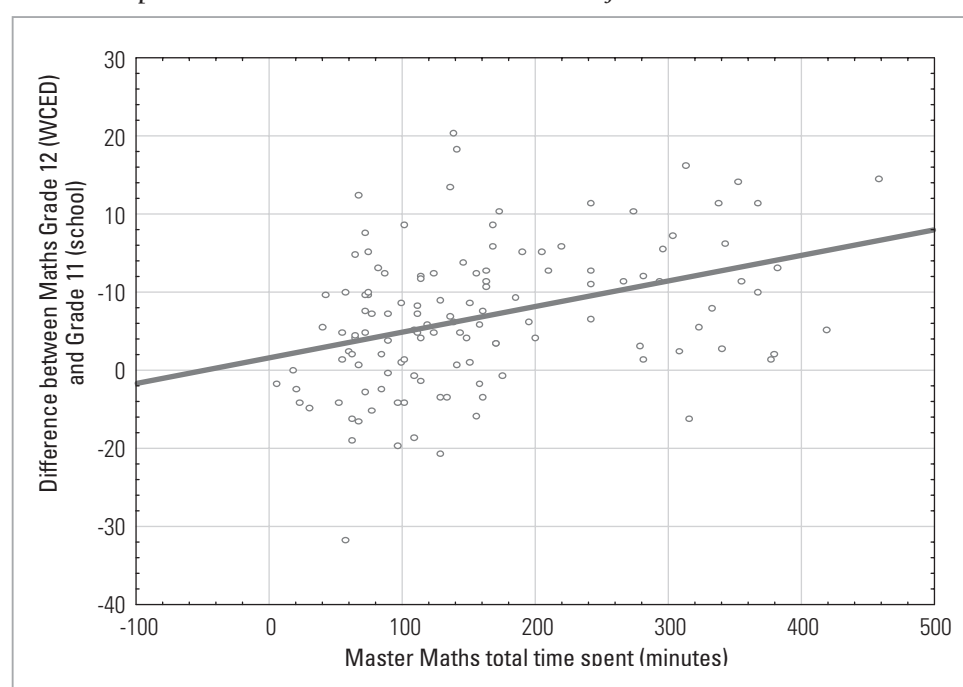
“Somewhat surprisingly, Lipsey and Scriven agreed that randomised trials are the best method currently available for assessing programme impact (causal effects of a program) and that determining program impact is a main requirement of contemporary (education) program evaluation” (Donaldson & Christie 2004).

Both Scriven and Lipsey recognised the undeniable theoretical advantage of using a randomised design in education programme evaluation, but recognised too that for practical and ethical reasons, it was not always desirable or feasible (though it is chastening to note that the Campbell Collaboration Social, Psychological, Educational, and Criminological Trials Register includes nearly 13 000 such trials and is growing fast). Nevertheless, Scriven at least believes that quasi-experiments with sound designs could be used to determine valid programme effects. This conclusion is echoed by two publications of the US National Research Council of the National Academies (NRC 2002, 2005). In these two reports, titled *Scientific Research in Education* and *Advancing Scientific Research in Education* respectively, as in the Claremont debate, we see the US education research community girding its loins to toughen up its evidentiary base and the training requirements at graduate level that this will require. This debate is also beginning in South Africa.

THE KHANYA EVALUATION

I conclude with an example from work in which I have recently been involved. It is frequently impossible to conduct a true experiment in education settings, largely because interventions

Figure 1: Relationship between time spent by learners on Master Maths and their improvement between Grade 11 and Grade 12 final mathematics examinations



are started before the researchers arrive on the scene (Taylor, Muller & Vinjevoold 2003). Researchers are therefore often unable to assign treatment and control conditions randomly to a sample population. Nevertheless, it is usually possible to randomly select from within the treatment population and from within a matched control population. This form of investigation, called a quasi-experiment, is increasingly common in education, and although it does not permit making causal inferences, does at least allow fairly indicative correlational inferences.

A colleague and I were commissioned by the Western Cape Education Department (WCED) in 2003 to establish whether a rather expensive investment in IT was worth the time and expense. A chosen sub-set of schools, all of them serving poor and disadvantaged neighbourhoods, had been given computer laboratories, their teachers specifically trained, WCED support staff specifically allocated to help them, and software provided for a range of subjects. We decided to investigate the mathematics software, called Master Maths (MM), and the question we sought to answer was: Does the administration of MM software to a random sample of treatment schools measurably improve learner performance in maths, when compared to a random sample of matched control schools? The study found that there was a strong correlation between the amount of time spent, and number of sessions spent, logged on to MM (dosage) – that is time on task – and improvement in maths performance from grade 11 to grade 12. The relationship between amount of time spent on MM and improvement in maths performance is positive, statistically significant and moderate in strength (see Figure 1 and Table 2).

Table 2: Pearson product moment correlation coefficients for the relationship between time spent on Master Maths and improvement in mathematics performance

	Difference between results on Grade 11 and Grade 12 mathematics examinations
Time spent on Master Maths	$r = 0.37$ ($p < 0.001$, $n = 125$)
Sessions on Master Maths	$r = 0.36$ ($p < 0.001$, $n = 125$)

The study also found that the intervention was delivered at widely differing strengths, and overall at an alarmingly low dosage level: treatment learners were logged in for an average of two and a half hours per six months. This low dosage level is a common feature of IT interventions, and of education interventions in general, and is a confounding factor when assessing the impact of any education intervention.

The result gives a firm message to the WCED that their investment is paying off, and that it would pay off even more if they took steps to ensure that the dosage of the intervention was maximised. Did they heed the message? It is hard to say for sure. The expensive Khanya project continues, but we do not know whether the dosage has increased. Did the WCED fully appreciate the findings? Again, it is hard to say, but we suspect that the answer is equivocal. The relative unfamiliarity of education policy-makers with reading the implications of hard data will have played a role. This simply underlines the extensive public responsibility of researchers to make sure that their results, and the policy implications, are properly grasped by the public custodians of social services provision, but first they must have a valid, reliable evidentiary base with which to bargain. Anything else leaves them stranded in an increasingly suspect ivory tower.

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The elitism of evidence

A paradox of human rationality

Mpilo Pearl Sithole*

A debate on the significance and utility of evidence in human life is long overdue, since we are often confronted with situations where evidence is either very important for decision-making or where it is extensively abused. There is no doubt that for human communication to be possible, there has to be common reference ground, and evidence can very neutrally fall into that space; or as a tool in decision-making, evidence can be used to prove and convince people in the context of multiple or unknown possibilities. It can therefore be said with confidence that evidence is integral to human rationality. This paper is in response to Les Irwig's critical argument on evidence and scientific reviews and is specifically targeted at what he refers to as 'preferences'. His argument for critical implementation of the outcomes of scientific reviews is bold enough to imply that scientific outcomes must be located within rigour in critical specific implementation as well. This paper zooms into the arena of practitioner–recipient relations and looks at the issue of individual preferences, influenced as they often are by both experience and culture.

When one abandons deliberating on the direct influence of culture in thinking and reasoning patterns (something which is quite risky to indulge in anyway), and looks at the human mind as a whole, it is clear that there are things that can be said about its fundamental need to speak from an evidence point of view, or at least to strive towards being 'objective'. 'Striving' towards being objective needs to be stressed here, as it would seem that the human mind can only strive to be objective; but perhaps objectivity is not something that humans must achieve. The line between objectivity and subjectivity is drawn by the very nature of human beings being rational (in other words, having to attribute reason and/or value) and therefore viewing things with an unavoidably judgemental eye. A human being who is not giving value to what he/she sees or experiences might as well be an object. A human being has to make a conscious effort *not to judge* what he/she experiences, or alternatively find it 'new' so that he/she can formulate fresh impressions about it. However, it is almost impossible to be human and not to have judgement, preferences or impressions. It is thus inhuman to be completely objective. The mind needs *something* to judge; and in cases where judgement is politicised (in that it involves personas with issues at stake), the mind usually needs evidence in its 'partisan' sense of providing proof. Evidence has been used as a fundamental need in human interaction, as signified by its central place in legal matters and in science. It relies on the senses and on the communal endorsement of the senses. Hence the positivist element of evidence comes into being – evidence must be concrete, tangible, witnessed or capable of being endorsed through repeatable measures.

The ability to seek and the need to find evidence is therefore a fundamental constituent of what makes humans distinct. However, the human pursuit of innovation and excellence

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that is enabled by the projection of positivism has led to evidence being seen in the context of vocations – institutionalised through the education system and branded with hierarchies perpetuating inequalities. The scientific world is the epitome of the hierarchy – the uneducated, students, the learned and scientists form a hierarchy of what striving for objectivism, within a choice of fields, is about. However, like anything that exists in power dynamics of hierarchies, particularly involving resources, reliance on evidence has been abused. Empires and territories of elitism have been formed, and abuse of power by some and disempowerment of others has resulted – all in the implied name of evidence. Evidence exists in a problematic context in which it is made elitist. It is argued in this paper that this is a paradox of rationality from which evidence is born. This is a two-level paradox. Firstly, rationality is a paradox because it calls for *objectivity* ('tangible' logic/evidence) and *reason* (attribution of value) at the same time. Secondly, evidence needs to be provided from the point of view of what is known, but the institutions that make it a vocation want to provide it in their own terms, generic and not comprehensible to everyone, which then makes it unreachable, limiting accessibility through the already known. The paradox is that something, which starts off from reason, ends up abandoning 'the reasoning subjects' and making itself an elite system of its own. What this means is that there is an artificially imposed incomprehensibility informing the way science and technology is often spoken about, or perhaps if not so artificial, it needs to be translated from the depth of theory to communicable language that links it with perspectives of normal people who should benefit from the knowledge.

Science and technology can be more human friendly than its practitioners make it out to be, if translation from the generic can be encouraged. It is in fact debatable whether scientists should continue to talk among themselves and not make an effort to translate their findings and get input from others. The classic cases are the rigidly maintained divisions between Western medicine and traditional medicine, economics as a science and livelihood systems, social models (for example, democracy, legislated programmes) and their applicability to real social life, and so on. These divisions unfortunately encourage and lead to other more deliberate forms of abuse of objectivity and evidence that are perpetuated by those privileged or trusted to handle evidence. It is clear that elitism is not sanctified. The practice of law has slightly different challenges. Its context of 'trial' binds it to be event-based and positivist in its practice. Perhaps other than acknowledging this limitation, it should be accepted that it must do its best not to make mistakes, but it can do little to change the situation for as long as normal senses and repeatable actions of causality are the basis of judgement. The reason why the Nkuna/Rasuge case of 2005 was quite unique in South Africa is because the major piece of evidence proving the misdeed (murder) was not found, and there was just sufficient indicative evidence to prosecute and find the accused guilty.

To return to abuse of evidence, when evidence is abused, it is made to be an absolute element that exists unproblematically and not in the context of a contestation between that which is subjective and the questionable desirability of absolute objectivity. We have to start by refuting this absolutism. To do this, we can start by examining what being subjective means. Firstly, being subjective means 'approaching things from a particular angle or perspective'. This is not necessarily negative as in fact there is hardly any instantly rounded perspective of looking at things or issues. Objectivism is 'achieved' through incremental attempts at holism – looking at all perspectives bit by bit. Science is also objective within specific disciplines, which are delineated perspectives of looking at reality from various scales – hence the often intuitive desirability of interdisciplinary initiatives in academia and other interventionist missions. Subjectivity and objectivity are thus part of the same continuum.

Secondly, there is subjectivism that says 'I have other ways of knowing that cannot be translated to normal objective ways'. This does not mean that the person ceases to be objective, but it means that they are not operating at a normal level and they realise it. It is a

question of different social cosmologies that people operate in and that influence their means of perception. A decent way for the objective and scientific who believe in provable logic would be to declare ignorance of this subjective ability on the basis of its self-professed lack of tangibility or proof. However the positivists tend to turn positivism into a belief system by wanting to contest this type of subjectivism as simply not possible or not true. Of course they cannot prove that it is not true because it is declared extra-positivist – and then they are forced to acknowledge that they *believe* it is not true, implying belief that positivism is the only thing that is true. However, people who are subjective in this way do not cease to understand (or participate in) the objective world of fact and proof, but they profess added abilities. This is another area prone to abuse. In other words, the extreme sides of the subjectivity/objectivity continuum are dangerous to reach and incur potential abuse as they are approached. This is unfortunately the uncomfortable location of evidence – it can either be reified or be hidden. The middle point is difficult to fix.

It is not possible to pronounce evidence as being completely overrated, since that is a contextual issue that depends on the specifics of each case under scrutiny. However, I think that at this historical juncture of social transformation, evidence can be accused of elitism, creating differentiation between those who purport to apply it systematically and those who apply it subjectively. This paper argues that despite the factual nature of scientific evidence, it is still prone to perspectives and reification that the human intellect is constrained to operate within and practise. There are three areas in which this elitism can be demonstrated. The first is the abstraction of both objectivity and subjectivity, with the former subordinating the latter. The second is the specialist jargon of evidence, which has secluded science from lay knowledge. The third is the institutional abuse of evidence – a self-perpetuating corruption rooted in the tautology of evidence and inherent trust in it and its specialists. Evidence is trustworthy and therefore not dubious, preferably as handled by institutionalised specialists. It can therefore hardly be put on trial for being abused.

THE HIERARCHICAL ABSTRACTION OF BOTH OBJECTIVITY AND SUBJECTIVITY

The link between evidence and positivism is something that people generally understand, perhaps as a general need to be concrete and practical, especially in communication. However, trained proponents of positivism believe that nothing else genuinely exists but positivism. They are almost completely subjective about objectivism, and yet tend to label the non-positivist with subjectivism. There are different senses for deciphering evidence, sight being the ideal. One of the weaknesses of science is its inability to blatantly admit to not knowing that which happens in the subjective arena of people's cosmologies. Cosmology is the broader world in which people locate and understand the normal and pragmatic world – cosmology is a world that is larger than what the objective factual world contains. In addition to the objective world, cosmology often includes religion and other notions of the interaction between the seen, the unseen and the hidden potency of the seen, such as trees, animal products and other objects that produce auras. People often co-exist with their different cosmologies (see, for example, Sithole 2000: 218–258)

Science cannot be expected to deal with these, but it can be expected not to judge them completely. The reason why the relationship between traditional healing and Western medicine has not been forged successfully is that there has not been a separation of the biochemical aspects of healing in traditional healing from the cosmological aspects, so that strategic links between the biochemical aspects and Western medicine can be forged. Traditional healers are regarded as living completely in the subjective world of their spirits, and their ability to engage in trances is interpreted as either escapism or psychological trickery. Until these issues are



dealt with – in ways that do not impose abstraction of people's subjectivity, recognition of different and unique ways of deciphering reality, possibilities of linkages on objective elements, and admission of ignorance about cosmological subjectivities – there cannot be progress towards exploring traditional medicine as possibly coming up with real solutions to illnesses.

Lack of consideration for cosmology is responsible for misunderstanding about patients' choices in hospitals where issues of religion emerge as blocking the potential for saving of lives. Rejection of blood transfusion is a popular example of this situation. In these situations, an accessible professional view and information becomes as much an ethical responsibility as allowing one to take one's own *informed* decision in the end. Unfortunately, cosmological aspects of life can lead to stereotypes about people. People are often told what is best for them without being told the details of why – then 'best for you' becomes an imposition over people. It does not matter what transfusion will do for

someone. If they reach an *informed* decision of 'no', they must be allowed to say 'no'.

EVIDENCE AT THE PODIUM: THE SPECIALIST JARGON OF EVIDENCE

It seems that in their fascination with starting from a sterile environment and controlling experimental factors, scientists forget that for issues that impact directly on people, people will start from 'what appears to be' and track the causes. This is about adopting a semi-objective approach of 'reading from experience' or from 'what appears to be' and tracking causality from that stance. Scientists have an urgent challenge to take what they know and

translate it or make it talk to the understanding of 'what appears to be'. Instead of doing this, they scorn those who from the scientists' point of view appear to be propounding subjectivity. There is nothing wrong with being subjective, but there is something wrong when the concept of subjectivity is abused by those who are supposedly objective to stereotype knowledge from those uncultured in objectivity, so that they do not attend to 'what seems to be' even if cast in quite objective terms. There is nothing too subjective about saying that AIDS seems to be killing the poor more than the well-to-do, and challenging science not to simply relegate this to the arena of social science and social intervention programmes but also to state exactly the nutritional, physiological and even genetic basis for this. Some people will listen to the seventh level translations of science (eat a balanced meal, you will be safe), but some require a third level translation of science (for example, the virus changes form as it matures in the body, cannot be controlled



biomedically and can only be toned down by general strength of the body via specific types of nutrition and physical fitness). If some people wish to understand exactly, in percentage terms, the reduced rate of progression to AIDS illness when eating well and being fit, as compared to when food is unbalanced and there is lack of fitness, let that information be provided in those terms. Whatever the level, it has to be cast from the angle of 'what appears to be', or related to what is already

understood for specific people. Moreover, it is not fair to expect people to listen to commands for behavioural change without sufficiently obliging their requests for explanations.

When President Thabo Mbeki expressed doubt about whether AIDS is caused by HIV rather than poverty, there was an outcry from the South African scientific world on the President's 'mistake' in revealing this doubt in public. Here we had one of the most pragmatic individuals on the continent standing up and doubting what scientific evidence had proclaimed as an undisputed relationship of causality between a virus and an illness. It was, from the point of view of certain health scientists, shocking.

What is equally shocking is how these health science critics of the Mbeki doubt, some of whom both conduct pragmatic health science based on laboratory evidence and have interests in African scholarship and Africanness, forgot about the people's angle of knowledge reception. Their judgements of 'the mistake' were thus issued from the elevated scientific podium. They have not asked what is before people as a whole, including the President, as knowledge on the causality of AIDS. Are people not justified in looking at patterns of illness, linking it to the observations and circumstances in which they occur and deriving meaning from that information? How else are non-scientists supposed to make impressions of illness? Is it not true that where poverty is acute, AIDS is also acute – both in terms of the rate of infection and also in terms of quickly reaching the illness stage? What evidence exists and what evidence is *apparent and reachable* are important issues that inform action.

It is patronising for science to communicate only that which is supposed to influence people's behaviour/actions. Some people will only act confidently once they are given the logic behind the desired change in behaviour that is communicated to them – no matter how simplified that logic is. Evidence is quite important, but its status as the truth in the face of experience, no matter what the impact is, has to be reviewed. Different people react differently to different medication, for example. This is sometimes understood in terms of their other physical conditions, but sometimes the reasons are unknown; the reactions they report simply do not make sense. This does not mean that the negative reaction does not exist. Evidence must exist in the context of an interface with experience, especially where people's lives are directly under scrutiny as in health. Evidence and experience must be given equal status of negotiation. Acting on the basis of only one and not the other can have fatal consequences.

Science has to allow subjectivism to a degree of pursuing or assessing its own utility from the angle of potential users, or even urgently, casting its explanations from the angle of users. We do not want to revere science for being scientific; we want to revere science for its ultimate utility to people. Its own abstraction/reification of methods is only a means to this end to which it must return via fitting translations.



INSTITUTIONAL ABUSE OF EVIDENCE

Research reviews that Chalmers (2005) and others see as the main information base for policy and practice have limitations in the way they treat real human life. In principle they are useful, but there is a need to remember that practical interventions must be informed by much more than the aggregates they generate – environmental issues of each case are equally important. It is the same old fundamental issue of social life: democracy of a referendum type is good in principle, but when it comes to individual human life, there is little bliss in majority versus minority choices or deriving decisions through data aggregates. When the issue is health, it might be more desirable to operate from an equal consideration of general trends and the specific details of each health issue as derived from the subject, even to inform treatment rather than simply diagnosis. Research reviews tend to work on aggregates and averages in order to arrive at generic conclusions of what the causes are, or the best combinations for treatment. Unfortunately, in practice little is done to situate the generic, aggregate-derived 'products' with respect to the specifics of the individual. This should be the meeting area of science and experience where what people say they experience is taken seriously. It may perhaps be said that this is catered for in the training of health professionals, but like many professionals, people tend to prioritise what their training tells them, and it becomes the patient's duty to search, via multiple self-referrals, for someone who gives due regard to the patient's perspective, and someone who is a considerate listener. Alternatively, patients who can afford to simply expose themselves to 'different hands' so that someone may end up identifying the real issue or other contributing factors.

Natural science does not see this in itself, because 'in theory' it should not be happening. It is social science that has fundamental problems. Chalmers (2005) quotes Oakely (2004: 15) arguing that:

... the usefulness of social science to public policy has been, and is severely restricted by, a number of features of social science behaviour related to its generally anti-scientific stance: opposition to systematic reviews as a way of making social science cumulative, disregard for the need for methodological rigour in assessing different strategies to promote human well-being, and a retreat into the safe but sterile reaches of paradigm warfare, especially the false harbour of qualitative methods and anti-positivism.

This is the epitome of scientific conviction on objectiveness, to the point of being religious about it. The problem about such views is that they often fail even to realise that evidence will answer the questions of what and how with respect to material/physical manifestations, but it will be limited in addressing the question of why certain things happen in the first instance. Human beings look at the objective reality in the context of other grand explanations of why certain things happen to them. The blunder of objective science is not to realise that those explanations are not alternatives to objectivity but add or locate it within broader conceptions of reality. Hence social science rightly tracks the meeting zone of what is factual or objective with broader explanations derived from and informing people's consciousness.

This is a fundamental issue, but there are other issues that derive from this. Objective practitioners in any field do not trust the hand of the untrained. For example, 2006 began with doubt about the safety of tap water in Pietermaritzburg. A number of residents fell ill, while the darker colour of water prompted one of them to submit a sample for testing to the responsible water authority. The Witness reported on 13 February 2006 (Pewa 2006):

On Wednesday morning ... I ran my bath water and noted that it was a funny beige colour. I checked all the other outlets to make sure it wasn't a dirty pipe. Sure enough the water was definitely weird," ... [Cunningham] said.

Cunningham filled a sterilised bottle with tap water and took the sample to the Umgeni Water offices to be checked.



"All people are equally rational and trustworthy ..."

That night ... I barely slept, I was in distress and pain. The next morning ... I paid a visit to the doctor. He said quite a few of his patients were suffering the same symptoms", said Cunningham. She said the results of the tests showed that the water contained 727 counts of coliform bacteria per 100 ml of water. She was told the acceptable level is zero or 10 counts at worst.

When the results of that sample proved that the water had a very high content of the harmful bacteria, the whole debate turned to the fact that this cannot be trusted as the real outcome, because the person who took the sample was an ordinary person, not from the water authority itself, and that procedurally the results should not have been released to this person. One wonders whether this water authority will find the contents of the water it provides to be problematic. One also wonders whether, with the lapse of time between the identification of this problem that prompted an outcry and the time it takes the water authority finally get to draw a sample, no improvements will have been made to the quality of water. Of course, the discrepancy of results between the first 'illegitimate' test and the test by the 'legitimate' authority will be attributed to ignorance or unreliability of the untrained in handling samples. The untrained are in a structurally inferior position in terms of taking issue with things produced under 'scientific rigour'. Even the parties involved sense the discomfort of their own privileged voice, as they also claim to have sent 30 other samples "to an accredited laboratory" while they conducted their legitimate tests



"... but those who act on behalf of institutions are more rational and trustworthy than others"

and awaited results; moreover, they also mention an “independent” laboratory (*Witness*, 14 February 2006: p2).

Who handles evidence (for it to be trustworthy) is still a big issue. Evidence is not used in the interests of people but in the interests of the institutions; those interests are the ones that are protected first and foremost. People are potentially dangerous to the interests of the institutions. If science is not done for its own sake and is truly done in the interests of people, it must find a way to prioritise people. Hammersley (2005) argues that “practice is necessarily a matter of judgement, in which information from various sources (not just research) must be combined”. To assume that a particular source of evidence is already in a privileged position of greater trustworthiness, even before dealing with the fact that all knowledge can be fallible, may be a big mistake that challenges the assumptions of equality of basic human intellect in handling logic generally.

CONCLUSION

As I indicated earlier, whether evidence is overrated needs to be a case-specific question for every practitioner. However, for us to arrive at practice informed by such questions, we need to eliminate the elitism that infests evidence-based studies. Evidence-based studies are very important; they are the basis for scientific achievements in all fields that influence and improve human life. However, such studies must be regarded as one source of information, and practitioners must be able to read the context within which their type of information co-exists with other information. There is an ethical responsibility to enable informed decision-making by both practitioners and the people served. This can only be done by maximum, or at least equal, sharing of information by all from all perspectives. The question is not only that “if evidence informed policy works in practice, does it matter if it doesn’t work in theory?”, as Chalmers (2005) put it. It is also whether evidence-informed practice centralises the values of equality and ethics in the interaction between people and practitioners, not simply to produce evidence but in how evidence is used in decision-making.

Policy and science fit together because of the need to produce equal standards according to which to treat or coordinate all members of the population. However, these standards must not preclude efforts to take cognisance of human preferences at individual and local level. It must always be borne in mind that human life is not to be forced into straightjackets of objectivity to the point of restricting choices based on broader human experience and rational abilities. Policy-making itself has failed to break away not only from reifying objectivity, but also from being an instrument that protects institutions and practitioners more than it enhances empowerment of or appropriate impact on the recipients of public intervention. Other than being direct protection occasionally, at its minimum this protection is in the emphasis on traceable action – working within sufficient ability to record action so that there is recourse for the institution, rather than the impacted population concerned. This is to say nothing about the scope left for the manipulation of outcomes of any disputable action to favour institutions, which verges on abuse. This is a dilemma of policy that requires careful and strategic hard work to overturn, despite the entrenched, disciplinary-straight jacketing that exists, conditioning intellectual creativity. Thus while evidence is absolutely crucial for policy formulation, policy itself must begin to carve its relationship with impact and preferences.

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General discussion

- **Thabo Dithane:** In the Master Maths interventions, did the researchers investigate the performance schools to see why they were performing at that level, since there are high performance schools in mathematics and natural sciences that do not use Master Maths. Could you elaborate on the comparison and how the data were obtained?
- **Johan Muller:** The intervention and control schools selected for the study were chosen so as not be part of any other intervention. They were thus schools that were relatively intervention free. There are very few schools that do not have between five and eight ongoing interventions at any one time. It is very difficult to isolate effectiveness, which is why the non-reactive measure of actual logged-on time was used.
- **Themba Mdlalose:** I would like to suggest that the group that spent the most time logged on to Master Maths may have done so because they were not intimidated by mathematics in the first place. It should therefore not be surprising that they performed better.
- **Johan Mouton:** I was struck by the fact that the four papers considered different ways of looking at evidence. Prof. Irwig's paper looked at the way in which scientific evidence in the field of medical research can be interpreted in different ways depending on whether the evidence is rated as less or more robust. Some of the interesting findings from systematic reviews show that within the scientific community where systematic reviews are now being used, previous policy decisions could have gone different ways if there had been a more systematic approach to the use or non-use of evidence.

The comparison between law as a field of practice (Dr Illsley paper) and medicine as a field of science (Prof. Irwig paper) shows up how the notion of evidence is used quite differently and how the nature of practice in law produces a very different approach.

What I found particularly useful about Prof. Muller's approach is that he reminds us that we cannot speak about evidence unless we have a broad understanding of the underlying epistemology and methodology of knowledge sectors. We always have to link any discussion of evidence to understanding different notions of knowledge. Perhaps the debate will progress more if we (1) accept that classical distinctions between objectivity and subjectivity are not particularly useful in talking about scientific evidence and (2) that we must link discussions about notions of evidence with different notions of science and scientific practice. This explains some of the useful points made by Dr Sithole about communicating science to different audiences.

- **Sharon Fonn:** I do not want to dispute the value of evidence-based medicine. It has an enormous place and a role to play, but it is also true to say that what you can generalise from randomised controlled trials is limited, firstly to the degree to which those populations represent the general population, and secondly in the kinds of questions that are answered. Frequently, the tyranny of evidence-based medicine is such that the research required to move from evidence to policy to practice is devalued because it does not fit into the classical form.

I was particularly impressed by the contribution by Dr Sithole, as it speaks to the breakdown of our ability to make inroads, for instance, in the area of institutionalised programmes for HIV. Even where we have outstanding RCT-based evidence that treatment works, we are still not bringing people in to treatment even when we can deliver. We have to understand why. I think the presentation speaks to the research gaps and our failure to address such issues.

In designing studies, we have to start looking at who designs them and who asks the questions, and underline the separation between those who are considered to be imbued with greater knowledge than the rest of us. The best evidence of that comes from a 20-year-old movement that asks where the women are in science and why issues around gender are ignored.

One of the best examples of that was a study of insecticide-impregnated bednets in West Africa, where they were being used, but the expected decreases in child mortality were not evident. Primarily, this was because in the design of the RCT study, no-one asked who makes decisions in the household. Because that question was not asked, it did not become evident that the primary decision-maker in the family, the father, would be the one sleeping under the bednet, and that the pregnant women and children at risk of death from malaria were not sleeping under the bednets.

The issue is not that there is a problem with RCTs, but who designs them and who comes up with the questions that need answering.

- **Les Irwig:** The comments by Prof. Fonn are a rich source of many issues. I feel strongly, as you point out, that RCTs will often have limited applicability for a variety of reasons. That is why it is a great sadness to me that there are not more such trials done in South Africa and other low and middle income countries, as there will often, as in the examples I showed, be differences. However, we are often left in a situation in which we do not have a chance to assess whether there are differences or not. This calls for more local trials.

It is also true that RCTs are limited in the questions they can answer, but we are nowhere near that limit yet. With respect to the example from the educational sphere that Prof. Muller was talking about, where computers were a highly expensive intervention in the selected schools, my view is that to be just and fair, those schools should have been randomly selected. This becomes an ethical issue. The structure and framework exist to look at how the children from those schools do in examinations. It thus does not seem necessary to use observational evidence to make inferences.

In terms of applying results, there will be other important issues, and often they will come from observational studies. The example of who makes the decisions is a classical one. This relates to some of the issues that Dr Sithole raised in terms of institutions. Often we have gone into massive trials to evaluate the benefits of an intervention (for example, screening), but there are no small trials to evaluate how people perceive the downside of screening. These are issues that need to be addressed.

There is the problem of abuse of institutional privilege. For instance, women were not given all the information they needed to make decisions on screening for breast cancer. I believe that we need more trials. We do not need to see them as unique or the only source of evidence, but we need to see them as a way of getting the best evidence of whether a policy works. Often they will be necessary not only in terms of biological information but also to see how to provide information to people. If we pick up some of the issues that Dr Sithole raised, we need to go through the cycle of trying to understand how people see things and to use that to develop ways of explaining science. We still need trials to see if the ways we have identified actually work.

- **Joseph Otieno Malo:** (1) Evidence from cosmology is either subjective or objective. Evidence can be classified as subjective and objective, or it can be applied objectively or

subjectively. If so, which one is admissible? This relates to total world knowledge, which has to do with experience, which can be either communicable or non-communicable.

(2) The National Academy of Science of Kenya was given land to build its headquarters. There were problems, and the land was grabbed from the National Academy a number of years ago. Two years ago in court, a lawyer stated that the report of the government commission on land on the matter is admissible, and should be used so that the land is given back to the National Academy. Yet the lawyer defending the party that had grabbed the land said that the report is inadmissible. This calls in question the notion of evidence used in law.

(3) If we have a health problem, we do basic research. There are many problems associated with stem cell research, which has ethical, religious and political dimensions. There is evidence that stem cells can be used to cure disease, but how do we advise given the ethical, religious and political dimensions.

- **Mpilo Pearl Sithole:** My presentation tried to avoid the hierarchy between subjectivity and objectivity because the argument is that causality depends on the kind of cosmology that people apply at any juncture. The objective material aspect is an element within the broader interpretation. It would be a problem to devalue objectivity. The current problem is the serious doubts on a qualitative level. Qualitative methods are supposed to inform what the previous speaker was talking about – what is essential from the perspective of people – so that relevance is attained.
- **Thea Illsley:** The problem referred to with respect to the lawyer in Kenya amply illustrates the issue of ‘hired guns’ and the fact that lawyers and not only experts can act as hired guns. The problem we have in common law countries such as South Africa and Kenya is that the proceedings are party-driven, and the parties decide on the best evidence in the circumstances and what is admissible and what is not, as compared with more inquisitorial countries.
- **James Volmink:** Let me leave you with a provocative quote on the application or use of evidence: “The notion that right-minded people will naturally make decisions based on best available evidence is a misleading and dangerous idea.”

Opening address

by the Honourable Minister of Science and Technology, Mr Mosibudi Mangena

President of the Academy of Science of South Africa, Professor Robin Crewe

ASSAf Council Members

Professor Ann Dowling of the Royal Society of London

Foreign Secretary of the US National Academies, Dr Michael Clegg

Chairperson of NACI, Professor Calie Pistorius

CEO of the HSRC, Dr Olive Shisana

International and Local Scientists

Distinguished guests and delegates

Ladies and gentlemen

This symposium takes place at a time when South Africa is reflecting on the impact of policies promulgated and implemented since 1994.

Science and technology has much to offer towards the development of South Africa and the continent. All of us are called upon to contribute to the realisation of this promise through whatever means possible.

The significance and contribution of ‘evidence-based’ information in the policy-making discourse is not difficult to understand. However, given the complex relationship between research and policy, the culture of academia and the funding practices of commissioners of research, the current ethos of ‘evidence-informed’ public policy poses many technical, methodological and epistemological challenges.

This Double Symposium on the ‘Nature of Evidence’ and ‘Science-based Advice for the Nation’ has an important contribution to make in exploring the urgency and growing importance of evidence as the basis for making informed policy and practical decisions across the world. It also offers the Academy of Science of South Africa (ASSAf), which is an independent and authoritative provider of evidence-based advice on a broad range of nationally significant topics and issues, an opportunity to examine its own role in the national science system.

We do hope that the symposium will also develop proposals on how government, and perhaps the nation at large, can best draw on the knowledge and skills of the science community in addressing development issues. This will go a long way in highlighting the importance of, and optimal approaches towards, independent, evidence-based advice to government and other role players.

The use of evidence-based knowledge is especially vital in developing countries where resource constraints preclude chances of entertaining any dubious solutions and experiments from elsewhere that might result in harmful consequences. Evidence-based advice therefore requires closer cooperation between government, research-based organisations and national academies of science to ensure that policy-making and planning draws on the best available information.

In like vein, we should guard against dismissing out-of-hand the wisdom derived from traditional practice and common sense, bearing in mind that not all reliable knowledge should necessarily be derived from random sampling experimentation. At all times, we should shy away from the temptation to make a cult out of laboratory-based research or modern science-based reviews. Such evidence is intended to inform and guide; not to direct decision-making processes outside cultural, traditional, religious and community beliefs and perspectives relating to social issues.

For instance, it is common knowledge that long before the discovery of antibiotics, Africans had already identified plants that could treat bacterial infections, and they used them to cure wounds and disease. African agricultural practices were based on the environmentally friendly tradition of multi-cropping ecosystems in which different crops were planted side by side, and farmers simply saved their seeds for planting the following growing season. This wealth of information was not patented, however. It was considered a birthright and a part of the knowledge that was handed down from generation to generation.

Modern science and research would do well to incorporate such tried and tested applications of knowledge to develop solutions to some of the pressing nutrition and health challenges facing Africa today. No-one can deny that African agriculture could benefit from some modern biotechnologies such as molecular marker-assisted selection to screen for seeds with characteristics suited to various conditions. African farmers also need to utilise irrigation technology to overcome the droughts that can cripple rain-fed agriculture. Such improvements, together with land, seed and the collective indigenous knowledge about our fragile environment, are not only cardinal to the survival of African agriculture, but can also provide models for reversing some of the environmentally harmful effects of modern commercial farming practices.

It is always important to bear in mind that ‘knowledge’ is relative and mutable. That which may be considered certain and fixed in science at one point in time may be overruled by new discoveries at a later stage. It is equally true that evidence-based biological research cannot necessarily be applied with uniform success. This reality calls for humility, not dogmatism, in the way we approach evidence-based policy, planning and practice.

Policy-makers inevitably intervene in the lives of other people, sometimes with unintended or unwanted effects. That is why social policies should be informed by rigorous, transparent and up-to-date evaluations of relevant empirical evidence, and their implementation and impact subjected to systematic and reliable empirical research.

Both researchers and policy-makers would do well to remember the instructive words of the 6th century BC Greek philosopher, Xenophanes, who claimed that: “Through seeking we may learn and know things better. But as for certain truth, no man hath known it, for all is but a woven web of guesses.”

Given the important role played by evidence-based advice, scientists and researchers must fully understand the implications of their work for policy development and policy evaluation. To this end, we have an obligation to engage in collaborative research that goes beyond methodological rigour to encompass moral, social and political responsibility.

It is therefore incumbent upon African scientists and researchers to be vigilant to the intrigues of commercialisation and politics that can cloud scientific research and results. They must always ensure that the collaborations they engage in reap mutual socio-economic benefits for Africa. After all, this is the only way in which our investments in scientific and technological developments can assist the continent to leap forward on the path to genuine sustainable economic development.

In closing, I wish to express my confidence in the ability of this symposium to provide insights into the role research can play in the development of policy advice, and the quality and depth of research that is required to ensure that advice is indeed informed by reliable

evidence. This symposium also provides a platform and opportunities for relationship-building, networking and shared learning. We hope this meeting will succeed in generating fruitful and illuminating outcomes.

It is now my pleasure to declare this Academy of Science of South Africa Symposium on 'Evidence-Based Advice' open. Thank you very much for your attention.

SYMPOSIUM 2

Evidence-based advice

How can governments and the nation at large best draw on the knowledge and skills of the science community?

The African Science Academy Development Initiative

A decade of commitment – why is the voice of science crucial in addressing global issues?

Michael Clegg*

My goal in this presentation is to describe an exciting new initiative aimed at increasing the influence of science academies in Africa. The African Science Academy development initiative, seeks to make science academies valued sources of science advice to policy makers in sub Saharan Africa. In this context science is defined broadly to include not only fundamental science but also its applications in agriculture, engineering and medicine. The African Science Academy development initiative is a ten-year project, which should be long enough to achieve substantial progress making science academies valued and independent sources of science policy advice. Moreover, ten years may provide sufficient time to create sustainable linkages between academies and policy makers so that the academies of sub Saharan Africa can become valued resources to their countries and societies. Why should these linkages be given special emphasis? This question is eloquently addressed in an influential report of the InterAcademy Council (IAC, 2004) that argues that no nation can succeed in the global economy of the 21st century without strong local science, engineering and medical institutions. Why is science important?

Science is the world's most successful means of knowledge creation. It deals exclusively with arguments based on evidence, and its results are subject to independent confirmation by others. Science is the source of technological innovation and it provides the knowledge to create new opportunities and new ways of adapting to the world. During the 20th century, over 50% of the increase in prosperity resulted from increases in science and technology knowledge. When we look ahead to the next fifty years, projections show that the world population will grow by 2–2.5 billion people, which will place great strains on resources, including food production, water supply and quality, energy supply and ecosystem and species preservation. Problems are likely to be encountered from emergent diseases, land degradation and the challenge of maintaining the current quality of life. Already, about 0.5 billion people have inadequate water supplies, and that number is estimated to increase over the next 25 years to 2.7 billion. We are already entering a global energy transition, which will place great strains and demands on the global economy. Science has considerable knowledge that can help mitigate these problems if the information can be brought to policy-makers.

WHAT CAN SCIENCE ACADEMIES OFFER?

The challenges of environmental change, population pressure and emergent disease are global, but the implementation of solutions must occur through national or local governments.

* Michael Clegg, Foreign Secretary, US National Academies

Many nations have science academies, which can be important instruments in providing solutions to these challenges, because academies embody the independent voice of national science communities and are thus credible and independent sources of information and knowledge.

The US National Academies (NAS) was founded during the American Civil War, a difficult time in US history. Unlike many other science academies, the US NAS was founded with a dual purpose: (1) to recognise scientific achievement by electing people to membership in the academy as an honorary body, and (2) with the important service role of providing advice to government policy makers on issues of science and technology. Section 3 of the charter of the Academy (approved on 3 March 1863) reads:

The Academy shall, whenever called upon by any department of the government, investigate, examine, experiment, and report upon any subject of science or art ... the actual expense of such investigations, examinations, experiments, and reports to be paid from appropriations which may be made for the purpose, but the Academy shall receive no compensation whatever for any services to the Government of the United States.

The academy is a private organisation that over the years has evolved a major public policy function. The Academy produces some 250 book-length reports on major issues where science and technology intersect public policy every year. Examples of very influential reports that the Academy has produced over the last five years include:

- Stem Cells and the Future of Regenerative Medicine.
- Arsenic in Drinking Water: 2001 Update.
- *Climate Change Science: An Analysis of Some Key Questions.*

In addressing an issue, the Academy puts together a committee of experts representing all the various facets of knowledge related to a question. The expert committee reviews what is known, eventually arriving at a consensus on a set of policy recommendations. This relieves policy-makers from having to take decisions on difficult and controversial issues without scientific back up.

FINANCIAL SUPPORT

About 85% of the funding for the Academy comes from the federal government through contracts and grants from agencies for conducting studies. About 15% comes from state governments, private foundations, industrial organisations and funds provided internally. Almost all the international work of the Academy comes from philanthropic or academy resources. Sponsors enable, but do not influence, the work of the Academy.

INTERACADEMY PANEL

In 1993, the academies of the world combined to form a global network of academies known as the Interacademy Panel (IAP) to share best practices and knowledge in ways that would assist partner academies in dealing with local problems. One of major purposes of the IAP is capacity building of member academies. A workshop was held four years ago in Trieste, Italy, the headquarters of the Interacademy Panel, aimed at addressing the question of science capacity building for academies in sub-Saharan Africa. The result was the formation of the Network of Academies of Science in Africa. Following this event there were indications that the Gates Foundation might be willing to provide major funding for a project aimed at academy capacity building in sub-Saharan Africa. Leaders from most of the academies in sub-Saharan Africa came together in Washington DC to begin developing a proposal to the Gates Foundation. The proposal that was presented to the Gates Foundation set the following goals:

- To strengthen the capacity of African academies of science to provide evidence-based advice to government policy-makers and national stakeholders.
- To build African governments' appreciation of and demand for advice from national science academies.

African science academies faced the following main challenges:

- They were primarily honorific organisations.
- Administrative and physical infrastructures were underdeveloped.
- Membership did not necessarily cover all areas of science.
- Depth and breadth were limited in local scientific communities.
- There were competing advisory structures to local governments.
- Governments tended to be insensitive to academy inputs.
- There were academic obstacles to a service culture.
- Funding potential was uncertain.
- National pride hindered the cooperation of academies from different countries.

When the Gates project began in 2004, the first challenge was to select three academies for intensive engagement from the seven science academies of sub-Saharan Africa. Programs were then developed to engage less intensively with the remaining four academies. The process of partnership selection involved visits of teams from the US National Academies to each of the academies and governments of the seven countries: South Africa, Ghana, Senegal, Cameroon, Kenya, Nigeria and Uganda. In three cases, the team met with the head of state, indicating a high level of interest in Academy involvement on the part of leaders of government. All seven academies were found to meet the selection criteria for primary partners, namely:

- Academy leadership track record.
- Partners committed to a sustained effort.
- Potential for financial sustainability.
- Potential to contribute to national progress.
- Government open to science advice.
- Government stable and engaged.
- Academy management: merit-based.
- Critical mass of national and regional expertise.
- Quality workshop plan.
- Quality approaches to fiscal management.
- Regional leadership.

The task of selecting three primary partner academies was difficult, as all seven met the criteria, but ultimately the following three were selected:

- Uganda National Academy of Science (which received funding worth US\$3 million).
- Nigerian Academy of Science (which received funding worth US \$1.8 million).
- Academy of Science of South Africa (which received funding worth US \$1.5 million).

The US National Academies continues to engage less intensively with the academies of Ghana, Senegal, Cameroon and Kenya by providing strategic planning grants.

Consensus activities

The capacity building aspect of the programme is meant to help the academies provide the sorts of advice to their governments that the US National Academies has been providing to the US government over the last 143 years. One of the ways in which this is pursued is through consensus activities, whereby a detailed report is developed on a major issue (such as global climate change). Policy studies or other formal advisory activities explore in depth the science and technology dimensions of an issue of importance to the country and its government. Studies offer evidence-based guidance to national decision-makers on issues related to science and technology. Consensus activities are intended to issue conclusions

and recommendations in the name of the academy, because the procedure is independent of sponsors and government and is managed to minimise biases and conflicts of interest. Consensus means that the committee of experts composed to look at the issue has to arrive ultimately at a consensus on the facts or evidence and the recommendations that the Academy will forward to the government. This means that consensus circumscribes what the scientific community agrees to be the current state of knowledge on a major issue.

Convening activities

Another aspect of the work of the US National Academies is convening activities, which bring together, in a neutral setting, representatives of academia, government, industry and others for discussions to illuminate critical issues and potential solutions consistent with the society's priorities, values and resources. They are not intended to issue conclusions and recommendations in the name of the academy because the procedure is not necessarily independent of sponsors and government or free of biases and conflicts of interest. Examples of convening activities include the roundtables and forums at the US National Academies on issues as diverse as:

- Forum on Microbial Threats.
- Roundtable on Science and Technology for Sustainability.
- Disasters Roundtable.
- Vaccine Safety Forum.
- Clinical Research Roundtable.
- Forum on Drug Discovery.
- Government-University-Industry Research Roundtable.
- Roundtable on Environmental Health Sciences, Research and Medicine.

The African science academy initiative is divided into three phases:

- Phase 1, years 1–3:
 - ☐ Partnership development, assisting partners in recruiting expert staff .
 - ☐ Establishment of forum on evidence-based policymaking.
- Phase 2, years 4–6
 - ☐ Co-conducted policy advisory activities with full funding.
 - ☐ Independent policy advisory activities with full funding.
- Phase 3, years 7–10
 - ☐ Additional independent policy advisory activities with matching funds.

Work during the current year (Year 2: 2005–2006) entails partnership development, including the development of work plans and budgets; identifying common expectations about collaboration; infrastructure development; staff recruitment, hiring and training; development of a Forum for Evidence-Based Health Policymaking; and the exploration of other policy-advisory models. Institutional policies are planned to support the conduct of consensus studies.

The final aspect of the project is convening a major meeting among all seven partner academies each year, the first of which took place in Kenya in November 2005, hosted by the Kenyan Academy of Sciences. This event includes:

- an annual networking symposium to provide an opportunity for academies to share progress and knowledge on topics addressed by policy activities and;
 - annual collaborative learning workshops to provide a support network for African and US academies staff and to share problem-solving and best practices for study implementation.
- The learning workshop at the first annual meeting focused on mechanisms for capacity building in academies.

The initiative is administered by the NAS Board on African Science Academy Development, including a number of very experienced people as well as the foreign secretary of each of the three academies:

- Enriqueta Bond (Chair): Burroughs Wellcome Fund.

- Jo Ivey Boufford: New York University.
- George Bugliarello (*ex officio*): Polytechnic University.
- David Challoner (*ex officio*): University of Florida.
- Michael Clegg (*ex officio*): University of California-Irvine.
- Princeton Lyman: Council on Foreign Relations (former ambassador to both South Africa and Nigeria).
- Narciso Matos: Carnegie Corporation of New York (former executive director of the African Association of Universities).
- Cheikh Mbacké: The Rockefeller Foundation.
- Mamphela A. Ramphela: The World Bank (from South Africa).
- David Satcher: Morehouse School of Medicine (former Surgeon-General of the USA).
- Phillip Griffiths: Institute for Advanced Study.

The initiative requires the investment of the very capable and dedicated staff of the US National Academies. The core staff are all experts in their own fields:

- Board Director, Patrick Kelley (IOM) – medicine.
- Financial Officer, Jim Banihashemi (IOM).
- Nigeria Liaison, Clara Cohen (PGA) – agriculture.
- South Africa Liaison, Barney Cohen (DBASSE) – population and demography.
- Uganda Liaison, Patricia Cuff (IOM) – medicine.
- Research Associate, Katherine McClure, (IOM).
- Research Assistant, Ijeoma Emenanjo (PGA).

The US National Academies is very grateful to the Bill and Melinda Gates Foundation for providing the resources to make the initiative possible.

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DISCUSSION

- **Wieland Gevers:** Is there a mechanism in the academy for evaluating the impact and outcome of each of its published studies?
- **Michael Clegg:** There are a number of evaluation mechanisms, most of which are informal. Our experience has been that some of our studies have an immediate impact. For example, we released a study in September 2005 on the fact that all the indicators on S&T development in the USA are declining. The study made a number of recommendations on how to turn around the S&T enterprise in the US. Three of the four recommendations were picked up in President Bush's State of the Union address.

In other cases, we have found that the reports have only had an impact after about a decade. We try to anticipate emerging issues, and will even approach members of Congress to suggest questions that pose a number of S&T issues and need to be investigated. Subsequent negotiations may lead to a Congressional appropriation directing that such a study be undertaken by the NRC. We also try to shape the questions so as to address broader societal issues. Through this process, the studies often anticipate emerging to five years before the problems become apparent to the government. We continue to engage with appropriate people in government about how to go about implementing the recommendations. With regard to the AIDS programme, a formal process has been set up to evaluate progress. We have engaged two private consulting firms to evaluate the project and provide feedback on failures and successes.

- **Jonathan Jansen:** I assume your cooperation with the African academies of science is built on a strong model of reciprocity. What are you hoping to learn from the African countries?
- **Michael Clegg:** There is much that we can learn from our partner academies. Hopefully we are approaching the task with a high level of humility. We do not pretend that we have all the answers. We do think that the problems that the world will face over the next 50 years will require the engagement of the science community on a global level, but the only way of dealing with the problems is nation by nation. We want to work together with our partners to strengthen them and make them more effective, but we do not have a one-size-fits-all solution, and we expect to learn from each of our partners about what works and what does not in their particular context.

An obesity epidemic: Science and policy

Jeffrey P. Koplan*

The study under discussion is not presented for its technical and scientific content, but as an example of the process and approach and use of data and evidence in compiling a US National Academies of Science report. The presentation reports on a process by the Institute of Medicine.

The study of the epidemic of childhood obesity in the US raises issues of the role of randomised controlled trials and their effectiveness and limitations, the relationship of evidence (objective versus subjective), and a population perspective versus a focus on the individual.

The issue of obesity has long been one of cosmetics and aesthetics. However, over the last decade in particular, it has been shown that there are health relationships to adult and childhood obesity. In adult obesity, they cover a range of physiological outcomes, many of which are disabling, some of which reduce quality of life, and many of which lead to premature death. The health impacts in both the long and short term include the following:

- Psychosocial.
- Cardiovascular.
 - Hyperlipidemia, hypertension, respiratory, cardiac.
- Medical.
 - **Diabetes Mellitus**, Polycystic ovary disease, gall bladder disease, osteoarthritis, cancer.
- Pregnancy and the postpartum.
- Mortality.

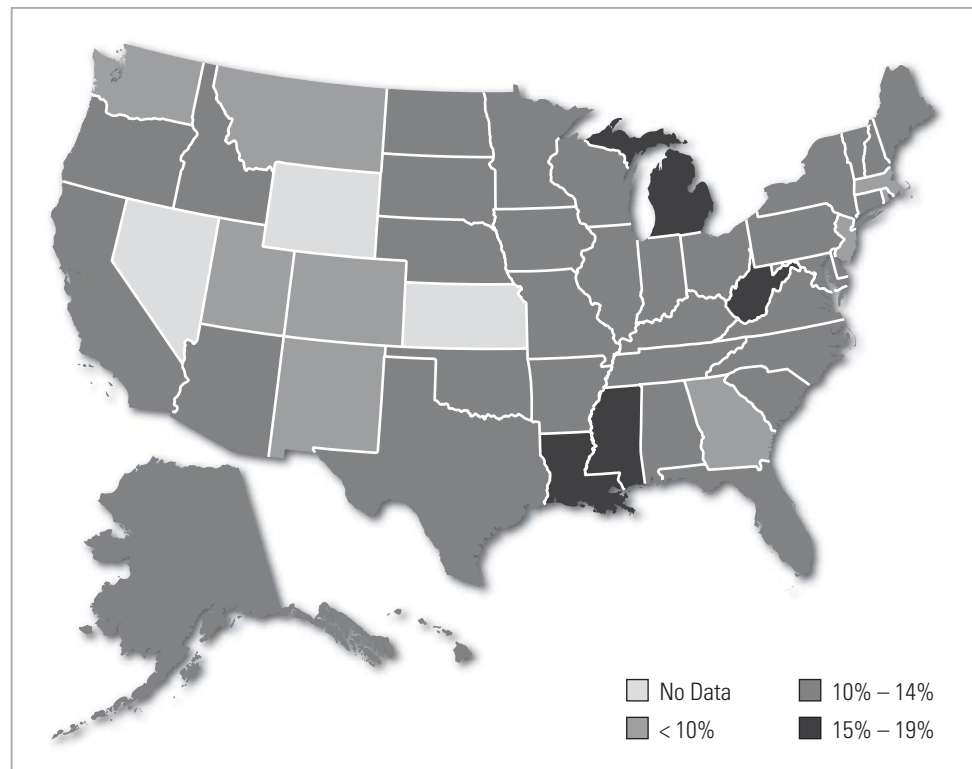
The maps for 1991–2003 (from the Behaviour Risk Factor Surveillance System) record the increase in the percentage of obese adults (Figures 1–7). Obesity has been defined as being 30 lbs overweight, or a body mass index (a relationship of weight to height) of 30 or more. In 1991, between 15 and 19% of the population of three states were classified as obese. By 2003, obese adults accounted for at least 15% of the population in all states; 20–24% of the adults in most states were obese; and in five states, 25% or more of the adult population were obese. Figure 8 shows a corresponding increase in insulin-dependent diabetes. The growth in obesity can be considered as an epidemic.

Reasons for the increase in adult obesity include the innumerable social and economic changes that have taken place in US society, including:

- Oversized serving sizes are growing in prevalence.

* Jeffrey P. Koplan, Chairperson of the US Nas, Committee Study Report and Woodruff Health Sciences Center of Emory University

Figure 1: Obesity trends among US adults (1991)



- Thousands new products on grocery shelves, most of which have high calories and many of which have high fat content, and almost all of which are unnecessary for the human diet.
- Snacking is becoming more prominent. Instead of confining eating mostly to three meals, people are finding opportunities all day to snack.
- Food is more readily available at non-traditional outlets, such as petrol stations.

Figure 2: Obesity trends among US adults (1993)

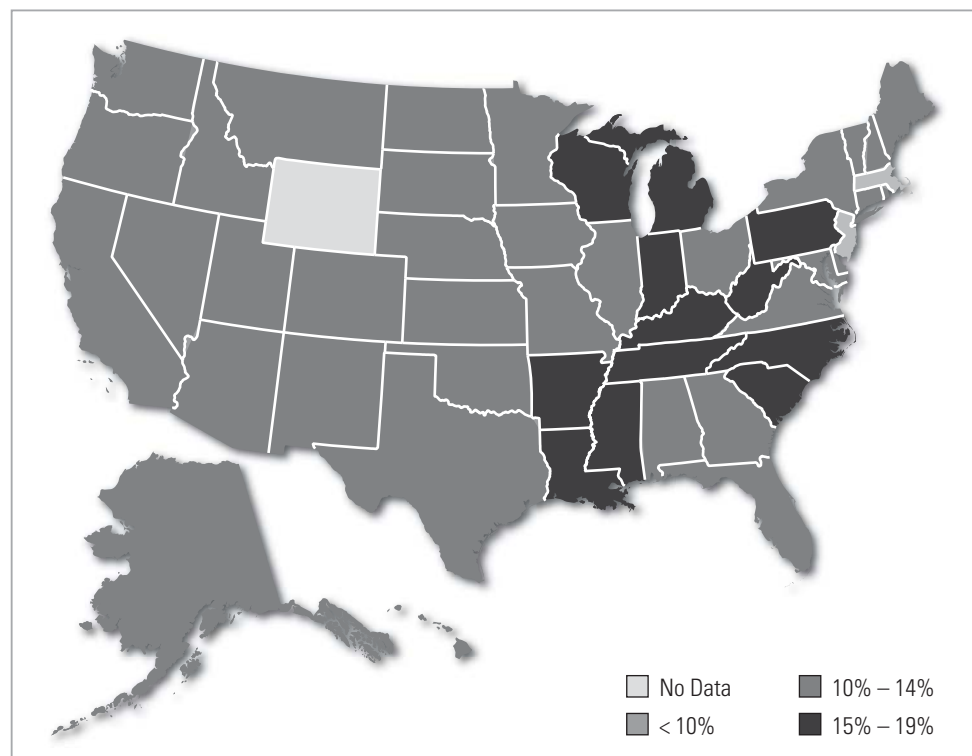
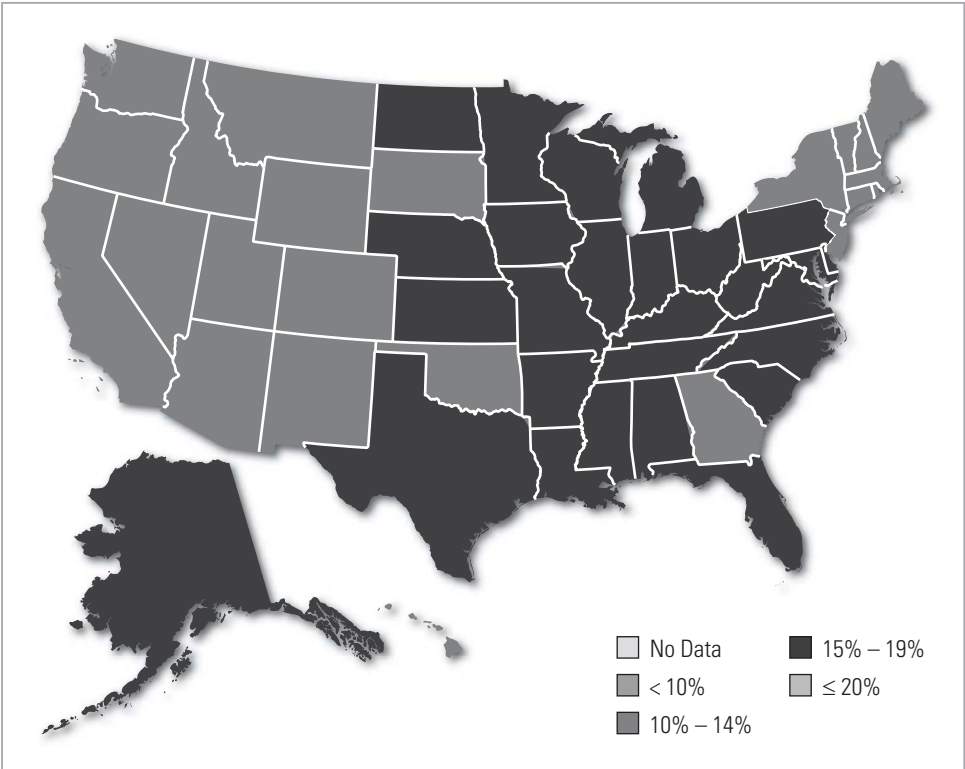


Figure 3: Obesity trends among US adults (1995)



- The amount of soft drinks consumed per person shows a marked increase.
- Physical activity has decreased for much of the population. Mechanisation of the workplace has limited the amount of physical activity in jobs that used to require it.
- Transportation has increased and people therefore walk less.
- Passive screen time in front of the television or computer has increased for most children.
- Food advertising has increased.

Figure 4: Obesity trends among US adults (1997)

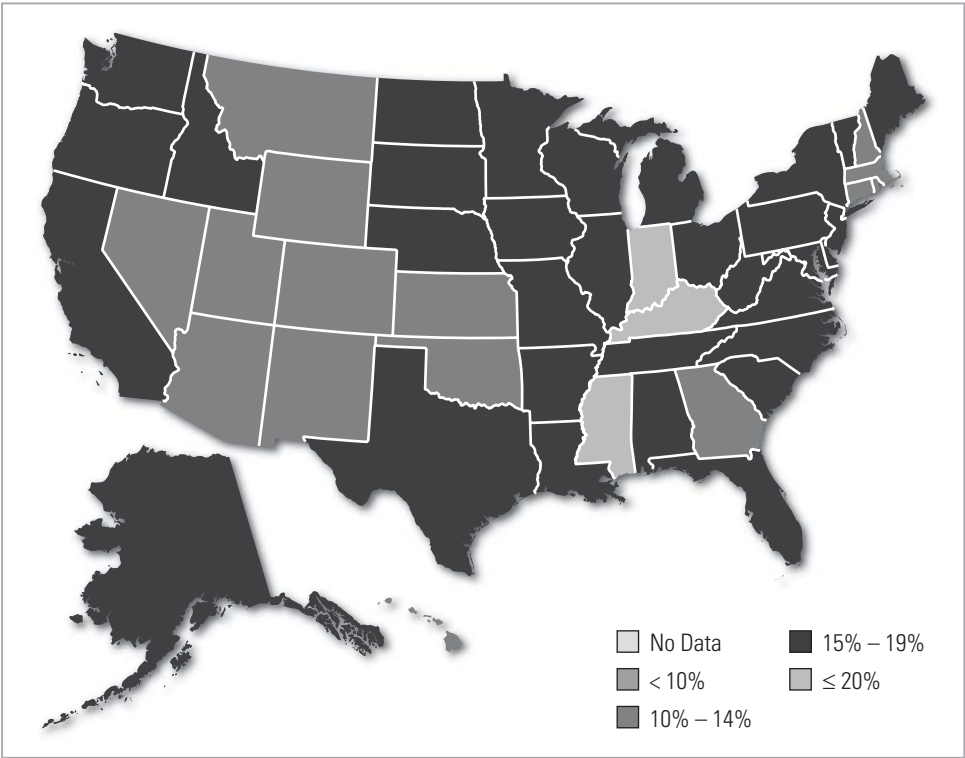
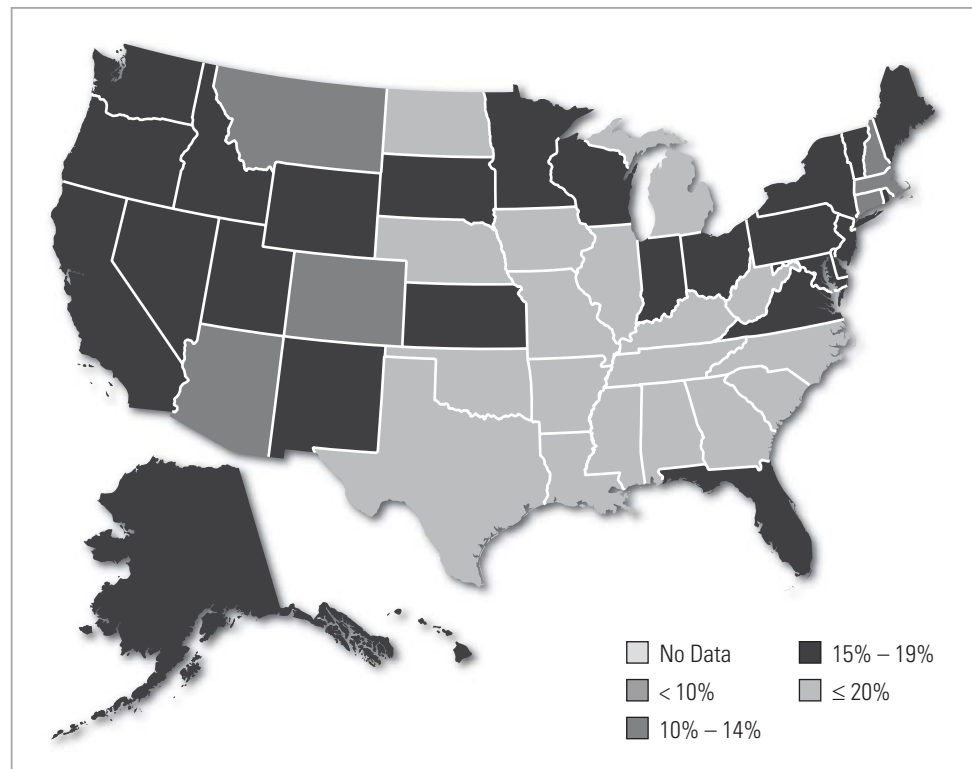


Figure 5: Obesity trends among US adults (1999)



- There is evidence that people tend to snack in front of the television rather than engaging in physical activity.
- Community designs contribute. Traditional community design encouraged people to get out to walk and do things such as walking to buy the newspaper. New US suburban community designs have no sidewalks and they discourage walking. Procuring the needs of the household generally entails travelling by car.

Figure 6: Obesity trends among US adults (2001)

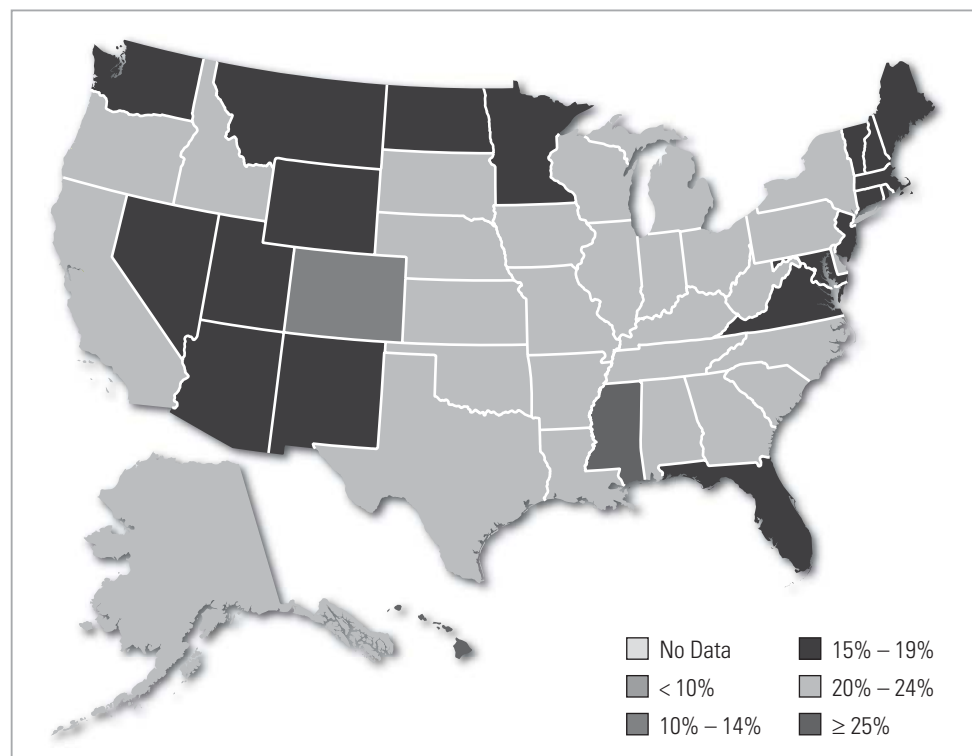
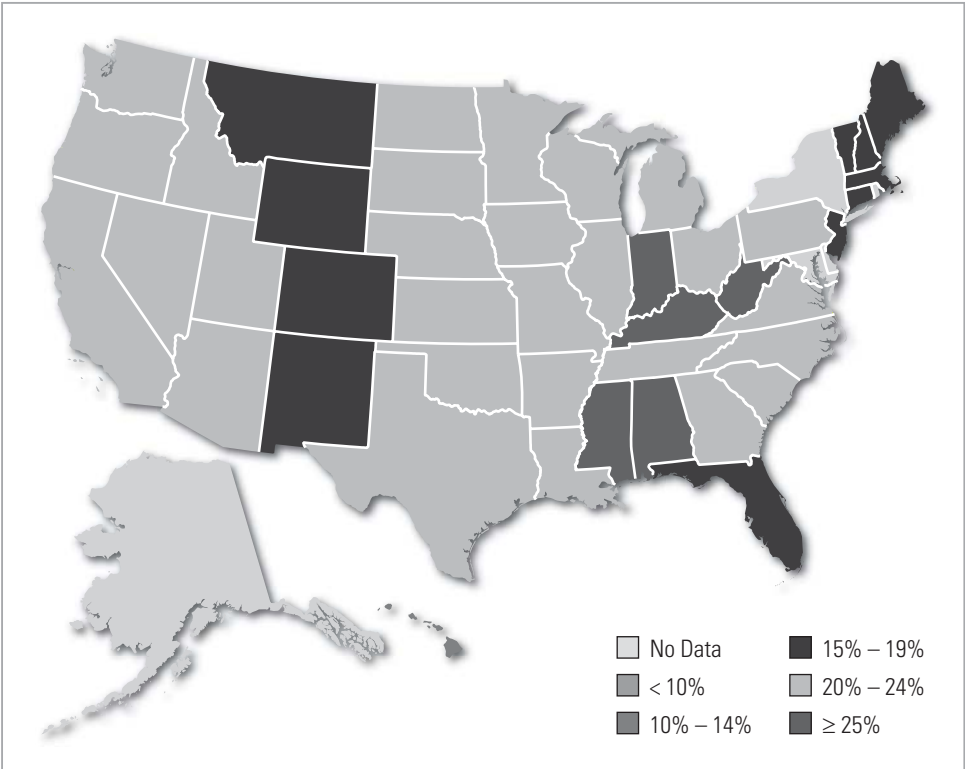


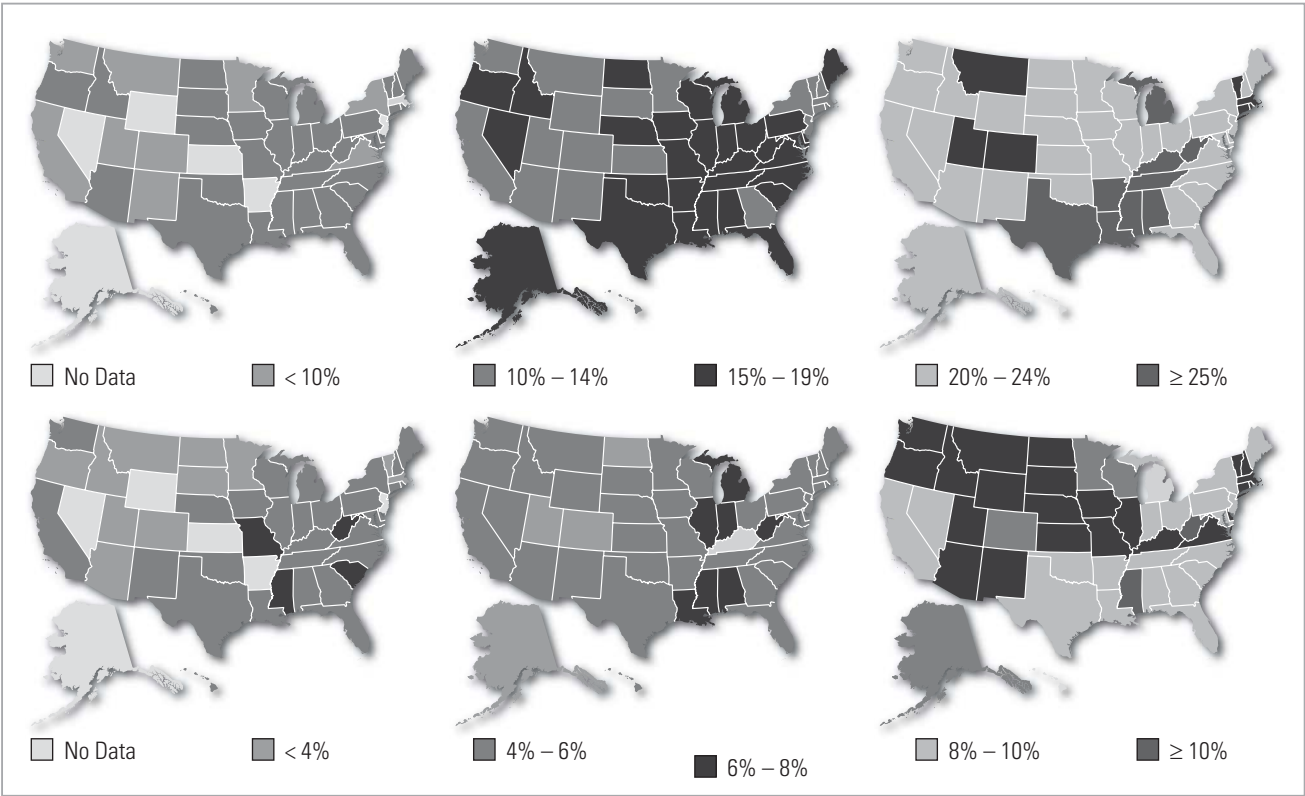
Figure 7: Obesity trends among US adults (2003)



■ Most schools, where children spend most of their time each day, have dropped the requirement for physical activity.

Growing obesity is a major problem in the US, but recent studies from many countries show troubling increases in childhood obesity and overweight, even in countries such as China where until recently there were almost no problems with obesity:

Figure 8: Prevalence of diabetes among US adults (1990–2004)



- Australia – Magarey (2001).
- Canada – Wilms (2003).
- China – Luo (2002).
- Finland – Kautianien (2002).
- France – Heude (2003).
- Germany – Kalies (2002).
- United Kingdom – Chinn (2001).

In Africa, adult women in South Africa show a BMI of 30 (Table 1).

Table 1: Statistics on overweight and obesity from most recent national prevalence surveys in adults

Africa	Survey date	Age range	Obese (% BMI > 30 kg/m ²)		
			Male	Female	Both
Ghana	1987-1989	20-65	1	6	3
Lesotho	1993	20-65	–	23	–
Morocco	1998-1999	18+	4	16	10
South Africa	1998	15+	9	30	21

The Institute of Medicine (IOM) was commissioned to conduct the study. The IOM study process is as follows:

- Studies are conducted under contract to a sponsor or several sponsors (and take between six months and two years to conclude).
- Each study is conducted by a multidisciplinary expert committee.
- The committee meets at intervals to address the scope of work and review the relevant scientific evidence to develop findings, conclusions and recommendations.
- The writing process is guided by the committee chair and IOM staff.
- There is rigorous blinded peer-review of the report before public release of the final report.

The study found an epidemic of childhood obesity. Since the 1970s, obesity prevalence has doubled for adolescents aged 12–19 years, tripled for children aged six to eleven years, shows an upward trend even among the youngest children under the age of two years and has doubled for preschool children aged two to five years. More than nine million US children and youth are obese. These figures mirror similar trends among US adults, as well as adults and children internationally. All groups are at risk – rich, poor; every state; every racial group; and every ethnic group show an upward trend in obesity. However, some groups are at higher risk than others, including poorer socio-economic communities and certain sub-populations, including Africa-Americans and Latinos/Hispanic populations. Parental obesity doubles the risk of adult obesity in children under ten years of age. Children and teenagers in high-risk subgroups may be more sensitive to, or less able to avoid, causal factors. No consensus has been reached about the mechanisms by which ethnic, socio-economic and regional disparities occur.

The investigation took place over a period of two years and resulted in the report *Preventing Childhood Obesity: Health in the Balance*.

REVIEW OF THE EVIDENCE

In reviewing the evidence, the committee faced a situation in which there were many epidemiological studies, few randomised control trials, substantial data linking obesity with various health issues and very limited obesity prevention literature upon which to base recommendations, although there was much anecdotal information, and many beliefs, opinions

and common wisdom. The need for rapid action in the context of an epidemic and a serious health problem meant that the committee strongly endorsed an action plan based on the best available evidence, while at the same time seeking the best possible evidence.

The committee took an integrated approach to the available evidence, reviewing qualitative and quantitative research from all over the world, including studies both large and small, studies that had been published and ones that had not. Parallel evidence from other public health issues was reviewed, as well as dietary and physical activity literature.

The literature showed common opinion about the energy balance, namely that there should be a balance between energy intake and energy expenditure, and that if these are out of balance, the person will gain or lose weight. We gave equal importance to the intake of calories and the expenditure of calories through exercise and physical activity. For children, it is essential to maintain the energy balance at a healthy weight while protecting health, growth and development, and nutritional status

OBESITY PREVENTION GOALS

The report formulated a number of obesity prevention goals, namely, to create an environmental-behavioural synergy for the population of children and youth that:

- Reduces the incidence and prevalence of childhood and adolescent obesity.
- Reduces the mean population BMI levels.
- Improves the proportion of children meeting Dietary Guidelines for Americans.
- Improves the proportion of children meeting physical activity guidelines.
- Achieves physical, psychological, and cognitive growth and developmental goals.

KEY CONCLUSIONS

The report concluded that:

- Obesity is a serious nationwide health problem requiring a population-based prevention approach.
- The goal is energy balance, characterised by healthy eating behaviours and regular physical activity to achieve a healthy weight while protecting health and normal growth and development.
- Societal changes at all levels are needed, involving multiple sectors and stakeholders.

KEY FINDINGS

The report found that leadership would be required to bring about normative change in behaviour among the whole population. Constant evaluation is needed of intervention programmes, as well as additional resources, efforts at all levels (from the highest levels of leadership down to communities) and changes in societal norms to move from the situation of obesity prevalence to one in which healthy eating behaviours and physical activity are the norm. The report recommended that:

Preventing childhood obesity is a collective responsibility ... The key will be to implement changes from many directions and at multiple levels.

The necessary change must be a collective responsibility. There is also a political perspective. Some political persuasions regard achieving an energy balance as an individual responsibility, outside the domain of the public health sector. The other extreme is to **consider the responsibility to be that of the larger community or society. The report contends that individuals, the community and the environmental conditions all play a role in determining levels of childhood obesity.**

CHANGING SOCIAL NORMS: PUBLIC HEALTH PRECEDENTS

There are a number of public health precedents for changing social norms, such as interventions with respect to tobacco control, under-age drinking, highway safety, use of seatbelts and child car seats, vaccines and fluoridation.

KEY STAKEHOLDERS INVOLVED

The report focused on the various key stakeholders involved, namely families, schools, communities, health care, industry, the media and government and developed an action plan that targeted each group.

ACTION PLAN FOR OBESITY PREVENTION

National public health priority

At the national level, the report urged the federal government to take a more active, visible role and to couple funding and programmes with high-level rhetoric, thereby stressing the importance of the problem. It was recommended that government at all levels provide coordinated leadership. There were specific requests in terms of grants, research and programmes, namely:

- With respect to federal coordination, the President should request that the US Department of Health and Human Services Secretary convene a high-level task force to ensure coordinated budgets, policies and programme requirements and priorities.
- Programme and research efforts are required to prevent childhood obesity in high-risk populations.
- Resources are needed for state and local grant programmes, as well as support for public health agencies.
- Federal nutrition assistance programmes and agricultural policies should be independently assessed.
- Research and surveillance efforts are required.

One of the ways in which such a report is valuable is its use in subsequent evaluation of government response to the recommendations.

Healthy school environment

The report recommended that schools provide a consistent health-promoting environment, with the following more specific recommendations:

- The US Department of Agriculture and state and local educational authorities should develop and implement nutritional standards for all competitive foods and beverages sold or served in schools; ensure that all school meals meet dietary guidelines and pilot programmes to expand school meal funding in schools with a large percentage of children at high risk of obesity.

The report further recommended that state and local educational authorities should:

- Ensure at least 30 minutes of moderate to vigorous physical activity during the school day.
- Expand opportunities for physical activity at school, including physical classes, intramural and interscholastic sports programmes and other physical activity clubs, programmes and lessons; after-school use of school facilities; use of schools as community centres; and walking and biking to school programmes.
- Enhance health curricula with a behavioural focus, nutrition, physical activity, reducing sedentary behaviours and energy balance.

- Develop, implement and evaluate pilot programmes to explore innovative approaches to both staffing and teaching about health, nutrition, physical activity, and reducing sedentary behaviours.
- Develop, implement and enforce school policies to make schools advertising-free to the greatest extent possible.
- Involve school health services.
- Conduct annual assessments of each student's weight, height and BMI percentile and make the information available to parents.
- Perform periodic assessments of school policies and practices related to nutrition, physical activity and obesity prevention.

Healthy home environment

A healthy home environment is needed to promote healthy eating and regular physical activity through:

- Exclusive breastfeeding for the child's first four to six months.
- Providing healthy foods, considering nutrient quality and energy density.
- Encouraging healthy decisions with respect to portion size, and how often and what to eat
- Encouraging and supporting regular physical activity'
- Limiting recreational TV screen time to less than two hours per day for children, which would be a considerable improvement on the six hours per day average found for many pre-adolescents.
- Parents acting as role models.
- Discussing the child's weight with a health care provider.

Families need to educate their children on how to shop for ingredients and cook a meal, rather than buying pre-cooked meals and warming them up. Many families do not have a table around which families can enjoy a meal together. These factors all point to the normative changes required across society.

DISSEMINATION OF THE REPORT

National television, newspapers and magazines gave considerable coverage to the report, which helped to disseminate the message, and there were many interviews of committee members. It is necessary to continue to keep the recommendations of the report regularly in view of the different groups of stakeholders in the years following its appearance.

The process of preparing a report for the US National Academies is hard work, requiring committee members to give considerable amounts of time voluntarily. The chair will have a particular goal, as will each of the various committee members, and the committee process serves to bring the various goals closer together.

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DISCUSSION

- **James Volmink:** From my understanding of the study, much work went into tracking down reliable evidence, but at the end of the day, little solid or reliable evidence on interventions could be found. It is of interest that there was a large range of stakeholders involved in the process and that the committee did extensive searches for evidence. How transparent is the process of documenting the evidence and how do you evaluate the evidence for quality?
- **Jeffrey Koplan:** The attempt is made to keep the processes as transparent as possible. For example, there are a series of open meetings at which a wide range of people are invited to present, giving a spectrum of opinions and views. These meetings are open and are announced publicly, so that anyone is able to attend and ask questions of the panel. The committee meetings are closed to members of the committee only to allow open exchange. The drafts of the report go out for a wide range of tough anonymous reviews. Many of the reports are extensively revised over time. However, the report ultimately has to represent a viewpoint and express a set of recommendations.
- **Joseph Otieno Malo:** I would like to ask about the use of growth hormones in the USA. Could these contribute to the situation of obesity?
- **Jeffrey Koplan:** There are US National Academies reports on the use of hormones in animal feed. I am of the opinion that there are far too many additives in animal feed. There is a strong and growing movement in the US towards more organic vegetables and animal products. It is difficult to explain the outbreak and speed of the spread of obesity on the basis of other factors such as genetic, hormonal, chemical and toxic. These issues deserve to be studied carefully in the context of health, but one would be hard pressed to invoke them as an explanation for the increase of obesity especially when we have plausible other causes. Although a hamburger, for example, might contain growth hormones in the meat, its impact is largely through the levels of cholesterol and saturated fats.
- **Madlala-Routledge:** The South Africa Department of Health will be hosting an international conference on diabetes later this year. Your talk was therefore very informative in this regard. I am interested in the role of the slimming industry. Could you share what you have done in the US to regulate the advertising and claims made by this industry, which cause people to become obese through trying various slimming methods.

With respect to the action plan, you include the energy balance as an objective. Perhaps we should also add the nutrition balance, because in South Africa we have a problem in poor settings, where people consume energy in the wrong form or in an unbalanced form. There are children in the rural areas that walk ten kilometres to school and back each day but yet are obese. The problem is not a lack of exercise but inappropriate nutrition.
- **Jeffrey Koplan:** We use the term 'energy dense foods' to describe what you suggest. Food choices make a big difference, and nutritional balance is extremely important.
- **Robert Kriger:** I would like to suggest that just as there is a hierarchy of policies, there is an understood hierarchy of evidence. How do the US National Academies and science deal with the fact that its own evidence-based policy recommendations may be superseded by

another more powerful in the hierarchy of policies. Your report, for example, exists in the domain of health policy, versus economic policy versus foreign policy.

- **Elisabeth Lickendorf:** When you begin an investigation such as you undertook for this report, how much time do you allocate for the very in-depth process?
- **Jeffrey Koplan:** The committee has about six two-day meetings per year for two years. Between meetings, members will be reading and reviewing relevant material and making abstracts. When the report is written, the task is given to a few of the committee members. During the last three months, as chair of the committee, I spent between 25% and 50% of my time reading and rereading and rewriting the successive drafts. The report was completed over a three-year period.

The hierarchy of evidence changes over time and is a brutal issue for any public health sector. As the evidence changes, the conclusions of a report can be outvoted. It behoves people to continue to look at the current state of knowledge and to redraft initial reports accordingly.

There is also a hierarchy of policy with political and economic overtones. Conflict of interest is an important issue for any committee. Every single committee requires each member to verbally describe, around the table, the types of conflict of interest they may have. This goes beyond the work the committee members may have done for companies (in the case of this report, in the food industry) and extends to personal biases, where one works and the nature of one's work. For instance, if one was an academic at a university that derives much of its endowment and funding from a large carbonated soft drink company, one would be required to declare this.

In terms of the hierarchy of policies, government will also have a hierarchy of issues that drive them and how they interpret the report. Nevertheless, the value of the US National Academies process is that government cannot ignore the fact that there is a published document that has been widely read and on which the press has reported that calls them on how they set their policies. You can disagree with the evidence, which makes for a rational debate, and you can disagree with the policies and point out that government has ignored the evidence for economic gain or political reasons, which changes the nature of the debate. Partners in the recommendation process become the press, the scientific community and other policy- and decision-makers who all play an important part in controversial reports. Whether the issue is stem cells or food additives, there are huge political implications. The US National Academies provides a positive way for scientists to engage in political processes.

Nanoscience and nanotechnologies

Brief, processes and recommendations of the study by the Royal Society and the Royal academy of Engineering

Ann Dowling*

POLICY WORK AT THE ROYAL SOCIETY AND THE ROYAL ACADEMY OF ENGINEERING

Both the Royal Society and the Royal Academy of Engineering are committed to providing decision-makers with impartial, credible and timely evidence-based advice on the scientific aspects of public policy and policy for science. They produce major policy reports and statements as well as holding workshops that bring policy-makers and scientists together to tackle issues of importance. Regular contact between the vice-presidents and staff of the two academies and policy-makers ensures that the academies address topics that policy-makers are concerned about. Close links with their scientific communities (including the fellows and the researchers that they fund) enable the academies to identify emerging scientific issues that they can bring to the attention of policy-makers (for example, the Royal Society's report on Ocean Acidification in 2005). They also respond to consultations from the UK government, UK parliamentary committees, the European Commission and other organisations on subjects such as energy policy and science funding.

When an international scientific voice is required, both academies join with other national academies either through formal networks (such as the Inter-Academy Panel) or informal networks (as in the case of the statements on climate change and Africa issued by the academies of the G8 countries and others in July 2005).

Both academies regard their independence as crucial to the credibility of their policy work, which is funded primarily from their private funds and a block grant from the UK government. In the case of externally commissioned studies, such as the study on nanotechnologies commissioned by the UK government, a number of steps are taken to maintain this independence. The academies insist that the commissioning body is not involved in the selection of the working group members or its methods of working, and does not view the report before it is printed.

BRIEF FOR THE NANOTECHNOLOGIES STUDY

Nanoscience and nanotechnologies involve studying and working with matter on an ultra-small scale. One nanometre is one-millionth of a millimetre, and a single human hair is around 80 000 nanometres in width. Nanoscience and nanotechnologies encompass a range of techniques rather than a single discipline, and stretch across the whole spectrum of science, touching medicine, physics, engineering and chemistry. They are widely seen as having huge potential to bring about benefits in areas as diverse as drug development,

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water decontamination, information and communication technologies, and the production of stronger, lighter materials.

In 2003, nanoscience and nanotechnologies were beginning to attract rapidly increasing investments from governments and businesses in many parts of the world. Against this background of increased research funding and interest from industry, several non-governmental organisations (NGOs) and some nanotechnologists were expressing concerns about current and potential future developments in nanotechnology. In the UK, the media was beginning to highlight both the hopes and concerns about nanoscience and nanotechnologies.

In June 2003, the UK government approached the two academies to address the opportunities and uncertainties around nanoscience and nanotechnologies. The following terms of reference were agreed for the study:

- Define nanoscience and nanotechnologies.
- Summarise current and foreseeable applications.
- Assess whether there are any health, environment, safety, ethical or societal implications or uncertainties.
- Identify areas where additional regulation needs to be considered.

PROCESSES

The methodology of the study was designed to ensure openness, transparency and independence from government (as outlined in a previous section).

The academies assembled a working group to advise them. In addition to nanotechnologists (from academia and industry), the working group included academics and NGO representatives with expertise in toxicology, environmental impact, bioethics, consumer affairs, public engagement and perception of risk. The inclusion of a wide range of stakeholders on the working group ensured that it addressed the issues that were of concern to all the groups that were interested in the development of nanotechnologies.

Extensive external input to the study (from the UK and overseas) was sought via written evidence (over 110 submissions); workshops with scientists and engineers, NGOs, health and environment experts, industry and regulators; and oral evidence sessions. In addition, the working group commissioned the first UK survey of public attitudes to nanotechnologies in the form of a quantitative survey of 1 000 people and qualitative workshops with two focus groups. The evidence was posted on a dedicated website as it became available, and feedback on it was encouraged. This was essentially the first comprehensive study of the range of issues around nanotechnologies in the world, and it was followed with great interest. Regular updates were published so that interested parties could follow the progress of the study. The evidence was accessed extensively during the study by those seeking information on nanotechnologies and their potential impacts.

The report of the working group was approved for publication by the councils of the two academies, following rigorous peer review by a review group comprising fellows of both academies. The final report, *Nanoscience and Nanotechnologies: Opportunities and Uncertainties*, was published in July 2004.

The media were used throughout the study to publicise the call for evidence and, once the report was published, to promote the recommendations. There was extensive coverage of the report in the UK and international media, and coverage was generally well balanced.

There was a very positive response to the conduct of the study and its recommendations across a wide range of stakeholders, from industry to NGOs. Broadening the working group to include non-scientists was particularly highlighted (including by the UK Science Minister), as an important change in the scientific community's approach to assessing new and emerging technologies.

KEY CONCLUSIONS AND RECOMMENDATIONS OF THE STUDY

The report confirmed that nanotechnologies have great potential, both now and in the future. The working group noted, however, that the extensive hype about the potential for nanotechnologies as well as about their risks was unhelpful to their development.

The report concluded that most nanotechnologies pose no *new* risks to health or the environment (for example, computer chips that exploit nanoscale areas), but there was concern about the potential impacts of manufactured nanoparticles and nanotubes that are ‘free’ rather than fixed within a material. The relatively greater surface area of nanoparticles and nanotubes, and their probable ability to penetrate cells more easily, raised concerns. However, the report highlighted the lack of research into the risks to human health and the environment. A comprehensive programme of research was recommended to address these uncertainties. It was recognised that initially there was a need to build research capability in this field. In addition, international collaborations and exchange of data were also regarded as essential. The academies have been disappointed that the UK government’s report on research into the potential impacts of nanotechnologies (published in November 2005 as one of its responses to the academies’ report) lacks dedicated funding for the work on exposure to nanoparticles and impact on human health and the environment which is needed to underpin appropriate regulation. However, the European Commission will fund research programmes in this area as part of its Framework Programme.

With respect to the social and ethical impacts of nanotechnologies, many of the issues raised in the short term are not unique to these technologies. They relate to who will control and benefit from their exploitation. In the longer term, concerns have been raised about how applications of nanotechnologies might impact on privacy (for example, through the development of tiny sensors) and human enhancement (as a result of the expected convergence of nanotechnologies with biotechnology, information and cognitive sciences). The report recommended further research into the social and ethical issues arising from nanotechnologies and that ethical and social implications of advanced technologies form part of the formal training of all research students and staff in these areas.

Given the fact that chemicals in the form of nanoparticles and nanotubes may have different properties from those in the larger form, it cannot be assumed that their toxicology will be the same. The report recommended that all regulators should review existing regulations to determine whether they are appropriate in relation to hazards outlined in the report. In particular, the working group recommended that: chemicals in the form of nanoparticles or nanotubes be treated as new substances in chemical regulations and labelling; workplace exposure limits in industry and academia be reviewed; and ingredients in the form of manufactured nanoparticles undergo a full and independent safety assessment by a scientific advisory body before use (for example, in cosmetics). The UK government has since ordered a regulatory review, and the European Commission is examining European regulations for consumer products containing nanoparticles.

The small survey of public attitudes undertaken as part of the report revealed that only 29% of those questioned had heard of nanotechnologies. Of those, most felt that the field would yield positive benefits and hoped that nanotechnologies would improve our future quality of life. More in-depth workshops revealed that, as with any new technology, although there were major concerns about nanotechnologies (for example, the possible side effects of nanotechnologies and whether enough was being done to establish what they are), there was also much that the participants thought was positive (for example, the possible medical applications such as targeted drug delivery). The report recommended public dialogue about the development of nanotechnologies to inform key decisions about their development and more detailed research into public attitudes to nanotechnology. Since the publication of the report, a number of programmes of research into public attitudes and public dialogue exercises have been initiated.

Finally, the working group concluded that there should be a more systematic approach to identifying the health, safety, environmental, social, ethical and regulatory issues associated with new and emerging technologies. They recommended that the UK government’s Chief Scientific Advisor establish a group to bring together a wide range of stakeholders to look at new and emerging technologies, to identify at the earliest stage where any adverse impacts might arise and to advise on how these might be addressed. In response to this recommendation, part of the remit of the new science and technology horizon-scanning centre established by the UK’s Office of Science and Technology will be to engage with stakeholders.

ONGOING ACTIVITIES

In the 18 months since its publication, the academies have continued to actively promote the findings of the report. They have scrutinised the various responses to the report that have been published by the UK government and are in regular contact with the relevant government departments. In response to one of the recommendations of the report, the UK government has asked the Council for Science and Technology (the government’s top-level advisory body on science and technology policy issues) to review the implementation of the report’s findings after two and five years. The academies will be contributing to these reviews.

The academies are also involved, via the working group and staff members, with a variety of international initiatives aimed at the responsible development of nanotechnologies.

RELEVANT WEB LINKS AND ADDITIONAL INFORMATION

Full details of the study, including the final report, the evidence and some of the follow-up work, can be found on the dedicated study website, www.nanotec.org.uk.

For further information about the study and the policy work of the Royal Society, contact: Rachel Quinn, Head of Science Policy (Rachel.Quinn@royalsoc.ac.uk) or see the Royal Society’s website, www.royalsoc.ac.uk/page.asp?id=1167.

Further information about the Royal Academy of Engineering can be found at www.raeng.org.uk.

Details of the UK government’s response to the academies’ report and its ongoing activities can be found at: www.ost.gov.uk/policy/issues/index.htm#Nanotechnology.

DISCUSSION

- **Wieland Gevers:** Given that most of the studies of the Royal Academy are self-initiated (unlike the US National Academies, where most of the studies are commissioned), how do you fund such studies?
- **Prof. Ann Dowling:** The Royal Society receives funding from the Government in the form of a Parliamentary Grant-in-Aid. Most of this is distributed as research grants to support young researchers. A small proportion of the grant provides the Society with the capability to undertake the policy studies it chooses to initiate. The rest comes from the Society’s own annual operating budget, some of which comes from fellows contributions. Occasionally the Society will undertake contracts from the Government. The terms of reference are agreed with the Government, but the Society has complete independence in the conduct of the study and the publication of the report. The contract negotiated for the nanotechnologies study enabled the Society to fund a survey of public attitudes and to employ more secretariat support.

The South African national biotechnology strategy

Iqbal Parker*

The South African National Biotechnology Strategy resulted from many initiatives on the African continent. In 1979, the Monrovia Strategy and in 1980 the Lagos Plan of Action looked at sustainable development in Africa and considered science for sustainable development. It was a very far-reaching plan, which called for increased Investment in S&T, but unfortunately the plan was a low priority for most of the countries that participated in developing it, despite the fact that science was a high priority for Asian countries.

The South African National Biotechnology Strategy was initiated in May 2001. By November 2001, several public information sessions had taken place in the major centres in South Africa, and the strategy had been placed on a website. The strategy received Cabinet approval in January 2002. It is notable that the completion of the approval process was achieved in less than a year. The strategy was implemented from April 2002.

In drafting the strategy, it was necessary to define the concept of biotechnology. The general definition of biotechnology is that biotechnology is a body of techniques that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use.

South Africa was already performing fairly advance first generation biotechnology, including enzyme isolation and isolation of products from plants and animals without any genetic manipulation. For instance, South Africa is one of the leading producers of horseradish peroxidase for use in enzyme-linked assays. The strategy addressed the importance of both first, second and third generation biotechnology, but focused on developing third generation biotechnology.

In terms of modern or third generation biotechnology, biotechnology is defined as a set of technologies including, but not confined to, tissue culture and recombinant DNA techniques, bioinformatics and genomics, proteomics and structural biology, and all other techniques employed for the genetic modification of living organisms, used to exploit and modify living organisms so as to produce new intellectual property, tools, goods, products and services.

WHY DID SOUTH AFRICA NEED A BIOTECHNOLOGY STRATEGY?

The White Paper on Science and Technology, published soon after democracy in 1994, considered science and technology as central to creating wealth, improving the economy and quality of life in contemporary society, creating an enabling environment for innovation, achieving the national imperatives of reducing the impact of HIV/AIDS, and addressing job

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creation, rural development, urban renewal, human resource development and regional integration. It was anticipated that biotechnology could play a major role in addressing these imperatives.

Government was faced with the challenge of meeting the twin objectives of creating jobs and economic growth without impacting negatively on human health and the environment. An Expert Panel was tasked with developing a strategy to achieve these twin objectives.

The development of the strategy entailed a process within government as well as a process carried out by the Expert Panel.

The government process involved creating an Inter-departmental Steering Committee (including the departments of Health, Trade and Industry, Agriculture, Science and Technology and Education),to draft the Terms of Reference for the Expert Panel. The steering committee continued to drive the process during and after the preparation of the strategy.

Once constituted, the Expert Panel adopted a process of defining outcomes and objectives based on the terms of reference and undertaking a situational analysis, which included recording a solid history of engagement in first generation biotechnology (agriculture, food, health) and noting the widening gap between South Africa and other countries in terms of second and third generation biotechnology, even compared to certain other developing countries. Given that new biotechnology is more research intensive, highly networked and multidisciplinary, it required a new approach, which was addressed in the strategy. The strategy identified current problems and made recommendations for strategic interventions.

The framework for analysis adopted by the panel took the approach, from the beginning, that the strategy was determined by the need to create outcomes, specifically the creation of a viable biotechnology industry in South Africa, supported by the required human resources, expertise, infrastructure and financial assistance, to produce biotechnology goods and services that meet national needs.

The strategy document is structured as follows:

■ Chapter 1: Introduction

- ☐ Nature of biotechnology.
- ☐ Why a national strategy?
- ☐ Methodology and scope.
- ☐ Structure of the report.

■ Chapter 2: Socio-economic and international context for biotechnology in South Africa

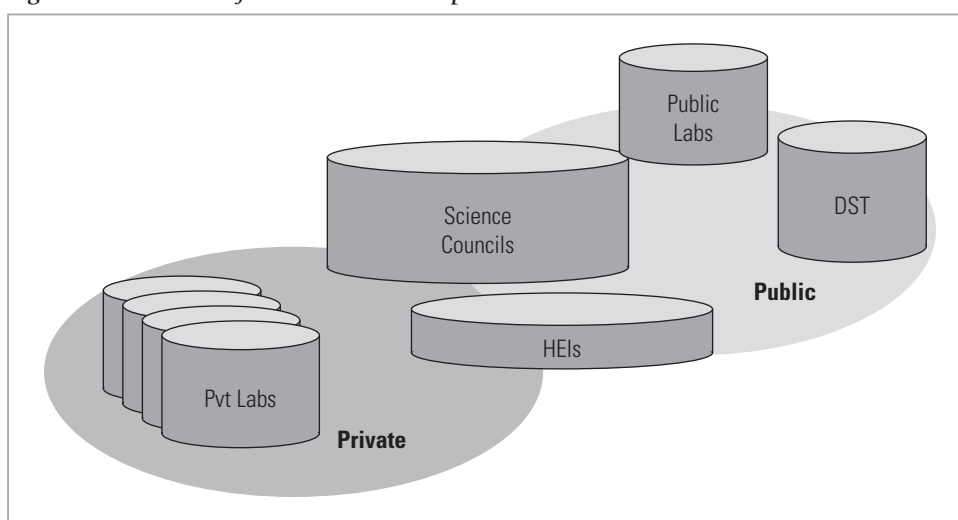
- ☐ Economic, environmental and socio-political context in South Africa .
- ☐ Lessons from the rest of the world.
 - *Brazil (which has been very successful, Cuba (which has developed some of the first vaccines) and Nigeria (which at the time was involved in developing its own biotechnology strategy). Representatives of each of these three countries served on the panel.*
 - *USA and Australia, with consideration of how to adapt to the South African context the circumstances which had made biotechnology successful in those countries.*

■ Chapter 3: Key issues and problems in South Africa

- ☐ Institutional arrangements.
- ☐ Human resource considerations, the impact of the brain drain and the lack of trained people.
- ☐ Funding of biotechnology R&D, which has been insignificant in South Africa compared with developed countries.
- ☐ Commercialising biotechnology (many academics are unfortunately opposed to this).
- ☐ Policy and legal instruments (existing and new).
- ☐ Ethics.
- ☐ Public understanding, not only with respect to biotechnology but science and technology in general.

The situational analysis shows the private and public sector components (Figure 1). The funding for the public sector component comes mostly from the Department of Science and Technology, and there are some public laboratories in the departments of Health, Science and Technology and Agriculture. The science councils are funded by both the private and public sectors and include the Medical Research Council under the Department of Health, the CSIR and National Research Foundation under the Department of Science and Technology, and the Agricultural Research Council under the Department of Agriculture. There are also a number of privately funded laboratories, as well as higher education institutions, most of the funding for which comes from the public sector. One of the problems has been the very limited communication between the public and private sectors. The proposed strategic interventions considered ways of encouraging the public and private sectors to work more closely together towards converting basic research findings into end products.

Figure 1: The South African R&D landscape



■ Chapter 4: Proposed Strategic interventions

- ☐ Proposed principles for the biotechnology strategy.
- ☐ Institutional arrangements.
- ☐ Human resources development (including importing expertise where necessary).
- ☐ Creating industrial opportunities, enhancing the culture of venture capitalism and expanding funding opportunities.
- ☐ Policy and legislative reforms.
- ☐ Enhancing international cooperation, (following an era in which South Africa had been subject to international isolation, and links had to be re-established with international colleagues).
- ☐ New and innovative financing.
- ☐ Ethical issues.
- ☐ Public understanding of biotechnology.

■ Chapter 5: Recommendations

- ☐ New institutional arrangements.
- ☐ The formation of a Biotechnology Advisory Committee was recommended, to advise the government, to determine funding priorities and alignment, to seek cohesion and coherence, to promote biotechnology and monitor progress and to ensure an appropriate regulatory environment. The committee would comprise experts from both South Africa and abroad to advise in an authoritative and independent way. Ideally, some members of the Expert Panel should serve on the committee for the sake of continuity.

The establishment of Biotechnology Regional Innovation Centres (BRICs), which receive a budget and have a brief to develop and fund business plan development, fund researchers and promote their interaction with industry with a view to producing end products. The funding for the BRICs would come from government. The role of the BRICs was to establish and maintain focused technology platforms, drive the new approach to commercialisation of biotechnology, attract contract staff, develop incubators, ensure well-equipped infrastructure and develop intimate market links.

- The strategy requested that new funding worth R180 million be set aside to fund the strategy, particularly the BRICs. (The initial budget was R100 million, rising to R155 million in 2005, which is approaching the proposed target).
- It was recommended that bioinformatics nodes be set up, with high-powered computational ability,.
- It was recommended that a bioethics committee be set up (this has been done under the auspices of the Department of Health).

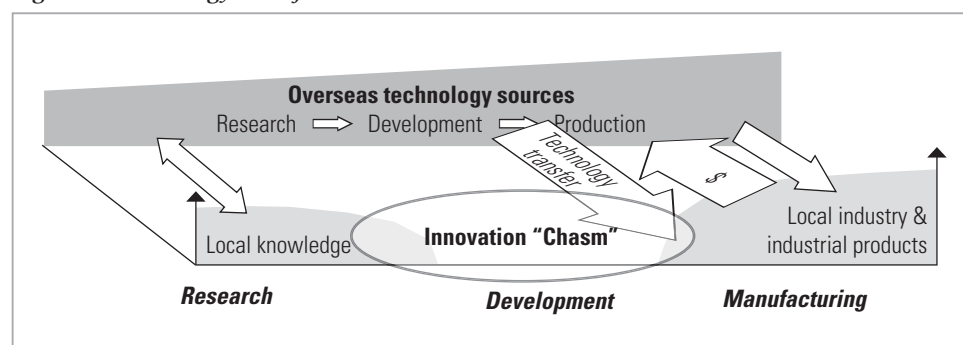
- The strategy outlined the responsibilities of the various government departments in realising the strategy.

The strategy identified the following crucial focus areas for South Africa, in which indigenous knowledge is embedded:

- Human health.
 - Vaccines.
 - Biopharmaceutical production.
- Food security.
- Increased agricultural yields.
- Animal health.
- Sustainable industrial development.

One of the problems identified in South Africa is the 'innovation chasm' (Figure 2). Local knowledge tends to be exported, research is done abroad and the technology is then imported for the purposes of manufacture. The net result is an outflow of monetary value from the country with a subsequent negative impact on the economy, with very little monetary inflow. The strategy recommended funding to address this situation.

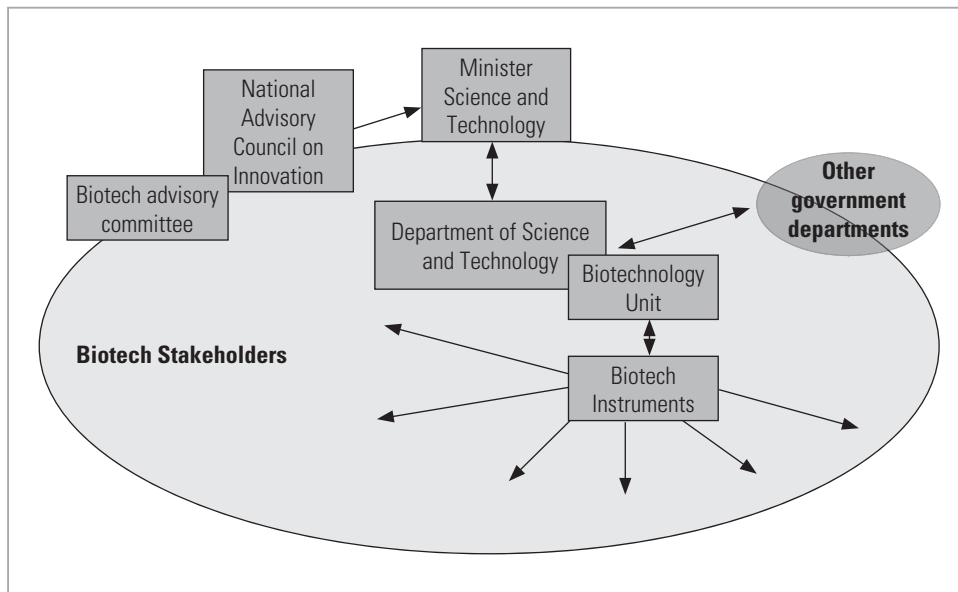
Figure 2: Technology transfer – The innovation 'chasm'



OUTCOME OF THE STRATEGY

The Department of Science and Technology has set up a Biotechnology Unit involving the departments of Health and Agriculture (Figures 3 and 4). The Biotechnology Unit in turn has set up a number of instruments: the technology platform, including the national bioinformatics node and platforms for functional genomics, fermentation and micro array. The function of the national bioinformatics node is to develop bio informatics capacity in South Africa, provide bioinformatics network infrastructure and develop a functional genomic platform.

Figure 3: Support for biotechnology in South Africa. See figure 4 for details of the Biotechnology Unit



Support for biotechnology innovation and commercialisation includes the BRICs (the fourth one to have been set up – PlantBio – focuses mostly on plant biotechnology), the Innovation Fund provides sizeable funding for biotechnology while the incubators were set up to focus on providing technology platforms. The Biotechnology Advisory Committee is being set up and is one of the ways in which public issues will be addressed. The public understanding of biotechnology serves to promote a fact-based understanding of biotechnology and facilitate public engagement in biotechnology. Several frontier programmes such as the South African AIDS vaccine and TB vaccine initiatives are also in place.

Expenditure on biotechnology, genetics and genetic engineering in South Africa has increased 300% over the period 2002–2004 (Figure 5). Research councils account for the highest percentage of expenditure of biotechnology (51.3%), followed by higher education institutions (30.3%) and business (18.4%) (Figure 6). Several key biotechnology companies have been established since the implementation of the strategy, most of which are in Gauteng and the Western Cape.

In early 2000, there were about a dozen biotechnology companies in South Africa. The impact of the strategy is that by 2003, there were 47 core biotechnology companies in the

Figure 4: The DST Biotechnology Unit

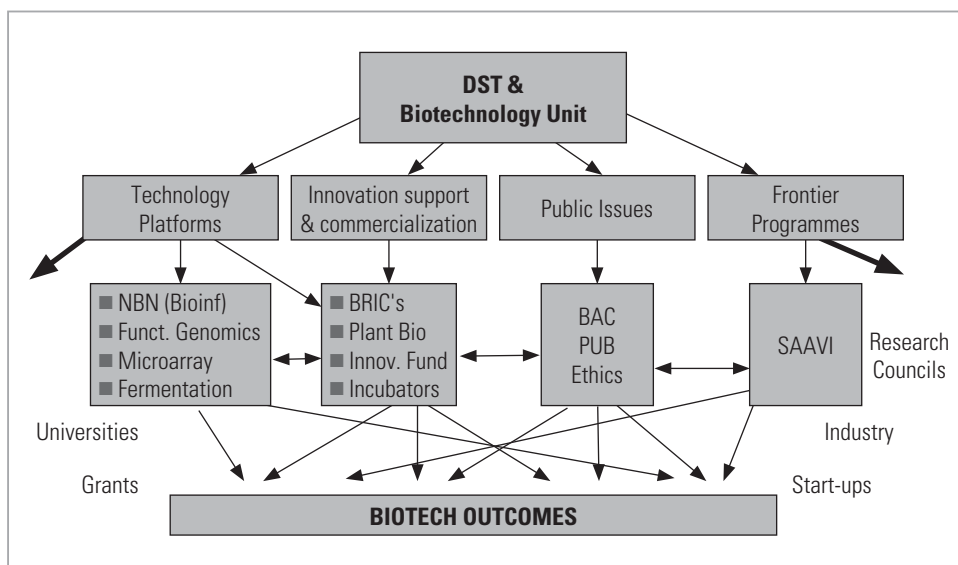
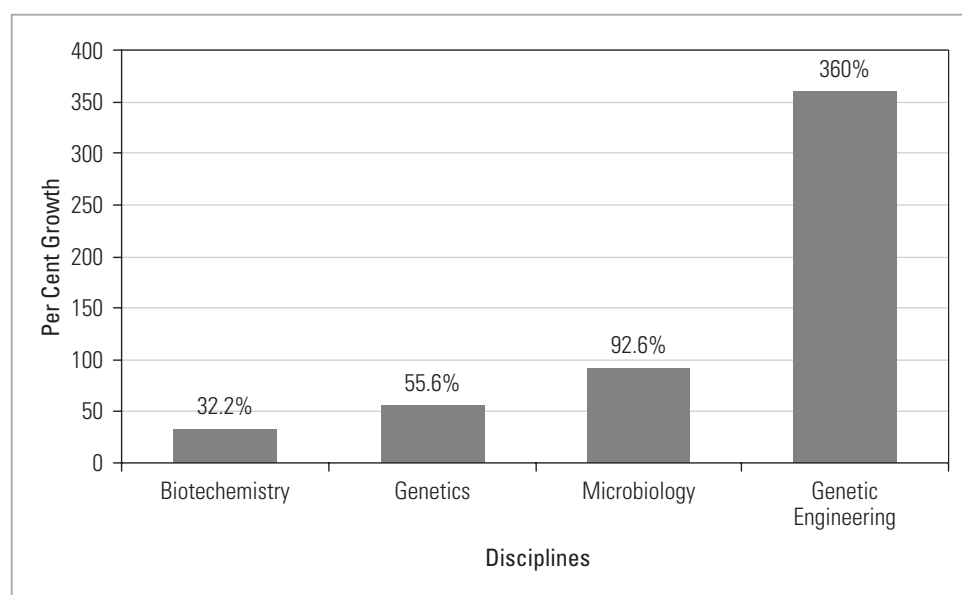


Figure 5: Growth in R&D expenditure on biotechnology-related disciplines in South Africa (2002—2004)



country (with approximately two new ones being set up each year) and 59 non-core but biotechnology-capable companies. At least 3 500 people are employed in the biotechnology sector, which brings in annual revenue in excess of R368 million.

South Africa is developing a bid to host the third component of the International Centre for Genetic Engineering and Biotechnology. The other two components were established in Trieste (Italy) in 1984, mostly with funding from the Italian government and in New Delhi, with funding of US\$120 million from the Indian government.

Basic research is funded almost entirely by government (Figure 7). Along the pipeline towards the development of an end product, however, government expenditure will inevitably decrease. There should be a concomitant increase in expenditure by industry as the product nears completion, but this culture is poorly developed in industry in South Africa and needs to be inculcated through specific instruments, not only in biotechnology but also in other areas of science and technology.

The role of biotechnology in the growth of a sustainable economy and job creation is very clear and it is important that we continue to emphasize the importance of the applications of scientific knowledge in the economy.

Figure 6: Performers of biotechnology and related fields in South Africa according to funds spent (2004)

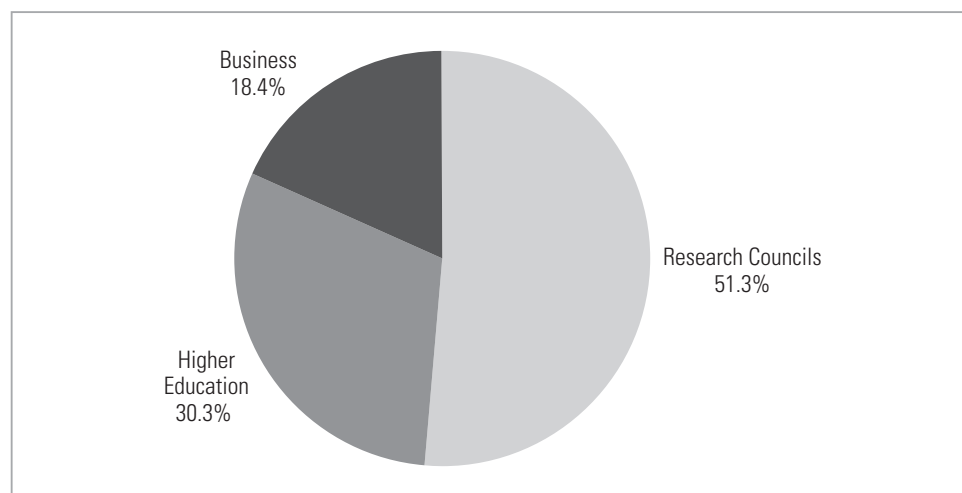
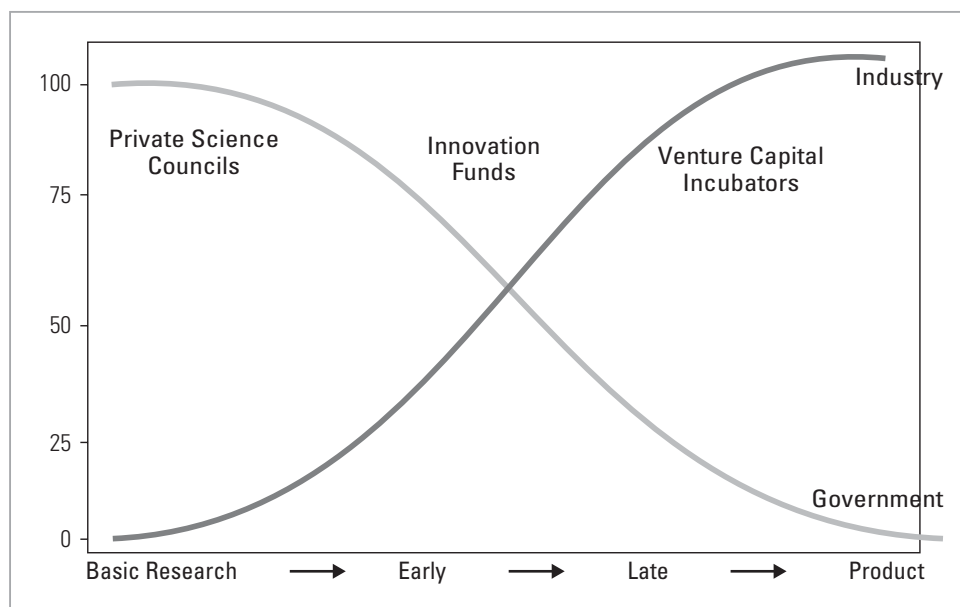


Figure 7: Funding streams



DISCUSSION

- **Lukhele-Olorunju:** Are there any moves by government to intervene and make industry understand the role it needs to play?
- **Iqbal Parker:** The strategy recommended that the Department of Finance look at tax concessions and tax holidays for companies that invest in R&D. The Department was not keen to pursue this avenue at the time, but just yesterday the Minister of Finance announced a 150% tax deduction on investments in R&D. So we are going in the right direction!!

How NACI interprets its brief

Calie Pistorius*

INTRODUCTION

The necessity and importance of providing science advice to government is accepted as a basic premise of this paper. There is a comprehensive body of knowledge that argues the point and describes best practices in this regard (see, for example, Morgan & Peha 2003; Kelly et al. 2004; Government of Canada 2000). This paper deals with the National Advisory Council on Innovation (NACI), as one of the organisations that provide science advice to government.¹ The focus of this paper is on how NACI interprets its brief. A discussion of the various branches of government as well as various relevant interpretations of the term 'science' is given in order to put the discussion of NACI, into perspective. The functions, objectives and composition of NACI are discussed within the context of the NACI Act, together with NACI's current structure and mode of operation. The paper concludes with a number of observations and recommendations, including suggestions of institutional structures that may be considered.

SCIENCE ADVICE TO GOVERNMENT

Although it is accepted that all governments need scientific advice, it is useful to explore what is meant by the terms 'government' and 'science' and the resultant government/science space, in order to put the discussion of NACI itself into perspective.

Government

National governments usually have a number of branches, each with its own functions. Each of these branches also has its own needs with regard to the nature of the advice that it requires. Science and technology in its various forms and manifestations is very prevalent in most government departments and functions, and hence there will also be a very prevalent need for scientific advice in most government departments.

The executive branch of government typically consists of a head of state (for example, a president as is the case in South Africa and the US, or a prime minister, as is the case in the UK, Australia and Canada) and a cabinet consisting of a number of ministers. The ministers usually have ministries, and head one or more government department. Some countries have

¹ The views presented in this paper are those of the author and do not necessarily reflect the official position of NACI.

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a specific minister for science and technology (such as South Africa), whereas others do not (as in the US). The fact that South Africa has a minister for science and technology will necessarily have an effect on the structure of the scientific advice system in the country.

As an example of the provision of scientific advice to a head of state, consider the case of the President of the US. The President draws on a number of mechanisms for scientific advice. The most important of these are the Office of Science and Technology Policy (OSTP) (OSTP 2006) and its director, and the President's Council of Advisors on Science and Technology (PCAST) (PCAST 2006). PCAST is co-chaired by the Director of the OSTP and a prominent expert drawn from the private sector, and consists of about 22 other prominent experts who are drawn from academia (including the presidents of universities such as MIT and Georgia Tech), think tanks, as well as the private sector. Recent PCAST reports include topics such as *Building out Broadband*, *Assessing the US R&D Investment*, *The Science and Technology of Combating Terrorism*, *Improving the Nation's Electrical System* and *Technology Transfer of Federally Funded R&D*. PCAST has also been designated as the overseer of the Network and Information Technology R&D programme and as the National Nanotechnology Advisory Panel. In South Africa, the President convened the International Investment Council to advise him (South African government 2005), but this body focuses more on macroeconomic issues than on science *per se*.

The legislative branches of governments have different functions and roles from the executive branches. They are nevertheless as much in need of scientific advice as the executive branch, albeit of a somewhat different nature. In the US, for example, the legislative branch of the government is the Congress, which is served by the Congressional Research Service (CRS) as well as other bodies with regard to advice (including scientific advice). The Office of Technology Assessment (OTA) served the Congress from its creation in 1972 until 1995, when its funding was cancelled. In South Africa, there is no dedicated body that offers scientific advice to Parliament.

Science

For the purpose of this discussion, we shall consider the term 'science' to refer to the natural sciences, including mathematics, agriculture, biological and life sciences, as well as technology and engineering. In its 'basic' form, advice on science would in some way or another refer to a consensus among scientists regarding the current state of knowledge about some aspect of science. This aspect, and advice associated with it, deals essentially with what is known about the laws of nature.

The application and exploitation of science and technology, as defined above, takes one beyond the realm of applied science itself and into the world of innovation. As is the case with the terms 'science' and 'technology', definitions and interpretations of the term 'innovation' abound. For the purpose of this discussion, however, a useful way of looking at the notion of innovation is that it involves two components – an invention component and a market exploitation component. In the case of technological innovations, the first component is very often associated with the basic scientific idea (or combinations thereof). It is where classical scientific R&D is brought to bear. The second component adds the entrepreneurial, market-orientated aspects. This is where commercialisation, market acceptance and diffusion come into play. It has been said that whereas inventions create new knowledge, innovation creates new wealth. In the same sense, whereas the scientific part of the invention component deals with the laws of nature, the rest of the innovation process is much more predicated on human nature and the laws of mankind. Providing advice on matters of innovation necessarily implies that both components (the invention and market components) should be addressed.

There is a very strong link between innovation on the one hand, and economic growth and competitiveness on the other. In this regard, it is also useful to distinguish between innovation at organisational, industry, regional and national levels.

At the national level, the notion of a national system of innovation (NSI) is a useful one. In an NSI, the various institutions that must play their roles, such as universities, science councils, industry and industrial laboratories and the various governmental departments and agencies, are important elements – as are national education, economic development, competitiveness, quality of life, financial and physical infrastructure, the intellectual property regime and competition environments, social welfare and health. In the current timeframe in South Africa, human resources and skills availability have become critical components of the NSI. The linkages between the various role-players, both at home and abroad, are significant characteristics of any NSI. The system of providing scientific advice to government can also be deemed to be an important element of the NSI.

It is evident that as one broadens the scope of the term ‘science’ to include the notions of innovation and national systems of innovation, the area that is covered in terms of ‘science advice to government’ becomes very large indeed, and reaches far beyond advice on issues of science *per se* (that is, the laws of nature). In addition to science and innovation, numerous policy-related issues also come into play, which by their nature all have political slants.

Science advice to government

Governments must formulate and execute policies. It has already been pointed out that science and the related issues of innovation and the national system of innovation feature prominently in many of these. When giving advice to government on policy matters, in this case those relating to both science and innovation, one must also consider the political view and implications. Providing scientific advice to government becomes more than just a matter of ‘speaking truth to power’. The government, whether it is the head of state, a minister or other organ of the executive branch, or elements of the legislative branch need advice that they can use and apply in the policy and political environments in which they function. In order to be useful, the advice must support and enhance the receiver’s decision-making ability.

Very often, the nature of the advice is such that it will address or contain elements of impact assessment. Technology assessment is a class of policy studies that systematically examines the effects on society that may occur when a technology is introduced, extended, modified or discontinued (Porter et al. 1991). It assesses the obvious and direct as well as the indirect, unintended and delayed consequences. This can be done in the scientific and technological, social, cultural, behavioural, health, economic, environmental, political and related arenas. In this regard, impact assessment is closely related to the assessment of risks. Foresight exercises, of the type that was conducted in South Africa a number of years ago, also assess emerging technologies. This is typically done with regard to their potential impact on society as well as their potential for commercial exploitation.

In any NSI, it is necessary to develop indicators that show the ‘state of the NSI’. These are often informed by audits and surveys, and can be presented as surveys of research and development (R&D), innovation and competitiveness, for example.

NACI

The National Advisory Council on Innovation (NACI) was established by the National Advisory Council on Innovation Act (Act 55 of 1997), with the purpose of advising the Minister of Science and Technology on issues relating to the national system of innovation.

NACI’s objectives

NACI’s objectives are set out in section 3 of the Act. It is stipulated that NACI shall advise the Minister and, through the Minister, the Ministers’ Committee and the Cabinet, on the role and contribution of science, mathematics, innovation and technology (including indigenous technologies).

- In promoting and achieving national objectives, namely to:
 - Improve and sustain the quality of life of all South Africans.
 - Develop human resources for S&T.
 - Build the economy.
 - Strengthen the country's competitiveness in the international sphere.

NACI's functions

The Act stipulates that in order to achieve its objectives, NACI may, or shall at the request of the Minister, advise on:

- The coordination and stimulation of the National System of Innovation (NSI).
- The promotion of cooperation within the NSI.
- The development and maintenance of human resources for innovation through selective support for education, training and R&D in the higher education sector and at science councils, science and technology institutions (SETIs) and private institutions.
- Strategies for the promotion of technology innovation, development, acquisition, transfer and implementation in all sectors.
- International liaison and cooperation in the fields of science, technology and innovation.
- Coordination of S&T policy and strategies with policies and strategies within policies and strategies in other environments.
- The structuring, governance and coordination of the S&T system.
- The identification of R&D priorities in consultation with provincial departments and interested parties, and their incorporation in the process of government funding of R&D.
- The funding of the S&T system in respect of its contributions to innovation, including:
 - A framework for national and government expenditure on R&D.
 - The building and maintenance of S&T capacity by way of selective funding of training and R&D.
 - The distribution of funds allocated to science councils.
 - The funding of R&D in all sectors.
 - The funding of national facilities utilised for research.
- The establishment, phasing out, rationalisation and management of:
 - Science councils.
 - National facilities utilised for research.
 - National R&D programmes conducted by research councils.
 - S&T institutions with the NSI.
 - The promotion of mathematics, the natural sciences and technology in the education sector in consultation with the Minister of Education and the Minister of Labour.
- Strategies for:
 - The promotion and dissemination and accessibility of scientific knowledge and technology.
 - The promotion of the public understanding of S&T and its supportive role in innovation for development and progress.
- The establishment and maintenance of IT systems to support:
 - The monitoring and evaluation of the overall management and functioning of the S&T system and the NSI.
 - The continuous revision of S&T policy to address changing and new circumstances.
- Developments in the fields of science, technology and innovation that may require new legislation.
- Any other matter relating to science, mathematics, innovation and technology, including indigenous technologies, which the Minister may refer to NACI, or in respect of which NACI may deem it necessary to advise the Minister.

Composition of NACI and criteria for membership

The Act stipulates that NACI shall be composed as follows:

- A chairperson appointed by the Minister.
- Sixteen to 20 members appointed by the Minister (after consultation with the Ministers' Committee and after submission to the Cabinet for notification).
- A CEO (who is automatically the Director-General [DG] of the Department).
- An officer of the Department of Trade and Industry (appointed by the Minister with the concurrence of the Minister of Trade and Industry).

Apart from the two government officials, the other members (including the chairperson) of NACI are appointed in their personal capacities and serve on a part-time basis. These members are typically appointed for a period of four years, although they may be reappointed.

The Act states that the members, other than the two government officials who serve in their official capacity, shall be persons who have:

- Achieved distinction in any field of science and technology in their own right or in the context of innovation.
- Special knowledge or experience in relation to the management of science and technology or innovation.
- Special insight into the role and contribution of innovation in promoting and achieving national and provincial objectives, or;
- Special knowledge and experience of the functioning of the NSI within the science and technology system or any other aspect of NACI's domain of responsibility.

NACI must be broadly representative of all sectors and be constituted in a manner that will ensure a spread of expertise regarding:

- National and provincial interests.
- Scientific and technological disciplines.
- Innovation.
- Needs and opportunities in different socio-economic fields.
- Research and development in all sectors.

Structure and operation of NACI

By virtue of its Act, NACI is very closely tied to the DST. The Director General (DG) is the CEO of NACI, and the secretariat and its staff are all appointed as employees of the DST. It is notable that NACI has a much tighter relation with the DST than the Council on Higher Education (CHE) has with the Department of Education (DoE), for example.

The Act allows NACI to establish subcommittees to assist it in performing its functions. The SET4W committee (Science, Engineering and Technology for Women committee, previously known as the South African Reference Group on Women [SARG]) is particularly active. A subcommittee dealing with biotechnology is also foreseen. The Indicators Group was also recently moved from the DST to NACI.

NACI has currently organised itself into five working groups, namely:

- Infrastructure for innovation promotion.
- Human capital and knowledge base.
- Science, technology and innovation for competitiveness.
- Social dimensions of innovation.
- Position and role of NACI in the NSI.

In order to provide advice, it is necessary for NACI to remain informed about the issues that fall within its domain, and especially those on which it is formulating advice at any given time. Although NACI can to some extent rely on its own councillors and researchers, it will typically contract out the research that provides the background and evidence on which its advice is based. Upon receiving the research report, NACI will then deliberate the findings

and recommendations, and formulate its advice. The research must typically be interpreted, analysed and presented in a format that will be useful to the Minister. NACI has in the past made a number of its research reports available to the public, often in cooperation with other bodies. The reports *Flight of the Flamingos* (Kahn 2004) and *Growth and Innovation* (Fedderke 2001) are examples of studies that were undertaken jointly with other organisations and published. NACI also publishes an annual report every year. General information on NACI and its activities is available on its website (NACI 2006).

Examples of recent advice from NACI to the Minister of Science and Technology include advice on the mobility of R&D workers, the utilisation of research findings and shortages of technical skills.

The point was made earlier that there is clearly little dispute that governments need advice on scientific matters. However, it was argued that the notion of 'science advice to government' is very broad, both with respect to which part of the government is to be provided with advice on the one hand, as well as the definition of science on the other. In order to understand how NACI interprets its brief, it is therefore necessary to pose the question not only with regard to what is determined and required by the NACI Act, but also within the context of the government/science space, which has already been discussed.

With regard to its brief, NACI must obviously execute its statutory duties as determined by the Act. The Act is clear with regard the component of government to which NACI must provide advice, namely, the Minister of Science and Technology.² It is also important to note that the Act requires NACI to provide advice, as opposed to executing on its own advice. If, for example, NACI is of the opinion that there should be increased effort with regard to the public understanding of science and technology, it must advise the Minister to this effect, rather than launching a major initiative of its own accord.

It is clear that the range of issues on which NACI can provide advice, as set out in its objectives and functions, whether self-initiated or at the request of the Minister, is extremely broad. Given the nature and structure of the Council and the fact that councillors all participate in NACI on a part-time basis, it is not practical or possible for NACI to address all the issues mentioned in the Act simultaneously. Unless the Minister specifically requests advice on a particular matter, NACI initiates advice on a subset of the issues mentioned in the Act.

The question remains how NACI interprets the notion of 'science'. Since its inception, NACI has not, either of its own accord or at the request of the Minister, provided advice on any science or technology issue *per se*, if by science and technology we mean dealing with the 'laws of nature'. Instead, it has focused on issues of innovation and the national system of innovation. These issues are more concerned with the 'laws of humankind' than with the laws of nature as alluded to earlier.

The issues with which NACI has been involved include the funding of science councils, research and the 'science vote', various issues regarding the provision of human resources for science and technology, as well as competitiveness. As the national council that must advise the Minister on matters related to innovation, NACI's primary focus should be on innovation and related matters. Although there is an abundance of definitions for the terms 'innovation' and 'national system of innovation', it is clear that the spectrum of issues that fall into these domains is much broader than science and technology in the strict sense.

In summary, NACI is a statutory body that gives advice to the Minister of Science and Technology (and through the Minister to the Ministers' Committee and the Cabinet) on issues

2 The Act actually refers to the Minister of Arts, Culture, Science and Technology. Since the promulgation of the Act, the Department of Arts, Culture, Science and Technology (DACST) has been split into two separate departments, viz. the Department of Science and Technology (DST) and the Department of Arts and Culture (DAC). As far as NACI is concerned, it is understood that it provides advice to the Minister of Science and Technology.

pertaining to the national system of innovation. The advice can be at the request of the Minister, or initiated by NACI itself. NACI is not, and does not, perform the functions of a science council (such as the Humans Sciences Research Council, the Council for Scientific and Industrial Research or the National Research Foundation), a think tank or a public forum (such as the National Science and Technology Forum), a government department (although it is very closely associated with DST) or a learned society (such as the Academy of Science of South Africa [ASSAf], the South African Academy of Engineers [SAAE] or the Royal Society of South Africa [RSSAf]).

THINKING ABOUT INSTITUTIONAL STRUCTURES

There is growing recognition of the importance of providing science advice to government. Learning from the experience of other countries as well as our own, it is clear that the mechanisms for providing such advice to government are important elements of the NSI in their own right. It is also evident that the ‘science advice system’ should consist of a number of different bodies – ‘horses for courses’. These will typically include NACI, ASSAf and the other academies as well as other institutions. As we go about designing a better science advice system for the country, we must ensure that we take a broader view and include all the elements of advice that may be necessary to support the NSI. The National Science and Technology Audit and the Foresight Exercise that were undertaken in South Africa a number of years ago, for instance, were coordinated by the Department of Arts, Culture, Science and Technology but have not been repeated. The DST does, however, produce regular R&D Surveys. These types of exercises, including surveys aimed at assessing the ‘state of the NSI’, which may include innovation as well as competitiveness indicators, should form part of the broader effort of science advice and the evidence supporting the advice. Even though the Indicators Group is currently accommodated within NACI, we should consider whether the system would not be better served by a separate dedicated structure for that purpose. In this regard, we should perhaps investigate organisations that were created for that purpose in other countries.

Even a cursory investigation shows that there are a very large number of public and private organisations across the world that are dedicated to the functions as discussed, including the Office of Technology Assessment (OTA) and the Institute for Prospective Technological Studies (IPTS).

The OTA was a body that advised the US Congress (that is, the legislative rather than the executive branch of government). It was created in 1972 and was de-funded in 1995. The OTA performed numerous impact assessment studies of various aspects of technology with the aim of informing members of Congress. The OTA fell foul of political intrigues during the mid-1990s but had an excellent reputation for the technical work that it performed. It served as the model for a number of ‘mini-OTAs’ around the world, particularly in Europe.

The IPTS is a Joint Research Centre of the European Commission. It was established in 1994 and is located in Seville, Spain. The mission of the IPTS is to provide techno-economic analysis support to European decision-makers by monitoring and analysing science and technology-related developments, their cross-sectoral impacts, their interrelationships in the socio-economic context, as well as future policy implications.

CONCLUSIONS

There can be little doubt that the various branches of government, whether the executive or legislative branches or other organs of state, need scientific advice. In any country, the system for providing scientific advice to government forms an essential element of that country’s

national system of innovation. South Africa must strengthen its capacity for developing, giving and receiving scientific advice vis-à-vis the government. This point is also made with regard to the achievement of the Millennium Goals (Juma & Yee-Cheong 2005). We must ensure that we understand the nature of scientific advice in all its facets, and that we have the intellectual capacity and the organisational structures in place to do so.

NACI is an essential element in South Africa's system of scientific advice to government in that it advises the Minister of Science and Technology on issues relating to the NSI. It should not, and cannot, however, be the only body that provides scientific advice to the government. The government/science space is very vast, and is best served by a number of organisations that are designed to address the various modalities. NACI has been in existence for eight years, and the time may be ripe to review its role and functions, particularly with regard to the complementary role that it must play in relation to other bodies in the national scientific advice system. It is currently engaged in an internal review of its operations and its place in the NSI.

NACI will probably do best by concentrating on policy issues relevant to the national system of innovation, rather than on issues of science and technology *per se*, but consideration should be given to formalising the functions of technology assessment and foresight.

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DISCUSSION

- **Jonathan Jansen:** Given that the CEO of NACI is the Director-General of the Department of Science and Technology, whom does NACI advise?
- **Calie Pistorius:** NACI advises the Minister of Science and Technology.
- **Candice Levieux:** At no point have you spoken of the role of advising on innovation through the lens of social science. Is that because your remit was very technologically focused?
- **Calie Pistorius:** There are many social scientists in NACI. There is one task group in particular for social aspects, and the others all have a social element.

- **Jan Geertsema:** Since NACI focuses on innovation, is there any body that provides specific scientific advice to the Minister.
- **Calie Pistorius:** Nothing prevents NACI, at the request of the Minister, from providing scientific advice, but so far the Minister has not done so. There are many other bodies in the country that could fulfil this role, such as the science councils. Another issue is the extent to which the national academies can perform this function.

Mobilising science advice for public policy-making in Africa

Public policy-making in the context of NEPAD and the Africa Union (AU)

John Mugabe*

As one moves from the national to the regional context, there is a growing range and complexity of issues (including economic, social, political, environmental, trade and security) that underpin Africa's development. The institutional nature and scale for policy-making also develops multiplicity, regional and continental scales and geopolitical diversity in moving from the national to the continental. One of the issues is the tension between anglophone and francophone countries. Another is that the concept of stakeholder is very different in the regional and continental context. The tension between policy and politics becomes pronounced, and political statements are often mistaken for public policy. There are weak policy analysis foundations (including an absence of strong institutions dedicated to policy research and analysis).

THE PLACE OF SCIENCE IN PUBLIC POLICY-MAKING AT THE NEPAD AND AFRICA UNION LEVELS

There is a twofold relationship between science and public policy-making: (1) science advises policy-making when policies are concerned with scientific and technological issues; and (2) policy can boost scientific and technological research. This relationship serves to reduce uncertainty and complexity and to increase knowledge of the nature of problems.

Economies are becoming increasingly dependent on the production, distribution and use of knowledge, which means that social and economic policies are increasingly influenced by science and technology. There is a need to avoid continuous reform of policy and reduce policy conflicts, thereby reducing the costs of policy development.

CHALLENGES OF MOBILISING SCIENCE FOR BETTER POLICY-MAKING IN THE NEPAD AND AU CONTEXTS

There is a weak tradition in the NEPAD and AU contexts of seeking science advice. The forerunner of the AU, the OAU, paid limited attention to science. Scientific institutions and programmes are weak. There is limited public and political demand for scientific advice or support for science, and a scarcity of information on sources of reliable scientific and related advice.

Structures for regionalism are not strong, and some states are unwilling to transfer policy-making authority to the regional and continental level, including NEPAD and the AU. The organisational space for policy-making is still largely externally defined, and policy prescriptions are made by donors.

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EVOLVING INSTITUTIONAL ARRANGEMENTS

The African Ministerial Council on Science and Technology (AMCOST) provides an example of a mechanism for procuring scientific advice, as do the NEPAD-AU advisory panels (for example, the High Level African Panel on Biotechnology, the Experts' Working Group on Science, Technology and Innovation Indicators, and the Task Group on Water Sciences). An AU Summit on Science and Technology is planned for 2007 to mobilise African science and scientific institutions.

There is emerging consultation between NEPAD and the science academies to find a role for the academies in NEPAD policy-making efforts. However, this will be difficult unless the Ministers at national level have confidence in the academies. There is possible participation of the Network of African Science Academies (NASAC) in AMCOST subsidiary bodies. The United Nations has a cluster on NEPAD and there is collaboration between UNESCO, UNCTAD and NEPAD.

ICSU's strategy in Africa

Science, technology and innovation for sustainable development in Africa

Sospeter Muhongo*

ICSU's strategy is to apply science and technology for sustainable development in sub-Saharan Africa.

ICSU is one of the oldest NGOs in the world. Its forerunners were the International Association of Academies (IAA) (1899-1914) and the International Research Council (IRC) (1919-1931). The International Council of Scientific Unions (ICSU) was formed in 1931 and changed its name to the International Council for Science in 1998. ICSU will be 75 years old on 11 July 2006.

Four ICSU regional offices are to be set up in acknowledgement of the importance of science and technology in the socio-economic development of any country. The African regional office was the first to be set up in 2005. The second is to be established in Kuala Lumpur, the third in Mexico and the fourth in the Arabic region.

ICSU has considerable clout in strengthening international science for the benefit of society. Global membership in January 2006 stood at 104 national members (18 of which were from Africa) and 29 scientific unions. Other affiliates include interdisciplinary bodies and joint initiatives such as:

- Assessment bodies (for example, the Millennium Ecosystem Assessment).
- Thematic bodies (for example, the Committee on Space Research [COSPAR]).
- Global Environmental Change Programmes (for example, the World Climate Research Programme [WCRP]).
- Monitoring and observation bodies (for example, the IGOS-Integrated Global Observing System).
- Data and information bodies (for example, the CODATA Committee on Data for Science and Technology).
- Scientific associates (for example, the International Foundation for Science [IFS]).

The vision of ICSU is:

- Science is used for the benefit of all in the global society, with universal and equitable access to high quality scientific data and information and all countries contributing to generating the new knowledge necessary to establish their sustainable development pathways.
- Excellence in science is valued and scientific knowledge is effectively linked to policy-making.

The mission of ICSU is to strengthen international science for the benefit of society by:

- Identifying and addressing major issues of importance to science and society.
- Facilitating interaction among scientists across all disciplines and from all countries.
- Promoting the participation of all scientists, without any segregation, in the international scientific endeavour.

* Sospeter Muhongo, director of the Africa office of the International Council of Scientific Unions (ICSU)

- Providing independent, authoritative advice to stimulate constructive dialogue between the scientific community and governments, civil society and the private sector.

The major strategic activities of the ICSU strategic plan: (2006–2011) can be summarised as follows:

- Planning and coordinating research:
 - Global environmental change (GEC).
 - International Polar Year (IPY, 2007–2008).
 - International Year of Planet Earth (IYPE, 2007–2009).
 - Natural and human-induced hazards and disasters.
 - Millennium Ecosystem Assessment-follow up.
 - Energy.
 - Human health.
 - New scientific horizons.
- Science for policy activities:
 - Global Earth Observation Systems (GEOS) – advice on implementation of a new Global Earth Observation System of Systems.
 - Sustainable development (WSSD 2002) – science for policy.
 - Commission on Sustainable Development (CSD) scientific input from ICSU.
- Strengthening the universality of science:
 - Universality principle in the conduct of science.
 - Intellectual property and copyright: interaction with key players (for example, World Intellectual Property Organization [WIPO]).
 - Science and society.
 - Regional offices.
 - CIS countries.
 - Capacity building.

The strategy of ICSU in Africa is to deploy science, technology and innovation to eradicate poverty on the continent. About 40% of sub-Saharan Africa (about 250 million people) live in absolute poverty. The gross national income (GNI) is about US\$400 billion (compared with US\$176.2 billion for Hong Kong alone). The GNI per capita in Africa is about US\$490 (compared with US\$25 860 for Hong Kong). The highest GNI per capita in Africa in 2004 were in the following countries, which do not come close to the GNI per capita in Hong Kong:

- Seychelles: US\$7 350.
- Mauritius: US\$4 100.
- Botswana: US\$3 530.
- Gabon: US\$3 400.
- South Africa: US\$2 920.

The Millennium Development Goals cannot be achieved without the practical application of science, technology and innovation:

- Eradicate extreme poverty and hunger.
- Achieve universal primary education.
- Promote gender equality.
- Reduce child mortality.
- Improve maternal health.
- Combat HIV/AIDS, malaria and other diseases.
- Ensure environmental sustainability.
- Develop a Global Partnership for Development.

The ICSU Regional Office for Africa has selected the following priority areas for the period 2006–2009:

- Sustainable energy.

- Health and human well-being.
- Natural and human-induced hazards and disasters.
- Global change.

SUSTAINABLE ENERGY

Energy is very important for socio-economic development, impacting on transportation, industry, commerce and agriculture. Africa produces only 6.2% of global energy and consumes only 2.6%. Over 77% of the population of Africa has no access to electricity, which is the highest percentage when compared with other continents. This is why ICSU has selected energy as one of its highest priorities.

Africa has estimated coal reserves of 48 750 million tons, which is approximately 6% of the global total. These reserves are conservatively estimated to last 227 years. Africa has estimated uranium reserves of 613 000 tons, which are estimated to last 94 years, with non-enrichment assumed. Global energy generation by means of coal has remained high over the last decade, ranging between 38 and 39% between 1990 and 2001.

Of the approximately 816 million people in Africa in 2001, it is estimated that:

- 1 in 4 has a radio (205 million).
- 1 in 13 has a TV (62 million).
- 1 in 35 has a mobile phone (24 million).
- 1 in 40 has a fixed line (20 million).
- 1 in 130 has a PC (5.9 million).
- 1 in 60 uses the Internet (5 million).
- 1 in 400 has pay TV (2 million) (TU, UNESCO, Jensen).

This is another area in which more effort is required.

HEALTH AND HUMAN WELL-BEING

Health is another area of focus for ICSU. Africa has a population of about 703 million and an annual population growth of 2.1%, which is above the economic growth rate of many of the countries on the continent. Life expectancy at birth is 45.8 years, which is the lowest in the world. Life expectancy at birth in sub-Saharan Africa is decreasing. The mortality rate among infants per 1000 live births is 103. The prevalence of HIV/AIDS as a percentage of the population aged 15–49 is about 8.5%.

Table 1: Net enrolment in education as a percentage of the relevant age group

	Primary	Secondary
South Africa	89	66
Botswana	81	54
Lesotho	86	22
Swaziland	75	32
Mozambique	55	12
Egypt	90	81
Jamaica	95	75
Mongolia	79	77
Hong Kong	98	72

Table 2: Education inputs: 2002/2003

	Public expenditure on education: % of total government expenditure	Pupils per teacher (primary school)
South Africa	18.5	35
Botswana	25.6	27
Lesotho	18.4	47
Swaziland	–	31
Namibia	–	22
Mozambique	–	67
Egypt	–	22
Hong Kong	21.9	20
India	12.7	41
China	–	20
United Kingdom	11.4	17
United States of America	17.1	15

Africa has the lowest school enrolment rate in the world, as well as the lowest primary school completion rate. Even in South Africa, which is better off than most other countries on the continent, the secondary enrolment is only 66% (Table 1). The low secondary enrolments negatively affect the pool from which science students can be drawn.

Public expenditure on education as a percentage of total government expenditure in South Africa, Botswana and Lesotho is higher than in the UK and USA (Table 2). Despite this, the number of pupils per teacher in South Africa, Botswana and Lesotho is approximately double the number in the UK and USA. Overcrowded classrooms negatively affect the quality of education. Primary and secondary enrolment in Mozambique is particularly low, with only 55% of the age cohort enrolled in primary education and only 12% in secondary education. The relatively high secondary enrolment in other developing countries such as Egypt, Jamaica, Mongolia and Hong Kong means that with time, their pool of scientists will grow relatively to countries in sub-Saharan Africa.

Food production in Africa has been increasing at a far slower rate than the growth in population. There is poor access to improved water sources in sub-Saharan Africa, especially in rural areas (Table 3).

Table 3: Access to improved water source (2002)

	% of urban population	% of rural population
South Africa	98	73
Botswana	100	90
Namibia	98	72
Mozambique	76	24
Lesotho	88	74
Swaziland	87	42
Angola	70	40

NATURAL AND HUMAN-INDUCED HAZARDS AND DISASTERS

Hazards and disasters are a manifestation of both deep earth and surface processes within the earth-system; and these include:

- Earthquakes.
- Volcanoes.
- Landslides.
- Floods.
- Collapse of constructions: engineering geology.
- Sea level changes: tsunamis, tornadoes.
- Global warming: greenhouse gases.
- Solar system: fall of meteorites.

Scientists with a very good understanding of the earth-system and its concomitant processes are needed for chatting out mitigating strategies and plans on natural and human-induced hazards and disasters in Africa.

GLOBAL CHANGE

Human-induced hazards and disasters include:

- Water pollution: heavy metals and toxic elements.
- Deforestation: aridity, soil erosion, landslides.
- Siltation: rivers, lakes, water pipes, dams.
- Disposal of tailings: mining waste disposal.
- Acid drainage: source: mines, chemical industries, etc.
- Destruction of ecosystems:
 - Sand-gravel mining.
 - Construction of dams and houses.
 - Over-harvesting of edible animal and plant species.
- Social problems: child labour, health care, immigration problems.

Figure 1 shows that Africa has few scientists researching global change. Of all the regions of Africa, West Africa has the highest number of scientists of global change, but even then, these total fewer than 300.

Figure 1: Regional distribution of scientists of global climate change

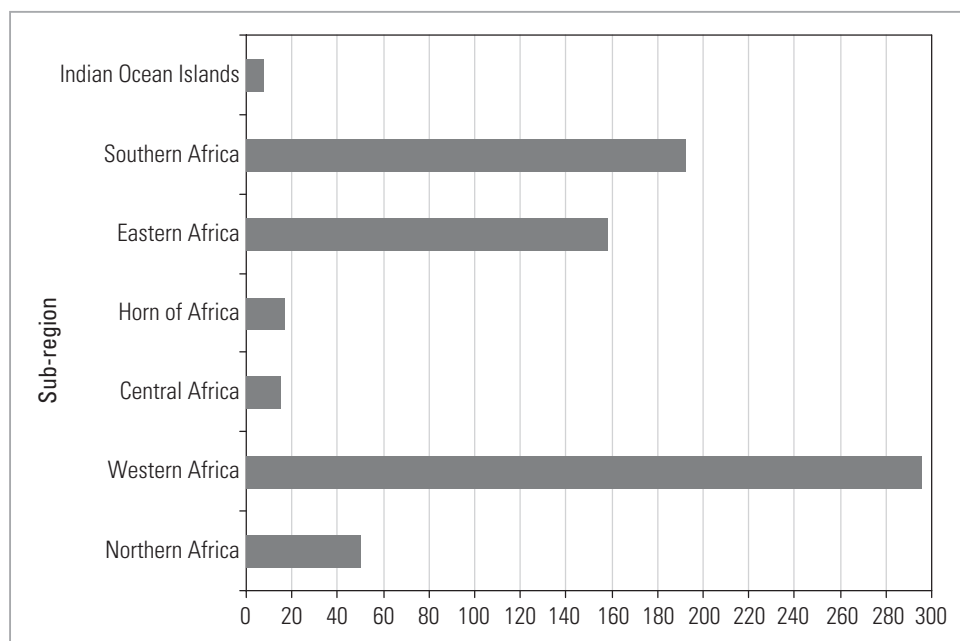
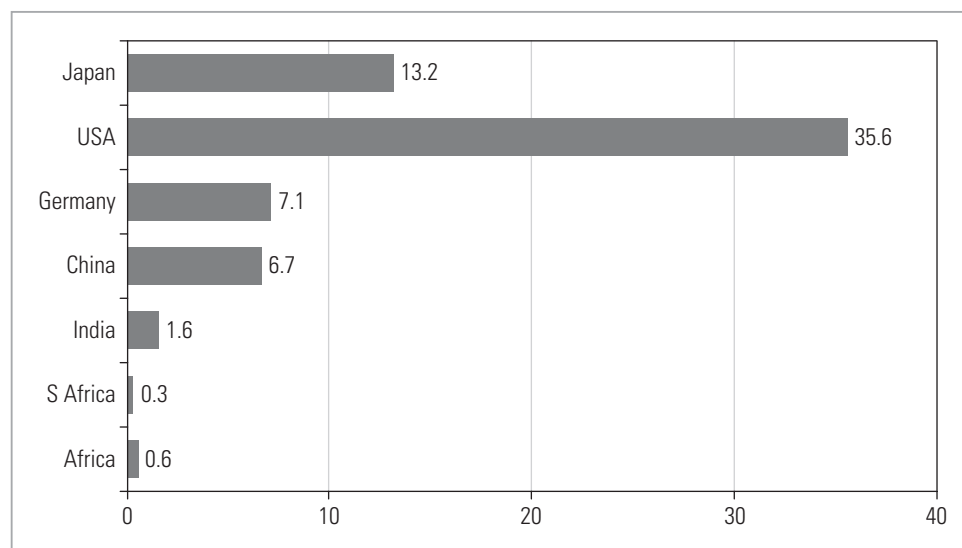


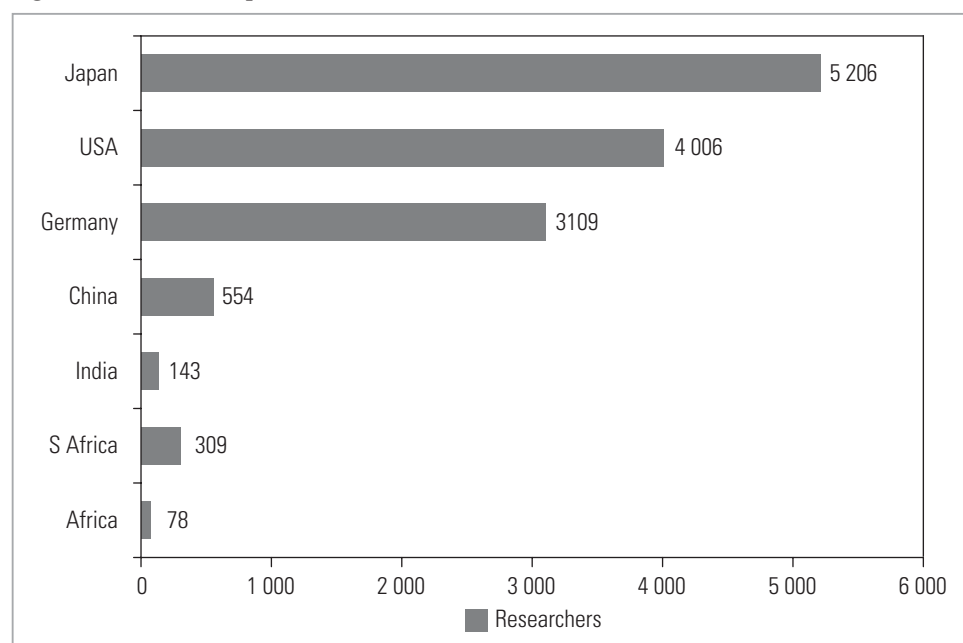
Figure 2: Global Gross Expenditure on R&D (GERD) (2000)

Global research

Almost 80% of the world population live in developing countries, which account for only 28% of world researchers and spend only 20% of global gross expenditure on R&D (GERD), compared with developed countries, which have only 21% of the world population but 72% of world researchers but spend 80% of GERD, which amounted to US\$746 billion in 2000 (Table 4). Developing countries such as India and China each account for more GERD than the whole of Africa combined. The USA alone accounted for 35.6% of GERD in 2000, compared with only 0.6% for Africa (Figure 2). Japan alone has 5 206 researchers per million inhabitants, and the USA 4 006 per million, compared with only 78 per million in Africa (Figure 3).

Operational strategy of the ICSU Regional Office for Africa

The operational strategy of the ICSU Regional Office for Africa is to have a small, efficient, well-functioning office, and to build up a database of African experts, including those in the Diaspora, so as to develop networks of science experts on the continent. The Regional Office

Figure 3: Researchers per million inhabitants (2000)

intends to have programmes on capacity building, promote indigenous knowledge and skills, address issues of gender balance and the youth, organise outreach and advocacy activities, form strategic partnerships and to engage in fund-raising for its programmes and projects. It has already well-established partnerships with UNESCO, the Academy of Sciences for the Developing World (TWAS) and the African Union (AU). Between March and June 2006, the Regional Office is preparing science plans based on the chosen focus areas, namely: health and human well-being, sustainable energy, natural and human-induced hazards and disasters and global change, as well as a Diaspora project. The latter project intends to deploy the notion of, “brain gain and brain circulation” from the African experts working and living outside the continent (in the Diaspora). The four science/work plans which are being developed by leading African scientists and engineers; will be evaluated and approved by grassroots sciences, engineers and policy-makers on 25-27 September 2006 in Pretoria (South Africa); during the 2nd Regional (Africa) ICSU Consultative Forum . It is envisaged that over one hundred stakeholders including grassroots scientists, engineers, policy-makers, and politicians will attend this forum in order to evaluate the workability of the African-prepared science/work plans.

In conclusion, I would like to emphasise the importance of science for society and development by citing Bertolt Brecht,(1939) who wrote on the *Life of Galileo*:

“The aim of science is not to open the door to infinite wisdom, but to set a limit to infinite error”.

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How a science council provides research-based advice

Olive Shisana*

Research councils have a broad mandate from Parliament to conduct, coordinate, foster and disseminate scientific information of public benefit; to collaborate with departments and tertiary institutions; to advise the Minister in these respects and to undertake commissioned work, for which they may charge fees.

The vision of the HSRC is to become a human and social sciences research council serving as a knowledge hub where public policy and discourse on current and future challenges for South Africa and the African continent are independently researched, analysed and where research-based solutions to human and social problems are developed. The vision is aligned with the mission of the organisation.

In terms of its mission, the HSRC is a non-partisan organisation that generates scientific knowledge through its research and analytical work in the social and human sciences, to provide critical and independent information to different role players, whether in policy development, media analysis, advocacy or debates so that they can make informed decisions.

The HSRC performs this function and plays this role in the following areas (Figure 1):

- Child, Youth, Family and Social Development.
- Democracy and Governance.
- Education, Science and Skills Development.
- Social Aspects of HIV/AIDS and Health.
- Society, Culture and Identity.
- Urban, Rural and Economic Development.

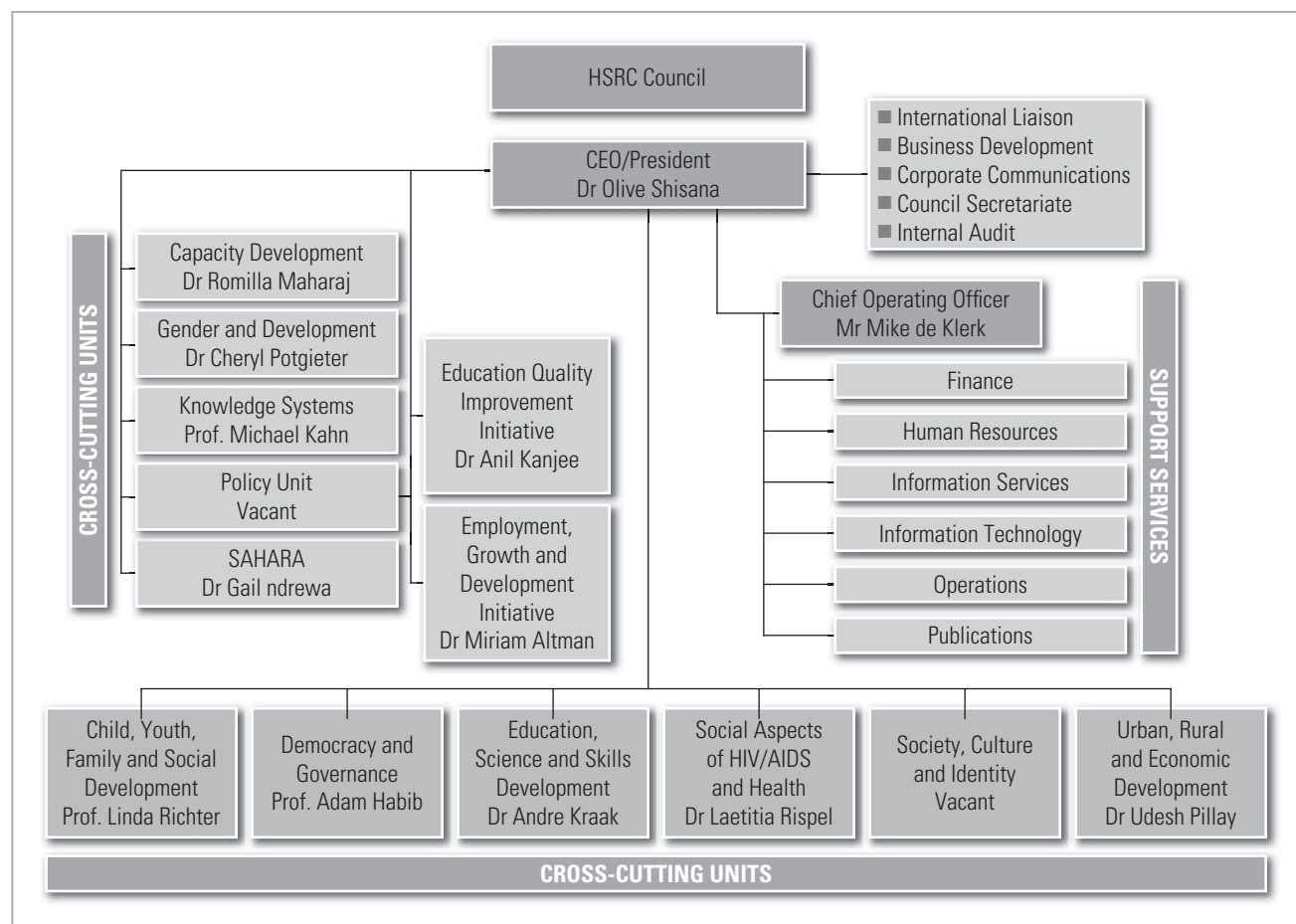
The HSRC also focuses on the cross-cutting areas of knowledge systems as well as gender and development. Because the organisation is particularly concerned about the issue of informing policy, the HSRC has created a Policy Unit (Figure 1), which will play a role in filling the gap between researchers and policy-makers.

Scientists should always remember that the path from knowledge generation to knowledge use is a long and meandering one. In between the release of the findings and adoption of a policy there are intervening factors, such as the political and economic situations and social values that guide actions of policy makers.

The sources of evidence-based knowledge emanating from social scientists include reports of original research, summaries, critiques and commentaries, systematic reviews, meta-analyses, evidence-based guidelines (an area in which the social sciences are still weak) and comprehensive knowledge databases. The medical and clinical fields are far more developed with respect to evidence-based guidelines even though the methodology for meta-analysis

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Figure 1: Structure of the HSRC



that is used was developed by the social sciences, particularly in the area of psychology and education.

Social scientists employed by the HSRC generate substantial outputs. Reports of original research emanating from the HSRC in a single year include the following outputs, which are listed on the website:

- 100 peer-reviewed journal articles published in 2004/2005 (by about 120 researchers).
- 118 books and chapters in books published in 2004/2005.
- 100 reports (prepared for government and other sources).
- 32 newsletter articles: review.
- 105 conference proceedings and abstracts.
- Bibliographic databases.

Arising from the research conducted by the HSRC scientists, policy makers can review their own policies or use it to decide whether a new policy is warranted.

Publications that are not peer-reviewed are listed on the HSRC intranet.

EXAMPLES OF RESEARCH-BASED ADVICE

HSRC involvement with ASGISA and JIPSA

The Accelerated and Shared Growth Initiative of South Africa (ASGISA) is a strategic initiative of government, to work together with business and labour, to overcome six major blockages to a higher and more sustainable economic growth rate. One of those six blockages is the skills crisis facing South Africa. The Joint Initiative on Priority Skills Acquisition (JIPSA) is a key technical working group within ASGISA with representation of government, business,

labour, civil society and the HSRC, working together to assist in solving the skills crisis in a limited set of high profile interventions.

The HSRC has contributed significantly to the debate on skills development in the last five years by arguing the importance of both high-level and intermediate-level skills in the national economy, and has indicated that both are in short supply in key areas (for example, artisans and engineers in the manufacturing, mining, construction and energy sectors). This argument has now been adopted by government, which is seeking major interventions in the training of artisans and engineers in the short to medium terms.

The skills development infrastructure of the parastatals (such as Eskom and Transnet) is a critical component of government's ability to roll out its large-scale investment programme in improved public infrastructure. However, Eskom and Transnet have lost their former capacity to produce large numbers of intermediate and highly skilled technical workers, and this capacity will need to be speedily rebuilt.

The HSRC will assist in providing action-oriented research and information to JIPSA so that the chosen interventions (such as improving the training capacity of parastatals) will succeed. The HSRC will help provide the information base upon which the other players in JIPSA and ASGISA can act to ensure success in the pursuit of the 6% growth target.

Centre for Science, Technology and Innovation Indicators

A key project for the Department of Science and Technology falls under the Centre for Science, Technology and Innovation Indicators (CeSTII), which was established on the basis of a DST ring-fenced grant. Its mandate is to conduct S&T surveys, build and maintain capacity and support a network of excellence in S&T policy. The activities include annual R&D surveys (to develop official statistics), the first official Innovation Survey and S&T policy analysis.

The impacts of the Centre for Science, Technology and Innovation Indicators include generating indicators and evidence-based policy briefs that inform S&T planning for DST and other departments, seminal work on the mobility of R&D personnel, the development of S&T policy with AU/NEPAD, the recognition of South African S&T indicators by the OECD (which enables South Africa to be compared with other countries) and promoting the international standing of South Africa.

Government has acknowledged the advice received via the R&D surveys as follows: "R&D Surveys provide data ... that are essential for planning at system and organisational level, and which furnish key indicators of national competitiveness" (Minister Mangena, 14 April 2005).

HIV/AIDS

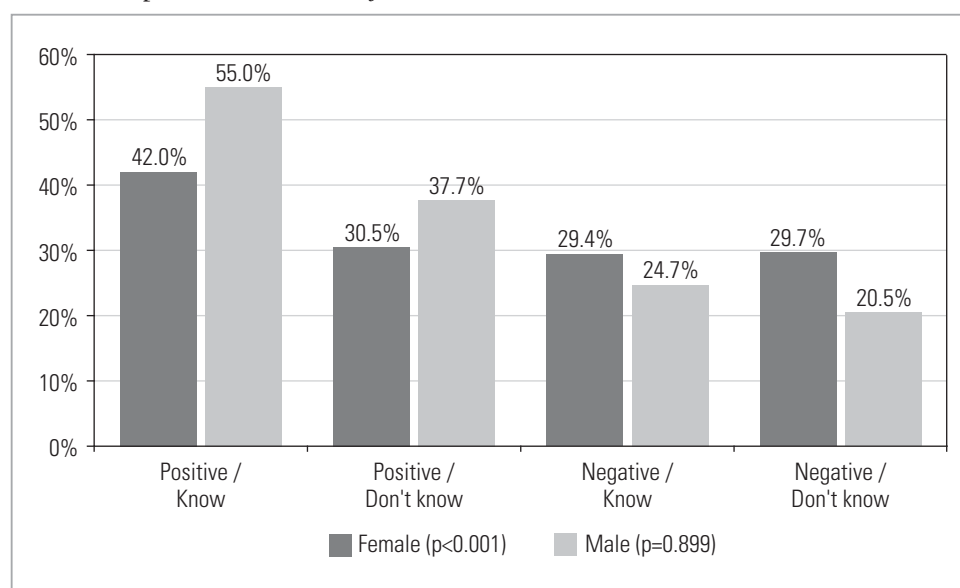
HIV/AIDS is another area in which the HSRC informs government. Due to the controversial nature of the topic, the HSRC follows the route of sticking closely to the facts (some of which are illustrated in Figure 2) and providing data in tables that are readily interpreted.

Government acknowledged the Nelson Mandela/HSRC study on HIV/AIDS (2002) in the following statement dated 5 December 2002:

The results of the survey by the HSRC and Nelson Mandela Foundation give cause for hope as well as reason to intensify action to combat HIV/AIDS through implementation of our comprehensive programme.

The research adds further depth and detail to the body of knowledge that researchers, scientists and statisticians have been producing to measure the progression and impact of the epidemic, and to inform our programme to combat it. It brings new information about linkages between prevalence, behaviour and communication.

Figure 2: South African sexually active adults (15 years and older) (2002) – Gender of the respondent, awareness of HIV status and condom use



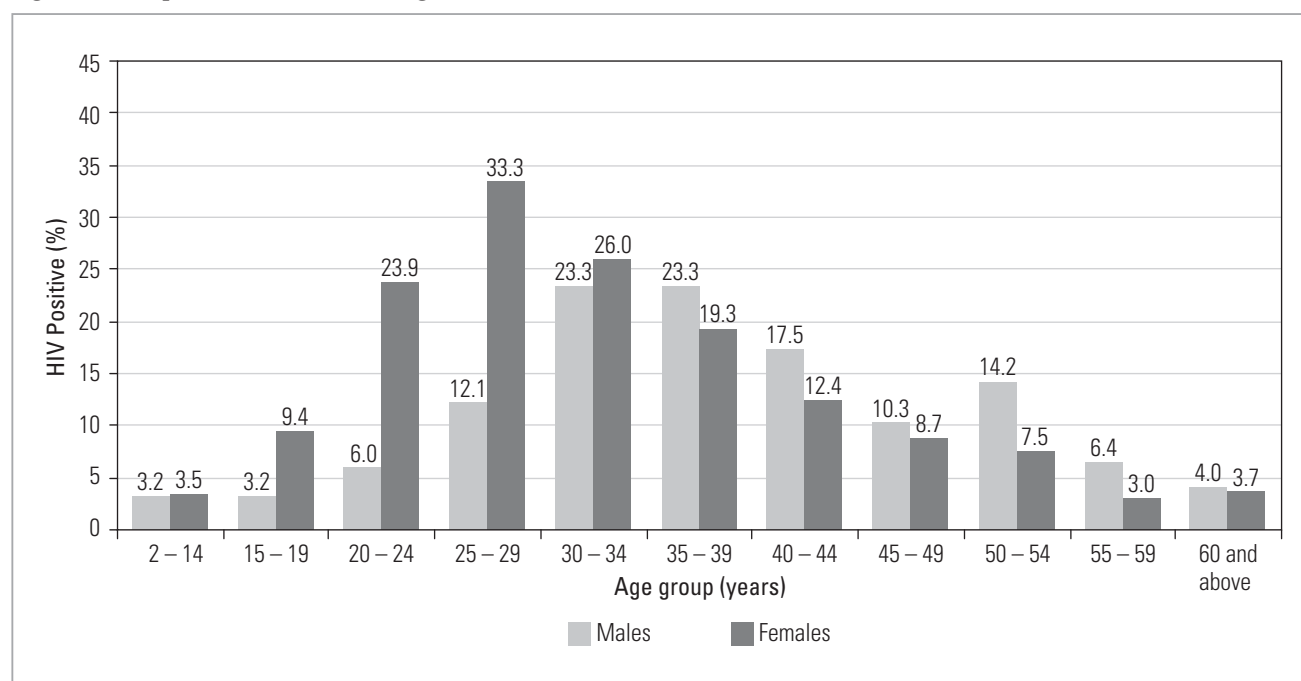
The results are broadly consistent with previous research and point to the same strategic choices and approach that informs the Five Year Strategic Plan and the Cabinet Statements of 17 April and 9 October this year.

A follow-up study in 2005 showed that HIV/AIDS is prevalent in all age groups, not only in the youth (Figure 3).

Government acknowledged the importance of the 2005 study in the following statement dated 30 November 2005, indicating that the HSRC message that AIDS prevention programmes should focus not only on the youth but also on older people had been received:

Government notes the results of the survey by the HSRC and Nelson Mandela Foundation released earlier today. The results give both a cause for hope as well as a reason to intensify action to combat HIV and AIDS through implementation of our Comprehensive Plan for Management, Care and Treatment of HIV and AIDS.

Figure 3: HIV prevalence by sex and age (2005)



As part of our activities to mark 2006 as 'the year of accelerated HIV and AIDS prevention', government will intensify its interventions targeted at particular risk groups highlighted by the report including people between the ages of 25–29 years and those older than 50.

CHALLENGES TO RESEARCHERS AND POLICY-MAKERS

Researchers face a number of challenges in South Africa in getting the results of their research to be considered by government. They may be unable to package their results in comprehensible form, or may publish results without having shared them with policy-makers. Policy-makers do not wish to be confronted by new evidence for the first time in the media, without having been previously briefed. Researchers may at times ridicule policy-makers for not using the information they have generated, forgetting that they are one of many stakeholders. Researchers may not know where to intervene in the research–policy nexus, and another issue is that the research that has been done may not be a priority for policy-makers.

Policy-makers similarly face a number of challenges in that political imperatives may interfere with the absorption of evidence. Researchers may be considered not to be credible sources of information and to rely too much on intuition. The jargon used in research may deflect from the message, since politicians may not be specialists in the area. Researchers may fail to conduct research on critical policy issues, and may be constrained by budgets.

CONCLUSION

It should be borne in mind that the path from research to policy is never a straight line, but meanders. Even good research may not be taken up in policy, or may face a delay in doing so. There may be too many interacting variables.

Generating evidence for policy-making is critical, given South Africa's human and social problems.

DISCUSSION

- **James Volmink:** I am in favour of the HSRC moving into doing systematic reviews in the social sciences. What is the position of the HSRC on conducting randomised controlled trials? Are any being conducted, or are any planned?
- **Olive Shisana:** The HSRC's position is that we would like to conduct randomised controlled trials to test interventions. However, the situation is difficult. We conduct intervention type research, rather than randomised control trials, where we study people living with HIV/AIDS and consider how to prevent HIV transmission. Such research has been done in the USA and it is now being done in South Africa and in ten countries across Africa. The HSRC is not averse to the idea of using randomised controlled trials where possible. Such trials are a big challenge to the social sciences

Advice we need, and how we need it

A governmental perspective on advice from academies

Adi Paterson*

This paper is prepared from a policy pragmatist position, to provide insight into how people in government work and what works for them and what does not. As much as we can talk about evidence and advice, it is a flawed process. There is no consistent process by means of which advice enters government. Sometimes the tactics of delivering advice can be more important than the substance in getting the job done.

The opening paragraph of *Real Science* (John Ziman 2000) reads:

Science is under attack. People are losing confidence in its powers. Pseudo-scientific beliefs thrive. Anti-science speakers win public debates. Industrial firms misuse technology. Legislators curb experiments. Governments slash research funding. Even fellow scholars are becoming sceptical of its claims.

One of the big challenges Ziman raises is that the consensus about science under modernism has evaporated. This has happened at a time when governments have become much more important actors in science and technology. An example is that of Canada, as described by Jorge Niosi in *Canada's National System of Innovation* (2000):

Whatever its level of unity and coherence, Canada's NSI was the product of both market forces and public policies. In Canada as a late industrialiser, the latter were probably more powerful than the former.

This statement has significance for Africa, where all countries are late industrialisers. The statement tells us that if that was the experience of Canada in moving from a resource-based economy to a more knowledge-intensive economy, governments will be major actors in making that transition.

The problem is that the prevailing policy consensus in most global bodies is that the private sector is the major actor in this transformation. However, if one studies systems of innovation and what actually happens, the private sector has never been successful in transforming a resource-based economy to knowledge-based economy. Governments have therefore to be major actors, but if there is no capacity in governments to act, there are serious problems. Not only do we have the situation in which science, which has built most of Western wealth in one form or another, is now under attack and people are deeply sceptical of it, but in the developing world the 'pill' that is offered is the private sector.

From my experience in the science and technology review in Nigeria, there is no private sector research in the country. For example, Nigeria has no research initiative (either private or public) to look at the downstream uses of the oil it produces and exports. What possibility is there to generate consensus that could be important? One of the unasked questions of advice today is why there is so much bad advice in existence, based on no more than

Thatcherite opinion-making about how private sectors act in real systems of innovation. We have absorbed a whole set of beliefs, at the highest level, about systems of innovation that are wrong and where there is no evidence to back up the positions that are taken.

Science itself is changing. Michael Gibbons in *Changing Modes* (edited by André Kraak of the HSRC) writes:

It is necessary to abandon the notion that science and technology are distinct, institutionally defined activities. Basic science has become inseparable from technological innovation ... This is evident in such areas as molecular biology, biotechnology, new materials, nanotechnology ...

It is challenging to think that today, most patents in new fields are generated in public research universities. The largest global patenter in biotechnology in 2005 was the University of California. The largest patenter in the developing world in 2005 was CSI in India, with 134 patents in the US Patent Office. That is about ten more patents than the whole nation of South Africa produced and registered in the US patent system in the same year. The economics of knowledge is changing, and the fundamental nexus of the debate is around issues such as intellectual property in new areas of research.

Policy itself is changing. Michael Gibbons in *Changing Modes* says:

The policy process will need to develop a new management style ... That management style can be summarised in two notions: increasing permeability of boundaries and brokering.

What does this mean for the treasured notion of independence? While independence is important, it can be one of the greatest sources of disfunction in developing states, because independence creates the sense that new knowledge is not trustworthy, because it is the integratedness of policy decision-making, when there are calls to make in a developing society, which sometimes creates impetus for it. I consider Michael Gibbons to be right in that policy people are no longer not independent observers generating a view; they are brokers of truths that they believe to be important. Policy activists and people that provide evidence, support and advice for policy have to think through the notion of permeability versus the notion of independence.

One of the first principles in providing evidence for advice is whether to wait to be asked, in other words, whether the advice will be solicited or unsolicited. If one can answer that question, one's strategy becomes clear. If you are not going to be asked for the advice, but you feel that you should give it anyway, there will be a certain strategy for getting that advice into the public domain and discourse. However, if the person to whom you wish to give the advice is in some sense an advice partner, in that they requested the advice, the situation is fundamentally different. In many settings where advice is usually accepted, there will be very special partnerships in place to allow that to happen effectively. Solicited advice can sometimes have a sledgehammer effect on confused consciousnesses, but you need to understand how to use it.

The points of conflict in advice need to be considered – the ethical responses to scientific progress. We are living in a world where people who have benefited from modern advances in pharmaceuticals, for example, now think that most of what pharmaceutical companies do is bad. This complicates discussions of the next generation of pharmaceuticals.

Post-modern relativism pricks many balloons, as well as many issues that are not balloons. Post-modernism is seductive, but we need to understand the challenges.

We need to understand the science–politics nexus. Science has a dynamic of its own. If you are in a northern European society, science is about five times as big as agriculture as a factor of production in the economy. Scientists have to understand that they are actors in the system and not passive observers reflecting on the nature of the system. Issues of self-interest and community interest tend to lie below the surface, but if they are detected and are not dealt with the same attitude to the truth as content issues, scientists can get into trouble.

Tshilidzi Marwala of the Science and Technology Policy Forum, in reflecting on the situation in South Africa, made the following comment in Japan in 2005:

What are the measures we need to implement to ensure that the transformation to a developed society is achieved in the shortest possible time?

He was formulating a concept of science as an opportunity space. That seems to be a deep, profound and inherently complicated agenda for science and technology.

ADVICE FROM THE ACADEMIES

Contribution of science and engineering to quality of life and sustainability

In reflecting on advice by academies, the contribution of science and engineering to quality of life and sustainability is a key issue. It is by no means agreed by everyone that science contributes to quality of life and sustainability. Sustainability is a big issue for global science following the World Summit on Sustainable Development. One of the key areas to work on is promoting science and public consciousness by looking at this area of discourse. A recent survey has been conducted in all 11 South African languages of people's understanding of biotechnology. It is fascinating that most people, when questioned in their indigenous language, considered that the most reliable sources of information on biotechnology must be universities, followed by government. The fourth and fifth most important were regarded as industry and specialised NGOs that are opposed to biotechnology. One has to consider how complicated the policy space can be.

Limits to scientific knowledge, and the attendant ethical and precautionary considerations

The limits to scientific knowledge, and the attendant ethical and precautionary considerations are important areas. Scientists hate to expose their limitations and acknowledge that they cannot explain everything, but this issue would be a worthy challenge for academies to take up. It is when scientists are borne up by the hype of the problems they can solve, and are not telling people about the problems they cannot solve, that they experience certain types of difficulties. This is the honesty question. Do academies understand that in relation to society they should not be triumphalists?

Science and technology in relation to pressing local issues

One of the major critiques of African scientists throughout the continent is that their research questions are formulated in laboratories in the developed world. Their research questions are not informed by local conditions. This leads to deep questions about the real agenda of science.

Defence of science in a post-modern world

The distinctive nature of science in relation to other knowledge systems and its value in terms of its contribution to society is important.

Promoting teaching, learning and essential 'bodies of knowledge' for science and engineering

The accessibility and attractiveness of science and technology to young people is a crucial issue in which academies can play a role.

The dynamics of science and technology

It is important to note that science is changing and that there are new options and attendant risks in new knowledge domains.

HOW TO GIVE ADVICE?

The first issue to think through in giving advice is generosity versus scarcity. If you give advice too often, you may build trust but lose your impact. If you are too generous with advice, you may be thought not to be working hard enough on specific advice that may be more relevant and useful. However, if you deliver a scarcity of advice, you may not generate sufficient interaction to build trust. This requires striking a careful balance.

The de-personalised observer 'construct' and advice

Politicians are not in favour of the journal article, which is the researcher's favoured means of communicating research findings. The style of writing journal articles has become completely depersonalised, yet much of politics is concerned with the way people feel and what they personally engage with.

Stiletto versus shotgun

Advice that is too broad and covers a vast field ('shotgun advice') is not very effective. 'Stiletto advice', which is very specific and is hammered home, is generally preferable.

Sufficiency versus completeness

Scientists may be reluctant to complete their advice, always wanting to do further research to fill in the gaps. Policy-makers have to act and therefore require advice that is sufficient, although not necessarily complete.

Caution versus courage

Scientific advice may be couched in such timid and cautious terms that officials and politicians may not recognise it as advice. Advice should be clear and well-packaged if it is to have impact.

Independence versus engagement

I do not believe that it is possible to take an independent position in the age of post-modernism. There are only different positions from which one can engage in the debate, although one may notionally have a construct of independence. When people ask for independent advice, they are not asking for independence, but for a construct that has been engaged with enough people so that any special interest can be revealed clearly in order to move forward. The idea that a developmental society can afford the epistemological category of independence when things are urgent and resources are scarce is problematic.

EVIDENCE

There is an approach that considers that public opinion is evidence, as shown during the negotiations of the World Summit on Sustainable Development. Such an approach could result in a rapid descent to fascism. There is also a view that the findings of legal and international courts should be regarded as evidence, as opposed to science-based evidence. If we as scientists are serious about what we believe in, we should always write 'science-based' in front of the word evidence.

DISCUSSION

- **Wieland Gevers:** To me the functionally important independence is the removal of the vested interest to the largest degree possible so as to have a mandating consensus, based on evidence and without any particular agenda built in from the start. Philosophically, I

agree that independence is not possible, but operationally and functionally, independence is that part of the science base that is not vested and is willing to take a position.

- **Olive Shisana:** For the HSRC, independence means telling the results as they are, without changing them to suit a particular policy position. The results should speak for themselves. Interpretation is another matter, and should be reasonable.
- **Adi Paterson:** The closer you are to the natural sciences and their content base, the better your chance of achieving something like independence in giving advice. The vested interests that most people think about when giving advice are those that are visible to them as an externality, for example, a politician taking a decision, or the allocation of resources. However, very little thought is given to the fact that a policy position may be the synthesis of a range of positions that scientists have adopted, and that there is always a degree of pragmatism involved in reaching the point of giving evidence. The tendency in giving advice is to hide the diversity of opinion, view or approach from the person to whom the advice is given so as to give the position more apparent independence and confidence. The official or politician may then discover the range of opinion when discussing with others the advice received, thereby exposing the dilemma that the advice represents.

When you are very close to science, and to issues that are computable, it is easy to make a compelling case, sometimes forgetting that the fact that we can do the computation is because we neglected another field of science that we thought was less important.

As soon as issues of sociology, economics or quality of life arise, we are working in the field of informed focused opinion. I would agree with Dr Shisana on the immutability of well-researched data, but I am not sure that that is the same as independence. The advice that is given should be seen as an engagement. It is only advice when it is accepted and acted upon, which is a more operational than objective view of advice.

Summary discussion

Jonathan Jansen*

In concluding, I would like to pose some direct questions, invite comment from the floor and then sum up.

To Michael Clegg and Ann Dowling: If government is in fact a major funder of your work, how is the independence of science and scientific enquiry secured?

To Olive Shisana and Calie Pistorius: Would you talk about specific instances where your advice was ignored and why you think this happened?

To Molapo Qhobela and Wally Morrow: Do we in South Africa have a culture of giving and receiving advice, and if not, how can it be developed?

To Robin Crewe and Wieland Gevers: Where do we go from here? What happens to the inputs and products of the symposium? What can participants expect?

■ **Michael Clegg:** The answer to the question of the extent to which scientists can be independent if government funds their studies is partly procedural. We at the US National Academies often work behind the scenes with elements of government to try to get them to understand that there is a question of importance that they need to consider. Frequently we work to give them the questions. Why does government want to fund scientists? The US government is quite different from paramilitary systems in that it is built on conflicting antagonistic forces. In the US model, the Congress is inherently suspicious of the executive branch trying to take too much power. The judicial branch is juxtaposed against the other two and serves as a kind of 'relief valve' on that conflict.

Often we end up in a setting in which there is a contentious question, for instance what the scientific consensus is on global climate change. The executive branch may want coverage, but does not want to come down with a particular position. They would rather say that the scientific consensus is the following, and we therefore defer to the experts. That gives scientists a certain space in which to operate, which allows us to say things that are not dictated by the funding.

The other part of the answer is procedural in the sense that when we take on a project on a high-stake issue, we work hard to appoint a committee that encompasses all the knowledge and the range of biases on the subject. We end up with a committee that has to reach consensus about the span of knowledge on the subject that they all agree on, given their conflicting opinions. That then comprises the advice that is given in the report. The advice could be regarded as quasi independent. I know the definition of independence in a probabilistic sense; I am less clear how to define independence in the societal or social context.

■ **Ann Dowling:** I suspect that if all funding for science comes from government, it is very difficult to be independent. Only two Royal Society studies have been funded directly by

government. The Royal Society is thus not relying on 'repeat business', and independence rests on the fact that the government can choose to take or leave the results.

We took the following steps to ensure that the government had no say in the recommendations of the Nanotechnology Study Report. The government did not determine when the report would come out. The committee did not discuss the emerging conclusions with any member of the government or allow them to see the draft report. If we had, there could well have been pressure to change the recommendations. It was made clear that members of the government would not see the report until it was printed. We also had strong members in the working group who were removed from a government commission. They acted as members of the working group, and that was what I encouraged them to do.

- **Olive Shisana:** I remember a recent case when the HSRC did a study for the Education Labour Relations Council. We had in the team members from government, the unions and other parties. We identified the problem of HIV among educators to be confined to 11 districts in the country. We also indicated that about 10 000 educators needed antiretroviral therapy. We recommended that rather than rolling out the entire programme for educators, or even just including them with the rest of the population, the initiative focus on the 11 districts and then progressively include the other districts. The Department of Education did not feel that it was appropriate to implement this recommendation with respect to the 11 districts. Instead, they considered that the treatment of educators should be done as part and parcel of the normal antiretroviral therapy programme for the country run by the Department of Health. They considered that the Department of Education should not have a specific responsibility to provide treatment for educators, because this is not their mandate. We were trying to be creative, but the state could not accept the proposed change of mandate.

- **Calie Pistorius:** The question reminds me of a statement I once heard that in government, a Minister is never late, only detained elsewhere. In the same vein, a Minister is never wrong. NACI advice is not ignored, although in some instances we might find a lack of timely implementation, as it takes a long time for the machinery of state to do so. The advice may also be blended with advice from other departments, and may appear in the programmes of another department. The essence is that we need a sharper mechanism for tracking advice.

- **Molapo Qhobela:** There is not enough giving and receiving. Those of us who give advice are often under the impression that civil servants have no clue what they are receiving and as a consequence, what can you expect as a result of quality advice? However, we also spend an enormous amount on consultants, some of whom are employed to read and assess the advice received. This is the reality of how things happen. Another aspect is to receive lengthy reports telling you something you already know.

I have two suggestions: (1) for both givers and receivers, simply put critical engagement on the issues using evidence, rather than anecdote or gut feel and (2) spend some quality time in each others' worlds. Reality hits when you spend time in an environment you do not know.

- **Mark Orkin:** Science councils (and on a smaller scale NGOs and consultants) are better practised at giving advice than higher education institutions, perhaps because they are so diverse and numerous. For improvement in the situation, ASSAf, by contrast, has a major role to play in acting as a professional body drawing judiciously on the large pool of intellectual resources at the universities, at the highest level of expertise and in a multi-disciplinary way, to generate advice on big national issues. We have examples from the UK and USA of how to focus university-based advice through commissions, but these are generally government-appointed.

With respect to receiving advice, my impression is that because South Africa is still a new nation and is trying to build things, often under quite strong public pressure, government

often solicits advice and receives science-based evidence gratefully and sometimes acts upon it with scary speed of scale, making social scientists hope desperately that their recommendations were right when they see huge investment in implementation.

To help improve the process of giving solicited advice, we should follow the suggestions made in Dr Shisana's presentation, which were clearly the result of huge experience in managing science-based evidence into the political process.

- **Wally Morrow:** Apartheid was based on the virulent system of relativism. During the 1990s, when we had rampant egalitarian stakeholder politics in South Africa, we had a strong conviction that the only basis for any kind of advice or policy was the expressed interest of particular groups. This left us with a legacy that we still live with. One of the results is the tendency to look at who is talking rather than listen to what they are saying or what kind of evidence there may be. There is in some quarters a strong anti-intellectual bias, and a feeling that if advice comes from an intellectual source, it cannot be good advice. I do not want to overestimate that, or to underestimate the difficulties of forming policy in a field such as education, but the three years I spent in the Department of Education were bitterly frustrating because the key figures in the Department never engaged in discussion with us about the recommendations we were making in a very direct and focused way. I feel that this had something to do with the legacy of relativism.

- **Robin Crewe:** Where to from here? The question was raised to some extent in Dr John Mugabe's presentation, in which he indicated that the academies have a specific role to play. The academies in the past have been organisations that essentially gave recognition to people that had reached eminence in their field. ASSAf has defined itself in a much more activist sense, in that it sees a second part of its role as understanding the terms of engagement when you want to give advice. To some extent, this is driven by engagement with the US National Academies of Science, which have been funding the development of African academies and have indicated that they have a role to play in offering advice to government and other role players in society that are looking for advice. We should not only think in terms of giving advice to governments, but we may have other areas in which we wish to give advice as well.

Organising this symposium was essentially an intervention on the part of the Academy to gain as great an understanding as possible of what the terms of engagement are likely to be. We need to understand such terms of engagement in order to be effective in giving advice that arises from the studies that we conduct.

One of the things that has not been discussed extensively today is the issue that giving advice tends to be nationally embedded. The nature of the advice structures in different countries is very different. We need to understand these structures so as to hit the right target in giving advice.

- **Wieland Gevers:** The niche of the academies is to present in a consolidated way a mechanism that can be trusted because it can be transparently presented and understood.

It is crucial that we take stock. We have heard implicit and explicit accounts of how some organisations see their role. The ASSAf Council will have to take stock of exactly how it will deal with the issue of engagement and independence; how it will see to it that the fundamental operational value of what it does is maximised; and that it gains the trust of the system and plays a valuable role.

Our partnership with the US National Academies has shown us how they do things in their context, and we have learnt a lot. Today's meeting has provided considerable food for thought of what an indigenous version can do.

- **Jonathan Jansen:** What I take away from this Symposium is the need for humility in our dealings with evidence. There are limits to what we can know. The best available evidence is as much a product of science as it is a cultural construction.

What counts as best evidence is adjudicated by human subjects, within particular institutional privileges. I am more comfortable to talk of intersubjective agreement than of objectivity, as this begins to set limits on what we can know and how it is possible to know. We have become aware of the need for trust, and the fact that trust is not a given but is built up over time in working together to develop our best understanding of how to proceed.

What came up very clearly, especially in listening to our colleagues from abroad, was the interdependence of social and scientific problems and how it has become more important for us to begin to talk about exchanging ideas, people and technologies on an ongoing basis. If that is true transnationally, it is also true within the nation state.

Is evidence overrated?

Jonathan Jansen* considers the admissibility of evidence.

At first blush, the arguments of evidence-based advocates seem deceptively simple: public policy and professional action should be based on, or informed by, the best available evidence preferably derived from systematic reviews (also called research synthesis or meta-analysis). To argue against such a position seems irrational. Who would deny that decisions based on 'the best evidence' should inform policy deliberation and professional action across every sphere of decision-making including education, medicine, crime prevention, economics and urban planning?

The idea of 'evidence' has taken on new significance in universities, governments, science academies, and professional associations, and among practitioners. With its origins in the field of health care¹, an evidence-based or, as some prefer, an evidence-informed movement has gathered pace in major parts of the world. In the USA, for instance, federal funding for new programmes has become conditional on the use of 'randomized control trials' in areas ranging from health care to education. At the Institute of Education, University of London, an evidence-based unit has been set up in the social sciences: the Evidence for Policy and Practice Information and Coordinating (EPPI) Centre. And there is an entity hosted by the Medical Research Council (MRC) in Cape Town that builds capacity in the science of research synthesis, prepares systematic reviews of the effects of health care interventions, and promotes evidence-based health care practice and policy in sub-Saharan Africa.

However, the stridency and tone of certainty of some of the advocates of evidence-based decisions have raised probing questions and even reservations among 'hard' and 'soft' critics of this movement. What follows are personal reflections on, and criticisms of, some of the powerful positions in the 'evidence' debate.

THE QUESTION OF POLITICAL CONTEXT

There is a difference between 'hard' and 'soft' advocates of evidence, not simply with respect to style and approach, but also in their approaches to truth, culture, and the nature of knowledge.

The soft advocacy of evidence can demonstrate sensitivity to, and accommodation of, matters of ethics, autonomy, complexity, judgment, and transparency in randomized controlled trials in the search to establish 'the best evidence' for a particular medical intervention, for example, as well as humility and concern for social justice not always apparent among the hard advocates of evidence. But it can, nevertheless, underestimate the political context of evidence and evidence-based pursuits.

Professor Jansen is a leader in the field of education in South Africa. A former high school teacher, he has a doctorate from Stanford and an honorary doctorate from the University of Edinburgh. He is Dean of Education at the University of Pretoria and Vice-President of the Academy of Science of South Africa.

Objectivity needs to be rescued from its laboratory pretence of being universal and timeless, and redefined as 'intersubjective agreement'.

Evidence is never neutral; it operates within a political context especially when it advises people in power. The very questions posed, and the designs followed, predispose research towards particular kinds of evidence. On the local scene, nothing demonstrates more powerfully the politics of evidence than the response of authorities to research questions and results, on topics such as the following:

- how many teachers are HIV positive in South Africa?
- how much mathematics do South African teachers actually know?
- how does South Africa rank in primary school science compared to other African countries? (TIMSS-R)
- how many new teachers does South Africa really need?

Of course, it needn't be an education question that draws political fire. Try this one on the powerful:

- does South Africa have more or less crime today than in 1994?

Few would deny that the results of commissioned research, whether from within or outside government, are always subject to political intervention. This might not mean direct censorship or incarceration, for new democracies (such as South Africa) have a subtler response to disconcerting information. It takes the form of delay, editing, claims of uncertainty, the questioning of methodology (if not the methodologist), and the citation of rival studies. One of the commonest words in the post-1994 South African lexicon is "moratorium". That a modern, sciencecommitted state like South Africa could even question, from within the corridors of power, causal agency in the HIV-to-AIDS debate, continues to puzzle the science community and the lay public alike.

The claim, therefore, that 'the evidence speaks for itself' is without foundation. The issue, rather, is: Who speaks for the evidence?

THE QUESTION OF DISCIPLINARY CONTEXT

How is the subject of evidence treated in different fields – such as law, education, and anthropology?

Lawyers think about evidence very differently from researchers in the health sciences in general and in the evidencebased movement in particular. The standards of evidence are different, for legal minds argue by precedent and 'on the balance of the evidence'. In courtrooms, evidence presented and decided on is deliberately selective. Judgment draws on, but is not confined to, expert opinion. And, crucially, evidence is led in an adversarial context in which 'the legal hired hand' is a much greater factor than objective rules of balanced reporting. The legal use of 'evidence' leaves one with the intriguing notion of *eminence-based* decision-making in the field of law.

In the field of education, policymakers remain wary of research, partly because of frequent lack of rigour in social sciences fields. But the problem also lies much deeper in the antagonism between scientific and practitioner modes of inquiry. Educational inquiry is charged with holding poorly codified practices, compared to the natural sciences, which therefore offer little potential for generalizing from the results of a single study. Yet there appears to be growing consensus about the importance of evidence (as well as its limits) in professional activities such as evaluation.

An anthropological perspective uncovers powerful, and often unspoken, connections between evidence, rationality, and the world of research through riveting questions such as: Who makes the claim to have 'the evidence'? Whose evidence counts? Our lenses can be criticized for focusing on the seen, material world, and for failing to value evidence in relation to the people that the evidence claims to serve – and also for overvaluing institutions from which evidence comes. What kinds of institution are valued, and deemed fit to pronounce

on evidence? By whom are they given such status? In this context, the question of evidence is inescapably a question of power.

Such a variety of perspectives mean that disciplinary contexts matter a great deal in speaking about evidence. A common example of how complicated it can get is the body of classic studies on the relationship between class size and student achievement. Probably no subject has received so much attention in the field of education through the application of metaanalytic methods. Yet, depending on which body of research you study, the results are mixed. Why? What are the problems?

One – the complexity problem. The sheer number and complexity of variables (teacher experience, national culture, subject matter, teacher qualifications, pedagogical strategy, and many more) involved in seeking to establish the relationship between the number of students in a class and the level of academic achievement attainable, are formidable.

Two – the compositional problem. It depends on who's in the class in the first place. Is it middle-class children with high levels of cultural capital, or poor children with illiterate parents? Random assignment of groups doesn't begin to deal with this challenge, especially when the study is conducted in developing contexts whereas the standard research claims are being made elsewhere.

Three – the curriculum problem. By considering nothing but class size in the research design, and 'holding constant' what's being taught, there is more than methodological finesse at play. Students could be achieving well on an outdated or offensive curriculum, for instance, yet the significant variable of curriculum content is thereby neatly set aside in the pursuit of simple causality.

Four – the ethical problem. The research findings come in, then what? What do they mean for poor schools, operating in contexts where the results are simply irrelevant because class size is overwhelmingly determined by the national education budget rather than by definitive research results.

Five – the political problem. To whom does class size matter? Sure, the test scores might determine that class size within broad limits (say, no more than 50 students per class) does not matter. But I've yet to meet a teacher experiencing the daily toil of classroom life who would find any meaning in such a result. This kind of systematic review of class size effectively has to sacrifice the power of experience and the emotions of teaching for a sanitized account of what, or rather who, counts.

I raise the example of class size and student achievement to suggest that where human actors are involved in an endeavour as exhausting as teaching, such a research context is infinitely more complex than that of a simple inquiry to establish if drug X is better than drug Y in dealing with tuberculosis.

MORE QUESTIONS THAN ANSWERS, AND THAT'S A GOOD THING

The health sciences give such a powerful context for the evidence debate because the consequences of intervention (or non-intervention) are immediate: the subjects could, quite literally, die. The 'harm' versus 'good'

INTERROGATING 'EVIDENCE'

Here are some serious questions that arise about the relationship between research and policy, and about the theoretical, methodological, and political problems of evidence.

- Is 'scientific evidence' (such as that derived from careful methods such as meta-analysis) not simply one of many sources of authority in making social or medical decisions?
- What is the role of judgment in decision-making?
- What should be the status of traditional beliefs, values, and understandings when faced by scientific claims and conventions?
- Does evidence-based policy not in fact privilege causal modelling and the material or physical world?
- Given the instability of evidence as new knowledge replaces old, how should strident claims about evidence be evaluated?
- How 'culture-dependent' is evidence? How well do claims about evidence travel across contexts and cultures?
- How does evidence-driven policy or practice deal with uncertainty?
- As claims as to 'the best evidence' vary across disciplines – for example, in law compared to medicine – what are the implications for universal or sciencebased claims about evidence?
- How valid are non-scientific (nonrational?) sources of evidence?
- How neutral is evidence-based policy and practice? And how far do power, politics, and political interests (funding agencies, pharmaceutical companies, Western governments, and others) in fact determine the choice of questions, the design, and even the outcomes of scientific inquiry?
- What ethical and moral problems arise with evidence-based scientific methodologies (such as randomization) when they're applied to humans?

question in evidence debates therefore turns the heat onto those who dare question the activity of 'getting to the truth.' In such pursuits, however, it's possible to overlook two significant questions about knowledge, knowing, and power that lie at the heart of the dispute.

First, is rigour possible only within systematic review? To answer 'yes' constitutes striking arrogance. It means ignoring the methods of inquiry and perspectives on knowledge that have greatly enlightened scholarship across the disciplines in the past 60 years. It accepts the tyranny of positivism to the exclusion of other ways of knowing and of knowing in different contexts. It refutes the notion that evidence, like the truth, has many faces.

Second, what social questions are ignored by the way in which evidence-focused inquiry is pursued? What is 'held constant' in class size research can often be much more important than the variables we choose to play with.

AND SO, ON TO THE FUTURE...

I propose, as have others, the need for humility in both advocates and critics of evidence. Clearly we need evidence; and there is no question that in certain fields, like education and the social sciences more broadly, the degree of rigour and credibility in research remains a major problem.

But we should also recognize that what counts as 'best evidence' is itself a matter adjudicated by human subjects, within the privileged status of particular kinds of institution that we deem fit to make such pronouncements. In this context objectivity needs (again) to be rescued from its laboratory pretence of being universal and timeless, and redefined simply as 'intersubjective agreement'.

One thing that the evidence evangelists cannot refute is this: the truth, historically, is unstable, and what counts as fervent knowledge claims in one generation of medical practice is typically scorned among the next generation of physicians. Yet, frozen in time, each generation would proclaim its truth with a frightening certitude.

We are in danger of taking the social, natural, and medical sciences back into the epistemological dark ages if zealotry rather than humility defines the terms of the evidence debates.

NOTES

- 1 The evidence-based approach has been spearheaded by powerful international groups such as the Cochrane Collaboration (named after the British epidemiologist, Archie Cochrane), to which the EPPI Centre in London is closely linked. The entity hosted at the MRC in Cape Town that focuses on evidence-based activities is the only accredited Cochrane Collaboration entity in Africa.

Appendix 1:

List of acronyms

AIDS	Acquired immune deficiency syndrome
AMCOST	African Ministerial Council on Science and Technology
ASGISA	Accelerated and Shared Growth Initiative of South Africa
ASSAf	Academy of Science of South Africa
AU	African Union
BAC	Biotechnology Advisory Committee
BMI	Body mass index
BRICs	Biotechnology Regional Innovation Centres
CC	Conventional cytology
CEO	Chief executive office
CeSTII	Centre for Science, Technology and Innovation Indicators
CHE	Council on Higher Education
CODATA	Committee on Data for Science and Technology
COSPAR	Committee on Space Research
CSD	Commission on Sustainable Development
CSIR	Council for Scientific and Industrial Research
DAC	Department of Arts and Culture
DACST	Department of Arts, Culture, Science and Technology
DBASSE	National Academies' Division of Behavioral and Social Sciences and Education
DG	Director-General
DoE	Department of Education
DST	Department of Science and Technology
DVI	Direct visual inspection
GDP	Gross domestic product
GEC	Global environmental change
GEOS	Global Earth Observation Systems
GERD	Gross expenditure on R&D
GNI	Gross national income
HEI	Higher education institution
HIV	Human immunodeficiency virus
HSRC	Human Sciences Research Council
IAA	International Association of Academies
ICSU	International Council for Science
IFS	International Foundation for Science
IGOS	Integrated Global Observing Strategy
IOM	Institute of Medicine (US)

IPTS	Institute for Prospective Technological Studies (Joint Research Centre of the European Commission)
IPY	International Polar Year
IT	Information technology
IYPE	International Year of Planet Earth
JIPSA	Joint Initiative on Priority Skills Acquisition
LBC	Liquid-based cytology
LBD	Learning by doing
MIT	Massachusetts Institute of Technology
MM	Master Maths
NACI	National Advisory Council on Innovation
NBN	National Bioinformatics Network
NEPAD	New Partnership on Africa's Development
NGOs	Non-Governmental Organisations
NSI	National system of innovation
OAU	Organisation for African Unity
OSTP	US Office of Science and Technology Policy
OTA	US Office of Technology Assessment
PCAST	US President's Council of Advisors on Science and Technology
PUB	Public understanding of Biotechnology
R&D	Research and development
RCT	Randomised controlled trials
RSSAf	Royal Society of South Africa
S&T	Science and technology
SAAE	South African Academy of Engineers
SAAVI	South African AIDS Vaccine Initiative
SARG	South African Reference Group on Women
SET4W	Science, Engineering and Technology for Women National Advisory Committee
SETI	Science and technology institution
STIs	Sexually transmitted infections
TB	Tuberculosis
UNCTAD	United Nations Conference on Trade and Development
UNESCO	United Nations Educational, Scientific and Cultural Organisation
US/ USA	United States/ United States of America
WCED	Western Cape Education Department
WCRP	World Climate Research Programme
WIPO	World International Property Organisation
WSSD	World Summit on Sustainable Development

Appendix 2:

Attendees

Arndt, Dr Reinhard	Consultant
Arnold, Ms Robyn	Write Connection cc
Baker, Dr Graham	ASSAf – SAJS
Chisholm, Dr Linda	HSRC
Clegg, Dr Michael	US National Academies
Cohen, Dr Barney	US National Academies
Crewe, Prof. Robin	University of Pretoria
Dhansay, Dr MA	MRC
Dithane, Mr Thabo	BSTEP
Dowling, Prof. Ann	Cambridge University
Dube, Dr Pamela	Department of Education
Duffey, Ms Hellen	SAAE
Dweyr, Ms Chantal	CHE
Erasmus, Prof. Theuns	University of Pretoria
Fonn, Prof. Sharon	WITS
Gantsho, Mrs Kholeka	BMS Wellness
Geertsema, Prof. Jan	North-West University
Gevers, Prof. Wieland	ASSAf
Gledhill, Dr Irvy	CSIR
Gous, Ms Jennifer	University of Pretoria
Govender, Mr Logan	HSRC
Gräbe, Prof. Ina	Suid-Afrikaanse Akademie vir Wetenskap en Kuns
Green, Dr MJ	Sasol Technology
Greene, Mr Ryan	University of Pretoria – University of Maryland
Hough, Mr JJ	DST
Illsley, Dr Thea	University of Pretoria
Irwig, Prof. Les	University of Sydney
Jansen, Prof. Jonathan	University of Pretoria
Kanise, Ms Fundiswa	ASSAf
Koplan, Dr Jeffrey	Woodruff Health Sciences Centre
Kruger, Mr Robert	NRF
Kruger, Dr Bingle	SAAE
Labane, Ms Zinhle	Department of Education
Le Roux, Mr Braam	SAAE
Ledwaba, Ms Khanya	ASSAf
Lephalala, Dr Mirriam	UNISA
Levieux, Ms Candice	NRF

Lickindorf, Dr Elisabeth	ASSAf – Quest
Loringart, Prof. Peter	Consultant
Lucen, Dr Anusha	DST
Lukhele-Olorunju, Dr PE	ARC
Mabina, Ms Boitumelo	ASSAf
Madlala-Routledge, Ms NC	Ministry of Health
Malo, Prof. Joseph Otieno	Kenya National Academy of Science
Mampane, Ms Sharon	University of Pretoria
Masindi, Ntungu	NRF
Mati, Dr Xola	ASSAf
Matlebyane, Mr Martin	US Embassy
Matshoba, VS	DPLG
Mbananga, Dr Nolwazi	MRC
Mdlalose, Dr Themba	TARC
Mendelow, Prof. Barry	NHLS
Milne, Prof. FJ	WITS
Mini, Dr Simphiwe	DST
Mizrahi, Prof. Valerie	NHLS
Mjwara, Dr Phil	CSIR
Mlosy, Dr Christopher	CSIR
Mokubyane, Ms Angeline	Department of Education
Moodley, Dr Sagren	DST/NACI
Morrow, Prof. Wally	Free Range
Motlhanke, Mr Simon	Department of Education
Motsoeneng, Mr Molefi	CUT Free State
Mouton, Prof. Johan	SU
Mugabe, Dr John	NEPAD
Muhongo, Prof. Sospeter	ICSU
Mukumela, Mr Marcus	Limpopo Led Programme
Muller, Prof. M	University of Pretoria
Muller, Prof. Johan	University of Cape Town
Myers, Dr Glenda	WITS
Narsee, Hersheela	Department of Education
Niehaus, Jansie	NSTF
Nkomo, Dr Mokubung	University of Pretoria
Noma, Ayanda	NRF
Nontombana, Ms Nompucuko	Department of Education
Nqeno, Mrs Nosi	Department of Justice
Nqeno, Mr Phumzile	PK Travels
Nukeri, Dr Jabulani	SAASTA
Orkin, Dr Mark	Consultant
Owen, Mr Leslie Dennis	SA Forestry Journal
Padi, Dr Thabo	UNISA
Page-Shipp, Dr Roy	Consultant
Parker, Prof. Iqbal	University of Cape Town
Paterson, Dr Adi	DST
Pistorius, Prof. Calie	University of Pretoria
Potgieter, Dr Johannes	DTI
Pouris, Prof. Anastassios	University of Pretoria
Qhobela, Dr Molapo	Department of Education

Ramaite, Dr Idi	University of Venda
Ramaite, Ms Rudzani	ASSAf
Rehle, Prof. Thomas	HSRC
Routledge, Mr Jeremy	Phaphama Initiatives
Sehlapelo, Mrs Hlengiwe	University of Pretoria
Shisana, Dr Olive	HSRC
Silulwane, Ms Nonkqubela	NRF
Sithole, Dr Mpilo Pearl	Association for Rural Development
Smith, Dr Hennie	Consultant
Smith, Mr Edwin	University of Pretoria
Sonnekus, Prof. Inge	UNISA
Spencer, Ms Lynder	UNISA
Steiner, Dr Gita	Columbia University
Ushewokunze-Obatolu, Dr Unesu	Department of Veterinary Technical Services – Zimbabwe
Van Bever Donker, Mr Jan	University of the Western Cape
Van der Linde, Ms Ina	HSRC
Van Heerden, Prof. WFP	University of Pretoria
Venter, Ms Wilna	HESA
Venter, Ms Anneke	UNISA
Volmink, Prof. James	Stellenbosch University
Vorster, Prof. Hester	University of Potchefstroom

2006

Evidence-based Practice: 'Double Symposium' Proceedings on Problems, Possibilities and Politics

Academy of Science of South Africa (ASSAf)

Academy of Science of South Africa

Academy of Science of South Africa (ASSAf), (2006). Evidence-based Practice: 'Double Symposium' Proceedings on Problems, Possibilities and Politics. [Online] Available at: DOI <http://dx.doi.org/10.17159/as>
<http://hdl.handle.net/20.500.11911/51>

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