Scientists have a powerful role in determining South African government health policy: Unpacking how and why different scientists may suggest very different policies

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Appropriate public health policy, and the associated budgetary decisions, are extremely important to society, and rely on expert scientific input. Scientists who provide this input, typically medical researchers alongside statisticians specialising in medical data, are required to produce objective, transparent analysis that will aid the politicians who make these crucial policy decisions. In this article we give examples of how scientists who publish work in the area of public health can overlook critical aspects of data analysis and arrive at inappropriate conclusions not supported by the data. We believe that all data used in such studies should be freely available, and suggest principles that scientists and journals should adhere to in order to ensure that the statistical models used on the data and the conclusions reached on the basis of the statistical analysis have been subjected to intensive interrogation by as large a pool of scientists as possible.

South Afr J Pub Health 2023:6(3):e936. https://doi.org/10.7196/SAJPH.2023.v6i3.936

A recent speech by former President Mbeki has reminded us of the terrible impact of HIV/AIDS on South African (SA) society. Mbeki took a denialist position on HIV/AIDS that arguably resulted in the loss of millions of SA life-years (see the statement released by the SA Academy of Science, and endorsed by the SA Medical Research Council, 27 September 2022[1]). The HIV/AIDS pandemic was followed by the COVID-19 pandemic, the impact and management of which was less clear cut, and will be the subject of intense analysis and debate for many years. At the centre of both these public health crises was the scientific community, who advised and influenced the politicians in charge of public policy. The assumed nature of science is that it transcends uninformed, anecdotal debate, and is based on verifiable facts. In the case of public health policy, the advice of scientists directly affects societal wellbeing and mortality, and scientists thus have a particular responsibility to give appropriate advice. However, among a relatively small pool of scientists in this country, vastly different positions can be taken on optimal public health policy. The question remains as to whether the differences in position taken by scientists using verifiable facts are influenced by pre-entrenched ideological standpoints that seemingly influence their conclusions, and/or differences in methodological and epistemological approach. In both cases, there is a need for these stances to be made transparent. In this article we will consider two examples where scientists have used data in the public health arena but not taken cognisance of some fundamental statistical principles when coming to their conclusions – conclusions that can shape and determine public health policy in SA.

The scientific analysis of data shapes public health policy

The first example demonstrates a case where different scientific opinions emerged from what appeared to be the same set of underlying information. Scientists in the public health area work with collected data, available theory and experience to assess and forecast the effect of disease on the wider community. Under the Mbeki administration, the vast body of scientific opinion had concluded a clear-cut causal linkage between HIV and AIDS, which in turn had resulted in sharply increased mortality in SA from the mid-1990s. However, this causality became politically contentious in SA when it was denied by the Mbeki administration to such an extent that it resulted in the delayed implementation of provenly successful antiretroviral treatment (ART) in the country.

Fig. 1 shows the clear increase in mortality as HIV became entrenched and was untreated by ART, and how, subsequently, the late implementation of ART reversed the impact of HIV.[2]

It is clear how the implementation of ART reversed the dramatic decrease in life expectancy associated with the HIV/AIDS pandemic from 1990 to the early 2000s, and one would expect that the use of such data by scientists in subsequent analyses would take cognisance of this historical reality.

However, the conclusions of a recent, high-profile scientific article published on the topic of SA public health policy in the prominent Oxford University Press publication *Health Policy and Planning*, by Edoka and Stacey[3] take no account of the dramatic impact of ART on the profile of mortality in SA. The article uses data from the period 2002 - 2015 to estimate the statistical relationship

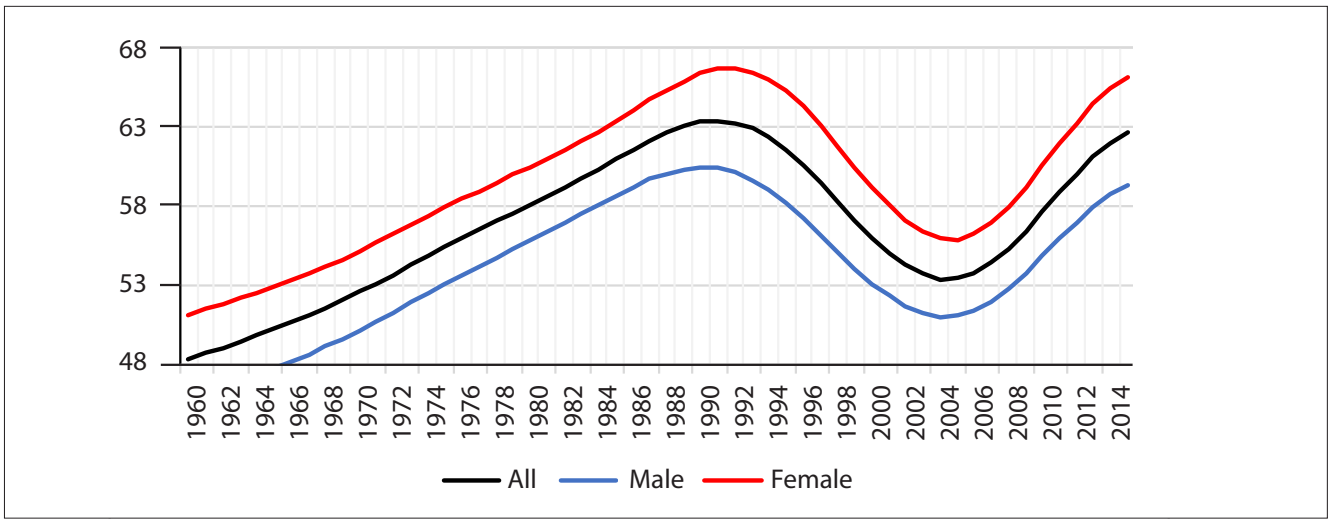

Fig. 1. Life expectancy, South Africa, 1960 - 2015.[2]

between mortality and health expenditure. In order to do this, the assumption has to be made that the relationship estimated is stable over the given period. Ignoring the clear indications that the relationship between mortality and health expenditure was structurally different over the pre-ART period (2002 - 2005) when compared with the post-ART implementation period (post 2005), the statistical estimation proceeded under the assumption that the relationship was constant over the entire period. The relationship between mortality and inflation-adjusted per capita health expenditure was estimated as an *elasticity* over the selected time period using linear regression analysis. In this case, the elasticity estimated indicates the expected percentage impact on mortality that stems from a 1% increase in (inflation-adjusted) per capita health expenditure. The elasticity would be expected to be negative, and the higher the elasticity estimate in absolute terms, the higher the effectiveness of per capita health expenditure in reducing mortality.

On the basis of their estimated elasticity, the analysis of Edoka and Stacey[3] would imply that, even after the ART implementation, SA health expenditure was relatively ineffective in lowering mortality.

In a critique of this work, Barr[4] pointed out that the relationship between health expenditure and mortality was clearly dependent on the period over which the statistical analysis was conducted. Barr[3] showed that shifting the regression estimation period to that subsequent to the implementation of ART (2005 - 2018) indicated that health expenditure (including that on drugs such as ART) was of the order of four times as effective as that which Edoka and Stacey[3] had concluded. It is clear that Edoka and Stacey's[3] scientific conclusions compared with those of Barr[4] would have had radically different implications for budgetary allocation to health departments in SA. Here were two SA scientists coming to vastly different conclusions with the same data. Perhaps more worrying was that the response of Edoka and Stacey[5] to the Barr[4] critique was to effectively agree with the Barr[3] conclusions for SA national level data, but to claim that the same could not be said when using SA *provincial*-level data, which they regarded as more appropriate. However, this provincial-level data remain unpublished and unavailable for researchers, so that the inexplicably different results obtained for provincial as compared with national data (over the same period) are unable to be properly interrogated.

The conclusions regarding the effectiveness of health expenditure on mortality of the type discussed above have further, perhaps even more critically important implications for SA society. While the elasticity estimate, as discussed above, can be used to infer the effectiveness of per capita health spend on mortality, it has also been used to infer the value to SA society of a SA citizen's death averted, the so-called value of statistical life (VSL). A consequence of the vastly different estimates of elasticity calculated by Edoka and Stacey[3] on the one hand and Barr[4] on the other, given the same set of available national data, are that the VSL estimate using the Edoka and Stacey[3]-derived elasticity is more than four times as large as the VSL estimated by Barr.[4] This estimate of VSL is put forward as a means to estimate the cost to society (from a SA government perspective) for a range of ills that cause death in society and thus impact the allocation of public funds in order to mitigate their effect. These include the deaths from the HIV or COVID-19 pandemics, as well as the deaths caused by a range of societal risk factors, including car accidents, alcohol-related disease and smoking, as seen through the eyes of the SA government. For example, Matzopoulos *et al.*[6] estimated the total cost of alcohol damage to SA society to be around ZAR250 billion in 2009 prices; critically, 76% of this amount comprises a VSL-based monetary figure for the cost of deaths attributed to alcohol. However, if one uses the VSL estimated by Barr,[4] and assumes the same number of SA alcohol-attributed deaths as Matzopolous *et al.*,[6] one obtains a rand figure for the cost of alcohol-attributed deaths to SA society that is 24% of the figure estimated by Matzopolous *et al.*,[6] equating to a markedly lower rand estimate of the total cost of alcohol-harm to SAsociety (see Barr[4]). Not surprisingly, the whole notion of statistically estimating VSL is fraught with disagreement and remains highly contested. Reducing the value of life to a monetary value is problematic and the estimate is fragile, as our unbundling of the effects of data selection on resultant estimates of VSL

demonstrates and ignores the fact that 'life' and 'value' are inherently multifaceted concepts. 'Value' in health policy is something that should ideally be tackled in a transdisciplinary manner, taking into account both context and societal aspirations, revealing the trade-offs and value judgements inherent in the debate (see, for example, Maguire and Murphy[7]). Such methodology has however, not yet been applied in SA, and policy interventions are still largely evaluated in overall rand value terms.

Correlation and causality – a critical difference

Our second example draws on an article by Chu *et al*.,[8] who use data on the number of trauma admissions and the number of trauma-related operations at a Worcester hospital over the period 1 January to 28 December 2020 to draw conclusions about the efficacy of 'bans on alcohol … to decrease health facility traffic during national emergencies'. We propose that their resulting assertions of a causal connection between alcohol lockdowns and health facility traffic are, in fact, unfounded, and that the statistical analysis they use requires assumptions that are never tested and that superficially, at least from the data depicted in Fig. 1 in the Chu *et al*.[8] article, appear not to be satisfied. Moreover, the statistical analysis, at best, estimates an association between trauma admissions (and trauma-related operations) over five different periods in 2020, and the different levels of alcohol restrictions applied by the government over those periods. It certainly does not establish a causal connection that runs from restrictive alcohol access to reduced trauma admissions at the hospital. In fact, it is easy to show, using the exact same trauma admissions data, that we could equivalently conclude that it was the curfew restrictions that were applied over the period considered that caused the changes in trauma admissions.

In reality, there will be a large number of factors that impinge upon trauma admission rates at a particular hospital. In a statistical model, we generally hope to identify the most important of these factors and include them in the model. In the Chu *et al*.[8] model, the only variable included that could explain trauma admissions is the level of alcohol restrictions. However, there are clearly many other factors that affect trauma admissions and are also related to the various COVID restrictions imposed by the government, but which have not been included in the model; these are known as confounding factors. For example, the levels of trauma admissions could be affected by altered levels of gang violence, availability of hard drugs on the street, altered levels of traffic on the roads, reduced presence of pedestrians on the streets, etc. All of these factors are conceivably related to the various COVID restrictions put in place during 2020. Fox *et al*.[9] and Kraemer *et al*.[10] for Austin (Texas) and China, respectively, have shown that, in particular, there is a close association between the levels of hospital admissions and overall decreased mobility under COVID restrictions. The failure to accommodate these factors introduces them as confounding factors in the model, as they clearly affect hospital admissions, are clearly related to the COVID restrictions, but are not included in the model. Hence any conclusions based on the Chu *et al*.[8] model, which has only alcohol restrictions as an explanatory factor, is ignoring these unidentified, underlying causes. This means that attributing the cause of the changes in trauma admissions to the various levels of alcohol restrictions, as the Chu *et al*.[8] article does, is simply not justified.

The model results that Chu *et al*.[8] obtain simply tell us that there is an association between the trauma admissions over five 100-day (*pro rata*) periods at the hospital and the levels of alcohol restrictions applied by the government over each different alcohol restriction period. But, as mentioned above, this does not imply that it is the alcohol restrictions imposed that are responsible for the changes in trauma admissions. Moreover, due to the fact that there are such limited data, it can be said that the model has no predictive power at all. That is, one cannot say that if alcohol restrictions were reapplied in the future, a similar pattern of trauma admission changes would occur at the hospital in the future.

In summary, one can only conclude that the statistical analysis in the Chu *et al*.[8] article cannot lead one to pronounce on the efficacy of government policy decisions (such as the efficacy of alcohol bans for impacting hospital admissions), and, as such, the conclusions drawn from the model used are misplaced and misleading.

Data that inform public policy debates must be freely available

Appropriate government policy relies on accurate statistical estimates from appropriate models and appropriate data. The examples above indicate that the consequences to society of statistical estimates may be huge. Scientists, particularly statisticians, have an obligation to make completely transparent the assumptions of the models they use, the competing models that could have been used as viable alternatives, as well as the limitations of the data they are basing their modelling on.

Furthermore, data that are used for statistical/quantitative modelling in published papers should always be made available for other researchers to interrogate/re-model. An appropriate route for interrogating the efficacy of health expenditure in SA is, at the very minimum, to publish all the data used and carefully explain the implications and assumptions of the models used.

Placing statistical analysis and statistical results in a proper context is vital for enabling an audience to critically absorb information and form an opinion.

It is the job of the statistician to ensure that the context of the data that are used is fully understood and conveyed. The introduction of ART completely changed the profile of mortality in SA, and models aimed at analysing the efficacy of policy clearly have to take cognisance of this fact. The analysis of the COVID pandemic will be an equally challenging area of statistical analysis, particularly in the face of unreliable data, multiple COVID variants and the lack of consensus on how to define, collect and accommodate excess death data.

Scientists have a material influence on the configuration of public health policy, including the allocation of public money to health. Particularly in the developing world, this places extraordinary responsibility on these scientists to produce research that is subject to thorough interrogation, is transparent and which is expressly committed to independence from any particular ideology. We suggest, on the basis of the discussion above, and the examples

cited, that published research that explicitly or potentially informs public health policy should abide by the following principles.

Firstly, that the data on which any conclusions are made are published in their entirety. In addition, particularly in the case of time series data, that justification is given as to why the particular timespan of data has been used and whether a wider span of data is available. In addition, is it reasonable to assume that the underlying model is unchanging over the period selected? This could be tested by splitting the data over different periods and testing whether the model estimates change significantly. Moreover, if it is established that different spans of the data may be considered more or less reliable than others, one might consider weighting the different spans of data according to their perceived reliability; the most obvious example of this, particularly if the model is used to produce forecasts, is simply to weight the more recent data progressively more than the past data.

Secondly, that health policy decisions be viewed and analysed within a transdisciplinary paradigm. Scourges such as the COVID-19 pandemic are an obvious example of a case where government responses needed to take into account the intertwined systemic effects of policy interventions not only on public health directly, but also on the economy and hence people's livelihoods, as well as the stability of health service provision, all within the context of shifting global responses and positions. A transdisciplinary approach embraces collaboration and inclusivity across multiple disciplines including civil society, in order to ensure effective and legitimate policy formulation, and resists the tendency to simplify complexity into a single scale reflecting monetary value.

Thirdly, an acknowledgement that statistical methodologies and model approaches to any problem are varied, and interpretation of the results can thus be nuanced. This is applicable to studies focused on health policy issues as much as anything else. It would be unrealistic to expect any piece of research to comprehensively consider the range of methodologies available, but if the data are made available to other researchers, it would allow them to consider the impact of changing the methodology and/or the model.

The fourth and perhaps broadest principle is the fact that statistical analysis of data using a statistical model in any context is always associated with uncertainty. In turn, the uncertainty is unknown and must be estimated. Therefore, the uncertainty associated with any conclusions arising from statistical analysis needs to be made explicit in real, contextually specific terms. Where possible, conclusions should be rigorously interrogated with as many different data sets in as many different settings as possible.

We believe that journals that publish articles that suggest a direction of public policy in the health arena need to be cognisant of these issues and, themselves, adopt publication criteria that encourage debate and interrogation from the community of scientists engaged in the debate at hand. Public policy in the health arena is simply too important not to adopt these criteria.

Declaration. None.

Acknowledgements. None.

Author contributions. Equal contributions.

Funding. Both authors receive general funding support from the University of Cape Town and the National Research Foundation. No other funding has been received from any source for the writing of this manuscript.

Conflicts of interest. None.

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Accepted 5 September 2023.