Inside the black box: modelling health care financing reform in data-poor contexts

Di McIntyre1* and Jo Borghi2,3

1Health Economics Unit, University of Cape Town, Observatory, South Africa, 2London School of Hygiene and Tropical Medicine, London, UK and 3Ifakara Health Institute, Dar es Salaam, Tanzania

*Corresponding author. Health Economics Unit, University of Cape Town, Health Sciences Faculty, Anzio Road, Observatory, 7925, South Africa. E-mail: Diane.McIntyre@uct.ac.za

Accepted 11 January 2012

Modelling the likely financial resource requirements and potential sources of revenue for health system reform options is of great potential value to policy-makers. Models provide an indication of the financial feasibility and sustainability of such reforms and highlight the implications of alternative reform paths. There has been increasing use of financial models of health sector reform in recent years, particularly since the development of user-friendly software such as SimIns, which was developed by the World Health Organization (WHO) and Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ). This paper outlines the process of developing country-specific spreadsheet-based models to explore the financial resource requirements of health system reform options in South Africa and Tanzania. Building one’s own model, although time consuming, allows for greater flexibility and forces the analysts to give careful consideration to the assumptions underlying the model. The core variables in our models are: population, health service utilization rates and unit costs. The paper outlines the types of disaggregation of these variables, the range of possible data sources, key challenges with securing accurate data for each variable, and relevant evidence on which to base key assumptions, and how we went about addressing these challenges. We also briefly review how to model the revenue-generating potential of alternative sources of health care financing. The intention of the paper is to provide guidance for analysts who wish to develop their own models, and to illustrate, with reference to the South African and Tanzanian modelling experience, how one has to adapt to data constraints and context-specific modelling requirements.

Keywords Health care financing, modelling, universal coverage, South Africa, Tanzania

KEY MESSAGES

- Using modelling to assess the financial feasibility and implications of alternative health system reform paths can be of great value in supporting evidence-informed policy-making.

- Developing one’s own spreadsheet model has a number of advantages, including allowing greater flexibility to reflect specific country circumstances and requiring the analyst to carefully evaluate the assumptions built into the model.

- A pragmatic approach should be adopted in data scarce contexts, but all assumptions should be made explicit and justified.

- The modelling process can highlight priority areas for improved data collection.
Introduction

There is growing international interest in pursuing health care financing options that promote universal coverage. Before embarking on a process of major health system reform, policymakers want an assurance that the reforms they are embarking on are feasible. A key concern is whether the reformed system will be affordable, i.e. that adequate revenue can be generated to meet the resource requirements of the reformed system.

Valuable tools have been developed in recent years that can assist countries in estimating future health care expenditure and revenue-generating potential. The best known and most widely used software is SimIns, which was developed collaboratively by the World Health Organization (WHO) and GTZ. This is a computerized spreadsheet model which allows for the assessment of future health expenditures associated with social health insurance or community health insurance through a 10-year projection. It has a user-friendly interface and allows quite rapid simulations to be undertaken. However, it can be somewhat rigid particularly if one wants to explore different reform paths and adjust key system design elements.

The alternative is to develop one’s own spreadsheet based model which, as we have discovered, is an extremely time-consuming exercise and requires individuals with a good understanding of the local health system and proposed reforms as well as spreadsheet and quantitative skills. Nevertheless, this process has a number of advantages. It allows for greater flexibility in terms of exploring alternative reform paths and the extent of sensitivity analyses that can be undertaken. Equally importantly, it forces one to look inside ‘the black box’ and to pay considerable attention to the assumptions that are being used in the model. This is particularly important in engaging with policy makers who wish to be assured that assumptions are evidence-based and justifiable and that all relevant factors have been taken into consideration.

This paper provides an overview of key methodological issues in modelling the financial resource implications and affordability of alternative approaches to moving towards universal coverage, using examples from South Africa and Tanzania. It attempts to provide insights for others who may wish to develop similar models, and particularly to highlight the challenges faced in data-poor contexts and possible solutions.

There are four main stages to modelling health care financing reform, which we review in turn:

Step 1: Developing health care financing reform scenarios,
Step 2: Modelling resource requirements for different scenarios,
Step 3: Modelling revenue availability for different scenarios,
Step 4: Undertaking sensitivity analyses.

Step 1: Developing health care financing reform scenarios
The first stage in the development of a model is to identify the specific health care financing reform scenarios to be modelled. A useful starting point is to review current health policy debates to ensure the model results can feed into these discussions. Scenarios could also be envisaged so as to stimulate such debates. As noted by Chichon et al. (1999: 26): ‘...before the modelling process can begin, the goals of national health policy must be determined…The nature and design of the model is determined by the health policy.’

It is therefore useful to undertake interviews with key health sector actors (Gilson et al. 2012), review available policy documents and, in contexts where policy options are being debated publicly, to undertake a media analysis. In South Africa, specific reform options were being discussed at the time of the study that guided the development of scenarios. In Tanzania, there was a commitment to achieving universal coverage and moves had been made to more closely integrate the two largest insurance schemes, but no public debate about the process was yet underway, and hence we developed our own scenarios to stimulate such a discussion.

In order to allow for a meaningful assessment of different reform scenarios, it is helpful to evaluate the status quo, or current situation, where no reform takes place. Reform scenarios can then be defined, for example, in terms of population coverage through pre-payment mechanisms, the benefit package offered under the pre-payment mechanism(s), provider payment mechanisms and other relevant design features (see Box 1). It is advisable to limit the number of reform options to a few (not more than three or four) most likely scenarios. This will make their review by policy makers and other key actors manageable.

Box 1 Developing reform scenarios in South Africa and Tanzania

The status quo in South Africa consisted of a system of private voluntary insurance covering about 16% of the population (McIntyre 2010a) with limited growth over time, with the remainder of the population being covered through tax-funded public services. Private schemes cover a prescribed package of chronic conditions and inpatient services, but may offer additional benefits, while public services are relatively comprehensive, albeit with rationing and user fees at hospitals. This option was compared with: (1) a universal coverage scenario, funded largely through increased allocations to the health sector from general tax revenue and an additional payroll tax or surcharge on personal income for the formal sector, and offering comprehensive benefits at accredited public and private providers with no co-payments; (2) a scenario of mandatory extension of private insurance schemes which would cover primary as well as inpatient services for all formal sector workers and their dependants, with the remainder of the population remaining dependent on tax-funded services.

The status quo in Tanzania comprised tax and user fee funded public health services for the uninsured, 90% of the population, and health insurance cover for the remaining 10%, as well as out-of-pocket payments made direct to private sector providers. While multiple insurance schemes offer comprehensive benefits to the formal sector, the largest being the National Health Insurance Fund (NHIF) for public servants, voluntary schemes at community level offer public primary level care for the informal sector, such as the Community Health Fund (CHF) in rural areas and Tiba Kwa Kadi.
Step 2: Modelling the likely resource requirements for alternative scenarios

Projected expenditure can be estimated as the product of three core sets of data: population, health service utilization rates and unit costs of services (Figure 1).

Population estimates

Data sources

Population data are typically the easiest to secure of all the model variables, as central statistical offices often devote considerable demographic expertise to producing population projections, based on census data, inter-census trends, and fertility and death rates. However, in some contexts there may be multiple sources of projected population data. For example, in South Africa, due to the magnitude of the AIDS epidemic [with South Africa accounting for 17% of the global human immunodeficiency virus (HIV) burden (UNAIDS 2007)] and the controversy surrounding official population projections produced during the period of ‘AIDS denialism’ (Groeneveld et al. 2005; The Lancet 2005), the Actuarial Society of South Africa (ASSA) compiled population projections based on a very detailed and widely respected model of the impact of the AIDS epidemic on the South African population (Dorrington et al. 2004). These were used for the model in preference to census-based population projections.

Defining population sub-groups

To ensure model precision, it is necessary to divide the population into sub-groups that differ substantively in terms of utilization rates. Likely sub-groups for consideration include: age, geographic location and insurance status. However, it is important to bear in mind that utilization rates for a range of providers will need to be obtained for each population sub-group, and hence it is necessary to ensure that sufficient data are available to allow for this level of sub-group analysis.

In both Tanzania and South Africa, we disaggregated population by age to account for the different utilization rates attributable to young children (ages 0–4), older children (5–14), women of childbearing age (15–49) and the elderly (50+ in Tanzania; 50–59 and 60+ in South Africa) (see Table 1). In South Africa, there were also differences in utilization patterns between men and women that were not limited to the child-bearing age group, and so the population was divided...
into age–gender groups. This pattern was not evident in Tanzania, where we differentiated only between males and females in the 15–49 year age group. However, there were large differences in rural–urban utilization patterns, and so we disaggregated by geographic area (Figure 2). In both countries, we disaggregated by insurance scheme status due to the substantial differences in utilization rates between the insured and uninsured. Sometimes, the selection of population sub-groups may also be influenced by the design of a proposed health financing reform. For example, if a system was to offer free care to those under 18, a cut-point of 18 years may be preferable to 15 years.

### Common challenges

**Obtaining disaggregated population data:** While it is feasible to get overall population projections, it is not always possible to get these projections in the desired disaggregated format. Indeed, disaggregating the age–sex group population data according to insurance status posed a challenge. Ideally, it would be desirable to get such information from the relevant insurance

### Table 1 Levels of disaggregation and data sources for key model variables

<table>
<thead>
<tr>
<th>Disaggregation</th>
<th>South Africa</th>
<th>Tanzania</th>
</tr>
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<tbody>
<tr>
<td><strong>Population</strong></td>
<td>Age groups: 0–4; 5–14; 15–49; 50–59 and 60+ years; separately for males and females</td>
<td>Age groups: 0–4; 5–14; 15–49; 50+: considered separately for males and females for ages 15–49 only</td>
</tr>
<tr>
<td></td>
<td>Those with private insurance and those without</td>
<td>Area of residence: urban/rural</td>
</tr>
<tr>
<td><strong>Types of services</strong></td>
<td><strong>Public sector services:</strong></td>
<td><strong>Public sector services:</strong></td>
</tr>
<tr>
<td></td>
<td>Visits to primary care facilities (clinics or community health centres)</td>
<td>Dispensaries; health centres; district hospitals; regional hospitals; and referral hospitals</td>
</tr>
<tr>
<td></td>
<td>Outpatient visits to district, regional and provincial &amp; central hospitals</td>
<td>Faith-based services:</td>
</tr>
<tr>
<td></td>
<td>Inpatient days at district, regional and provincial &amp; central hospitals</td>
<td>Dispensaries; health centres; and hospitals</td>
</tr>
<tr>
<td></td>
<td><strong>Private sector services:</strong></td>
<td><strong>Private-for-profit services:</strong></td>
</tr>
<tr>
<td></td>
<td>Visits to general practitioners</td>
<td>Drug shops/pharmacies; dispensaries; health centres; and hospitals</td>
</tr>
<tr>
<td></td>
<td>Visits to specialists</td>
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<td></td>
<td>Visits to dentists</td>
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<td></td>
<td>Visits to retail pharmacies</td>
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<td></td>
<td>Private hospital outpatient visits</td>
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<td></td>
<td>Private hospital admissions</td>
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<tr>
<td><strong>Data sources</strong></td>
<td><strong>Population</strong></td>
<td><strong>Utilization</strong></td>
</tr>
<tr>
<td></td>
<td>Actuarial Society of South Africa (most reliable in context of AIDS epidemic) for current and future population with age and sex disaggregation</td>
<td>National census data for current and future population by age–gender and urban/rural area.</td>
</tr>
<tr>
<td></td>
<td>SACBIA survey for age/sex distribution of private insurance members</td>
<td>SHIELD survey for age/sex distribution of insurance scheme members and non-members</td>
</tr>
<tr>
<td></td>
<td>SACBIA survey for current utilization rates, disaggregated by age and sex and service type—benchmarked to Dept of Health’s Health Information System (HIS) for public sector and against information from largest private health insurance administrators</td>
<td>NHIF reports for urban/rural distribution of members</td>
</tr>
<tr>
<td></td>
<td>Norms used for future utilization rates (see text)</td>
<td>SHIELD survey for current utilization rates disaggregated by age, geographical location and insurance status and service type—benchmarked against inflated HMIS data (2006) and data from the NHIF</td>
</tr>
<tr>
<td></td>
<td>Public sector: Expenditure at each facility from National Treasury and utilization from Dept of Health HIS; ratio of the unit costs for inpatient care and outpatient visits for different categories of public sector hospitals calculated using a regression model (including expenditure, utilization and clinical personnel as an indicator of the size of the facility)</td>
<td>Average charges recorded by the NHIF</td>
</tr>
<tr>
<td></td>
<td>Private sector: Average charges recorded by private health insurance schemes</td>
<td>Average charges recorded by private health insurance schemes</td>
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</tbody>
</table>

**Notes:**

1. SACBIA (South African Consortium for Benefit Incidence Analysis) survey: A nationally representative household survey of 4800 households which collected comprehensive health service utilization data (see Ataguba and McIntyre 2012 for sampling details).
2. SHIELD survey: A household survey undertaken in three rural and four urban districts in Tanzania specifically for the SHIELD study and including 2224 households (see Mtei et al. 2012 for sampling details).
schemes. In South Africa, this was not feasible due to the large number of individual private schemes (over 120 at the time of the study) from which such data would have to be collected. In Tanzania, age–sex data were available only for principal members of the NHIF, but not for their dependants or for any of the other schemes. For this reason, household survey data (described further in the utilization section) were used to estimate the age–sex distribution of the population covered by a given insurance scheme. In both countries, it was assumed that the age–sex distribution of the insured would remain constant over time despite changes in overall scheme coverage levels, except in the universal coverage scenarios where the age–sex distribution would match that in the overall population.

Projecting the growth of groups eligible for insurance: When considering scenarios that involve different pre-payment mechanisms for the formal and informal sector, such as in Tanzania, it is necessary to project the likely growth of the formal relative to the informal sector. Labour Force Surveys can provide baseline estimates of the proportion of the population falling into the formal and informal sectors and the unemployed and economically inactive. One could then conservatively assume that the formal sector remains a constant proportion of the population. One could also base growth estimates on government commitments to expanding the tax base, if available. Alternatively, government commitments to the expansion of health workers and teachers could be used to proxy growth of the public formal sector, and social security growth models, such as those produced by the International Labour Office, could be used to proxy growth of the private formal sector. The inactive and unemployed population could be assumed to remain a constant proportion over time, or to change in line with government or International Monetary Fund (IMF) projections of unemployment growth. The informal sector population can then be estimated as the difference between the total population, the formal sector and the unemployed/inactive population. When insurance schemes cover dependents, it may be necessary to assume that dependents will be drawn from the inactive and unemployed population groups, to avoid over-complicating the model.

Utilization estimates

Data sources

Utilization data should be disaggregated according to the previously defined population sub-groups and by type of health service provider (see Table 1 for the list of provider categories used in Tanzania and South Africa). National health information systems can provide an estimate of overall utilization rates, by urban and rural area, and may provide some limited age–gender disaggregation (in Tanzania under-5s are classified separately). However, they do not offer information on utilization by insurance status, usually include data on public sector services only, and in many settings are unreliable. Health insurance schemes may also be able to provide information on the utilization of members by type of provider, but this may not be disaggregated by age–sex or area of residence (as was the case in both countries). In such instances, the only alternative data source is household survey data. However, nationally representative surveys such as the General Household Survey (GHS) in South Africa and the Household Budget Survey (HBS) in Tanzania cannot be used to derive utilization rates as they report on only one instance of service use and restrict questions on utilization to instances when there is self-reported illness within a relatively short recall period, therefore excluding preventive and chronic care services (McIntyre and Ataguba 2011). The level of disaggregation between different types of providers is also limited. Consequently, specific household surveys may need to be undertaken to compile utilization rates for outpatient and inpatient care across a detailed range of service providers. Household surveys were carried out in South Africa (4800 households) and Tanzania (2224 households) as part of the SHIELD project and used within the model (see Ataguba and McIntyre 2012 and Mtei et al. 2012 for sampling and other details).

Main challenges in estimating utilization

The main challenge of relying on household survey data is that, when disaggregated according to the population sub-groups, the number of observations for certain providers may be very small. It is therefore helpful to assess whether the age–sex
utilization distribution for a particular provider follows the expected J-curve (Cichon et al. 1999: 155–6) (see Figure 3). If not, the data can be adjusted for a particular provider and age (or age-sex) group by applying ratios derived from other providers where data were more reliable. For example, if utilization of central hospitals was low, and the 0–4 age group for central hospitals did not fit with the expected J-curve, the percentage share of total utilization for this age group in all public hospitals could be applied to the total utilization rates of central hospitals, to replace the data for this sub-group.

A further challenge is the projection of likely future utilization rates. In some countries, utilization norms may have been developed and can be used. For example, in South Africa, ‘ideal’ and ‘realistic’ utilization norms for primary health care services (Rispel et al. 1996) and hospital services (Monitor Company et al. 1996) were available for use in the model. As the primary care norms study was conducted in 1996, it was updated for changes in the epidemiological profile and the crude birth rate (McIntyre 2010b). These normative rates were based on the minimum number of required visits for certain interventions (e.g. to achieve full immunization in children, for appropriate antenatal care, for the monitoring and treatment of chronic conditions, etc.) as well as empirical studies in well-functioning facilities. The intention was to identify optimal utilization rates where unmet need was addressed, but not to accommodate moral hazard. Normative rates need to be reviewed regularly to take account of changing health technologies (e.g. a shift to day surgery reducing inpatient days for certain conditions).

If national normative targets have not been developed, then it may be necessary to make reference to the international literature on how utilization increased in other low- and middle-income countries (such as Thailand) following the introduction of universal coverage systems. In South Africa, some of the ‘ideal’ targets were above utilization levels in the highest income countries, which was regarded as unrealistic and these targets were adjusted downwards. When the reform being considered is the expansion of an existing insurance scheme, utilization rates from that scheme can be applied to a larger proportion of the population. There are drawbacks with all of these approaches (normative targets, relying on experience in other countries and extrapolating from an existing scheme that covers a specific group, usually higher income groups, to other groups). However, within a data-constrained context, one has to critically review alternative approaches, identify the most reasonable approach within the context of the proposed reforms and undertake extensive sensitivity analysis.

**Unit cost estimates**

**Data sources**

Unit cost refers to the actual cost of delivering a given service. In some countries rigorous costing studies may have been carried out that could be used within the model. While such an exercise was being planned in Tanzania, it had not yet commenced at the time of the modelling. The next best option would be to obtain facility-level expenditure along with total outpatient visits and inpatient days for all facilities to estimate the average cost of a visit and an inpatient day using statistical methods (this approach was used in South Africa for public facilities—see McIntyre and Ataguba 2011). However, if national information systems are unreliable, the cost data derived may appear unrealistically low (as we found in Tanzania). Data from insurance schemes on total claims divided by visits can also be used to estimate unit costs of care (this approach was used in South Africa for private facilities and in Tanzania for NHIF members). If such data are not readily available, insurers can be requested to provide average reimbursement rates for particular services. To estimate the unit cost of private providers used by the uninsured, reported out-of-pocket payments drawn from a household survey can be used. Finally, a review of available costing studies might also be carried out to estimate likely average costs.

**Common challenges**

When using national expenditure or claims data and visits/admissions to work out unit costs, an assumption about the relative cost of an outpatient visit and inpatient admission needs to be made. Although often assumed to be fixed (Lombard et al. 1991; Barnum and Kutzin 1993; Adam and Evans 2006), the ratio of expenditure per inpatient day to expenditure per outpatient visit varies considerably across hospitals of different levels (Lombard et al. 1991). Statistical methods can be used to more accurately estimate the ratio of outpatient visits to inpatient days, by regressing total expenditure for a particular facility type on total outpatient visits, inpatient days and, if available, numbers of nurses and medical doctors as a proxy for the relative size of the facility.

When deriving average costs from a literature review, some adjustments may be required to ensure consistency in the year of cost data and to take account of different costing methodologies used (this approach was used in Tanzania for the costs of services used by the informal sector and uninsured).

**Projections of changes to unit costs**

In estimating future unit cost trends, three factors should be considered:

1. Recent trends in unit cost increases in the public and private sectors.
2. Potential health system design impacts on unit costs (such as moving from fee-for-service payment for private General
Practitioners (GPs) to capitation and having a single purchaser under a universal system with significant purchasing power to influence reimbursement rates.

(3) The extent of capacity in the public sector to meet the additional demand resulting from a universal health system. In both South Africa and Tanzania, health services are presently very under-resourced, particularly in terms of staffing, but also basic equipment and the routine availability of essential medicines. Nevertheless, it is important to assess the extent to which efficiency improvements are possible in order to estimate the need for additional resources as accurately as is possible. In South Africa, a 6.8% real annual increase in unit costs was, therefore, assumed to be required for a 5-year period based on recent projections of additional resource requirements associated with improving staff-to-patient ratios (DBSA 2008). In Tanzania, health system strengthening costs were added in as a lump sum amount and phased in over the lifetime of the model. We derived estimates of the likely lower [based on meeting national human resource requirements (MOHSW 2008a)] and upper [based on comprehensive upgrading of primary care (MOHSW 2007)] level cost requirements to strengthen the health system.

Calculating expenditure

Once population, utilization and unit cost data sheets have been completed, a further spreadsheet can be constructed which computes expenditure as the product of these three sets of data for all possible sub-group combinations (as illustrated in Table 2 for South Africa). This process will invariably lead to extensive rows of data (4000 in South Africa, and over 20 000 in Tanzania). In Tanzania, a visual basic macro was developed to automatically compute expenditure. Pivot tables can then be constructed to summarize total expenditure by category of provider and by insurance status, geographic area, etc.

Benchmarking or calibrating the model

Before any projections are undertaken, the model should be ‘benchmarked’ (often called calibration) to maximize validity. Where reliable, national health information systems can be used to benchmark total outpatient visits and inpatient admissions predicted by the model. Insurance scheme data on utilization levels of members can also be used to benchmark specific population sub-groups (this was done in South Africa for private health insurance). Projected utilization rates can then be adjusted (upwards or downwards) to ensure that predicted utilization matches with actual utilization for the model base year.

Once utilization data have been benchmarked, expenditure data should also be benchmarked using available national data sources. In South Africa, national audited public sector and private insurance expenditure for 2007 and 2008 was used. In Tanzania, expenditure was benchmarked against National Health Accounts data for 2006 (MOHSW 2008b). In South Africa, further adjustments were made to utilization data in order to ensure that predicted expenditure aligned with audited data.
expenditure, as unit cost data were largely drawn from audited expenditure data and were felt to be reliable. In Tanzania, adjustments were made instead to unit costs, as there was considerable uncertainty around these estimates.

Deciding on time frame for projections
The decision on how far into the future to project expenditure (and revenue) data will depend on the expected or announced time frame for policy change and/or what is deemed reasonable for the realization of universal coverage. In both South Africa and Tanzania, a 15-year period was considered to be the shortest period in which it may be feasible to realize universal coverage, particularly in terms of developing additional service delivery capacity to cope with the utilization increases that will inevitably occur when financial barriers to service access are removed. It was assumed that target utilization levels would be achieved by the end of the projected period. However, we also considered a 5-year time frame in Tanzania, as government commitments to expanding coverage to 45% were set against a target date of 2015.

Other costs
The resulting model allows the estimation of the costs of health service delivery for a range of different providers. However, there is a range of expenditure items that cannot be meaningfully captured within the model. In all contexts, the costs of community health services, health worker training, facility maintenance and service administration, as well as environmental health activities and other public health interventions, will not be captured by the model. These cost categories will vary from place to place. For example, in South Africa, the costs of specialized hospitals for tuberculosis and psychiatric care and emergency medical services were not captured within the model. Also, given the magnitude of the AIDS epidemic and the roll-out of anti-retroviral treatment (ART), a separate model for ART costs was used (see Cleary and McIntyre 2010 and Cleary et al. 2008 for details of the ART model). In Tanzania, the costs of the National HIV/AIDS Control Programme and research and development were not captured within the model. Such items can be added in as a lump sum and assumed to increase in line with real unit cost increases for other services per year, except where specific future expenditure increase projections are estimated as in the case of the ART programme in South Africa. In both countries, an allowance was also made in the universal coverage scenario for the administration costs of the proposed single funding organization: National Health Insurance/National Health Insurance Fund (NHU/NHIF). This was estimated as a percentage of all other costs.

Step 3: Modelling revenue-generating potential of alternative scenarios
To assess the affordability of different scenarios, total expenditure can be considered as a proportion of the total government budget and of Gross Domestic Product (GDP). Where expenditures exceed existing allocations from general tax revenue to the health budget, alternative funding sources may need to be explored. In South Africa and Tanzania, likely future increases in the total government budget were based on projected real GDP increases (Braga et al. 2009; National Treasury 2010), based on the assumption that the ratio of government spending to GDP would remain constant.

For the universal coverage scenario in South Africa, an assumption was made that the allocation to the health sector from the overall government budget would increase over time to 15% (which is line with the Abuja declaration [OAU 2001]). The difference between the projected expenditure under universal coverage and the increased allocation from the government budget was calculated, and then alternative options for raising additional taxes to finance such an allocation were explored. This required obtaining information on the current distribution of taxable personal income across income groups and an assumption that taxable income would grow in line with GDP.

Analysis of expenditure and revenue can also be valuable at the level of individual schemes. In South Africa, we examined the required real private insurance scheme contributions per member to cover projected expenditure. This highlighted the implications for scheme members of the status quo and mandatory extension of private schemes scenarios. In Tanzania, we compared total expenditure to total revenue in terms of insurance contributions for the two largest health insurance schemes in Tanzania (the National Health Insurance Fund and the Community Health Fund), demonstrating the huge reserve of the NHIF and potential benefits from cross-subsidization between schemes.

The revenue estimates should be critically assessed within the context of fiscal space and household budget space to evaluate the feasibility of any required tax or contribution increases.

Step 4: Sensitivity analyses
Extensive sensitivity analyses are essential to assess the impact of changes in key assumptions on the modelled projections. Examples of variables where sensitivity analyses might be undertaken include:

- **Population variables**: rate of growth in formal sector employees, population coverage by pre-payment mechanisms, period of time over which changes in population coverage occur.
- **Utilization variables**: extent of utilization increases, period over which utilization changes occur, utilization of publicly funded health services or universal service entitlements by those with additional private insurance cover.
- **Unit cost variables**: magnitude of initial increased resourcing to improve quality of public sector services, average annual real cost increases in public and private sectors.
- **Other costs**: administration costs as a percentage of service delivery costs (e.g. for NHIF and private insurance schemes).
- **Revenue variables**: expected level of GDP growth; for example, given the relatively high projections of real GDP growth by the World Bank and IMF in Tanzania (around 7%) (Braga et al. 2009), we also considered two more conservative estimates of growth, of 2% and 4% (Utz 2007).
To illustrate the usefulness of such sensitivity analyses, Figure 4 shows one example from the South African status quo scenario. The main difference between the two analyses presented here is that in one (the solid lines), the current annual real rate of increase in unit costs in the private sector (of about 7%) is used, while the other (the dotted lines) assumes improved cost containment in the private sector with annual real increases being reduced to 5%. This highlights the critical importance of addressing the rapid real unit cost increases in the private sector within South Africa (referring to increases in fee rates as opposed to utilization increases); if they are not reduced, total health care expenditure in South Africa could reach nearly 14% of GDP within 15 years.

We undertook sensitivity analyses that considered the impact of combinations of changes in the different variables. We considered the most extreme ends of the spectrum (i.e. the combination of variable values that would result in the lowest cost or ‘best case’ and the highest cost or ‘worst case’ estimates) as well as what we considered to be the most likely value for each variable (i.e. the ‘best guess’ estimate).

Discussion

Models such as those described in this paper are not a crystal ball; they do not predict with absolute certainty future health care expenditure or revenue generation for funding health services. They do not replace the need for detailed actuarial calculations (in the sense of calculations based on the disease profile of health service users) at the time of implementing health care financing reform, to ensure adequate resources are made available on an annual basis and that the reformed system is sustainable in the long term. Undertaking this type of actuarial analysis requires sophisticated routine information systems that can provide diagnostic and service procedure information, which are generally lacking in low- and middle-income countries. Thus, financial modelling of the type presented here plays a very specific and important role. In particular, it is useful for stimulating debate and informing health policy decision-making by considering the implications of alternative reform paths. It also provides ‘high level’ estimates of the likely resource implications of reform that are sufficiently accurate to initiate reforms; these estimates can be refined as routine information systems on patients’ diagnoses and procedures undertaken are established or improved.

Therefore, a key priority in any country introducing major health system change should be to improve routine health information systems to enable accurate actuarial projections and implementation monitoring to be undertaken. Undertaking modelling of the resource requirements for alternative health care reforms well before reforms are initiated, thus, also has another important role; it is useful in highlighting the data elements that should be prioritized for accurate collection through routine information systems. The same data variables of importance for modelling (particularly age–sex and service category disaggregated utilization and unit cost data) are critical for annual actuarial analysis during the implementation of the chosen reform path (although actuarial analysis also requires disease incidence information).

Some may argue that one has to put these information systems in place before embarking on health system reform. However, an innovative approach was used in Thailand, where the National Statistics Office was persuaded to undertake certain household surveys (the Socio-Economic Survey and the Health and Welfare Survey) more regularly than was the norm, over the period of implementing their universal coverage policy, to enable monitoring of changes in service utilization and equity in financing and benefit incidence (Tangcharoensathien et al. 2007). This filled the data gap while routine health information systems were being improved.

Given the value of undertaking modelling of reforms, what key lessons emerge from our experience? The World Health Organization has made quite extensive use of the SimIns
Modelling health care financing reform is a valuable tool to inform policy debates about how to achieve universal health coverage, or to help stimulate such debates in countries. In South Africa and Tanzania, for example, the models have already sparked interest and stimulated discussions among key health sector actors.

While pre-existing models can be used, developing one’s own model can be useful to ensure adequate flexibility within the model to reflect specific country circumstances, and to really engage with the model’s underlying assumptions. Whichever approach is taken to modelling, a number of key decisions are required in relation to the core model components: population, utilization and unit cost, as well as the time frame for analysis, and scope of sensitivity analysis. The estimation of the resource requirements associated with different scenarios is probably the most challenging component of the modelling process, as data are often not readily available in the desired format. Pragmatism is therefore essential. We have tried to illustrate, through the examples of South Africa and Tanzania, which data sources can be used, the types of challenges that are likely to be encountered and possible solutions for dealing with them.

While it is important to improve data quality over time, the availability of high quality data becomes most important when implementation of financing reforms is underway. In deciding on the most appropriate reform path to pursue, it is possible to use the modelling approach described here, even in the context of data limitations. As is demonstrated in the reports on the application of this modelling approach in Tanzania and South Africa (McIntyre 2010b; Borghi et al. 2011), the sensitivity analyses indicate that core findings remain the same irrespective of uncertainty around some of the assumptions. We are convinced that it is essential to model the implications of alternative reform paths to inform policy decision-making. Ideally, the modelling should be conducted by local researchers as they are most familiar with the national health system and are best placed to critically evaluate what the most appropriate assumptions would be. Our hope is that this paper will assist country-level researchers in taking up this challenge.

Funding
This research was funded by IDRC (Grant number 103457) and the European Commission (Sixth Framework Programme; Specific Targeted Research Project no: 32289). DM is supported by the South African Research Chairs Initiative of the Department of Science and Technology and National Research Foundation. The usual disclaimers apply.

Conflict of interest
The authors declare having no conflict of interest.

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