PEER REVIEW HISTORY

BMJ Open publishes all reviews undertaken for accepted manuscripts. Reviewers are asked to complete a checklist review form (**http://bmjopen.bmj.com/site/about/resources/checklist.pdf**) and are provided with free text boxes to elaborate on their assessment. These free text comments are reproduced below.

ARTICLE DETAILS

TITLE (PROVISIONAL)	Long term financing needs for HIV control in sub-Saharan Africa in 2015-2050: modelling study
AUTHORS	Atun, Rifat; Chang, Angela; Ogbuoji, Osondu; Silva, Sachin; Resch, Stephen; Hontelez, Jan; Bärnighausen, Till

VERSION 1 - REVIEW

REVIEWER	Karen Grépin New York University, USA
REVIEW RETURNED	02-Sep-2015

GENERAL COMMENTS	This paper asks what are the long term financing implications of HIV control in Sub-Saharan Africa and using a modeling technique to estimate a potential range of possible financing needs. The paper is well written and uses methods that are appropriate to answer the above question. The results are clearly presented. My only comments below should be seen as comments rather than suggested edits. Your first conclusion in your conclusion section is not even in your summary list, you may wish to further emphasize this point as it is an important point. The second sentence in paragraph 1 of introduction is quite awkwardly worded - I still don't quite understand the meaning of "form mortality". I am not convinced that global health is "complacent" - especially since the citation provided seems to be for NCDs and this paper discusses HIV. My understanding is that the number of people initiating ART remains robust around 1 million people a year. I think this word choice is too strong - perhaps "risk" complacency. It might also be due to other forms of scale up issues. I think the evidence base around the claim that "by improving the health of the treated patients, it reduces hospitalization and lessons utilization of other healthcare services - releasing health system capacity". I think studies by myself, Nicholas Wilson, and others have shown that that scaling up ART might place constraints on health systems in the short run. I think the studies cited are weak to support this claim. There needs to be more discussion in discussion section about the fact that you ask this question for all of SSA but yet only present data for 8 countries. I don't think you can get around the data limitation but to claim that these 8 countries are representative of SSA is overstating. There are no french West African countries, for

	example. I did not fully understand the discussion about why the costs for VMCC were not included for those what have already reached scale. I suspect the costs of ongoing enrollments should be considered for these countries. What is the rationale for the target population for PMTCT screening calculation. I suspect I know why you did it this way, but you should spell it out. It is reasonable? Do others do it this way? I think one might want to consider more than just GDP in estimating your non-ARV costs, perhaps something primary health care related such as DTP3 coverage or something. Have the authors provided all of the parameter estimates that would be required for someone else to replicate their results using the UNAIDS model? I have not worked with it, so I don't know what is missing. Your conclusion that scaling up prevention saves money in long run is not well presented. You should present all models with and without prevention scale up to make this point more clearly. Please more clearly define terms like "HIV debt-to-GDP" and how they are calculated. You may wish to cite Mead Over's work on the idea of long term obligations. The paper lacks a good final conclusion.

REVIEWER	Alan Whiteside Balsillie School of International Affairs, Canada University of KwaZulu-Natal, South Africa
REVIEW RETURNED	04-Sep-2015

GENERAL COMMENTS	This paper is important but sadly is written in a manner that can only be described as tedious. The large number of tables and figures, including those in the appendices, break up the paper and make it difficult to read. It has a number of minor grammatical and typing errors, which really should not be present in a paper written by authors of this level of seniority. Some specific points are: • The authors have chosen to address challenges of HIV in nine countries with the highest burden of HIV and the most complete data. What is the definition of highest burden – here it seems to be total numbers, which immediately excludes Swaziland, Lesotho, Namibia, and Botswana, with their smaller populations, but eye-watering HIV prevalence rates. It would be useful to have a more detailed discussion of the choice of countries. • The paper uses the Goals Model from Spectrum and while, in my experience, this is a robust and useful model there are at least two other models which should be acknowledged. • For me the biggest problem lies in the figure given for treatment. The ARV cost of $132 PPPY is for drugs alone and is, I believe, correct. This paper has to look at the total cost of treatment (including human resources, hospitals, and other services) if it is to

	be credible and I don't see this being done. There may be a reason for this but the real total cost will change the figures dramatically. If it is excluded we need to know why. The figure of 20% to account for structural costs is simply not enough. • I totally agree with the need to explain the benefit of front loaded expenditures. This will only work if we are honest about what they are and find ways to make the argument. • This paper touches on innovative financing and it is certainly something that needs further investigation. More could be said. In conclusion, this paper is not yet ready for publication given the points I write about. I would be happy to see it again, as I think it is important and the authors are serious and influential scientists.

REVIEWER	Markus Haacker Harvard School of Public Health As all the authors, I hold an affiliation with the Harvard School of Public Health.
REVIEW RETURNED	08-Sep-2015

GENERAL COMMENTS	This paper appears to be competently done as far as the technical analysis is concerned. The authors appear to be well versed in utilizing the "Spectrum" software, and the analysis is explained adequately. I am not sure whether BMJOpen is a suitable outlet for the type of work performed. Part of the paper reads more like a policy report, and aspects of the discussion of financing provides more of a general review than a discussion that provides value-added. One oddity (appearing occasionally in policy reports, but less so in academic papers) is that one important conclusion is not supported by the analysis. The authors write that "Investing upfront in scale up of HIV services now to ensure high levels of coverage will reduce future expenditures." In contrast, their scaling-up scenarios all show higher expenditures both now and in the future, so at least until 2050 (the policy horizon of the study) the conclusion is incorrect. The major reservation I have regards the costing projections, and there are several issues. First, and positively, the study appropriately translates available evidence "MATCH data" in country-level estimates of ARV, distinguishing ARV costs (US$ 136 for first-line, and US$ 373 for second-line, constant across countries), and "non-ARV service costs" (apparently the non-drug costs of ARV, terminology a bit confusing here and should be clarified, assumptions broadly in line with MATCH non-drug costs), which differ between countries. Assumptions on transition to second-line therapy (about 2.8 percent annually) are also broadly appropriate within the Spectrum/Goals context. [Aside – is this transition rate still appropriate for the long-term projections performed here?] However, the MATCH data include costs on the facility level and those that can be directly attributed to provision of treatment (e.g., off-site lab costs). I.e., any indirect costs of providing treatment services are generally excluded, and the costs of providing treatment services therefore present an under-estimate.

	More broadly, the paper should make some allowance for the costs of running HIV/AIDS treatment and prevention programs. I see the value of a partial analysis just focusing on the costs or prevention and treatment interventions on the facility level. However, even if this was intended, in this paper the narrow focus of the costing results in a mismatch between the cost projections and the later discussion of financing needs – the latter make sense only if the overall costs of providing and running these HIV/AIDS services are included. The most important shortcoming of the costing is that the study lacks a discussion of how unit costs may evolve over time. The time horizon is 35 years. Based on current estimates and projections of the growth of GDP per capita, wages and salaries (in line with GDP per capita) may plausibly increase at a rate of 2-3 percent annually over this period, i.e., by 100 to 180 percent by 2050. I.e. unit costs including domestic human resource costs will increase very substantially over the projection period. A review of the costing assumptions underlying the paper suggests that costs are directly or indirectly (the latter are purchases of goods or services which in turn include domestic human resources) dominated by human resource costs. Consequently, it is plausible that the study underestimates the costs of providing HIV/AIDS services by about one-half in the outer years of the projections. For a combination of the reasons stated, the paper appears to very substantially under-estimate the future costs of HIV/AIDS services. Because country-level projections of the costs are reported here only in terms of the present discounted value of the costs 2015-50, any conclusion is partially speculative, but it appears that the cost estimates reported here are much lower than recent cost estimates of HIV/AIDS programs. This would mean that the results are misleading against the principal objectives of the paper (quantifying the “long term financing needs for HIV control”). If the study needs to be revised substantially before publication, it is worth considering re-doing the projections based on the country Spectrum files released by UNAIDS in 2015. UNAIDS (following the “Global Burden of Disease” estimates) has revised its estimates of HIV incidence and prevalence, and of survival of PLWH, very substantially, and these revisions would have considerable implications for the projections. It is understandable if such a re-estimate is not feasible at this stage, but the authors may at least point flag the issue. Small comments: Page 4, “and that form mortality” – garbled. Table 1: There is no such thing as “per capita gross domestic product income.” Usually the variable of interest is either “GDP per capita” or “gross national income per capita.” The link provided points to “GDP per capita,” but in constant 2005 dollars and not in 2013 current dollars as stated in table heading and shown in table. Also not that the GDP data for Kenya are off by a large margin – they are now estimated at over US$ 1,200 (and Kenya now belongs to middle-income countries), following revised GDP estimates in 2013 not yet reflected in the World Bank numbers quoted owing to institutional time lags. Page 7: “likely date until the current cohort of individuals receiving

	ART will need to continue treatment and care." There is no particular cut-off data for the current cohort. It is correct that many of today's PLWH will no longer be around in 2050, for general biological and HIV-specific reasons, but attrition is gradual. Also note that the projections include PLWH who become infected over the projection period, and many of these will still be around in 2050. It is unclear why the costs of HIV/AIDS programs are benchmarked against the level of external debt (private and public external debt) rather than the level of public debt (=domestic and external government debt). All figures from page 33 include scenarios with funny names ([Country] allCurrent – Copy; [Country] allScaleup – Copy), where [country] is my placeholder for the respective 9 countries shown.

VERSION 1 – AUTHOR RESPONSE

Reviewer 1

Comments	**Response**
Your first conclusion in your conclusion section is not even in your summary list, you may wish to further emphasize this point as it is an important point.	We have addressed the point
The second sentence in paragraph 1 of introduction is quite awkwardly worded - I still don't quite understand the meaning of "form mortality".	Changed to "from mortality"
I am not convinced that global health is "complacent" - especially since the citation provided seems to be for NCDs and this paper discusses HIV. My understanding is that the number of people initiating ART remains robust around 1 million people a year. I think this word choice is too strong - perhaps "risk" complacency. It might also be due to other forms of scale up issues.	Addressed
I think the evidence base around the claim that "by improving the health of the treated patients, it reduces hospitalization and lessons utilization of other healthcare services - releasing health system capacity". I think studies by myself, Nicholas Wilson, and others have shown that that scaling up ART might place constraints on health systems in the short run. I think the studies cited are weak to support this claim.	Cited:Wilson, Nicholas. "Child mortality risk and fertility: Evidence from prevention of mother-to-child transmission of HIV." Journal of Development Economics 116 (2015): 74-88. Grépin, Karen A. "Leveraging HIV programs to deliver an integrated package of health services: some words of caution." JAIDS Journal of Acquired Immune Deficiency Syndromes 57 (2011): S77-S79.
There needs to be more discussion in discussion section about the fact that you ask this question for all of SSA but yet only present data for 8 countries. I don't think you can get around the data limitation but to claim that these 8 countries are representative of SSA is overstating. There are no French West African countries, for	We rephrased the wording to narrow our focus to the high burden countries - the nine countries that make up roughly 75 percent of the number of people with HIV in SSA. This is pertinent since our paper focuses on the current and future burden of the disease.

example.

I did not fully understand the discussion about why the costs for VMCC were not included for those what have already reached scale. I suspect the costs of ongoing enrollments should be considered for these countries.	Rates of voluntary medical male circumcision (VMMC) in Nigeria, Kenya, and Ethiopia are already above the UNAIDS target level. These countries have historically had high VMMC rates, believed to be driven by cultural and religious practices. Therefore, there is no reason to believe they will require additional financing to maintain their high rates of circumcision.
What is the rationale for the target population for PMTCT screening calculation. I suspect I know why you did it this way, but you should spell it out. It is reasonable? Do others do it this way?	Addressed in text and appendix -- We assume universal screening of all pregnant women for HIV in line with PMTCT guidelines. Therefore we calculated the annual number of pregnant women using the following equation: Population of women of reproductive age (United Nations (UN) annual population estimates) * World Bank crude birth rates * Proportion of the year a woman is pregnant before delivery (9/12=0.75).
I think one might want to consider more than just GDP in estimating your non-ARV costs, perhaps something primary health care related such as DTP3 coverage or something.	Based on our literature review, we have not found evidence that suggests a relationship between non-ARV costs and primary care service performance. We did find several papers that used some form of income indicator (GDPpc, GNIpc), such as McCarthy, Owen, and Mead Over. "Projecting the Future Budgetary Cost of AIDS Treatment in Poor Countries: A Manual for the AIDSCost Computer Programs." Center for Global Development (2009). While we acknowledge the limitation of using only income to determine non-ARV costs, we decided to stick to this common approach.
Have the authors provided all of the parameter estimates that would be required for someone else to replicate their results using the UNAIDS model? I have not worked with it, so I don't know what is missing.	The Spectrum files provided by UNAIDS are publicly available. As recommended by UNAIDS, we adjusted the epidemiological parameters to fit the historical epidemiological curves. These files are available from UNAIDS upon request.
Your conclusion that scaling up prevention saves money in long run is not well presented. You should present all models with and without prevention scale up to make this point more clearly.	Agree that prevention does not 'save money', even with per capita figures. However, investing in prevention early on significantly reduce HIV incidence and prevalence in the long run. We rephrased our conclusion to reflect this.
Please more clearly define terms like "HIV debt-to-GDP" and how they are calculated.	Addressed
You may wish to cite Mead Over's work on the idea of long term obligations.	We could not locate the said paper but have cited Haacker et al

Reviewer 2

Comments	Response
The authors have chosen to address challenges of HIV in nine countries with the highest burden of HIV and the most complete data. What is the definition of highest burden – here it seems to be total numbers, which immediately excludes Swaziland, Lesotho, Namibia, and Botswana, with their smaller populations, but eye-watering HIV prevalence rates. It would be useful to have a more detailed discussion of the choice of countries.	We chose the nine countries in SSA that make up roughly 75 percent of the number of people with HIV in SSA. These countries have the highest number of people with HIV. While Mozambique has the fourth largest HIV population, it was excluded from the selection due to data availability.
The paper uses the Goals Model from Spectrum and while, in my experience, this is a robust and useful model there are at least two other models which should be acknowledged.	There are several HIV models that will allow us to estimate future financing obligations, such as STDSIM and BBH. We chose Spectrum because it is a publicly available modeling tool and is more user-friendly for policymakers interested in developing investment plans for HIV. Following the reviewer's feedback, we have added a sentence to acknowledge other models and justify our choice of using Spectrum.
For me the biggest problem lies in the figure given for treatment. The ARV cost of $132 PPPY is for drugs alone and is, I believe, correct. This paper has to look at the total cost of treatment (including human resources, hospitals, and other services) if it is to be credible and I don't see this being done. There may be a reason for this but the real total cost will change the figures dramatically. If it is excluded we need to know why. The figure of 20% to account for structural costs is simply not enough.	We include non-ARV facility costs that were derived from the MATCH study, as well as the 20 percent structural costs to implement these policy interventions. The 20 percent is in line with previous studies. We added further detail on the non-ARV costs
This paper touches on innovative financing and it is certainly something that needs further investigation. More could be said.	We agree about the importance of innovative financing and we have included details of potential sources. However this paper is focusing on estimating the future cost and not just financing and we have tried to balance the text.

Reviewer 3

Comments	Response
I am not sure whether BMJOpen is a suitable outlet for the type of work performed. Part of the paper reads more like a policy report, and aspects of the discussion of financing provides more of a general review than a discussion that provides value-added. One oddity (appearing occasionally in policy reports, but less so in academic papers) is that one important conclusion is not supported by the analysis. The authors write that	Noted and addressed

"Investing upfront in scale up of HIV services now to ensure high levels of coverage will reduce future expenditures." In contrast, their scaling-up scenarios all show higher expenditures both now and in the future, so at least until 2050 (the policy horizon of the study) the conclusion is incorrect.

First, and positively, the study appropriately translates available evidence "MATCH data" in country-level estimates of ARV, distinguishing ARV costs (US$ 136 for first-line, and US$ 373 for second-line, constant across countries), and "non-ARV service costs" (apparently the non-drug costs of ARV, terminology a bit confusing here and should be clarified, assumptions broadly in line with MATCH non-drug costs), which differ between countries. Assumptions on transition to second-line therapy (about 2.8 percent annually) are also broadly appropriate within the Spectrum/Goals context. [Aside – is this transition rate still appropriate for the long-term projections performed here?] However, the MATCH data include costs on the facility level and those that can be directly attributed to provision of treatment (e.g., off-site lab costs). I.e., any indirect costs of providing treatment services are generally excluded, and the costs of providing treatment services therefore present an under-estimate. More broadly, the paper should make some allowance for the costs of running HIV/AIDS treatment and prevention programs. I see the value of a partial analysis just focusing on the costs or prevention and treatment interventions on the facility level. However, even if this was intended, in this paper the narrow focus of the costing results in a mismatch between the cost projections and the later discussion of financing needs – the latter make sense only if the overall costs of providing and running these HIV/AIDS services are included.

20 percent of treatment and prevention costs is added to reflect costs above the facility level. This is in line with previous projection studies, such as AIDS2031 (2011) and Schwartländer et al. (2011).

The most important shortcoming of the costing is that the study lacks a discussion of how unit costs may evolve over time. The time horizon is 35 years. Based on current estimates and projections of the growth of GDP per capita, wages and salaries (in line with GDP per capita) may plausibly increase at a rate of 2-3 percent annually over this period, i.e., by 100 to 180 percent by 2050. I.e. unit costs including domestic human resource costs will increase very substantially over the projection period. A review of the costing assumptions underlying the paper suggests that costs are directly or indirectly (the latter are purchases of goods or services which in turn include domestic human resources) dominated by human resource costs. Consequently, it is plausible that the study underestimates the costs of providing HIV/AIDS services by about one-half in the outer years of the projections. For a combination of the reasons stated, the paper appears to very substantially under-estimate the future costs of HIV/AIDS services. Because country-level projections of the costs are reported here only in terms of the present discounted value of the costs 2015-50, any conclusion is partially speculative, but it appears

We agree with the reviewer that we do not incorporate different scenarios for how the unit cost changes over time. However to our knowledge there is no agreement as to how the unit costs will change with scale and over time. Based on our literature review, we have not found good evidence, both theoretical and empirical, for determining how unit costs change over time. The reviewer states that service costs may go up, however others have argued that efficiency will be gained with scale (for example, UNAIDS takes this approach). We highlight this limitation in the discussion section.

that the cost estimates reported here are much lower than recent cost estimates of HIV/AIDS programs. This would mean that the results are misleading against the principal objectives of the paper (quantifying the "long term financing needs for HIV control").	
If the study needs to be revised substantially before publication, it is worth considering re-doing the projections based on the country Spectrum files released by UNAIDS in 2015. UNAIDS (following the "Global Burden of Disease" estimates) has revised its estimates of HIV incidence and prevalence, and of survival of PLWH, very substantially, and these revisions would have considerable implications for the projections. It is understandable if such a re-estimate is not feasible at this stage, but the authors may at least point flag the issue.	As the reviewer suggests, the 2015 spectrum files are available, but not for all countries we cover (for example, Ethioipia files are missing in 2015). We choose to use the 2014 files but note this issue in the paper.
Page 4, "and that form mortality" – garbled.	Addressed
Table 1: There is no such thing as "per capita gross domestic product income." Usually the variable of interest is either "GDP per capita" or "gross national income per capita." The link provided points to "GDP per capita," but in constant 2005 dollars and not in 2013 current dollars as stated in table heading and shown in table.	Updated link
Also not that the GDP data for Kenya are off by a large margin – they are now estimated at over US$ 1,200 (and Kenya now belongs to middle-income countries), following revised GDP estimates in 2013 not yet reflected in the World Bank numbers quoted owing to institutional time lags.	We updated the GDPpc figures to 2014 data from the World Bank.
Page 7: "likely date until the current cohort of individuals receiving ART will need to continue treatment and care." There is no particular cut-off data for the current cohort. It is correct that many of today's PLWH will no longer be around in 2050, for general biological and HIV-specific reasons, but attrition is gradual. Also note that the projections include PLWH who become infected over the projection period, and many of these will still be around in 2050.	Agree that there is no clear cut off
It is unclear why the costs of HIV/AIDS programs are benchmarked against the level of external debt (private and public external debt) rather than the level of public debt (=domestic and external government debt).	The focus is on domestic funding from government not private funding
All figures from page 33 include scenarios with funny names ([Country] allCurrent – Copy; [Country] allScaleup – Copy), where [country] is my placeholder for the respective 9 countries shown.	We have addressed this issue

VERSION 2 – REVIEW

REVIEWER	Karen Grepin New York University, USA
REVIEW RETURNED	06-Nov-2015

GENERAL COMMENTS	This paper has significantly improved since the last version, however, I still have a few concerns about the paper, mostly in that I think it is trying to do too much and in the process does not manage to do the thing that I think it could do well, well enough. First, the figures should be better labeled to be consistent with the text to help the reader interpret them more clearly. The text refers to "scenarios" but the figures all use "500" "all current"' etc - terms that are not consistent with text. I suggest renaming these labels with the scenarios, maybe adding a table in the appendix with a longer description of each scenario. Figure 1 and 2 are basically the same thing. One should be moved to appendix. In figure 3, why not show both estimates (0%, 5%, 3% or just take one as your preferred and put the rest in the appendix). Figures 4a-d could be simplified into a single figure. I see no need to present annual data, instead data could be presented in 5 year or even 10 year groups and then all 4 scenarios shown in the same graph. I don't see the need to do a case study on tanzania, if so, it needs to be more elaborated on in the text. The assumptions made to scale up your estimates too all SSA Africa are not clear. I suggest dropping this analysis. It adds little. I don't understand figure 8 and the labels "GEA, RNE, EAE" are never defined so I don't know how to interpret them. The assumptions of what share of financing would be assumed to donors vs. domestic source is not at all explained. I would simply just present HIV financing needs to GDP and perhaps make a comparison to debt to GDP. The discussion is confusing. I would drop the whole discussion financing modes, or move this to your analysis section where I think it fits better. It is not supported by the analysis.

REVIEWER	Alan Whiteside OBE CIGI Chair in Global Health Policy, Balsillie School of International Affairs and Professor Emeritus University of KwaZulu-Natal
REVIEW RETURNED	25-Oct-2015

GENERAL COMMENTS	I would really like to see an assessment of the likelihood of resources being available and (this reflects my view), how decisions will be made in the event that they are not.

REVIEWER	Markus Haacker Harvard Chan School of Public Health
REVIEW RETURNED	24-Oct-2015

GENERAL COMMENTS	The paper has not undergone fundamental changes, the review therefore focuses on the points made in the earlier review and the extent to which they have been addressed. Authors state in their response letter that they "have revised the paper in the light of very valuable comments from the reviewers and have individually addressed all the points." There are, however, several points from the previous review which have not been addressed: (1) Previously, I observed that "the authors write that 'Investing upfront in scale up of HIV services now to ensure high levels of coverage will reduce future expenditures.' In contrast, their scaling-up scenarios all show higher expenditures both now and in the future." I cannot see in the revised manuscript whether or how this comment has been taken into consideration. Therefore, a more substantial discussion of how "investing upfront" translates into lower future expenditures is still required. E.g., lower treatment costs partly offset the scaling up of prevention expenses, as suggested by Figure 4. I also note that in the "discussion" section, this point is made differently as it focuses on health returns rather than "lower future expenditures" as a consequence of initial investments. (2) Lack of accounting for non-direct costs. This earlier comment apparently was erroneous, as I discovered after completion of the review. Authors state: "In line with the UNAIDS HIV investment framework, we added 20% to prevention and treatment costs to account for structural costs." This clarification though, should appear in the methods section, where the other costing assumptions are documented, and not under results. (3) Previously, I had observed under small comments that "it is unclear why the costs of HIV/AIDS programs are benchmarked against the level of external debt (private and public external debt) rather than the level of public debt (=domestic and external government debt)." The authors have decided not to go deeper into this, which – I suppose – is ok as it is a marginal point for the purposes of this paper. (4) The point highlighted as the "most important shortcoming of the costing" in the earlier review is the apparent lack of accounting for increasing human resource costs. The costs of HIV/AIDS programs are dominated by human resource costs (wages and salaries) which can be expected to rise over time, broadly in line with increases in GDP per capita, and GDP per capita is rising rapidly in sub-Saharan Africa, the region the paper is focusing on. E.g., the IMF projects an annual increase in GDP per capita of 2.5 percent through 2020, which - if this rate is maintained, would translate into an increase by 137 percent through the projection period of the paper under review. Not taking into account this cost factor therefore results in a very substantial under-estimate of the projected costs of the HIV/AIDS response. Based on a back-of-envelope calculation, I suggested that the study may underestimate "the costs of providing HIV/AIDS services by about one-half in the outer years of the projections." It is not clear whether or how this comment has been addressed. The authors (in the earlier and the revised version) appear to acknowledge the link between GDP per capita and the costs of

	HIV/AIDS services (excluding drugs) across countries: “we regressed the non-ARV costs by GDP per capita of study countries to derive the linear relationship that allowed us to estimate the non-ARV costs for other countries.” (N.B. Should this read “we regressed … on GDP per capita …”?) However, no mention is made as to how this cost is projected to change as GDP per capita increases. This means that the study lacks documentation of a critical aspect of the analysis, and it seems that the authors did not take account of rising human resource costs. In light of the long time frame (35 years), and the fact that the study links to macroeconomic concepts like debt sustainability (which also considers debt in the context of a growing economy), the analysis therefore appears mis-specified Small incidental observations: Page 14: “But these long-term investments will only be reaped if we invest now…” Should this read “long-term returns” instead of “long-term investments”? Review text to avoid ambiguous statements regarding annual costs of HIV/AIDS response and discounting. E.g., authors state that “with 3% discount rate the annual resources required would be $3.2 billion, $2.4 billion, and $1.8 billion in 2025, 2035 and 2050 respectively.” Resources required IN 2025 suggests that this is a statement regarding the (undiscounted) costs in that year, although from the context it appears that the projected costs are reported after applying some discounting.

VERSION 2 – AUTHOR RESPONSE

Reviewer 1
Comments
R1(1) Previously, I observed that “the authors write that ‘Investing upfront in scale up of HIV services now to ensure high levels of coverage will reduce future expenditures.’ In contrast, their scaling-up scenarios all show higher expenditures both now and in the future.” I cannot see in the revised manuscript whether or how this comment has been taken into consideration. Therefore, a more substantial discussion of how “investing upfront” translates into lower future expenditures is still required. E.g., lower treatment costs partly offset the scaling up of prevention expenses, as suggested by Figure 4. I also note that in the “discussion” section, this point is made differently as it focuses on health returns rather than “lower future expenditures” as a consequence of initial investments.

R(1) Response: We have included a sentence in the Discussion Section to indicate that investing upfront translates into both higher health gains and lower future expenditures but that lower treatment costs are partly offset the scaling up of prevention expenses, as suggested by Figures 3 and 4.

R1(2) Lack of accounting for non-direct costs. This earlier comment apparently was erroneous, as I discovered after completion of the review. Authors state: “In line with the UNAIDS HIV investment framework, we added 20% to prevention and treatment costs to account for structural costs.” This clarification though, should appear in the methods section, where the other costing assumptions are documented, and not under results.

R1(2) Response: Statement moved to methods section

R1(3) Previously, I had observed under small comments that “it is unclear why the costs of HIV/AIDS programs are benchmarked against the level of external debt (private and public external debt) rather than the level of public debt (=domestic and external government debt).” The authors have decided

not to go deeper into this, which – I suppose – is ok as it is a marginal point for the purposes of this paper.

R1(3) Response: Paper has been updated to reflect estimates benchmarked against total public debt.

R1(4) The point highlighted as the “most important shortcoming of the costing” in the earlier review is the apparent lack of accounting for increasing human resource costs. The costs of HIV/AIDS programs are dominated by human resource costs (wages and salaries) which can be expected to rise over time, broadly in line with increases in GDP per capita, and GDP per capita is rising rapidly in sub-Saharan Africa, the region the paper is focusing on. E.g., the IMF projects an annual increase in GDP per capita of 2.5 percent through 2020, which - if this rate is maintained, would translate into an increase by 137 percent through the projection period of the paper under review. Not taking into account this cost factor therefore results in a very substantial under-estimate of the projected costs of the HIV/AIDS response. Based on a back-of-envelope calculation, I suggested that the study may underestimate “the costs of providing HIV/AIDS services by about one-half in the outer years of the projections.”
It is not clear whether or how this comment has been addressed. The authors (in the earlier and the revised version) appear to acknowledge the link between GDP per capita and the costs of HIV/AIDS services (excluding drugs) across countries: “we regressed the non-ARV costs by GDP per capita of study countries to derive the linear relationship that allowed us to estimate the non-ARV costs for other countries.” (N.B. Should this read “we regressed … on GDP per capita …”?) However, no mention is made as to how this cost is projected to change as GDP per capita increases.
This means that the study lacks documentation of a critical aspect of the analysis, and it seems that the authors did not take account of rising human resource costs. In light of the long time frame (35 years), and the fact that the study links to macroeconomic concepts like debt sustainability (which also considers debt in the context of a growing economy), the analysis therefore appears mis-specified

R1(4) Response: We have included additional estimates that account for projected annual increase in GDP per capita. Estimates are provided as a summary in the Results section and presented in more detail in the Appendix

R1(5) Page 14: “But these long-term investments will only be reaped if we invest now…” Should this read “long-term returns” instead of “long-term investments”?

R1(5) Response: Corrected.

R1(6) Review text to avoid ambiguous statements regarding annual costs of HIV/AIDS response and discounting. E.g., authors state that “with 3% discount rate the annual resources required would be $3.2 billion, $2.4 billion, and $1.8 billion in 2025, 2035 and 2050 respectively.” Resources required IN 2025 suggests that this is a statement regarding the (undiscounted) costs in that year, although from the context it appears that the projected costs are reported after applying some discounting.

R1(6) Response: Statements have been rephrased.

Reviewer 2
Comments
R2(1): I would really like to see an assessment of the likelihood of resources being available and (this reflects my view), how decisions will be made in the event that they are not.
R2(2) Response: We have revised the section on innovative to indicate most promising sources of potential financing. Estimating exact amounts that might be available is beyond the scope of this paper and the subject of a another ongoing study.

Reviewer 3
Comments

R3(1) This paper has significantly improved since the last version, however, I still have a few concerns about the paper, mostly in that I think it is trying to do too much and in the process does not manage to do the thing that I think it could do well, well enough.

R3(1) Response: Thank you. We have revised the paper to shorten the text by ~10%.

R3(2) First, the figures should be better labeled to be consistent with the text to help the reader interpret them more clearly. The text refers to "scenarios" but the figures all use "500" "all current"' etc - terms that are not consistent with text. I suggest renaming these labels with the scenarios, maybe adding a table in the appendix with a longer description of each scenario.
Figure 1 and 2 are basically the same thing. One should be moved to appendix.

R3(2) Response: Figure 1 moved to appendix. Renamed Fig. S3. All subsequent figures renamed in order.

R3(3) In figure 3, why not show both estimates (0%, 5%, 3% or just take one as your preferred and put the rest in the appendix).

R3(3) Response: Changed name from Fig.1 to Fig. 2

Added the following explanation to chart:
“Bars represent estimates using 5% discounting. Lower and upper bounds of lines represent estimates using 3% and 7% discounting respectively.”

R3(4) Figures 4a-d could be simplified into a single figure. I see no need to present annual data, instead data could be presented in 5 year or even 10 year groups and then all 4 scenarios shown in the same graph.

R3(4) Response: Renamed. Now Fig. 3. Our intention is to highlight the trend within the three categories (tx, prevention, structural) in addition to comparing across the four scaling scenarios Charts updated to represent 5 year periods.

R3(5) I don't see the need to do a case study on tanzania, if so, it needs to be more elaborated on in the text.
R3(5) Response: Removed the Tanzania illustrative case. Related Fig. removed

R3(6) The assumptions made to scale up your estimates too all SSA Africa are not clear. I suggest dropping this analysis. It adds little.
R3(6) Response: Removed analysis with scale-up to all of sub-Saharan Africa. Paper now focuses exclusively on the nine (9) countries in the study. Related Fig. removed

R3(7) I don't understand figure 8 and the labels "GEA, RNE, EAE" are never defined so I don't know how to interpret them.
R3(7) Response: Renamed. Now Fig. 5. Explanation of acronyms added to current figure.

R3(8) The assumptions of what share of financing would be assumed to donors vs. domestic source is not at all explained. I would simply just present HIV financing needs to GDP and perhaps make a comparison to debt to GDP. The discussion is confusing. I would drop the whole discussion financing

modes, or move this to your analysis section where I think it fits better. It is not supported by the analysis.

R3(8) Response: We have presented financing needs to total public debt. We have not indicated what proportions should come from different sources. The issue of 'fair financing' is being explored in other studies and is beyond the scope of this paper.

We have substantially shortened the section on innovative financing and have improved the text to better link it to the Results and the narrative on future financing obligations.

VERSION 3 - REVIEW

REVIEWER	Markus Haacker Harvard School of Public Health Like all the authors, I am affiliated with the Department of Global Health and Population at the Harvard School of Public Health.
REVIEW RETURNED	05-Jan-2016

GENERAL COMMENTS	The paper has improved considerably since the last round of review, and in this round the authors have documented their responses diligently, and appear to have addressed most or all of them. The streamlining of the "financing" section benefits the paper in terms of improved focus and a clearer definition of its contribution. The most important comment raised by this reviewer in the earlier round regards the accounting for increasing human resource costs in the projections. This has been addressed in part - the authors provide alternative estimates which allow costs to rise in line with real GDP per capita. I still believe that it does not make much sense to focus the analysis on scenarios in which unit costs are assumed to stay constant over 35 years (in real terms), even though real GDP per capita and human resource costs are projected to grow rapidly over that period. Nevertheless, one may argue that the authors have addressed this point by making explicit the consequences of accounting for increasing human reosurce costs or not doing so. The comments below are a mixture on observations on some new sections (which inadvertently include some garbled sentences or errors) and a few further points (including some small "copy-editing") that I picked up during the review, while aiming to not introduce any fundamentally new points. (1) Introduction, 3rd paragraph: This could possibly be updated to latest data on treatment access, in a last round of copy-editing. Epi data in table 1 could also be updated, although the estimates later might be based on the files underlying these earlier data, which would be a reason to keep the epi data as is. (2) Table 1: "Per capita Gross Domestic Product income" in the title should be corrected to "GDP per capita" or "gross domestic product per capita," and the column heading "Per capita income" should read "GDP per capita." Review capitalized letters in table heading – gross domestic product is not normally capitalized if others terms are not. (3) "Methods" section, first paragraph: "We use the Goals module from Spectrum…" Actually authors appear to be using the "Goals" and "Resource Needs Model" modules.

	(4) “Methods” section, second paragraph: Shift insertion on 2015 Spectrum files before comma, do not capitalize “Currently”? (5) Page 8: “We use IMF projected GDP per capita growth rate of 2.5% for sub-Saharan Africa.” Note that the IMF publishes projections through 2020 only, and you extrapolate through 2050. Consider re-phrasing as: “We assume an annual growth rate of GDP per capita of 2.5%, in line with IMF projections for sub-Saharan Africa available through 2020. (6) P. 10: “We then estimate the present value of cumulative resources required by the nine sub-Saharan countries for 2015-50 at 3% discount rate with the costs of human resource and supplies increasing by the average projected annual GDP per capita between 2015 and 2017 of 2.1 percent.” The “present discounted value of cumulative resources” is awkward. The “present value” of resources required in 2015-50 already implies that they are added up. “The average projected annual GDP per capita” should be corrected to “the average projected annual growth of GDP per capita,” you should also be explicit on which countries the growth projections refer to. (7) Same para. as comment 6: More importantly, note that this paragraph contradicts the discussion in the methods section, including a reference to IMF projections of growth of GDP per capita of 2.5 percent, and not 2.1 percent (for the period 2015-17) as stated here. (See comment above on one ambiguity there.) I have checked the number of 2.1 percent, this is indeed consistent with the projection in the IMF World Economic Outlook for 2016 and 2017, but reflects relatively low growth (1.8 percent) in 2016 and higher growth (2.4 percent) in 2017. In general, it makes more sense to take the IMF projections for the outer years (about 2.5 percent) as a basis for projecting forward, as the short-term projections by the IMF include a lot of idiosyncratic factors (commodity prices, exchange rates, global economic trends), whereas the projections for the outer years are more sensible estimates for trend growth , stripped of short-term fluctuations). (8) Page 11, paragraph following Figure 4: “GDP per capita income levels” should read “levels of GDP per capita.” (9) Page 12, para. following Figure 5: Checks for consistency “resource need” – “resource needs.” (10) Page 12. About line 44: “While in 2013 the ratio of public debt to-GDP was 12% for Kenya and 29% for Uganda” – it appears (see Figure 6) that this mixes up public debt and the HIV/AIDS financing obligations, the numbers refer to the latter.

VERSION 3 – AUTHOR RESPONSE

1. Reviewer:
Introduction, 3rd paragraph: This could possibly be updated to latest data on treatment access, in a last round of copy-editing. Epi data in table 1 could also be updated, although the estimates later might be based on the files underlying these earlier data, which would be a reason to keep the epi data as is.
Response: Done

2. Reviewer:
Table 1: “Per capita Gross Domestic Product income” in the title should be corrected to “GDP per capita” or “gross domestic product per capita,” and the column heading “Per capita income” should read “GDP per capita.” Review capitalized letters in table heading – gross domestic product is not normally capitalized if others terms are not.
Response: Done

3. Reviewer:
“Methods” section, first paragraph: “We use the Goals module from Spectrum…” Actually authors appear to be using the “Goals” and “Resource Needs Model” modules.
Response: We hav clarified the modules used

4. Reviewer
“Methods” section, first paragraph: “We use the Goals module from Spectrum…” Actually authors appear to be using the “Goals” and “Resource Needs Model” modules.
Response: Addressed

5. Reviewer:
Page 8: “We use IMF projected GDP per capita growth rate of 2.5% for sub-Saharan Africa.” Note that the IMF publishes projections through 2020 only, and you extrapolate through 2050. Consider re-phrasing as: “We assume an annual growth rate of GDP per capita of 2.5%, in line with IMF projections for sub-Saharan Africa available through 2020.
Response: As suggested by the reviewer, we have revised the projections using IMF projections of GDP per capita growth rate of 2.5% for sub-Saharan Africa.

6. Reviewer:
P. 10: “We then estimate the present value of cumulative resources required by the nine sub-Saharan countries for 2015-50 at 3% discount rate with the costs of human resource and supplies increasing by the average projected annual GDP per capita between 2015 and 2017 of 2.1 percent.” The “present discounted value of cumulative resources” is awkward. The “present value” of resources required in 2015-50 already implies that they are added up. “The average projected annual GDP per capita” should be corrected to “the average projected annual growth of GDP per capita,” you should also be explicit on which countries the growth projections refer to.
Response: Corrected

7. Reviewer:
Same para. as comment 6: More importantly, note that this paragraph contradicts the discussion in the methods section, including a reference to IMF projections of growth of GDP per capita of 2.5 percent, and not 2.1 percent (for the period 2015-17) as stated here. (See comment above on one ambiguity there.) I have checked the number of 2.1 percent, this is indeed consistent with the projection in the IMF World Economic Outlook for 2016 and 2017, but reflects relatively low growth (1.8 percent) in 2016 and higher growth (2.4 percent) in 2017. In general, it makes more sense to take the IMF projections for the outer years (about 2.5 percent) as a basis for projecting forward, as the short-term projections by the IMF include a lot of idiosyncratic factors (commodity prices, exchange rates, global economic trends), whereas the projections for the outer years are more sensible estimates for trend growth , stripped of short-term fluctuations).
Response: The projections have been revised using the IMF figures

8. Reviewer:
Page 11, paragraph following Figure 4: “GDP per capita income levels” should read “levels of GDP per capita.”

Response: Corrected

9. Reviewer:
Page 12, para. following Figure 5: Checks for consistency “resource need” – “resource needs.”
Response: hacked the document and corrected

10. Reviewer:
Page 12. About line 44: “While in 2013 the ratio of public debt to-GDP was 12% for Kenya and 29% for Uganda” – it appears (see Figure 6) that this mixes up public debt and the HIV/AIDS financing obligations, the numbers refer to the latter.
Response: This has been addressed

VERSION 4 – REVIEW

REVIEWER	Markus Haacker Harvard T.H. Chan School of Public Health Like all the authors, the reviewer is affiliated with the Department of Global Health and Population at the Harvard School of Public Health.
REVIEW RETURNED	09-Feb-2016

GENERAL COMMENTS	The comments raised in the earlier review have been addressed. Authors and editors should take note of the following points observed during this review, which fall into the category of copy-editing and should not warrant another round of peer review. Title: Should this read "Long-term financing..." (hyphen added) rather than "Long term financing..."? P. 8: “As the IMF publishes projections through 2020 only, and we extrapolate through 2050 we assume an annual growth rate of GDP per capita of 2.5 percent, in line with the outer years of IMF projections.” This contains two grammar errors – change to “The IMF publishes” (remove “As”) or delete “and” before “we extrapolate;” and change "we assume" to "assuming" or "and assume." P. 11: “We next provide for the nine sub-Saharan countries with different HIV prevalence and levels of GDP per capita (Table 1) per capita expenditures from domestic and international sources and estimates of resource needs for treatment, key prevention services, and structural costs in 2015.” It seems that the repetition of “per capita” is accidental and incorrect, as the following Figure 5 shows the amount in absolute terms. Figure 5: This points to Resch et al. (2014) as source. This is not listed in references, presumably the source is the Resch et al. (2015) paper (which is listed in references but not referred to in paper). P. 12: “Figure 5 shows that” following Figure 5. Do you want to open two successive sentences with “Figure 5 shows…”?