

# Approaches to improving the efficiency of HIV programme investments

Minahil Shahid,<sup>1</sup> Ipchita Bharali,<sup>1</sup> Robert Hecht,<sup>2</sup> Gavin Yamey <sup>1</sup>

**To cite:** Shahid M, Bharali I, Hecht R, *et al*. Approaches to improving the efficiency of HIV programme investments. *BMJ Global Health* 2022;**7**:e010127. doi:10.1136/bmjgh-2022-010127

**Handling editor** Seye Abimbola

► Additional supplemental material is published online only. To view, please visit the journal online (<http://dx.doi.org/10.1136/bmjgh-2022-010127>).

Received 12 July 2022

Accepted 18 August 2022

## INTRODUCTION

Improving the efficiency of investments in HIV control programmes is critical to the ongoing HIV response and reaching the target of ending the AIDS epidemic as a public health threat by 2030 (Sustainable Development Goal 3.3). Donor fatigue and the gradual decline in donor disbursements, including the decade-long trend of declining bilateral funding for HIV from donor governments other than the USA,<sup>1</sup> present a challenge to sustaining the current level of HIV spending.<sup>2</sup> Even with the existing available resources, the global burden of HIV exceeds the funding available to address it.<sup>3</sup> In light of the negative economic impacts of COVID-19, donor funding for HIV could be under further threat.<sup>4</sup>

While there is widespread agreement that there is a need for additional resources to adequately address HIV, evidence suggests that new resources raised from international and domestic sources are unlikely to be sufficient in the near future.<sup>3</sup> Scaling up HIV services to achieve national and global targets will, therefore, require that countries take steps to get ‘more health for the money’—that is, to get the most out of available funding by improving the efficiency of the HIV response.<sup>3</sup>

In this article, we examine recent evidence from 2015 to 2020 on strategies to improve the efficiency of HIV programmes in low and middle-income settings (the three main types of efficiency are defined in **box 1**). Our search strategy is shown in online supplemental appendix 1. We aim to provide guidance to policymakers and HIV practitioners who are seeking to answer the following four questions related to HIV policy and investment decisions<sup>5</sup>

1. Value for money: How can policymakers get the most out of a fixed HIV budget?
2. Lowering unit costs: How can budgetary savings be achieved while delivering HIV services?
3. Delivery models for enhanced efficiency: Is one intervention superior to another in achieving the same goal for lower cost?
4. Tools to support action: How can use of cost-effectiveness help identify the most efficient interventions?

## Summary box

- ⇒ Current annual funding levels are insufficient to tackle the global burden of HIV and it is unlikely that these levels will increase substantially in the near future.
- ⇒ Improving the efficiency of investments in HIV control programmes is, thus, critical to the ongoing HIV response.
- ⇒ While there is considerable variation between countries, the most promising areas for efficiency include measures to: (a) reallocate resources to the most effective interventions, including testing and antiretroviral therapy, (b) reduce the unit cost of delivering key services via better targeting, procurement and management practices, (c) use community-based treatment support and target models to deliver interventions to the most affected groups and (d) use cost-effective interventions such as demand creation incentives, HIV self-testing, and integration of services.

3. Delivery models for enhanced efficiency: Is one intervention superior to another in achieving the same goal for lower cost?
4. Tools to support action: How can use of cost-effectiveness help identify the most efficient interventions?

## KEY STRATEGIES TO IMPROVE EFFICIENCY

### Value for money: How can policymakers get the most out of a fixed HIV budget?

A recent World Bank analysis found that government expenditures and spending on health are expected to fall or remain at pre-COVID-19 pandemic levels in many low and lower-middle income countries.<sup>6</sup> In cases where budget expansion may not be feasible, countries need to make allocative decisions that yield the highest return in health outcomes. In the HIV literature, these allocative decisions are guided by information on the relative cost-effectiveness of different interventions, which is used in modelling studies to estimate an optimal allocation of



© Author(s) (or their employer(s)) 2022. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

<sup>1</sup>Center for Policy Impact in Global Health, Duke Global Health Institute, Duke University, Durham, North Carolina, USA

<sup>2</sup>Department of Epidemiology of Microbial Diseases, Yale School of Public Health, New Haven, CT, USA

### Correspondence to

Dr Gavin Yamey;  
gavin.yamey@duke.edu

### Box 1 Defining efficiency

In this article, we refer to three main types of efficiency<sup>52 53</sup>:

- ⇒ Allocative efficiency: maximising health outcomes using the least costly mix of health interventions; for HIV, allocative efficiency means optimal allocation of HIV funding to the combination of HIV interventions that will yield the greatest impact.
- ⇒ Technical efficiency: the maximum output is produced with the least input, that is, the least unit cost; two ways to improve technical efficiency are economies of scale and scope.
- ⇒ Programme efficiency: optimal use of management, procurement systems, human resources, and information to support effective and efficient service delivery.

resources and its impact on HIV outcomes (infections and AIDS deaths averted).

Optima (hiv.optimamodel.com), a dynamic population-based compartmental model, has been used to model optimisation of investments of available HIV resources.<sup>7-9</sup> Studies suggest that the optimal distribution of HIV resources depends on the available HIV budget and the characteristics of each country's epidemic, response and targets. However, scaling up focused testing and antiretroviral therapy (ART) was found to be an efficient use of resources in nearly all settings.<sup>8 10</sup> Efficiency gains can also be achieved by targeting HIV prevention programmes towards the geographical regions with the highest HIV incidence.<sup>9</sup>

The Goals model has also been widely used to examine choices for reallocation of constrained resources for HIV prevention. Recent investment cases in Tanzania and Namibia, for example, suggest that a reallocation of prevention spending to outreach and prevention packages for key populations such as female sex workers would significantly increase the number of infections averted.<sup>11 12</sup>

#### Lowering unit costs: How can budgetary savings be achieved while delivering HIV services?

Budgetary savings can be achieved by reducing service delivery costs for key HIV services that absorb the largest share of spending, including ART, HIV counselling and testing (HCT) and prevention of mother-to-child transmission (PMTCT). These savings can be reinvested in expanded service coverage, reallocated to more cost-effective HIV interventions or spent in other priority health areas.

Studies indicate that there are large variations in unit costs for HIV services, including ART service delivery, HCT and PMTCT across and within countries.<sup>13-15</sup> Most of these variations can be linked to service delivery characteristics and management practices in HIV healthcare. In a nationwide study in Nigeria, for example, a large proportion of the variations in costs for HCT and PMTCT facilities could be explained by scale—that is, facilities with the highest volume of clients saw the lowest costs.<sup>14</sup> But even after controlling for scale, variation in unit costs persisted due to economies of scope: facilities providing

integrated HCT, PMTCT services and/or ART services were less costly. At the facility level, there were statistically significant associations between unit costs and management practices. External supervision, performance-based funding and government involvement in financial decisions were associated with higher costs, while community involvement and individual incentives were associated with lower costs.<sup>14</sup>

In Malawi, for HIV testing and treatment services, the highest costs were in facilities conducting the lowest daily number of tests (ie, variation due to scale).<sup>15</sup> ART service delivery unit costs in Kenya, Eswatini, Uganda, Zambia and Nigeria were also found to be inversely related to the number of patients served in a year.<sup>13</sup>

Budgetary savings can also be achieved by task shifting—asking less costly, decentralised health facilities, often managed by less expensive workers, to deliver the same HIV prevention and treatment services at lower costs.<sup>16</sup> Studies found cost savings from task shifting HIV prevention and care for a high-risk group (men who have sex with men) from government facilities to community-based organisations.<sup>16 17</sup> In low-resource settings, cost savings have been achieved by task shifting ART dispensing, especially to clinically stable patients (who are familiar with the routine of taking these drugs), from pharmacists to lower cost options. Such options include indirectly supervised pharmacist assistants, adherence clubs or other pharmacy-only refill programmes.<sup>16</sup> Task shifting was not found to negatively affect programme outcomes such as patient retention, viral load and mortality.<sup>18</sup>

A modelling study estimated that Tanzania could save over \$US 50 million a year (around 10% of total HIV spending) simply by switching from more expensive to less costly drugs and better targeting HIV testing.<sup>12</sup> Better procurement strategies, such as the use of pooled procurement mechanisms, have resulted in lower unit costs for HIV commodities and equipment and generated savings.<sup>19</sup>

#### Delivery models for enhanced efficiency: Is one intervention superior to another in achieving the same goal for lower cost?

Studies have evaluated service delivery models to determine if one is superior to another by comparing cost per unit of output. These include studies comparing approaches such as community-level versus facility-based treatment support services; universal versus targeted HIV screening in pregnant women; and targeting of voluntary medical male circumcision (VMMC) by age and risk behaviour versus no targeting.

*Community level versus facility-based treatment support services.* Community-based treatment support models can provide care for more clients at the same cost as facility-based models.<sup>20</sup> Available data suggest that community-based ART services, even if they are equivalent but not superior to clinic-based programmes, may be more cost-effective from a societal perspective. Personnel, operational, utility and transportation costs for patients

are more likely to be lower for community-based ART provision.<sup>21</sup> This cost saving, along with the knowledge of increased effectiveness in retention and viral suppression, makes community-based ART more cost-effective and sustainable in the long run.<sup>21 22</sup>

The differentiated service delivery (DSD) model has also been found to be highly cost-effective in multiple studies. DSD is a client-centred approach that simplifies and adapts HIV services across the cascade of care in ways that both serve the preferences and expectations of groups of people living with HIV while reducing unnecessary burdens on the health system.<sup>23</sup> This model uses approaches such as simplification, task shifting and decentralisation to improve service delivery.<sup>23 24</sup> Studies show that differentiated care models can result in significant efficiency gains in terms of reduced costs and health workforce needs.<sup>25–27</sup> Care must be taken, however, to design such models to reduce or avoid overhead costs and redeploy health workers for other tasks once the frequency or number of patient visits is reduced.<sup>26 27</sup>

*Targeting prevention versus offering it to all those eligible.* Multiple modelling studies show that there are efficiency gains from targeting VMMC by age.<sup>28 29</sup> Efficiency gains from age targeting are not achieved from a ‘one size fits all’ approach, but rather because the optimal age range varies across settings as well as by goals. For example, in Mozambique, studies show that scaling up VMMC in men aged 20–29 years will have the most immediate impact on HIV incidence, but the greatest impact over a 15-year period would be from circumcising men aged 15–24 years in Mozambique’s priority provinces.<sup>28</sup> On the other hand in Zimbabwe, large efficiency gains (measured as cost per infection averted) can be realised by targeting ages 15–34 years.<sup>29</sup>

Similarly, PrEP implementation can also be more cost-effective when targeted to those at substantial risk for HIV infection. A 2020 study on scaling-up PrEP in 13 countries showed that for most countries in the analysis, more than 50% of the HIV infections averted by oral PrEP in the scenarios examined could be obtained by rolling-out to female sex workers and serodiscordant couples alone.<sup>30</sup> Studies also showed that geographic prioritisation, prioritising women at substantial risk or those aged 22–29 years and prioritisation based on incidence (ie, when priority is given to those with an incidence rate of  $\geq 3\%$  per year) are all cost saving techniques and can result in efficiency gains.<sup>30–32</sup>

*Other interventions.* Studies have also shown that: universal screening in pregnant women is more cost-effective than a voluntary screening approach<sup>33</sup>; highly active ART has been found to be more cost-effective when initiated early in terms of CD4 counts and more cost-effective compared with other standard of care regimens<sup>34</sup>; lifelong ART for pregnant and breastfeeding women regardless of their CD4 count or HIV clinical stage (known as Option B+) is more cost-effective than ART given during pregnancy or breast feeding only (known as Option B).<sup>35</sup>

### Tools to support action: How can use of cost-effectiveness help identify the most efficient interventions?

Cost-effectiveness analyses point to a number of innovations, including demand creation incentives for VMMC, HIV self-testing and integration of HIV and complementary services, that have been found to achieve good value for money.

Economic compensation, including cash and vouchers, to increase uptake of VMMC has been proven to be cost-effective in a number of randomised controlled trials.<sup>36–38</sup> Studies show that it may be most cost-effective to introduce financial incentives in settings with an already high prevalence of VMMC to focus on men who would not have accessed the services otherwise.<sup>39</sup>

There is strong evidence of the effectiveness of community-based self-testing for HIV (HIVST) on increased testing coverage. HIVST also has the potential to be cost-effective, contingent on: (a) delivery to high burden settings with low coverage of HIV testing; (b) reductions in delivery costs through less resource intensive implementation and cuts in HIVST unit costs and (c) improvements in linkage to prevention among HIV-negative individuals.<sup>40</sup> HIVST has been shown to increase testing yield and improve health system efficiency by allowing the triaging of those without HIV directly to prevention services and freeing up health workers’ time.<sup>41 42</sup>

Integration of HIV and infectious and non-communicable disease screening has been found to be cost-effective in multiple settings.<sup>43–46</sup> Integration can reduce the total time required to provide care and is less costly than non-integrated screening due to reduced overhead costs, reduced patient transport costs and the time saved by the patient and provider. In studies reporting that the costs of integration were higher than the costs of standalone care, the overall integrated population-based screening was still likely to be cost-effective according to the commonly used ‘less than GDP per capita per DALY averted’ threshold.

Apart from screening, integration of HIV and family planning and sexual and reproductive health (SRH) interventions targeting sex workers were also found to be highly cost-effective.<sup>47–51</sup> The most cost-effective models for HIV and SRH combined interventions that were biomedical (eg, STI testing and treatment, HIV vaccination, female condoms), structural (eg, legal changes, microfinance, income-generating activities) and behavioural (eg, voucher incentives, voluntary counselling and testing) within existing health programmes.<sup>47</sup> The main drivers of cost-effectiveness included HIV incidence and prevalence among sex workers, number of sexual partners of sex workers and commodity costs.<sup>47</sup>

### POLICY IMPLICATIONS

Our review of the literature suggests that there are several ways to raise efficiency in HIV programming— through reallocating resources, lowering unit costs, implementing improved delivery models and focusing on cost-effective

interventions. Many of the recent studies cited here have applied these approaches. The use of optimisation tools such as Goals and Optima has also assisted countries in simulating different efficiency strategies before implementation by estimating expected efficiency gains, savings and impact on the epidemic.

Nevertheless, there are still opportunities for further improvement in the analytical tools and in their use by global and national decision-makers. Among the steps that can be taken include: (1) more widely disseminating the tools for optimisation modelling and training of national teams in their use, (2) creating and maintaining more complete databases on unit costs and expenditures for key HIV interventions, (3) directing more global and domestic funding to studies on costs and cost-effectiveness in HIV and (4) linking findings from these studies to decision-making processes in national ministries of health and global programmes such as PEPFAR and the Global Fund. This 'optimisation' of ongoing efforts to improve efficiency in HIV spending can have big payoffs for countries and institutions committed to achieving the 2030 goals for HIV/AIDS.

**Twitter** Minahil Shahid @shahidminahil22 and Gavin Yamey @gyamey

**Contributors** MS and IB are Research Associates at the Center for Policy Impact in Global Health, a health policy think tank headed by GY. RH at Pharos Global Health Advisors was engaged by UNAIDS to study sustainable, efficient and equitable HIV financing. RH contracted GY and his team to work on the 'efficiency' component of the larger technical report for UNAIDS. This article was drafted by MS, and edited by all contributors.

**Funding** This study was funded by the Joint United Nations Programme on HIV/AIDS (UNAIDS) under the project "Promoting efficiency and sustainable financing of AIDS responses (2020-22)."

**Competing interests** This work was part of a project funded by UNAIDS.

**Patient consent for publication** Not applicable.

**Ethics approval** Not applicable.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** All data relevant to the study are included in the article.

**Supplemental material** This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

**Open access** This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

#### ORCID iD

Gavin Yamey <http://orcid.org/0000-0002-8390-7382>

## REFERENCES

- Wexler A, Kates J. Donor Government Funding for HIV in Low- and Middle-Income Countries in 2020 [Internet]. p. 18, 2020. Available: <https://files.kff.org/attachment/Report-Donor-Government-Funding-for-HIV-in-Low-and-Middle-Income-Countries-in-2020.pdf>
- Oberth G, Whiteside A. What does sustainability mean in the HIV and AIDS response? *Afr J AIDS Res* 2016;15:35–43.
- Bautista-Arredondo S, Sosa-Rubi SG, Opuni M, et al. Assessing cost and technical efficiency of HIV prevention interventions in sub-Saharan Africa: the ORPHEA study design and methods. *BMC Health Serv Res* 2014;14:599.
- Oladele TT, Olakunde BO, Oladele EA, et al. The impact of COVID-19 on HIV financing in Nigeria: a call for proactive measures. *BMJ Glob Health* 2020;5:e002718.
- Pharos-UNAIDS-Efficiency-in-HIV-Financing-1-Jun.pdf [Internet]. Available: <https://pharosglohalhealth.com/wp-content/uploads/2020/09/Pharos-UNAIDS-Efficiency-in-HIV-Financing-1-Jun.pdf> [Accessed 05 Jul 2022].
- Kuroski C, Evans DB, Tandon A. *From Double Shock to Double Recovery: Implications and Options for Health Financing in the Time of COVID-19* [Internet]. Washington, DC: World Bank, 2021. <https://openknowledge.worldbank.org/handle/10986/35298>
- Minnery M, Mathabela N, Shubber Z, et al. Opportunities for improved HIV prevention and treatment through budget optimization in Eswatini. *PLoS One* 2020;15:e0235664.
- How should HIV resources be allocated? Lessons learnt from applying Optima HIV in 23 countries - Stuart - 2018 - Journal of the International AIDS Society - Wiley Online Library [Internet]. Available: <https://onlinelibrary.wiley.com/doi/full/10.1002/jia2.25097> [Accessed 06 May 2021].
- Kedziora DJ, Stuart RM, Pearson J, et al. Optimal allocation of HIV resources among geographical regions. *BMC Public Health* 2019;19:1509.
- The impact, cost and cost-effectiveness of oral pre-exposure prophylaxis in sub-Saharan Africa: a scoping review of modelling contributions and way forward - PubMed [Internet]. Available: <https://pubmed.ncbi.nlm.nih.gov/31538407/> [Accessed 06 May 2021].
- Namibia-IC-2.0-Pharos-Final-2-June-2020.pdf [Internet]. Available: <https://pharosglohalhealth.com/wp-content/uploads/2020/09/Namibia-IC-2.0-Pharos-Final-2-June-2020.pdf> [Accessed 13 Jun 2022].
- Hiebert L, Resch S, Schutte C, et al. Tanzania HIV investment case (IC) 2.0: using modeling to explore optimization under severe resource constraints. *J Glob Health Rep* 2022;5:e2021106.
- Cerecero-García D, Pineda-Antunez C, Alexander L, et al. A meta-analysis approach for estimating average unit costs for art using pooled facility-level primary data from African countries. *Afr J AIDS Res* 2019;18:297–305.
- Bautista-Arredondo S, La Hera-Fuentes G, Contreras-Loya D, et al. Efficiency of HIV services in Nigeria: determinants of unit cost variation of HIV counseling and testing and prevention of mother-to-child transmission interventions. *PLoS One* 2018;13:e0201706.
- Vyas S, Songo J, Guinness L, et al. Assessing the costs and efficiency of HIV testing and treatment services in rural Malawi: implications for future "test and start" strategies. *BMC Health Serv Res* 2020;20:740.
- Seidman G, Atun R. Does task shifting yield cost savings and improve efficiency for health systems? A systematic review of evidence from low-income and middle-income countries. *Hum Resour Health* [Internet], 2017. Available: <http://search.proquest.com/docview/1895141329/abstract/759F92F03BA4915PQ/1> [Accessed 11 Feb 2021].
- Yan H, Zhang M, Zhao J, et al. The increased effectiveness of HIV preventive intervention among men who have sex with men and of follow-up care for people living with HIV after 'task-shifting' to community-based organizations: a 'cash on service delivery' model in China. *PLoS One* 2014;9:e103146.
- Seidman G, Atun R. Does task shifting yield cost savings and improve efficiency for health systems? A systematic review of evidence from low-income and middle-income countries. *Hum Resour Health* 2017;15:29.
- Dubois P, Lefouilli Y, Straub S. Pooled procurement of drugs in low- and middle-income countries can lower prices and improve access [Internet]. VoxEU.org, 2021. Available: <https://voxeu.org/article/pooled-procurement-drugs-low-and-middle-income-countries-can-lower-prices-and-improve-access> [Accessed 05 Jul 2021].
- Forsythe S, Lee B, Tarimo K, et al. HIV treatment support services in Tanzania: a cost and efficiency analysis at facility and community levels. *Afr J AIDS Res* 2019;18:306–14.
- Nachega JB, Adetokunboh O, Uthman OA, et al. Community-based interventions to improve and sustain antiretroviral therapy adherence, retention in HIV care and clinical outcomes in low- and

- middle-income countries for achieving the UNAIDS 90-90-90 targets. *Curr HIV/AIDS Rep* 2016;13:241–55.
- 22 Community-based antiretroviral therapy versus standard clinic-based services for HIV in South Africa and Uganda (DO ART): a randomised trial - the Lancet Global Health [Internet]. Available: [https://www.thelancet.com/journals/langlo/article/PIIS2214-109X\(20\)30313-2/fulltext](https://www.thelancet.com/journals/langlo/article/PIIS2214-109X(20)30313-2/fulltext) [Accessed 23 May 2021].
  - 23 About Differentiated Service Delivery [Internet] [Accessed 31 Aug 2021].
  - 24 WHO | Key considerations for differentiated antiretroviral therapy delivery for specific populations: children, adolescents, pregnant and breastfeeding women and key populations [Internet]. WHO. World Health Organization. Available: <http://www.who.int/hiv/pub/arv/hiv-differentiated-care-models-key-populations/en/> [Accessed 24 May 2021].
  - 25 Barker C, Dutta A, Klein K. Can differentiated care models solve the crisis in HIV treatment financing? analysis of prospects for 38 countries in sub-Saharan Africa. *J Int AIDS Soc* 2017;20:21648.
  - 26 Roberts DA, Tan N, Limaye N, et al. Cost of differentiated HIV antiretroviral therapy delivery strategies in sub-Saharan Africa: a systematic review. *J Acquir Immune Defic Syndr* 2019;82 Suppl 3:S339–47.
  - 27 Kuchukhidze S, Long L, Rosen S. AMBIT project report number 02; 2019.
  - 28 Age targeting and scale-up of voluntary medical male circumcision in Mozambique [Internet]. Available: <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0211958> [Accessed 06 May 2021].
  - 29 Awad SF, Sgaier SK, Ncube G, et al. A reevaluation of the voluntary medical male circumcision scale-up plan in Zimbabwe. *PLoS One* 2015;10:e0140818.
  - 30 Pretorius C, Schnure M, Dent J, et al. Modelling impact and cost-effectiveness of oral pre-exposure prophylaxis in 13 low-resource countries. *J Int AIDS Soc* 2020;23:e25451.
  - 31 Glaubius R, Ding Y, Penrose KJ, et al. Dapivirine vaginal ring for HIV prevention: modelling health outcomes, drug resistance and cost-effectiveness. *J Int AIDS Soc* 2019;22:e25282.
  - 32 Mugo NR, Ngure K, Kiragu M. Prep for Africa: what we have learnt and what is needed to move to program implementation. *Curr Opin HIV AIDS* 2016;11:80–6.
  - 33 Bert F, Gualano MR, Biancone P, et al. HIV screening in pregnant women: a systematic review of cost-effectiveness studies. *Int J Health Plann Manage* 2018;33:31–50.
  - 34 Tse WF, Yang W, Huang W. A narrative review of cost-effectiveness analysis of people living with HIV treated with HAART: from interventions to outcomes. *Clinicoecon Outcomes Res* 2015;7:431–9.
  - 35 Tweya H, Keiser O, Haas AD. Comparative cost-effectiveness of option B+ for prevention of mother to child transmission of HIV in Malawi: mathematical modelling study. *AIDS Lond Engl* 2016;30:953–62.
  - 36 Kennedy CE, Yeh PT, Atkins K, et al. Economic compensation interventions to increase uptake of voluntary medical male circumcision for HIV prevention: a systematic review and meta-analysis. *PLoS One* 2020;15:e0227623.
  - 37 Ensor S, Davies B, Rai T, et al. The effectiveness of demand creation interventions for voluntary male medical circumcision for HIV prevention in sub-Saharan Africa: a mixed methods systematic review. *J Int AIDS Soc* 2019;22 Suppl 4:e25299.
  - 38 Torres-Rueda S, Wambura M, Weiss HA, et al. Cost and cost-effectiveness of a demand creation intervention to increase uptake of voluntary medical male circumcision in Tanzania: spending more to spend less. *J Acquir Immune Defic Syndr* 2018;78:291–9.
  - 39 Carrasco MA, Grund JM, Davis SM, et al. Systematic review of the effect of economic compensation and incentives on uptake of voluntary medical male circumcision among men in sub-Saharan Africa. *AIDS Care* 2018;30:1071–82.
  - 40 Indravudh PP, Choko AT, Corbett EL. Scaling up HIV self-testing in sub-Saharan Africa: a review of technology, policy and evidence. *Curr Opin Infect Dis* 2018;31:14–24.
  - 41 d'Elbée M, Makhetha MC, Jubilee M, et al. Using HIV self-testing to increase the affordability of community-based HIV testing services. *AIDS* 2020;34:2115–23.
  - 42 Ingold H, Mwerinde O, Ross AL, et al. The Self-Testing Africa (StAR) initiative: accelerating global access and scale-up of HIV self-testing. *J Int AIDS Soc* 2019;22:e25249.
  - 43 Kasaie P, Weir B, Schnure M, et al. Integrated screening and treatment services for HIV, hypertension and diabetes in Kenya: assessing the epidemiological impact and cost-effectiveness from a national and regional perspective. *J Int AIDS Soc* 2020;23.
  - 44 Nugent R, Barnabas RV, Golovaty I, et al. Costs and cost-effectiveness of HIV/noncommunicable disease integration in Africa: from theory to practice. *AIDS* 2018;32 Suppl 1:S83–92.
  - 45 Chang W, Chamie G, Mwai D. Cost and efficiency of a hybrid mobile multi-disease testing approach with high HIV testing coverage in East Africa. *J Acquir Immune Defic Syndr* 2016;73:e39–45.
  - 46 Zhang L, Tao Y, Woodring J, et al. Integrated approach for triple elimination of mother-to-child transmission of HIV, hepatitis B and syphilis is highly effective and cost-effective: an economic evaluation. *Int J Epidemiol* 2019;48:1327–39.
  - 47 Rinaldi G, Kiadaliri AA, Haghparast-Bidgoli H. Cost effectiveness of HIV and sexual reproductive health interventions targeting sex workers: a systematic review. *Cost Eff Resour Alloc* 2018;16:63.
  - 48 Gliddon HD, Peeling RW, Kamb ML, et al. A systematic review and meta-analysis of studies evaluating the performance and operational characteristics of dual point-of-care tests for HIV and syphilis. *Sex Transm Infect* 2017;93:S3–15.
  - 49 Bristow CC, Larson E, Anderson LJ, et al. Cost-effectiveness of HIV and syphilis antenatal screening: a modelling study. *Sex Transm Infect* 2016;92:340–6.
  - 50 Wall KM, Kilembe W, Inambao M, et al. Cost-effectiveness of integrated HIV prevention and family planning services for Zambian couples. *AIDS* 2020;34:1633–42.
  - 51 Hewett PC, Nalubamba M, Bozzani F, et al. Randomized evaluation and cost-effectiveness of HIV and sexual and reproductive health service referral and linkage models in Zambia. *BMC Public Health* 2016;16:785.
  - 52 Siapka M, Remme M, Obure CD, et al. Is there scope for cost savings and efficiency gains in HIV services? A systematic review of the evidence from low- and middle-income countries. *Bull World Health Organ* 2014;92:499–511.
  - 53 Benedikt C, Kelly SL, Wilson D, et al. Allocative and implementation efficiency in HIV prevention and treatment for people who inject drugs. *Int J Drug Policy* 2016;38:73–80.

## **Appendix 1**

To inform discussions about ways to drive efficiency in HIV prevention and treatment, we conducted a narrative literature review of the formal peer-reviewed and grey literature with a specific focus on recent literature published between 2015-2020. The literature search strategy was developed by the research team in consultation with a Duke University librarian (shown in Table 1 below). We applied the search strategy using Boolean search terms across three databases: PubMed, EMBASE and Web of Science, to identify relevant articles from peer-reviewed literature. A total of 9,545 articles were identified from the databases. After removal of duplicates, 3,340 abstracts were reviewed for relevance and 3,116 studies were found to be irrelevant at the title and abstract screening stage. 224 articles were fully assessed, out of which 49 articles were included in the synthesis. To identify relevant articles and reports from the grey literature, a Google search was conducted using the same search terms, and applied to the websites of major organizations such as UNAIDS, PEPFAR, Global Fund and the World Bank.

The team identified several inclusion criteria to determine eligibility of articles included in the report. First, all articles needed to be HIV-focused. Second, studies should have reported on a form of financing efficiency. Studies that only focused on clinical effectiveness of interventions without reporting financing efficiency were excluded from the review. Third, only studies that focused on low- and middle-income settings were included. Study protocols and clinical trials were excluded from the scope of the review.

*Table 1: Literature search strategy*

Key words	
<b>Terms 1</b>	"Acquired Immunodeficiency Syndrome" OR "HIV Infections" OR HIV OR "human immunodeficiency virus" OR AIDS OR "acquired immune deficiency syndrome"
<b>Terms 2</b>	"Economics" OR "Cost Savings" OR "Cost-Benefit Analysis" OR "economies of scale" OR "economies of scope" OR "integrated delivery" OR "integrated intervention" OR "financial" OR "costs" OR "value for money" OR "optimal resource allocation" OR "optimization" OR "resource analysis" OR "intervention" OR "policies" OR "service delivery" OR "operational capacity" OR "cost utility" OR "value for money" OR "model" OR "modeling" OR "budgets" OR resources
<b>Terms 3</b>	"efficiency" OR "efficient" OR "efficiently" OR "effective" AND "technical" OR "productive" OR "allocative" OR "implementation" OR "financing" OR "program" OR "programme"