Case Study | November 2015

From analysis to action

A case study on how allocative efficiency analysis supported by mathematical modelling changed HIV investment in Sudan

This brief presents a real-life example of how a group of government decision-makers, programme managers, researchers and development partners worked together to improve the allocation of HIV resources in Sudan and thereby better address the HIV objectives that the country strives to achieve.[1]

- The initial modelling analysis showed that by reallocating funds towards antiretroviral treatment (ART) and prevention programmes in Sudan, **37% of new HIV infections could be averted with the same amount of funding.**
- The Sudanese government then applied the findings in its national HIV strategic planning process and Global Fund concept note, and increased allocations to ART from 12% to 18% and HIV prevention for key populations from 7% to 29% of all HIV funding (as per the financial gap analysis including budgeted national, Global Fund and other resources) while de-prioritising HIV prevention targeted at the general population including HIV counselling and testing, condom distribution, and behaviour change communications.
- These allocations combined with additional technical efficiency gains would allow for increasing ART coverage from 6% in 2013 to 34% in 2017, **and more than double programme coverage for key populations.**
- The reallocations in the 2015–17 HIV budget for the national response are **projected to avert an additional 3,200 new infections and 1,100 deaths in these three years** compared to initially planned allocations.
- The reallocations were achieved through a rigorous HIV allocative efficiency analysis and evidence-informed policy process, conducted by a multi-disciplinary team of national and international partners working for the common goal **to make Sudan's HIV response more manageable and sustainable.**
- The case study discusses process and outcomes of this effort. It also offers some reflections on the application of mathematical modelling to strengthening decision-making of finite HIV resources, and some lessons learned about how to go 'beyond modelling' to **application of modelled allocative efficiency improvements to improving actual budget allocations for better health outcomes.**

GLOBAL BACKGROUND AND CONTEXT – Why must today's HIV investment decisions be evidence-informed?

Although the total global resources available for HIV in 2014 were an estimated US$ 20.2 billion[2], HIV resources are relatively tight in many low- and middle income countries (LMICs). Several factors require countries to re-think how HIV funding should best be allocated:

- In many countries, the ART programme locks up increasingly large sums and proportions of the available HIV resources. HIV has become a **treatable, long-term condition,** which will require decades of investment to continue provision of antiretrovirals to a growing cohort of people living with HIV.

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- International funding contributions to national HIV programmes have been stagnant or decreased, leaving some countries with **underfunded components of their national strategic plans for HIV/AIDS**. As the modalities and criteria of Global Fund (GF) support undergo change, HIV responses need to adapt their **resource mobilisation process**. The availability of domestic HIV funding might not necessarily improve as governments weigh up the **relative health impacts of investment** in different disease programmes and initiatives.
- The situation of HIV resources can also be compounded by **population growth** which, in selected countries, significantly affects the per capita level of HIV resources over time, especially when looking at HIV programmes for young people.
- In the drive to "take the services to the people" through **decentralisation** in order to increase service access and coverage across settings and plan services in response to local needs, national programmes can incur increased above-facility management and supply chain costs as well as larger facility level costs. ART costs per HIV patient have for instance been reported higher in small and less established treatment sites – which may in turn be classified as "less efficient" despite their role of providing a more convenient experience for the health care client albeit at a higher cost.
- Another dimension in the policy dialogue on HIV resource allocation is the **international time-bound HIV commitments** which may be very challenging to meet with available HIV resources, such as halving HIV incidence, eliminating mother-to-child infection, reaching universal coverage of voluntary medical male circumcision in 14 priority countries, and ending AIDS. As these goals draw on the same resources, a body of evidence is required to aid good decision-making.

In summary, there is enormous pressure on health and finance ministries and AIDS coordination authorities to use HIV resources wisely and in an impactful manner, with the long-term sustainability of the HIV programme in mind. Being able to **demonstrate impact, cost-effectiveness and/or return of investment** has therefore become a central theme in HIV and health economic decision making.

CORE QUESTION – How can allocative efficiency modeling support decision making?

There have been a number of models used to guide allocations to different HIV programmes and beneficiary populations.[3,4,5] Although mathematical models are not able to capture the complexity of the real world, they nevertheless contribute to the understanding of epidemic dynamics, costs, and impact of HIV programmes and interventions.[6,7] However, it has been repeatedly observed that resource allocation modelling has only had a limited impact on actual allocation of health resources[8,9,10]. Discussions around evidence-informed policy making often highlight the need for **better knowledge translation between academia and policy-makers**. They specifically identify the "disconnect" between the application of mathematical models to generate evidence for policy-decisions, and how strategy and policy development occurs and decisions are taken.

The GF now actively encourages countries to present in their funding requests **analytical and modelling evidence of epidemic impact of investments**.[11] Also, concept notes and budgets are now developed in close collaboration between GF and requesting governments, helped by partners providing analytical support. The U.S. President's Emergency Plan for AIDS Relief (PEPFAR) in turn states that their joint planning with governments and GF is a key strategy to optimise costs.[12] Their judicious application of resource allocation models is in fact supported by numerous HIV advisory, technical and funding bodies, including the Economic Reference Group[13], the Joint United Nations Programme on HIV and AIDS (UNAIDS), World Bank, GF and PEPFAR. The shifts in how investments are planned and allocated provide **opportunities for model-derived evidence to actually come to bear** in HIV allocative decision-making.

The **Optima model** used herein was developed to help HIV decision-makers and planners determine **optimal distribution of HIV investments to best serve national needs and priorities**. Optima is a mathematical model of HIV transmission and disease progression, which is integrated with an economic and financial analysis framework and a formal mathematical optimisation routine.[14, 15] It is a population-based and highly flexible tool providing an optimisation method to quantitatively and objectively determine

best allocations of HIV resources across numerous HIV prevention and treatment programmes. A variety of specific policy questions have been evaluated with Optima, ranging from the costs and impacts of ART scale-up among men who have sex with men in Bangkok,[16] to the impact of increased resource allocation to ARV-based strategies and sex work prevention programmes in Niger,[17] and the cost-effectiveness of needle-syringe programmes in Australia.[18] To date, the model has been used in over 20 countries to advise Government decision-making on HIV policy.

APPROACH IN SUDAN – Defining and changing HIV investment priorities in partnership

In 2014, the Sudan National AIDS Programme reviewed its national strategic plan on HIV and AIDS, while at the same time preparing a concept note for submission to the GF, the single largest funding partner of Sudan's HIV response. In this context the government of Sudan approached the World Bank and the Global Fund with a request to **conduct an allocative efficiency analysis** to inform the prioritisation of the national HIV response, and the GF asked the World Bank to assist in generating modelling evidence on high-impact GF HIV investments in Sudan.

The central theme of this case study is to report on the **results of both the modelling analysis and the policy and budgeting process**. The analysis involved from the outset a variety of actors from different institutions, who worked together under the common goal of achieving better value for money in Sudan's HIV programme. This included the allocative choices in the upcoming GF grant request as well as the national budget for HIV/AIDS. The **aim of the analysis process was actual change in allocations**, and therefore went well beyond the provision of a study report to the client government.

Key actors from government, programme management and implementation, surveillance, donor and development agencies, and academia, each brought their unique contribution into the partnership (fig. 1). They jointly defined the objectives of the analysis, agreed on model parameters and input data, vetted the preliminary model outputs, reviewed the recommendations made, and applied the findings to the allocative choices. The process culminated in assessing the likely HIV impacts of the improved, evidence-informed budget allocations.

Figure 1 Key actors in the partnership for Sudan's allocative efficiency analysis

1. Federal Ministry of Health	▪ Costing and expenditure data ▪ Context of health financing
2. Sudan National AIDS Control Programme	▪ Facilitation of efficient in-country consultation ▪ Leading data review process ▪ Technical inputs during consultations ▪ Expertise in HIV programme and surveillance data ▪ Contextual information on different programme areas
3. UNAIDS Country office	▪ Strategic insight into HIV epidemic and response ▪ Review of draft study results
4. WHO Country office	▪ Expertise in surveillance and programme data on HIV diagnosis, treatment and care
5. UNFPA Country office	▪ Data and contextual insights on HIV prevention and key populations
6. UNDP Country office	▪ HIV programme funding and management information
7. World Bank Country office	▪ Background information on HIV and health sector response
8. Global Fund	▪ Critical strategic advice on study objectives and design ▪ Facilitation of information sharing ▪ Support to epidemiological data review
9. University of New South Wales	▪ Leading the modelling analysis ▪ Model calibration ▪ Provision of model outputs and iterations
10. World Bank HIV team	▪ Coordination and liaison ▪ Centralisation of model input data ▪ Epidemiological, programmatic and cost analysis ▪ Leading report writing

METHODOLOGY – Leveraging tools for state-of-the art resource allocation analysis

The main tools employed were **data synthesis and triangulation**, and the application of the **Optima model**. Data on the wider development and health systems context was reviewed, as well as the available epidemic, demographic, costing and expenditures, and HIV response data to populate Optima. Trends in HIV and health financing were established. The following objectives were defined for the modelling analysis[19]: (1) Determine the optimal allocation of funds to minimise HIV incidence and/or disability-adjusted life years (DALYs); (2) Estimate the resource requirements to achieve moderate and ambitious NSP impact targets; and (3) Assess the optimal allocations to minimise future spending commitments.

The model input data, model parameters and constants were reviewed in a participatory consultation with key stakeholders. During this engagement, **ten populations** were defined for inclusion in the model: Female sex workers (FSW), their clients, MSM, children and —disaggregated by sex—youth, adults and older people. Due to lack of data, no drug-injecting population was included in the model. Then, **seven core HIV programmes** were identified for optimisation: HIV prevention for FSW, MSM, and clients of sex workers, general population prevention, HIV testing and counselling for the general population, ART, and Prevention of Mother-to-Child Transmission (PMTCT). For impact modelling, **three time horisons** were chosen: 2017, 2020 and 2030. Expenditure from the National AIDS Spending Assessment (NASA) for 2013 was used as a baseline scenario (total spending USD 12.2 million, programmatic spending USD 6.4 million USD). The Optima model was then calibrated to HIV prevalence data points available from the different populations. Cost-outcome curves were developed for the seven programmes included in the analyses. These curves define the **relationship between programme expenditure and outcomes** (such as HIV testing rate, condom use per population, or number of people on ART) and form the basis for the optimisation analysis. The curves are associated with the technical efficiency and resulting unit costs of a programme.

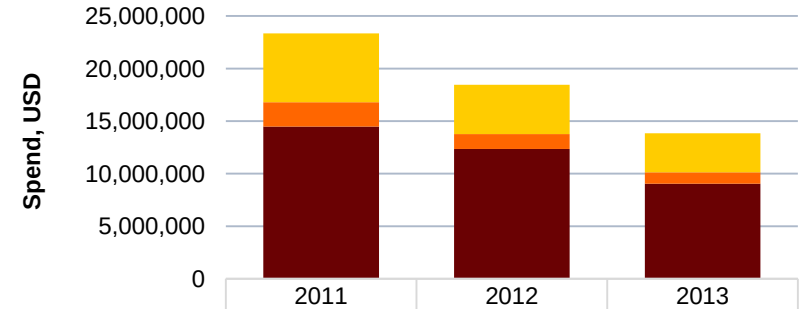
Model outputs were contextualised and reviewed with the key stakeholders, and a set of validated results and conclusions of the allocative efficiency analysis disseminated. The GF request was then re-oriented based on the analysis, and the Sudanese Government also re-prioritised the national HIV strategy and budget.

As a final step, the model was re-run to determine the impact of the HIV resource shift on cumulative HIV incidence, AIDS deaths and DALYs in the medium term (2015-2017) and in the long term (2015-2030) as well as the changes in cost-effectiveness of the medium-term response.

INITIAL RESULTS – Understanding context, identifying changes for better allocative efficiency and impact

The data review showed that Sudan's HIV response has seen **declining international and domestic funding levels** (fig. 2). Thanks to policies on free HIV services, the Sudanese people have overall been **protected from significant household spending for HIV** (but not health in general, fig. 3).

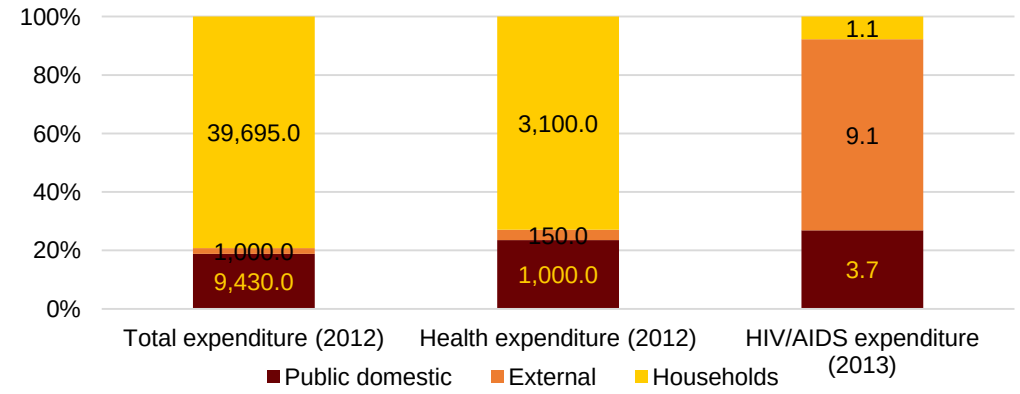
Figure 2 Main sources of HIV financing in Sudan (2011–13)



	2011	2012	2013
Public USD	6,558,053	4,698,522	3,717,832
Private USD	2,313,206	1,414,522	1,070,800
International USD	14,477,993	12,345,112	9,052,243

Sources: Based on AIDSinfo (http://www.unaids.org/en/dataanalysis/datatools/aidsinfo/) and DSAs 2012 & 2013
Note: private sources include for profit institutions and corporations and other private sources.

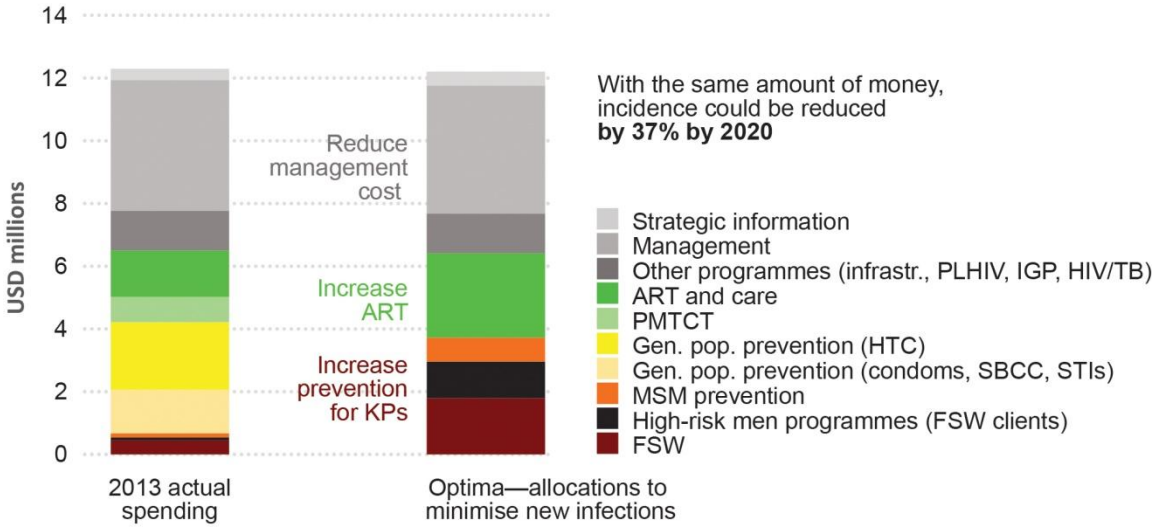
Figure 3 Household, state and aid contributions to Sudan's total health and HIV expenditures in USD million (2011–13)



Sources: OECD database for external aid, WHO-NHA database for health, 2013 NASA for HIV. World Development Indicators databank for household consumption data.
Note: The total expenditure from households is based on Household final consumption expenditure and is an approximation (http://data.worldbank.org/indicator/NE.CON.PRVT.CD), in the absence of a special survey on household expenditure.

Using NASA data, the pattern of past spending was determined (fig 4, left side). Optimisation analyses suggested that - with the same USD 6.4 million of programmatic spending as in 2013—**significantly better HIV impact could be achieved**. This by allocating more HIV funding to four priority, high-impact programmes: ART, HIV prevention among FSW, HIV prevention among men at higher risk including clients of FSWs, and MSM[20] (fig. 4, right side). It was established that such a prioritised response could avert an additional 19,000 cumulative new HIV infection from 2014 to 2020 (37% decrease) at the 2013 resource level, and achieve important reductions in HIV-related DALYs and HIV-related fiscal commitment. Another key finding was that targeting programmatic resources almost exclusively to key populations and ART delivery—while de-prioritising general population programmes—appeared to have important downstream effects on all population groups, leading to HIV incidence reductions across populations over the medium term, at lowest cost.

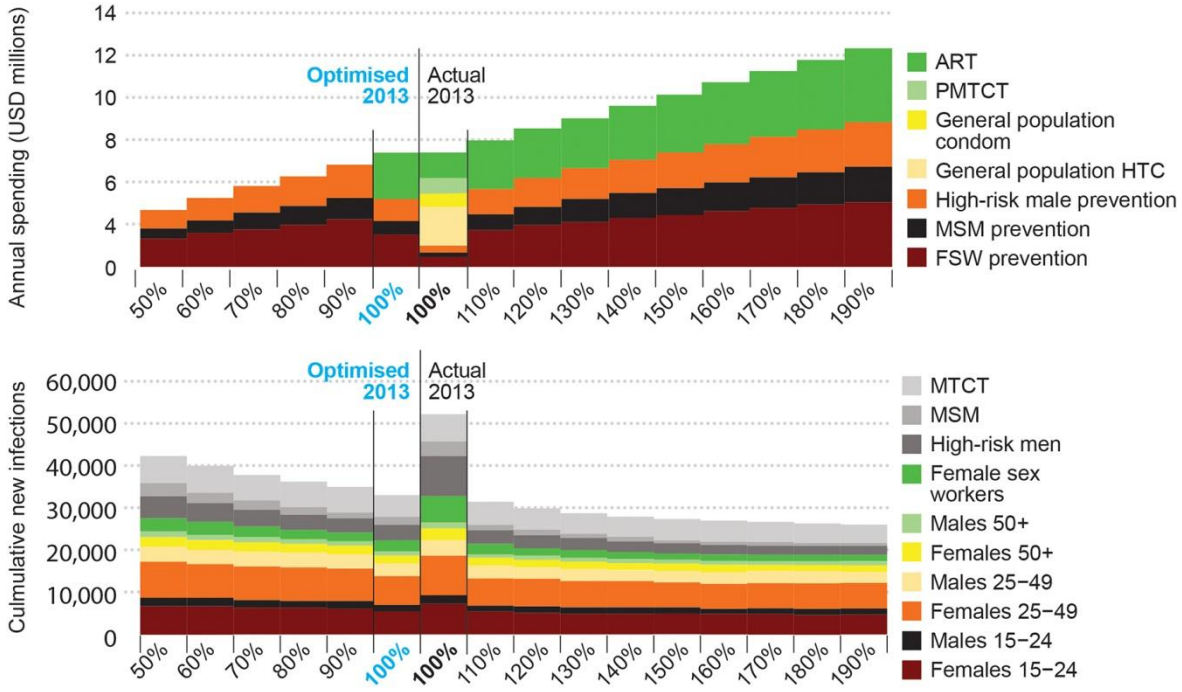
Figure 4 Spending pattern in 2013 and optimised allocations to minimise new HIV infections between 2014 and 2020, at 2013 resource level of USD 12.3 million



Source: 2013 National AIDS Spending Assessment for Sudan; populated Optima model for Sudan.
Note: Prevention packages do not include ART here and ART is shown separately for all populations combined. Expenditure areas not included in optimisation (effect on HIV incidence, morbidity/mortality not quantifiable): PLHIV involvement and support, Management, and Strategic information.

The analysis also explored scenarios of increased availability of programmatic funding beyond the USD 6.4 million of 2013, which could be obtained through mobilising additional HIV funds or by reducing management/ coordination costs. Optima outputs suggested that additional HIV incidence reductions could be obtained, and such evidence of additional impact may be a way to motivate efficiency gains in management and coordination (fig. 5). While exploring model outputs, it was also noted that:

Figure 5 Optimised allocations to minimise HIV incidence by 2020 at different budget levels, Sudan (empirical, higher PMTCT unit cost)



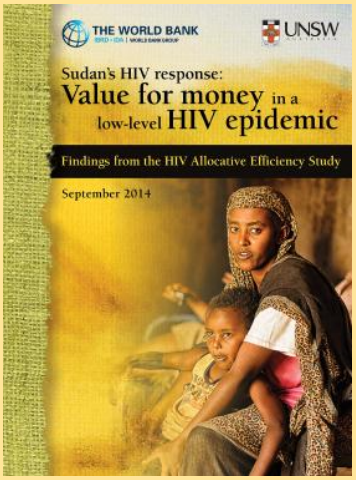
Sources: Populated Optima model for Sudan. Prevention packages do not include ART (which is shown separately).[22]
Note: 50% to 90% and 110% to 190% represent optimised allocations at different levels of funding.

At likely national HIV funding levels, **prevention programmes for the general population were not part of the optimal mix of HIV investments**, as their allocative efficiency is low in this highly concentrated epidemic. Optima-derived HIV incidence was below 0.05% in the general population.

At the 2013 level of total HIV funding (USD 6.4 million), PMTCT was neither part of the optimal mix of HIV investments (fig. 5), a finding that was attributed to the high cost per identifying one HIV positive pregnant woman, as HIV prevalence is low in this population.[23] According to additional analyses of PMTCT programme data, 76% of the 254 PMTCT sites did not identify an HIV positive woman in 2013. This suggested that increasing cost-effectiveness of the programme will require geographical prioritisation. Testing of pregnant women remained a priority amongst key populations at higher risk of HIV, and should be embedded within antenatal service provision as part of the country's universal health coverage efforts.

Box: Further insights – Achieving strategic impact targets rapidly is costly

Since governments are often required to plan for success within a few years, the partners also explored the best course of action for rapid impact. It was also estimated that the minimum programmatic spending to achieve moderate impact targets of 25% reduction in cumulative HIV incidence and AIDS deaths in the short-term was USD 8.1 million per year until 2016. Interestingly, the modelling results suggest that the cost for reaching HIV incidence targets is lower than cost for reaching HIV mortality targets, which require extensive coverage of HIV testing for find cases for ART initiation. Achievement of ambitious targets (50% reduction in HIV incidence and AIDS deaths in the medium term by 2020) would require an estimated USD 34 million annually for programmes (over 5 times spend of USD 6.4 million in 2013).



In order to minimise HIV-related DALYs in the population by 2020, very similar budget reallocations would need to be made as when aiming for minimal HIV incidence. Optimal allocations would avert approximately 29,300 additional HIV-related DALYs (23%) compared to the non-optimal 2013 allocation

pattern. Likewise, **optimal allocations to minimise fiscal commitments up to 2050 called for very similar allocation patterns.**

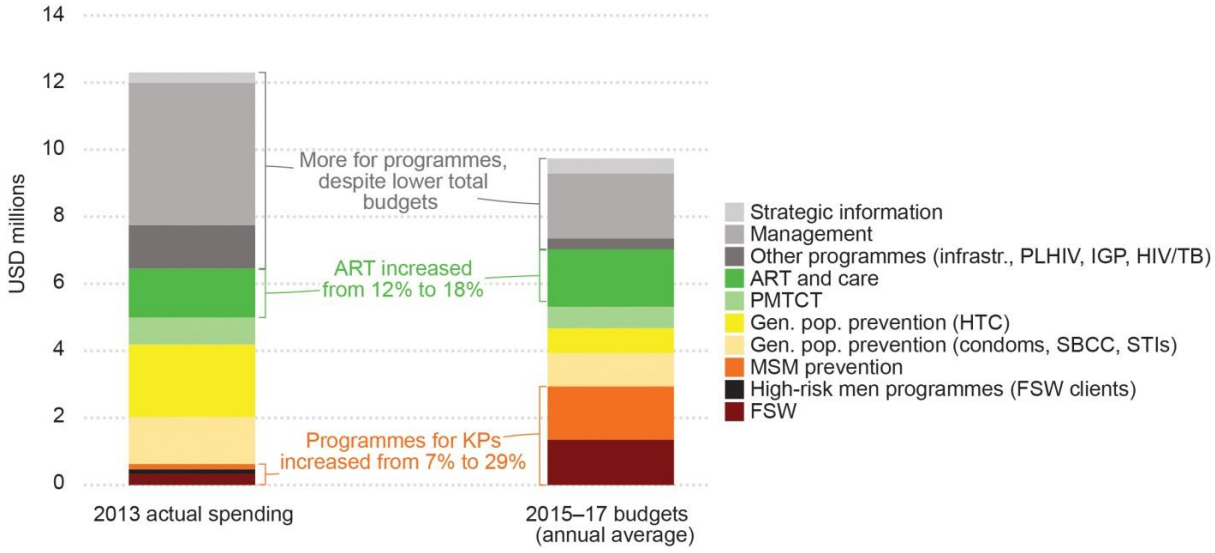
This suggested that the model-proposed intervention mix was robust for achieving different important objectives of preventing HIV transmission and minimising HIV morbidity, HIV mortality and HIV long-term costs.

The results of the allocative efficiency analysis were published in a comprehensive report. This had been preceded by two webinars on the preliminary results in order to get critical comments from the country-based partners and understand reactions to the findings. These exchanges created ownership of the process and the new evidence. The report is available on: worldbank.org

APPLICATION – Using new evidence of allocatively efficient investment for re-orienting HIV budgets

The results of the Optima analysis were used to inform the finalisation of the national HIV strategic plan and the concept note submitted to the GF for the period 2015–17. Figure 6 shows the actual allocations, which were made for the 2015–17 period according to the financial gap analysis carried out as part of the GF concept note preparation.

Figure 6 Reallocation of HIV resources in the 2015–17 budget for the HIV response



Source: 2013 National AIDS Spending Assessment for Sudan; Sudan concept note to the Global Fund 2015–17 including national financial gap analysis tables.

As was already anticipated before the analysis, there was an overall reduction in the level of funding for the HIV response in the 2015–17 period.[24] Despite a reduction from USD 12.3 million in 2013 to USD 10.0 million USD per year on average for the 2015–2017 period, **the amount available for direct high-impact programmes increased - in line with recommendations in the allocative efficiency analysis**—from USD 6.4 million to USD 7.2 million. This was achieved by reducing the budget lines for management and other cost. The largest increases were recorded for budgets for prevention among key populations, which increased from 1.3 million USD to 2.9 million USD and ART, which increased from 1.5 million USD to 1.8 million.

Increasing impact despite a reduction in the total funding available, was also achieved by critically examining management and other programme costs outside the core prevention, treatment and care programmes. In the actual budgets presented in the CN for the 2015–17 period, cost for other programmes were substantially reduced from US$1.25 million in 2013 to US$0.26 million on average per year in the 2015–17 period. A large contributor to the overall reduction were reduced allocations to income-generating projects, for which there was no clear evidence of an effect on AIDS deaths or HIV incidence, and which are beyond the comparative advantage of HIV service organisations.

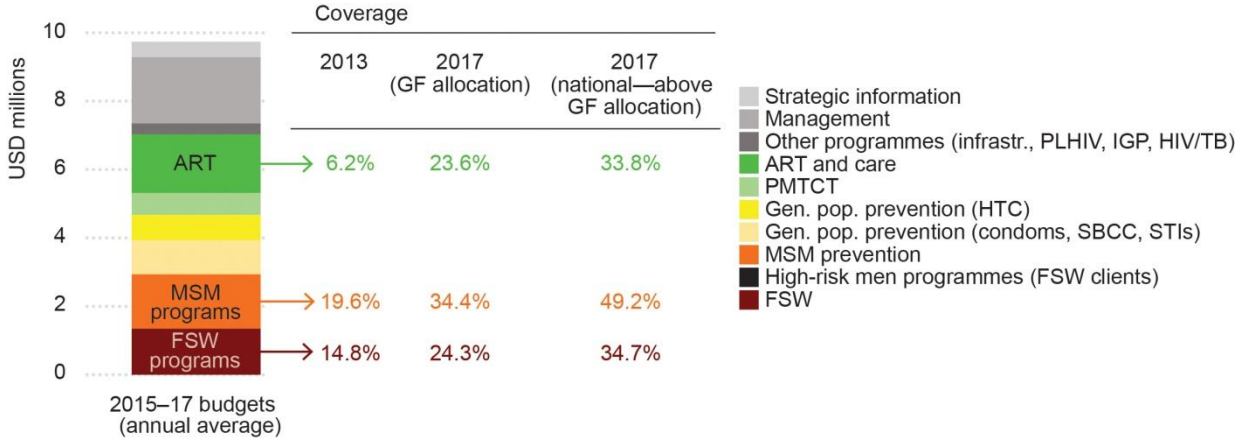
Overall management costs were also reduced from US$4.20 million to US$2.02 million. This required reductions throughout different budget categories including project administration costs for WHO as sub-recipient to Global Fund grants, training, HIV specific infrastructure. Through moving the focus away from HIV specific management and infrastructure, while at the same time strengthening targeted outreach

capacity, this shift in costs also represents a step towards integration of HIV programming and preparing for programme sustainability.

The optimal HIV allocation pattern suggested from the Optima model were therefore used, but other considerations taken into account. This illustrates how **resource allocation practices are under the influence of social, rights and equity considerations** that may not be considered in purely rational models. For instance, specific HIV prevention interventions for the general population, which were not part of mathematically optimised allocations, remain part of Sudan's HIV budget, but with reviewed and improved costs of delivery. This is in line with the recommendations made in the allocative efficiency analysis report. For the PMTCT programme, this meant reduced unit cost and geographic targeting to increase cost-effectiveness of the intervention in this highly concentrated epidemic.

Despite the reduced overall level of funding, the prioritised resource allocation is anticipated to allow for **substantial increases in coverage of Sudan's core HIV programmes**. Figure 7 summarises programme coverage targets, which are based on the actual costing of the GF concept note. Targets are presented both for the confirmed GF allocation and the full national programme allocations. In line with these targets, ART coverage would increase five-fold by 2017, thereby covering over a third of all people living with HIV, which would be a major achievement considering the low 2013 levels of ART and HTC access. Coverage of programmes for MSM and FSW is projected to increase more than two-fold by 2017 with a focus on key locations such as urban areas and States with higher HIV prevalence such as Red Sea and Kassala.

Figure 7 Coverage targets associated with 2015–17 budgets



Source: Sudan concept note to the Global Fund 2015-17, modular template.

IMPLICATIONS – Expected efficiency gains from revised HIV resource allocations

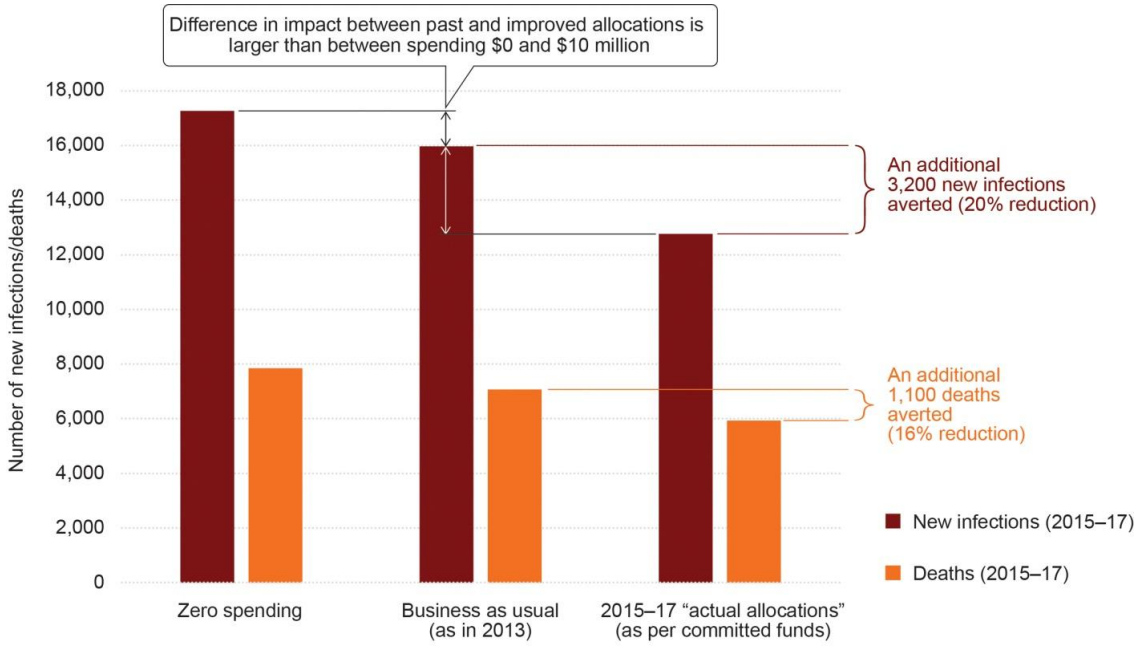
Additional Optima analyses were carried out to estimate the effect of the changed allocations on new HIV infections and deaths, as it was considered critical to understand what the impact of the actual allocations in the 2015–17 budgets would be. For this purpose, we compared the epidemiological effects of no HIV spending, HIV spending distributed between programmes as in 2013 ('business as usual') and actual 2015–17 allocations as outlined in the national financial gap analysis submitted with the GF concept note (fig. 8).

This analysis suggests that the 2015-17 actual allocations would avert 4,500 new HIV infections over the three years compared to no spending, which means **3,200 additional new infections averted** as compared to business as usual. Actual allocations are also projected to avert 1,900 deaths as compared to zero spending, or an additional 1,100 deaths averted as compared to business as usual. 12,300 DALYs would be averted compared to zero spending, an additional 7,400 DALYs averted compared to business as usual. The improved allocations are thereby **projected to avert an additional 20% of new infections, 16% of deaths and 13% of DALYs compared to business as usual**.

Additional analysis was conducted on the long-term effects of the change in resource allocation (fig. 9). For this analysis, we assumed that improved allocations would be sustained up to 2030 and compared the epidemiological effect of such an allocation to the effect of business as usual over the same time period.

This analysis suggests that **in the long-term, the effects of the improved resource allocation increases further**.

Figure 8 Epidemiological impacts of 2015–2017 budget allocations compared to zero spending and business as usual over the 2015–17 time period



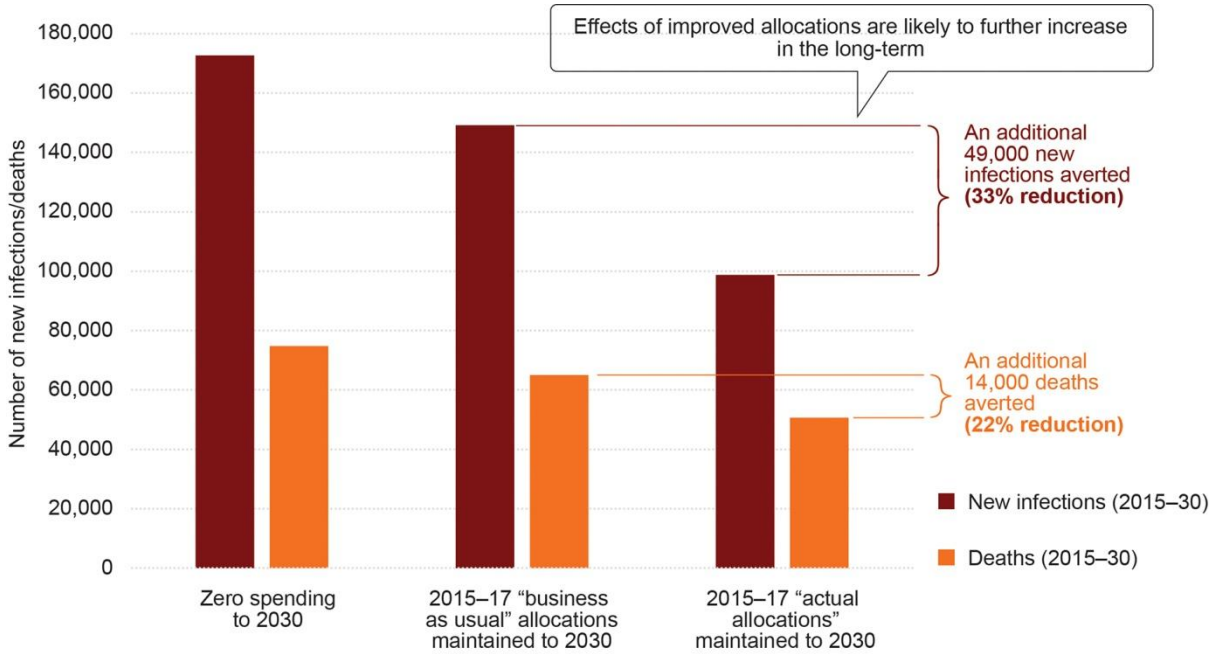
Source: Populated Optima model for Sudan

The 2015–17 allocations applied up to 2030 would avert 72,200 new HIV infections over the 16 years compared to no spending, which means 49,500 additional new infections averted as compared to business as usual.

The new allocations applied up to 2030 are also projected to avert 23,500 deaths as compared to zero spending, or an additional 14,100 deaths averted as compared to business as usual. 212,000 DALYs would be averted compared to zero spending, an additional 130,000 DALYs averted compared to business as usual.

The improved allocations are thereby projected to avert by 2030 an additional 33% of new infections, 22% of deaths and 20% of DALYs compared to business as usual.

Figure 9 Long-term epidemiological impacts of 2015–17 budget allocations compared to zero spending and business as usual (incidence and mortality impacts from 2015 to 2030)



Source: Populated Optima model for Sudan

CONCLUSION – HIV resource allocation dialogues need rational basis and stakeholder participation to make well supported decisions

This case study describes how the Government of Sudan has re-oriented the national HIV budget and the GF support toward higher-impact investments based on allocative efficiency analysis. Conducting a joint HIV allocative efficiency analysis was a key building block in informing the national HIV strategy and GF concept note, and improve actual HIV resource allocations. The following section summarises aspects of the process we found important in order to succeed.

Box: Key factors that facilitated the translation of results into policy

Team approach: All key players, who were needed to translate findings into policy, were involved from the beginning and the Sudan National AIDS Control Programme convened stakeholder meetings at managerial level demonstrating to all partners the government's commitment to getting better value for HIV money.

Placing model in context: The mathematical model was used as a tool supporting a broader allocative efficiency analysis, also, the modelling team had a good level of understanding of the environment in which decision-makers operate.

Consistent follow up: Various national and international agencies were involved in a process of consistent follow up on sharing of findings, finalising the national strategy and developing a GF concept note, while exploring possibilities for cost reductions and technical efficiency gains.

Timing tied to specific decision-making process: This analysis was done, while national strategic planning was ongoing and a GF concept note being developed. This made key players feel that the analysis is relevant and timely, which gave everybody a sense of urgency in contributing to the analysis, which in turn generated ownership.

Implementability of recommendations: One key advantage of the allocative efficiency analysis approach was that it provided recommendations, which were immediately implementable with given levels of funding and could be translated into concrete action plans within the national plan and GF concept note.

Analytical approaches and tools can help transform national HIV strategy, and **reduce subjectivity in how resources are allocated**. In the case of Sudan, better allocative decisions will help make the national HIV responses more sustainable and manageable through increased programme coverage of populations at high risk of acquiring or transmitting HIV, expansion of the ART programme, and selective programme scale-up in areas of higher HIV transmission. **The case study confirms the critical role of integrated epidemic and programme analysis in maximising impact of programmes on key health outcomes and improving the sustainability of national HIV responses.**

The joint partnership process was a learning curve for all: It familiarised the stakeholders with allocative efficiency and intervention effectiveness considerations including the importance of time horizon of impact, demonstrated the use of Optima and its data requirements, showed the necessity to strengthen decision-making about scarce resources, and how different strategic goals need to be weighed up. It also highlighted that cost-effectiveness and impact are not the only criteria for allocating resources in public health systems, and that the right to basic services and ethics are important considerations too. Some of the principles and broader lessons can be summarised as follows:

- **Engaging decision-makers at the beginning of a highly technical process—which involves cost estimations, assumption-making and mathematical modelling**—is essential for the results and their significance to be understood by non-modellers, and for the findings to be regarded as the product of collective input and work
- **Consistent message by international agencies –** GF, UNAIDS and World Bank jointly fostered the same participatory and country-based process and communicated as "one"
- **Contextualising model outputs in the wider financing and health delivery context** is necessary for good decision-making, as is the willingness to make decisions based on evidence, even if they are at times going against the status quo

- **Embarking on an allocative efficiency analysis with clear, consensual and immediately relevant policy questions** is a key success factor for the results actually bearing HIV allocative consequences in plans and budgets
- **Reaching out to forge a broad-based partnership between national policy-makers from the line ministries, programme managers, data analysts and the funding partners** enables the key stakeholders to appropriate the outcome of the analysis and bring in their specific and changing needs for evidence throughout
- When **all elements of the "decision-making process" are connected** and evidence generated and shared in a timely manner, the policy impact of an analytical study can be magnified

Acknowledgements

The allocative efficiency analysis and resulting budgeting process would not have been possible without the many contributions from stakeholders in Sudan.

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Citations and notes

[1] We greatly acknowledge the contributions of various colleagues working on this case study paper including: Nicole Fraser, Clemens Benedikt, Emi Masaki; Mohamed Osman Hamid Mohamed (The World Bank), Robyn Stuart, Cliff Kerr, Andrew Shattock, Richard Gray, David P Wilson (University of New South Wales, Kirby Institute, Australia), Maxim Berdnikov, Jinkou Zhao, Shufang Zhang (The Global Fund for AIDS, Tuberculosis and Malaria), Hamidreza Setayesh, Hind Hassan (UNAIDS, Sudan Country Office), Mohamed Mustafa, Abdallrahim Tarig Abdalla, Fatima Elhassan (Federal Ministry of Health), Mohammed Abdelrahim Sidahmed (seconded from World Health Organization, Khartoum)

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[20] ART (22% of all HIV funding instead of 12% as in 2013), Prevention services for FSWs (15% instead of 4%), Prevention services for high-risk men/SW clients (10% instead of 4%), and Prevention service for MSM (6% instead of 2%). Note that non-program expenditure for management and strategic information, as well as PLHIV support activities, are not considered in this optimal allocation analysis although they were 47% of all 2013 HIV expenditure.

[22] At low levels of spending, prevention programs for key populations were most effective in minimizing HIV incidence, but at levels of 2013 spending ART is part of the optimized mix. The cost-outcome relations for ART were structured in a way that there is initial set up and fixed cost. Therefore with low levels of funding ART cost per person reached is higher, but with increasing funding and coverage, the role of initial set up cost diminishes, a threshold is passed and ART becomes more cost-effective and absorbs substantial portions of funding.

[23] This remained unchanged with a substantially lower unit cost for PMTCT used in the 2015-2017 NSP (USD 2,666 per HIV positive woman receiving PMTCT services instead of USD 9,016 based on past program data). However, using the lower unit cost, PMTCT did enter the optimal allocation mix from 170% of the 2013 programmatic spending amount (USD 10.7 million) and above.

[24] Under the new funding model of the Global Fund the total envelope of resources available for HIV programmes in Sudan had declined, as revised HIV estimates for post-secession Sudan suggested that the epidemic is more concentrated than previously assumed.