Technical updates for UNAIDS HIV estimation tools

Report and recommendations from a meeting of the UNAIDS Reference Group on Estimates, Modelling, and Projections

16 – 17 October 2024

Table of Contents

Abbreviations

AEM	AIDS Epidemic Model
AIM	AIDS Impact Model
AHD	Advanced HIV Disease
ANC	Antenatal Clinic
AP	Asia and the Pacific
ART	Antiretroviral Therapy
ART-CC	ART Cohort Collaboration
ARM	Age and Risk Structured Model
ASM	Age Structured Model
CDC	US Centres for Disease Control and Prevention
CLHIV	Children Living with HIV
CM	Cryptococcal Meningitis
CrAg	Cryptococcal Antigen
CSAVR	Case Surveillance and Vital Registration
DQA	Data Quality Assessment
EECA	Eastern Europe and Central Asia
EMRs	Electronic Medical Records
EPP	Estimation and Projection Package
ESA	Eastern and Southern Africa
GAM	Global AIDS Monitoring
IRR	Incidence Rate Ratio
KOS	Knowledge of Status
KP	Key Population
(K)PSE	(Key) Population Size Estimate
LA	Latin America
MENA	Middle East and North Africa
PEPFAR	President's Emergency Plan for AIDS Relief
PHIA	Population-based HIV Impact Assessment
PLHIV	People Living with HIV
SSA	sub-Saharan Africa
UNPD	United Nations Population Division
VL(S)	Viral Load (Suppression)
WCA	West and Central Africa
WCENA	Western and Central Europe and North America
WHO	World Health Organization
WPP	World Population Prospects

The meeting of the UNAIDS Reference Group on Estimates, Modelling, and Projections was organised for UNAIDS by the Secretariat of the Reference Group (www.epidem.org), managed at SACEMA, Imperial College London, and the University of Cape Town. Participants of the meeting are listed at the end of this document (Appendix B).

Background

UNAIDS Reference Group on Estimates, Modelling, and Projections

The Joint United Nations Programme on HIV/AIDS (UNAIDS) relies on impartial scientific advice from international experts in relevant subject areas to provide guidance on how to best calculate estimates and projections of the prevalence, incidence, and impact of HIV/AIDS globally. The UNAIDS Reference Group on Estimates, Modelling, and Projections acts as an 'open cohort' of epidemiologists, demographers, statisticians, and public health experts to provide scientific guidance to UNAIDS and partner organisations on the development and use of the tools used by countries to generate annual HIV estimates, which are the source for UNAIDS Global HIV epidemic estimates. The Group is coordinated by a Secretariat hosted at the South African Centre for Epidemiological Modelling and Analysis (SACEMA), Harvard School of Public Health, and the University of Cape Town.

Meeting overview

The UNAIDS Reference Group held a virtual meeting, 16-17 October 2024, assessing the progress on the implementation of the recommendations made in the July 2024 meeting, identifying any obstacles, and planning next steps. This report contains a summary of presentations and discussions from the meeting. Meeting participants (see in Appendix B) can access these presentations on www.epidem.org. For those not in attendance, please reach out to the Secretariat at epidem@sun.ac.za for access requests. Appendix A presents the final recommendations. These recommendations guide UNAIDS in reviewing HIV estimates, assessing current methodologies, and identifying data for refining HIV estimates. The meeting agenda and objectives are in Appendix C. For records of previous meetings, visit www.epidem.org.

Meeting introduction

Mary Mahy highlighted the commitment of UNAIDS to ensure that countries have the necessary tools and capacity to understand their HIV epidemics. She thanked everyone for their collaboration, noting that working together to provide consistent messaging and tools to countries will make it easier for them to understand and respond to their HIV epidemics.

UNAIDS 2030 targets and the global AIDS strategy
The global AIDS response is shifting focus from the 2025 targets to the **2030 targets** as part of the next Global AIDS Strategy. The overarching 2030 targets include **zero new infections and zero AIDS-related deaths**, with specific metrics such as the 95-95-95 targets, measuring progress toward testing, treatment, and viral suppression. A technical expert group has been involved in defining and modelling the potential impact of these targets, which will form the framework for the next global AIDS five-year strategy adopted by countries. Accurate epidemic monitoring and estimates are crucial, as countries will report on new infections and AIDS-related deaths as part of global accountability mechanisms.

Upcoming workshops
The 2024/5 HIV estimates workshops will be conducted in various regions to provide hands-on training on estimation tools, ensuring country teams can effectively use Spectrum and related models. "Goals Day" or "AEM Day," will be included on the last day of every workshop.

- Goals is a module in Spectrum that allows sub–Saharan African countries to project future epidemic trends under different policy and programmatic scenarios. It helps countries to understand the potential long-term impact of different HIV interventions.
- AIDS Epidemic Model (AEM) is used for modelling epidemic trends in Asian countries where epidemic dynamics differ (concentrated among key populations).

These components are being added to support 1) PEPFAR, Global Fund, and UNAIDS sustainability roadmaps, ensuring evidence-based strategic planning and 2) The US Government's country operational plans (COP 2025), aligning country responses with long-term sustainability goals.

Eleanor Gouws provided an overview of the upcoming workshops (in-person over five days) which are crucial for ensuring that the necessary information is available for PEPFAR's COP process starting in February 2025.

- **Train the Trainers workshops**: Generalized epidemics (virtual), 18-20 November; Concentrated epidemics, early January 2025.
- **East and Southern Africa & Anglophone Western Central African Countries**: Johannesburg, 2-6; 9-13 December 2025.
- **Western Central Africa**: Togo, Generalized epidemics, 27-31 January; Concentrated epidemics, 3-7 February 2025.
- **Caribbean Countries**: Kingston, 20-24 January 2025.
- **Latin America**: Panama, 3-7 February 2025.
- **MENA and Eastern Europe & Central Asia**: Bangkok, two simultaneous sessions 17-21 February 2025.
- **Asia Pacific**: Bangkok, 23-28 February 2025.

Meeting objectives

Cari van Schalkwyk provided an overview of the Spectrum tools, data inputs and model outputs generated, aimed at providing a basic understanding of methods related to the objectives of the meeting. The meeting aimed to review new Spectrum input editors and outputs and propose updates to methods for estimating advanced HIV disease (AHD) in Spectrum.

Session 1: Advanced HIV disease

- Review new Spectrum input editors and outputs.
- Examine proposed updates to methods for estimating AHD.
- Discuss new inputs into program statistics and national-level outputs of AHD.

Session 2: Cryptococcal meningitis estimates

- Review the implementation of cryptococcal meningitis estimation in Spectrum.

Session 3: Key population estimates in sub-Saharan Africa

- Review key population estimates and the development of the Goals age-risk model.
- Discuss updates to the workbook, including the implementation of the Triangulator tool.

Session 4: Excess mortality among people living with HIV

- Review refined methods to separate AIDS deaths and non-AIDS excess deaths.

Session 5: Subnational estimates

- Review proposed updates to subnational demographics.

Session 6: ART coverage data discrepancies

- Review discrepancies between ART coverage data from different sources.
- Provide guidance on which data sources countries should use to inform their estimates.

Session 7: Incidence rate ratio fitting tool

- Discuss how the tool uses data on incidence by age and sex from household surveys and program ART data.

Session 1: Advanced HIV Disease (AHD)

The objectives of the first session were to:

- Review proposed updates to methods for estimating AHD in Spectrum.

Advanced HIV disease (CD4 <200) – triangulating data & Spectrum

Oli Stevens presented a follow-up to work shared in July 2024 in Addis Ababa, focusing on the estimation and modelling of Advanced HIV Disease (AHD) among people on antiretroviral therapy (ART) with a CD4 count < 200, and included comparisons of Spectrum estimates with Population-based HIV Impact Assessment (PHIA) data. There is a need to review the treatment interruption CD4 mechanism and explore alternate thresholds for defining AHD.

AHD prevalence among those on ART

Direct estimation of AHD among those on ART from Spectrum is not possible since CD4 count reflects the count at ART initiation, not the current count, as Spectrum does not model CD4 recovery. AHD prevalence among those undiagnosed or those diagnosed but untreated can be directly obtained from Shiny90. The presentation focused on estimating AHD prevalence among those on ART by viral load status and ART duration (<1 year and >=1 year) to create estimates internally consistent with program-reported viral load data and PHIA survey trends.

Disaggregation of people on ART by duration and viral load status:

The analysis was restricted to countries where the number of people tested for viral load exceeds half of the total number on ART. The total number of virally suppressed people on ART can be calculated as

$$Total\ \#VLS = \frac{vl_{suppressed}}{vl_{tested}} \times \#onART$$

This number can also be expressed as a weighted sum of viral load suppression by ART duration:

$$Total\ \#VLS = \left(\#onART_{<1yr} \times vls_{<1yr}\right) + \left(\#onART_{>1yr} \times vls_{>1yr}\right)$$

Viral load suppression rates at the two durations are both unknown, but viral suppression at longer durations is assumed to be higher than at shorter durations, with an assumed fixed difference of 0.75 on the logit scale. These two equations can then be set equal and solved for $vls_{<1yr}$ and all people on ART can be split into 4 categories of ART duration and VLS. **Note that the largest category is people who are on ART for >1yr and virally suppressed.**

Estimates of AHD in each of the four categories:

PHIA surveys present estimates of AHD by VLS status (but not duration on ART). Percentage AHD at each of the durations and over time were calibrated to match PHIA trends in countries with data, and VLS estimates for countries without such data (or <50% coverage) were imputed by fitting a relationship between ART coverage and VLS among those on treatment.

This simple but assumption heavy method reconciles 1) Numbers on ART by treatment duration; 2) Viral load testing data where available; and 3) PHIA data on %AHD by viral load status. Since a large majority of People Living with HIV (PLHIV) on ART in sub-Saharan Africa (SSA) are suppressed and on treatment >1yr, estimates of AHD prevalence are **very sensitive** to assumptions in this category.

Several key points and clarifications emerged from the presentation:

- **Association between AHD and viral suppression**: People on ART who are not virally suppressed are much more likely to have AHD - around 40% based on PHIA data. This is built into the model, regardless of how long they've been on treatment.

- **Applicability in non-PHIA countries**: The method currently only works in sub-Saharan African countries that have PHIA surveys and Shiny90 data.
- **Assumptions about VLS:** Viral suppression rates are estimated using Spectrum data by comparing ART coverage with the proportion suppressed. The method assumes people tested are on treatment but doesn't assume those not tested are unsuppressed. Only countries with at least 50% VL testing coverage are included, similar to Spectrum's approach for Global AIDS Monitoring (GAM) reporting. There was an interest in repeating this at different testing coverages to see if the association holds.
- **Cross-sectional nature of PHIA data**: The limitations of interpreting viral load suppression and immunologic recovery from cross-sectional PHIA data were discussed. PHIA surveys provide a snapshot in time, which makes it hard to assess CD4 recovery. People newly on ART may be suppressed but still have low CD4. The model accounts for this by assuming higher AHD in the first year on treatment, even for those who are suppressed. It was agreed that while cross-sectional data is currently what is available, there is a need to expand and strengthen this with more longitudinal data.
- **Early ART individuals in PHIA surveys**: The dynamic of picking up early ART individuals in PHIA surveys was acknowledged. The stratification of data aims to capture higher AHD in the first year even among those who are virally suppressed.
- People who stop and later restart treatment are counted as "diagnosed but untreated." The model allows for movement between treatment, interruption, and return.
- **Why diagnosed but untreated have more AHD:** This group often includes people who were on ART but stopped. That explains why they tend to have more AHD than people who have never been diagnosed. There was a suggestion to improve how the model reflects fast CD4 decline after interruptions.
- **Bias in viral load monitoring data**: Concerns were raised about potential biases in viral load monitoring data, depending on the type of sample. It was noted that while there may be assay bias, the bias in who gets a viral load done is likely larger (mitigated by only using data from countries with above 50% testing coverage).

AHD prevalence among those aware of HIV status, but untreated

At the July meeting, concern was expressed about high and increasing proportions of AHD among those who are aware but untreated, which includes 1) individuals who have been diagnosed but not yet initiated treatment, and 2) those who have been on treatment, interrupted, and returned to the untreated category.

Upon deeper investigation, it was found that in countries with PHIA surveys, Spectrum estimates of AHD prevalence among those aware but untreated aligned well with PHIA estimates.

Countries with concerningly high estimates of **AHD prevalence** in recent years are predominantly from Western and Central Africa, where **numbers** aware but untreated individuals have reached **very low levels** (potentially due to misspecification of ART numbers and/or interruption rates).

Since this category will therefore contribute very little to the **number of people with AHD**, these trends are not concerning.

Alternate thresholds for AHD

Two alternate thresholds for AHD were suggested: CD4 count <250, aligning with clinical stage 3, and CD4 count <100, as most cryptococcal meningitis (CM) cases are concentrated in this category. However, a comparison of AHD among the diagnosed and untreated from PHIA data showed that using a CD4 threshold < 200 aligns best with PHIA surveys, except in Côte d'Ivoire, Ethiopia, and Nigeria.

Estimates of Advanced HIV Disease from CSAVR

Guy Mahiane presented a comparison of AHD estimates from the CSAVR model and program data from 38 countries with data on CD4 at diagnosis. CSAVR estimates of AHD among newly HIV diagnosed individuals differ from program data. Comparing 74 country's data, CSAVR estimates of AHD at ART initiation were generally higher than at HIV diagnosis, as illustrated in the May 2022 meeting.

Advanced HIV Disease in Spectrum/AIM

John Stover presented on new input editors and outputs for estimating AHD in Spectrum. He proposed a much simpler approximation of adults on ART with AHD by using the estimate of adults on ART for less than six months who initiated with CD4 counts < 200, a method which captures those who dropped out of treatment and then re-initiated recently.

WHO definition	Spectrum implementation

ADULTS: All PLHIV with CD4 counts < 200 cells/mm3 plus those in Stage 3 or 4	• **Adults not on ART with CD4 counts < 200**
	  o Unaware of status
	  o Aware of status
	  o Use KOS among all adults to disaggregate
	• **Adults on ART for < 6 months initiating at CD4 < 200**

CHILDREN: All children living with HIV (CLHIV) under the age of five plus those 5-14 with CD4 counts < 200 cells/mm3	• **CLHIV under the age of five** • **CLHIV aged 5-14 with CD4 counts < 200 cells/mm3**

Discussion

Spectrum currently lacks functionality to model CD4 recovery or link viral suppression with CD4 status post-ART initiation. Any further disaggregation will rely on triangulation or imputation (e.g., from PHIA or cohort data), especially to track dynamic care patterns (e.g., interruptions, re-initiation).

- **Reporting AHD:** Spectrum should report both the prevalence of AHD overall and among new ART initiators, allowing for comparison with program data.
  The group agreed on the importance of having validation screens for AHD in Spectrum to compare estimates with GAM data, particularly focusing on CD4 distribution among people newly diagnosed and ART initiators. Concerns were raised about the potential biases in program data. CD4 count measurements at ART initiation are not consistently collected in many countries, leading to the risk of overestimating AHD prevalence compared to a representative sample. The group emphasized the need to communicate these uncertainties during validation. A visualization of CD4 testing coverage was also recommended to provide a clearer understanding of data limitations.
  Reporting AHD prevalence using the CD4 <200 threshold was agreed upon as straightforward and programmatically useful, whereas using CD4 <250 to approximate WHO stages III/IV would likely cause confusion.
  Stratification by viral suppression should be considered for internal calculations and specific programmatic uses, such as cryptococcal meningitis risk.
  It was noted that the WHO definition of AHD among children does not include children <5 on ART who are virally suppressed as currently assumed in Spectrum.

- **Decision on AHD estimation approach, proportion of individuals on ART with CD4 < 200:**
  - Stover's approach: Use people on ART for less than six months who started at CD4 < 200 as a proxy for AHD.
  - Stevens' approach: Disaggregate AHD by treatment duration and viral suppression status.

  While the disaggregated approach could provide more detailed insights, it involves a significant number of assumptions, making it potentially complicated for practical application. Further data is needed before deciding on wider implementation, including a comparison of outputs from the two proposed methods.

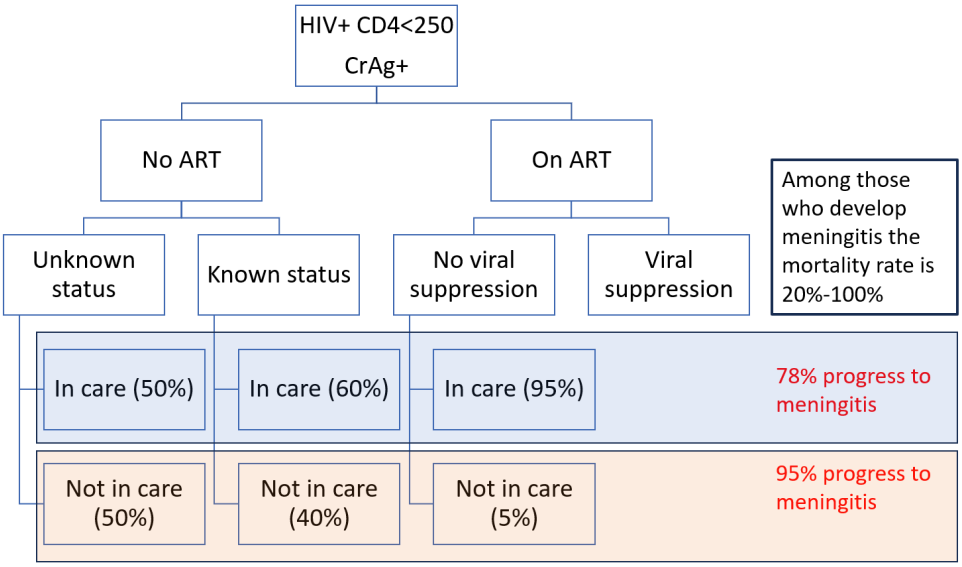
Session 2: Cryptococcal meningitis (CM)

Objective:
Review implementation of CM cases and deaths calculation in Spectrum using Minnesota model and AHD cascade data.

Cryptococcal meningitis and AIDS deaths in Spectrum

John Stover reviewed the implementation of the University of Minnesota model for cryptococcal meningitis (CM) in Spectrum, integrating AHD cascade data through the new editor. The presentation focused on adapting the model to estimate CM cases and deaths, drawing on Spectrum outputs combined with inputs from regional and country-specific estimates.

Structure of Minnesota model:



Data inputs:

- Prevalence of cryptococcal antigen (CrAg) among those at risk, with country-specific estimates available.
- Default assumptions for care linkage and progression rates to meningitis.
- Mortality rates for those developing cryptococcal meningitis, differentiated by income group.
- Fluconazole therapy coverage.

Key outputs included:

- Number of people with cryptococcal antigenemia by care category.
- Expected number of meningitis cases and deaths by care category.
- Proportion of AIDS deaths attributed to cryptococcal meningitis.

Stover presented an example for Uganda and highlighted the significant variability in CM/AIDS deaths and the proportion of AIDS deaths that are due to CM observed across different countries. This variability is driven by variability in CrAg prevalence estimates and AHD prevalence.

Discussion

The summary below captures the key points discussed following the presentation.

- **CrAg prevalence estimates:** Concerns were raised regarding the reliability of cryptococcal antigenemia prevalence estimates, given that they often rely on small sample sizes. Suggestions were made to consider using a weighted average that balances country-specific to regional estimates.
- Participants were interested in seeing global estimates for the proportion of AIDS deaths due to CM and how individual countries compare.
- **Model assumptions:** Concerns were expressed about the assumptions used in the model, particularly around the progression rates to meningitis for those in and out of care, and the uptake of fluconazole as a preventive measure. Some participants felt the progression rates seemed high and suggested further review. The need for clear communication of these assumptions to country teams to avoid confusion was emphasized.

Session 3: Key population size estimates in sub-Saharan Africa

Objectives:

- Review key population workbook timeline and process
- Review proposed use of Triangulator tool for PSE data synthesis in 2025 key population workbooks.

Key population data management in the estimates process

Keith Sabin highlighted the increasing importance of key population data in developing HIV estimates, especially in generalized epidemics. The workbook, which requests population size estimates, HIV prevalence, and ART coverage data by site and year, remains central to this process. He also discussed how a more inclusive process could be fostered by encouraging country teams to take ownership of their data through increased involvement.

Current workflow:

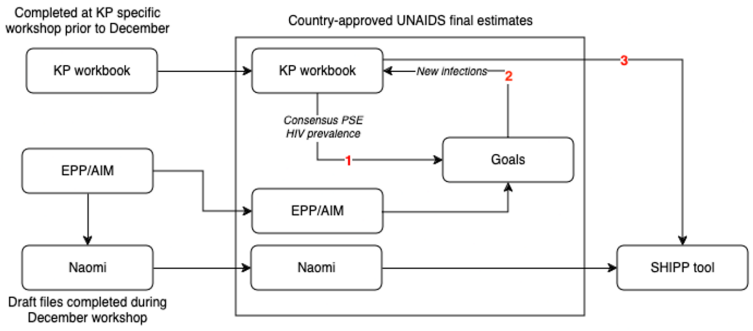
- The key population workbook is a standalone tool that collects data on population size estimates, HIV prevalence, and ART coverage for key populations.
- The workbook outputs consensus estimates for these indicators, which are then used in the broader HIV estimates process.

Proposed changes:

- Introduction of specific workshops for completing the key population workbooks before the main estimates' workshops.
- Validation of consensus estimates by national authorities to ensure they are recognized as official country data.
- Integration of these estimates into the broader HIV estimates process, including the use of the SHIPP tool for sub-national estimates.

Next steps:

- Organize workshops for Southern and Western/Central Africa regions to introduce the workbook and support country teams in completing it.
- Validate the inputs and outputs systematically, similar to the current process for GAM data.



Key population workbook updates for 2025 estimates

Oli Stevens provided updates on the Key Population workbook for the 2025 estimates, specifically emphasizing the integration of the Triangulator and Aggregator tools to aid in synthesizing population size estimates (PSE) data. The Triangulator incorporates uncertainty from the input data, which helps create weighted estimates. Stevens emphasized the challenge of managing data from programmatic

mapping and venue-based estimates, which often lack formal uncertainty values, and therefore would be excluded from the synthesized estimates.

District-level estimates:

- A new optional sheet for district-level key population size estimates (KPSE) will be included in the workbook.
- This sheet will help reconcile pre-existing district-level estimates with the national consensus estimate, ensuring consistency.

Process improvements:

- The tool will require users to enter confidence scores for each data source, ensuring that all estimates are critically evaluated.
- The district-level estimates will be scaled to match the national consensus, providing a more accurate picture of key population sizes at the sub-national level.

Demonstration of Triangulator/Aggregator tool

Carl Corcoran demonstrated the Shiny app that has been developed for the Triangulator/Aggregator tool that has been described in previous Reference Group meetings and are designed to estimate key population sizes at district and national levels.

- Triangulator: This model produces district-level consensus estimates by aggregating disparate individual study data. Users input population size estimates and assess confidence levels based on factors like study design and time elapsed. These confidence levels help scale uncertainty, and the data is processed using a hierarchical model to generate a posterior estimate for district populations.
- Aggregator: This builds on the Triangulator's outputs, combining district-level estimates and user-defined assumptions (e.g., urban-rural population relationships) to generate a national estimate.

The tool was demonstrated step-by-step:

- Users upload a KP workbook containing estimates. Confidence levels for each study are assessed. The Triangulator processes the data, incorporating priors and producing consensus estimates. The Aggregator combines district estimates with urban-rural ratios to generate a national estimate. Results can be downloaded, saving all Triangulator and Aggregator outputs into the workbook.

The tool ensures data validation, prevents progression without necessary inputs, and flags inconsistencies for correction. While still in development, it largely follows the envisioned workflow.

Discussion

The summary below captures the key points discussed.

- **Data ownership and involvement of country teams:** There was consensus on the need to enhance the role of country teams in managing and taking ownership of their key population data. While many analyses are still conducted centrally (in Geneva and London), there is a shift towards decentralizing some aspects to country teams, thereby fostering a greater sense of data ownership and enhancing data quality.
- **Confidence and uncertainty in estimates:** Emphasis on the need for clear guidance on assigning confidence scores to different KPSE. Discussion was held on the importance of considering the quality and recency of data when assigning confidence scores. Guidance on which sampling methods should receive higher scores than others should be developed, as well as metrics of when a country has enough district-level estimates to create a national consensus estimate.
- **District-level population size estimates:** The need for guidance on setting priors for district-level estimates was discussed, ensuring that these are based on reliable data and reflect the true population sizes. Participants noted the potential of the new district-level data sheet to improve alignment between national and district-level estimates, thus there would be consistency in data used for national programming and sub-national estimates used in other tools.

- **Validation and sensitivity analysis:** Participants expressed the need for validation exercises to reconcile the various estimates generated by different ministries and stakeholders, as inconsistencies often arise due to differing definitions or priorities. The consensus approach is aimed at addressing this by creating a unified estimate that can be used across stakeholders. Recommendations for conducting sensitivity analyses to understand the impact of different assumptions on the estimates.
- **Triaging countries for triangulator use:** Not all countries would be suitable for immediate use of the Triangulator tool, especially if there is insufficient data available. There was discussion on providing guidance on when countries should be directed towards using modelled estimates versus the Triangulator tool for their key population estimates. Pilot the workbook and Triangulator tool in a few countries before broader implementation to refine the process and address any issues, timely implementation of the workbook and Triangulator tool for the 2025 estimates round.

Session 4: Excess mortality among PLHIV

Objective:

- Review revision of method to address unexpected pattern that more excess deaths are due to non-AIDS causes at lower CD4 categories

Refinements to the disaggregation of excess mortality in people with HIV

Rob Glaubius presented on refining excess mortality modelling in Spectrum for high-income settings, by incorporating age-based and CD4-based mortality constraints. The goal was to improve how AIDS and non-AIDS excess deaths are estimated, ensuring alignment with empirical data and historical mortality trends.

Background: Spectrum currently categorizes all excess mortality among PLHIV as AIDS-related. However, meta-analyses indicate that non-AIDS causes constitute approximately 45% of excess deaths among PLHIV on treatment in high-income settings. Countries using CSAVR for estimates calibrate excess mortality based on national vital registration data, which may not align with Spectrum outputs.

Proposed rates: In July, a set of non-AIDS excess mortality rates was proposed for use in Spectrum, particularly for settings outside sub-Saharan Africa and for adults on or off treatment.
Observed patterns in mortality proportions by age and CD4 count were unexpected, leading to the need for further constraints and adjustments.

- AIDS-related deaths should account for a larger share of excess mortality in younger individuals (15-24 years) and a smaller share in older individuals (45+ years) due to increasing competition from other causes of death at older ages. This change aligns with observed competing mortality risks in older populations, where comorbidities play a larger role.
- The model initially attempted to enforce a constraint where AIDS-related deaths would account for a larger proportion of excess deaths at lower CD4 counts (CD4 < 50) compared to higher CD4 counts (CD4 > 500). However, this CD4 constraint was found to be infeasible, as it resulted in higher-than-expected AIDS-related mortality rates across multiple countries, failing to align with known estimates (~55% in 2019).

Refinements

- The model originally allowed non-AIDS excess mortality to vary by age, sex, CD4 count, and treatment duration.
- Simplifications were applied, leading to removal of sex-based and treatment-duration-based variations, which were found to be statistically insignificant.
- Model fitting was performed using incremental mixture importance sampling, generating posterior distributions for excess deaths attributable to AIDS.

After testing various constraints, the final version of the model:

- Retained the age constraint (higher AIDS-related mortality at younger ages, lower at older ages).
- Dropped the CD4 constraint (it led to inconsistent mortality estimates).
- Maintained variation by age and CD4 count but removed variations by sex, treatment duration, and exponent parameters.

Regional trends in excess mortality due to AIDS

The updated model was applied to data from 31 high-income countries in West and Central Europe and North America, using Spectrum's default high-income mortality pattern. Five additional countries had higher mortality patterns and were not included in the aggregated results. Distinct regional patterns were identified:

- High-income countries exhibit lower excess mortality rates and higher non-AIDS excess mortality rates, leading to a smaller proportion of excess deaths being due to AIDS (~55–60% by 2020).
- Latin America, the Caribbean, and Eastern Europe show similar declining trends but at higher overall mortality rates.
- The model predicts all excess deaths as due to AIDS in Middle East and North Africa (MENA), aligning with expectations given available data.

Discussion

Impact of mortality disaggregation on MENA estimates: Concerns were raised about the unexpected decrease in estimated PLHIV in MENA countries. This was attributed to numerical precision differences in mortality rate calculations, rather than a fundamental flaw in the model. It was recommended that North Africa maintain its mortality patterns in line with sub-Saharan Africa, with further refinements considered in the 2026 estimation round.

Long-term trends in AIDS vs. non-AIDS mortality: As ART coverage expands, the proportion of deaths due to AIDS will continue to decline. The updated mortality model does not shift the timing of the epidemic but does impact overall mortality levels, particularly in data-limited settings like Egypt. Future estimation rounds will focus on refining mortality assumptions for older adults, ensuring alignment between excess mortality trends and country-reported figures.

Detailed recommendations are available in Appendix A – recommendations.

Session 5: Sub-national estimates

Objectives

- Review proposed updates to sub-national demographics
- Review impact of moving away from urban/rural stratification on changes to key estimates in pre-data period.

Demographic inputs: subnational Spectrum files and EPP strata

Rob Glaubius presented a review of the demographic inputs used in subnational Spectrum files and subnational EPP stratifications. He focused on countries such as Ethiopia, Kenya, Zimbabwe, and Moldova, highlighting discrepancies between Spectrum estimates, WPP 2024, and national census data. The presentation also covered subpopulation files used in EPP for urban and rural populations.

Key findings

National and subnational population comparisons:

- **Ethiopia**: Discrepancies exist between Spectrum estimates and WPP 2024, with Spectrum showing a smaller population. The 2007 census data was also lower than WPP 2024 estimates. Further assessment is required to determine the best approach for improving estimates.
- **Kenya**: Better alignment was noted between Spectrum and WPP 2024, though some discrepancies exist in recent years. The 2019 census data was used for comparison. Subnational demographic updates are already in progress, making Kenya a model for other countries.
- **Zimbabwe**: Differences in age patterns were identified, with Spectrum showing a higher population than WPP 2024 and the 2022 census. The team will engage Zimbabwean authorities to resolve these inconsistencies.
- **Moldova**: Spectrum and WPP 2024 estimates were generally in agreement, except for a notable uptick in 2022 attributed to an influx of Ukrainian migrants. Migration assumptions may need updating to reflect recent geopolitical events.

Subnational EPP population files:

- Spectrum includes subpopulation files that provide urban-rural and regional demographic estimates. Most of these files were last updated in 2017 and may no longer reflect current population distributions. An internal review compared urban-rural population data from Spectrum to the 2022 UN Demographic Yearbook to assess the need for updates.

- Côte d'Ivoire (2021 Census): Rural population underrepresented in the subpopulation files. Differences in child population estimates, though less critical for HIV modelling.
- Gambia (2015 Census): Closer alignment with Spectrum files due to older census data availability. Some discrepancies in urban male populations.
- Botswana (2022 Census): Significant differences in urban-rural population distributions. The subpopulation files need updating to align with recent census data.
- Uganda (2014 Census): Some alignment issues in urban and rural population pyramids. If Uganda continues to use urban-rural stratification, the subpopulation files must be updated.

Discussion

- WPP 2024 changes will impact: perinatal transmission estimates; 90-90-95 HIV epidemic indicators; and age and sex-disaggregated projections. **Transparency is critical, and countries need to understand the impact of WPP 2024 updates on their HIV estimates.**
- Countries using subnational projections should be supported in reviewing and updating their demographic files.

- Spectrum subpopulation files will remain on hold until WPP releases updated urban-rural projections in 2025. Coordination with the UN Population Division is needed to confirm availability of age-sex disaggregation before any updates.

Session 6: ART coverage data discrepancies

Objectives

- Review Spectrum validation and input updates to support review and triangulation of ART coverage data discrepancies.

ART adjustments in Spectrum

John Stover focused on addressing discrepancies in Antiretroviral Therapy (ART) coverage data by reviewing the Spectrum validation process and input updates. The goal was to ensure accurate and reliable ART coverage estimates through improved data review and triangulation methods.

ART data discrepancies across sources

- National program data often differ from survey-based estimates, necessitating adjustments in Spectrum.
- Discrepancies arise due to variations in data collection methods, definitions of ART eligibility, and retention rates.
- Household surveys sometimes report lower ART coverage than program data due to self-reporting errors or survey non-response.

Key features of the Spectrum program statistics inputs editor

Stover introduced updates to the Spectrum program statistics inputs editor to improve ART data input, validation, and cross-checking.

- Users can input ART data from national health reports, surveys, and program records.
- A correction tool allows for modifications to ART numbers to align with observed data.
- New comparative tools highlight discrepancies between reported ART numbers and estimated HIV trends.

Adjustments for ART data

- To ensure accuracy in ART coverage estimates by adjusting for underreporting or overreporting.
- To maintain transparency by documenting any modifications made to ART data.
- ART data adjustments can be applied based on:
    - New data inputs – Incorporating updates from recent surveys and health system reports.
    - Historical trends – Ensuring consistency with previous ART coverage trends.
    - Cross-validation – Comparing ART data against HIV prevalence and incidence estimates.

Current use of ART adjustments

- Only 7 countries have used the adjustment tool for adult ART data.
- Only 2 countries have applied adjustments for pediatric ART.
- Adjustment ratios vary from 0.80 to 0.95, indicating differing country perceptions on overreporting.

Proposed changes to the adjustment process

To improve usage and visibility, the adjustment feature will:

- Move into the main ART data entry screen (currently located in a separate section).
- Set default values to 1.0, ensuring users actively decide whether to adjust data.
- Include a tool-tip explanation on when and why adjustments might be needed.

ART data validation and cross-checking

The validation process ensures that ART data is consistent with other health indicators, reducing errors and discrepancies.

Types of validation tools

- Trend analysis – Tracks ART coverage over time.
- Comparative analysis – Compares ART data against HIV prevalence and incidence trends.
- Anomaly detection – Flags inconsistencies in ART data reporting.

In some countries, program-reported ART coverage exceeds 100%, suggesting overreporting.

- ART coverage data does not always align with ANC-based ART estimates (from women initiating ART during antenatal care visits).

Proposed changes

- Add a direct validation button on the ART entry page to encourage real-time data checking.
- Expand comparative visualizations to better assess ART program data consistency.

Adjustments for subnational ART data

- Countries using subnational PJNZ files (e.g., Ethiopia, Kenya, Zimbabwe) report ART data by service location, not patient residence.
- This leads to distorted ART coverage estimates, where urban areas appear to have very high coverage while rural areas have underestimated ART uptake.

A new adjustment field will be introduced to:

- Account for patient movement between regions.
- Allow users to specify patient inflows and outflows for ART services.
- Nairobi records +X patients coming from other counties for ART services.
- Neighbouring countries record −X patients who seek ART treatment elsewhere.

This adjustment has been successfully tested in Kenya, which now tracks ART patients' residence in its electronic medical records.

Key findings

Discrepancies in ART coverage estimates

- Differences exist between program-reported ART coverage and survey-based estimates due to:
    - Variations in data collection methods.
    - Misalignment in reporting due to patient retention and migration.
    - Self-reporting errors in surveys.
- Some countries systematically over-report ART coverages, exceeding 100% for certain demographic groups.

Enhancements to ART data validation in Spectrum

- Spectrum validation now includes:
    - Comparisons between ART program data and antenatal clinic (ANC)-based ART trends.
    - Cross-checking survey-based ART estimates with program-reported numbers.
    - Tracking ART coverage over time relative to HIV incidence estimates.
- A direct validation button will be added to the ART editor screen for quick reference.

Subnational ART adjustments

- New adjustment options will help correct overestimated ART coverage in urban areas and underestimated coverage in rural areas.
- Countries with subnational PJNZ files will be encouraged to track patient movement between regions for ART services.

Discussion

Sex- and age-specific ART adjustment factors

- Only Burundi applied differential adjustments by sex, and this may have been due to pragmatic reasons (e.g., female ART coverage exceeding 100%) rather than data-driven choice. Participants agreed such disaggregation lacks empirical justification and may introduce errors.
- ART overreporting is typically systemic and unlikely to vary significantly by sex or age group. However, one country noted issues in child reporting, justifying a distinction between adult and paediatric adjustments.

Validation tools and sequence of fitting

- There was discussion around how validation against ANC-based ART coverage would be implemented and the fitting sequence between AIM and the program statistics editor. It was clarified that validation plots would reflect the most recent fit unless refitting occurs post-adjustment.
- **Sequence for adjustments:** first, adjustments for regional/international patient movement should be applied; then, proportional (DQA-based) scaling adjustments are implemented. Participants noted the importance of ensuring the **reallocation and adjustment logic is consistently applied** across tools including EPP, Naomi, Shiny90, and CSAVR. It was acknowledged that Spectrum currently passes adjusted ART totals to EPP via .ep4 files, and similar integration should be checked for Naomi and Shiny90.
- A suggestion was made to create a **guided workflow** within Spectrum, curating validation plots in a specific sequence and linking them to recommended adjustment steps based on outcomes. This aims to enhance usability and guide users through data review before finalizing ART estimates.

Subnational and cross-regional adjustments

- The discussion also touched on subnational ART estimates, particularly in countries with province-level Spectrum PJNZ files (e.g., Kenya, Zimbabwe, Ethiopia). A concern was raised that some ART estimates reflect service delivery location rather than patient residence, leading to overestimates in urban areas (e.g., Nairobi) and underestimates in rural areas. Proposals were made to add a geographic adjustment tool in Spectrum to correct for cross-regional patient movement. Countries with electronic medical records (EMRs) should be encouraged to provide patient residence data to improve ART allocation.

Naomi alignment and cross-tool calibration:

- Concerns were raised that Spectrum adjustments may override Naomi reallocations if not aligned.
- A strategy is still needed for how adjusted ART numbers influence program targets, especially where country systems (e.g., TX_CURR indicators) are not aligned with estimate adjustments. Participants recommended benchmarking ART coverage patterns across countries for quality checks.
- It was recommended that UNAIDS provide a slide deck or external visual resource comparing ART coverage trends across countries to help teams benchmark their own estimates, and linking such resources from within the Spectrum interface would enhance accessibility and uptake.

International ART recipients and migration:

- The new inter-regional adjustment feature was discussed for use in international contexts, such as Malawians receiving ART in Malawi but living in South Africa. Participants noted the risk of misusing this feature to adjust ART data.
- It was agreed to keep the feature available but controlled, with guidance that it should only be used when data on patient movement are available. Participants requested that the "allocated from another region" field be renamed to reflect that in national files this refers to international patient migration, while in subnational files it represents within-country regional shifts.

Session 7: Age distribution of new infections

Objective

- Review validation plots in the incidence rate ratio fitting tool

Incidence disaggregation in Spectrum

John Stover presented on incidence disaggregation in Spectrum, explaining how Spectrum receives incidence data from models like EPP or CSAVR and then needs to disaggregate it by age and sex.

- Incidence disaggregation: Spectrum receives HIV incidence data for adults (15-49 years) from models like EPP or CSAVR.
- Disaggregation methods: Spectrum has built-in default patterns (e.g., generalized pattern, concentrated pattern, IDU-driven pattern) but now increasingly estimates these patterns by fitting to either:
    - HIV prevalence data by age from surveys, or
    - ART numbers by age from program data.

Fitting process

If prevalence data is used, Spectrum compares estimated prevalence (solid lines) with survey estimates (points with confidence intervals). If ART data is used, Spectrum generates a plot comparing Spectrum estimates with ART program estimates.

Challenges and considerations

Spectrum lacks strong guidance on what to do when the fitting does not work well. While most cases produce a good fit, modifications can be tricky. The session was meant to explore whether additional guidance is needed to help users select the right data sources and validate their results.

Discussion

1. **Default patterns vs. fitting to data:** It was highlighted that countries are still using the generalized default pattern, which may be outdated and unjustified, particularly when country-specific survey or ART data are available. However, there was a prior conclusion that there was no need to update the generalized pattern, as most countries now have data to replace it. A suggestion was made to display a warning prompt in Spectrum when a user selects the default pattern, encouraging them to reconsider if country-specific data are available.
2. **Validation plot integration and comparability:** The utility of comparing ART program data with survey-based estimates to identify inconsistencies was highlighted.
3. **Interface and usability:** Avenir demonstrated Spectrum plots and discussed integrating ART program data more directly into the IRR fitting interface, improving user access to these plots. Concerns were raised about overloading the IRR fitting interface with plots, which could overwhelm users or cause them to misinterpret the source of inconsistencies. Users might incorrectly try to "fix" discrepancies in the IRR fitter rather than adjusting the underlying ART data. However, placing plots in context where they matter most (like the IRR fitter) could be beneficial, even if it leads users to dead ends, because it highlights the importance of checking data consistency.
4. **Context-specific guidance:** There was a suggestion to have conditional bullet-point guidance that could offer practical next steps (e.g., if ART coverage estimates are inconsistent with survey data, suggest checking ART input values). The need for a curated view or a recommended sequence of validation plots was emphasized to guide users logically through interpreting model outputs.
5. **Next steps:** Test changes in a few countries to determine what guidance or sequence of plots is most intuitive and whether new validation visuals help users make better informed decisions. Recommendation to explore integrating additional validation plots into the IRR fitting tool while still retaining them in the validation menu.

Appendix A

Recommendations

UNAIDS Reference Group on Estimates, Modelling, and Projections
Technical Updates meeting: 16-17 July 2024

Recommendation	Lead person(s)	Timeline
Session 1: Advanced HIV Disease (chair: Leigh Johnson) **Objectives:** • Review proposed updates to methods to estimate AHD in Spectrum		
Comparison of Spectrum AHD prevalence among diagnosed but untreated PLHIV with PHIA data Previously noted high levels and steep increases in AHD prevalence among diagnosed but untreated PLHIV in recent years are concentrated in WCA. Estimates in countries with PHIA surveys correspond well. In many WCA countries, while the percentage of AHD increased rapidly, the size of the 'diagnosed but untreated' population was very small. This may indicate ART data quality issues in WCA, such as over-enumeration of people on ART, leading to a small population of diagnosed but untreated PLHIV and sensitivity to interruption assumptions. **Recommendation:** Because the population diagnosed but untreated is small in WCA and contributes a small fraction to overall AHD, do not change the assumptions about CD4 changes after an interruption.		
Comparison of Spectrum AHD prevalence when including untreated PLHIV with CD4 counts 200-249 as having AHD with PHIA data • Report only on AHD prevalence using the CD4 <200 threshold in adults. Using a threshold of <250 to approximate the effect of including WHO stages III/IV is heuristic and is likely to cause confusion. • In upcoming 2025 estimates, ensure to review ART initiation and disease progression assumptions to ensure adjustments to match Thembisa do not create undesirable artefacts for other outcomes.		
Proportion with CD4 <200 among those on ART Recommended to report AHD prevalence among all PLHIV, including those who are on ART and virally suppressed, which is not available as an output from Spectrum model structure because CD4 recovery is not modelled. However, it was not yet determined which approach to estimate AHD among people on ART, among the following options discussed: 1) Assume only people on ART for less than 6 months, who initiated at CD4 below 200, contribute to AHD prevalence (as presented by John Stover). 2) Make assumptions based on PHIA data of AHD among those on ART who are virally suppressed or not, to estimate AHD prevalence among those on ART by ART duration and viral suppression status (as presented by Oli Stevens). 3) A combination of the two methods. 4) Obtain further ART clinical cohort-based information about CD4 count distribution according to baseline CD4, duration on ART and VL suppression status.	Working Group	2025 estimates

Recommendation	Lead person(s)	Timeline
Some of the specific issues to resolve: • How important is it to disaggregate AHD in ART patients into virally suppressed vs unsuppressed? This may be clinically important, but from a modelling/data perspective, this disaggregation is complicated. Mary-Ann Davies may be able to identify published information on CD4 distributions in virally suppressed patients. • Can approach (2) be adapted to take into account data on baseline CD4 distribution and rates of CD4 recovery during first year of ART? Leigh will share the publications underlying the Thembisa assumptions. • Approach (1) is intended to represent AHD only at early ART durations, not at longer ART durations. How would it be extended to longer durations? • We would ideally like to report trends in AHD prevalence over time, but some of the assumptions (based on data post-2015) might not be appropriate for earlier years. Perhaps this is not a major concern, since there were relatively few people on ART in the earlier years and in any case, most users aren't interested in older model estimates. • Validate approximation (1) to AHD prevalence in people on ART using PHIA data.		
Compare CSAVR's CD4 at diagnosis and Spectrum's CD4 at ART initiation • Investigate reasons for some of the poor correspondence between CSAVR estimates of AHD at HIV diagnosis and programme data (for example in Estonia and Japan). Is this because of the overall CSAVR estimated HIV trends in these countries being problematic? • Why does the modelled AHD prevalence increase exponentially in recent years in some countries? • Optionally, add into the CSAVR validation, any program CD4 data entered to GAM (about patients at initial diagnoses and/or at ART initiation) but not entered into CSAVR	Guy Mahiane	November 2024
New Spectrum AHD input editors and outputs Add an output to Spectrum for AHD at the time of ART initiation. This will be used primarily for validation purposes. However, there should be some form of guidance for people doing validation, noting the limitations of programme data (most significantly, that the completeness of baseline CD4 testing is often low, but also that programme data typically relate to CD4 at first ART initiation, whereas Spectrum also includes re-initiators). Capture AHD programme data indicators as: • Number initiating ART • Number tested for CD4 • Number with CD4 <200	Avenir Health	November 2024
Session 2: Cryptococcal meningitis (chair: Cari van Schalkwyk) **Objective:** • Review implementation of CM cases and deaths calculation in Spectrum		
Compare Spectrum outputs for AIDS deaths by care cascade stage and ART duration and CM model output for CM deaths by cascade stage and ART duration	Avenir Health	November 2024
Country-specific CrAG prevalence estimates are often based on small sample sizes resulting in high variability. Apply random-effects model to smooth country-specific CrAG prevalences.	TBD	November 2024
Validate Spectrum CM case outputs in Botswana and South Africa against programme data, which can serve as a lower limit for estimated cases (programme data only include lab-confirmed cases).	Joe Jarvis, Nelesh Govender, Avenir Health	November 2024

Recommendation	Lead person(s)	Timeline
Review estimates and definition of 'in care' by ART cascade stage (not aware of HIV; aware but not in ART; on ART)		November 2024
Session 3: Key population size estimates in sub-Saharan Africa (chair: Sharmistha Mishra) **Objectives:** • Review key population workbook timeline and process • Review proposed use of Triangulator tool for PSE data synthesis in 2025 key population workbooks		
Key population workbook process timeline, including review and UNAIDS validation Summary: Aim is to move from an external desk review process for collating key population surveillance data, to (1) country-led process of completing the KP workbook (building on the pre-populated efforts via the KP-data syntheses already completed re: countries across SSA); and (2) for KP workbook to become integrated within the full UNAIDS-estimation process (i.e. KP workbook feeding into the GOALS-ARM model whose national-level outputs are then fed back into the KP workbook, followed by KP workbook outputs then fed into the SHIPP tool). To achieve these two goals, a graduated process will include: (i) information/training with UNAIDS SI team who will bring together KP-knowledge experts within each country; (ii) implementation of KP workbook completion by country teams via 2-day workshop in Nov 2024 prior to in-person estimation workshops starting in Dec 2024. Issues raised & recommendations: 1) Review alignment with other estimates (especially regarding KP pop size estimates) conducted within-countries for the COP process, Global Fund applications, etc. 2) Develop an approach for validation of the KP workbook (e.g. same two pilot-test settings for GOALS-ARM KP [Kenya, Malawi]; countries which have already undertaken specific national-level estimates for KP PSE [Mali, South Africa]). The KP workbook validation could be supported by PEPFAR.	UNAIDS, KP working group	2025 estimates
Triangulator: implementation in key population workbook Issues raised & recommendations: (1) Triangulator recommended as an option (not requirement) (2) User guide for triangulator and aggregator steps: (a) transparency surrounding how to interpret "confidence" with more precision re: terminology, clarification on how inputs on confidence are used (relative/absolute scale); (b) guidance on priors for district-level and national-level	CDC	2025 estimates
Session 4: Excess mortality among PLHIV (chair: Eline Korenromp) **Objective:** • Review revision of method to address unexpected pattern that more excess deaths are due to non- AIDS causes at lower CD4 categories		
Implement in Spectrum 2025 the split of excess mortality among PLHIV (between AIDS and non-AIDS) for WCENA, LA, CAR, EECA and AP regions, using Avenir Health's implementation onto Spectrum's overall excess mortality patterns (unchanged, fitting ART-CC and IeDEA multi-site patient cohorts) – including the refinement imposing an increasing % of AIDS deaths in older ages. Apply the non-AIDS excess mortality for both on-ART and off-ART patients in these regions. Revisit for 2026 round the option to implement the same for MENA (whose excess mortality rates are equated to ESA/WCA, for lack of regional data).	Avenir Health	01 Jan 2025 End-2025
Session 5: Sub-national estimates (chair: Tim Brown) **Objectives:** • Review proposed updates to sub-national demographics		

Recommendation	Lead person(s)	Timeline

Demographic inputs: subnational PJNZ files and subnational EPP stratifications
 	
Summary: aim is to review current sub-national population urban/rural population distributions in both countries using sub-national Spectrum and countries using urban/rural population structure in EPP to see the extent to which WPP 2024 may affect the sub-national Spectrums and to decide if the subpopulation files should be revised and, if so, when.
 	
• For the five countries currently using Spectrum sub-national PJNZs, work closely with the countries to examine differences with WPP 2024 and with recent censuses, where available
  ○ Ethiopia, India, Kenya, Moldova, and Zimbabwe
  ○ In reviewing censuses, carefully examine and account for possible undercounting issues w/children and working age adults that can affect results. UN Population Division projections do account for these effects
• For other countries, recommend the teams consider updating their Spectrum projections to WPP 2024
  ○ Recommend UNAIDS Data Team and workshop facilitators work with countries to understand any resulting differences in projections
• On the updating of EPP subpopulation (subp) files for countries using urban/rural breakdowns:
  ○ Revise these files in 2025 when the next version of UN Population Division World Urbanization Prospects will become available
  ▪ Check with Patrick Gerland at UN Pop Division to verify that age-sex urban/rural stratifications will be available
  ○ Develop a process for the periodic updating of these files (assuming countries continue to use sub-national EPP fits)
• In terms of understanding differences between the EPP subpopulation (subp) files and censuses:
  ○ Undertake an examination like that presented at this meeting by Rob with earlier censuses to see how census rounds compare with the subp age-sex distributions
  ○ Develop a slide set for a sample set of countries to document how population projections change before and after a census is done as examples of the magnitude of uncertainty about population estimates
  ▪ Perhaps working with Patrick Gerland at UN Pop Division who had earlier said they could produce such results from historical WPP iterations preceding new census data
	Rob Glaubius	

Removing sub-national EPP stratification: impact on key estimates
 	
Summary: Review and decide on the provisional Reference Group recommendation from the Addis meeting of: Encourage users with urban/rural population structures to consider switching to a consolidated single national EPP region. Key points from the meeting were:
 	
• Jeff to provide an analysis of the impact of changing to a single national EPP region on key indicators for urban/rural Sub-Saharan African countries
  ○ Indicators: incidence, prevalence, AIDS deaths, and children living with HIV
  ○ Summary and report to be circulated in week after this meeting for review & discussion
• Reference Group to convene a virtual working group to review this and make decision on action on the Addis provisional recommendation
	Jeff Imai-Eaton, Working Group	Nov 2024

Session 6: ART coverage data discrepancies (chair: Jeff Imai-Eaton) **Objective:** • Review Spectrum validation and input updates to support review and triangulation of ART coverage data discrepancies		

Recommendation	Lead person(s)	Timeline
Summary: John Stover presented changes to Spectrum input editors, data visualization, and validation comparison plots intended to make tools for adjusting ART input data and triangulating data more accessible to users. Key changes presented were: • Moving specification of proportion adjustment to ART input data from a separate pop-up window to additional lines in the main adult ART input window, such that all users see the adjustment row. Similar line will be added to the child ART input window. • Adding a row for count adjustment who receive ART in other regions. Upon discussion, it was determined this feature could also be used to specify international adjustment of people residing in other countries if there is specific data quantifying this. • Add a button in the Programme Statistics ART editor to review the ART coverage validation with ANC ART coverage, instead of only appearing under Spectrum validation tab. Meeting participants endorsed the proposed changes and anticipated that they will improve engagement with critically reviewing ART programme data adjustments in the upcoming estimates round and suggested several further refinements to the proposed editors and validation plots. Additional steps, multi-country review resources, and guidance materials were suggested, as enumerated below:		
ART coverage validation plot: Additional refinements recommended for the plot showing population ART coverage versus ART coverage predicted from routine ANC ART coverage: • Add separate lines showing programme data ART coverage based on unadjusted and adjusted ART programme data • Add lines showing the observed ANC ART coverage and the predicted population ART coverage, to illustrate the predicted coverage • Add survey ART coverage estimates to the validation plot	Avenir Health	Nov 2024
ART coverage by sex validation plot: Create a new validation plot showing adult ART coverage by sex over time. For countries with household survey ART coverage, visualize comparison with survey ART coverage by sex. For other countries, illustrate some summary ranges to illustrate whether modelled ART coverage sex differentials are outside of typical ranges.	John Stover, Rob Glaubius, Jeff Imai-Eaton	Nov 2024
ART coverage by age validation plot: There is an existing plot comparing Spectrum ART totals by age and sex with survey ART counts by age. When age-stratified ART data are entered, add bars showing observed ART counts by age alongside the Spectrum modelled ART totals and survey estimated ART totals.	Avenir Health	Nov 2024
International ART resident adjustments: The new input lines for counts of patients allocated from/to another region may be used in national PJNZ files to account for net patients receiving ARVs from the national programme but residing in a neighbouring country or vice versa *if* there is quantitative information about number of clients taking treatment to/receiving treatment from outside the country. General adjustments to reconcile ART totals (without specific evidence of clients in other regions / countries) should be applied through proportional adjustments. • Adjustment calculation ordering: first regional/international count adjustments are applied to programme data total. Proportional adjustments are applied after. • **Recommendation:** Update "allocated from another region" terminology in Spectrum editor to reflect use potential use case for international adjustments. • UNAIDS should review draft and final Spectrum files collectively to assess any major imbalance in net ART clients allocated outside PJNZ files. PEPFAR will support review of country net ART allocation based on country programme partners expertise.		

Recommendation	Lead person(s)	Timeline
Guidance resources and examples: Create slides visualizing examples across multiple countries of typical and atypical ART coverage trajectories and triangulation results as guidance materials for users to compare their own country results and adjustment decisions. Prominently link from Spectrum software multi-country summary slides on HIV tools website. **Curation of validation plots:** Create a curated view of Spectrum validation plots and a sequence in which to view them. If possible, provide specific guidance based on results of validation plots for likely strategies to address discrepancies. **Other models / software:** Review other models and software to ensure that changes to Spectrum adjustments, namely the new region ART reallocation feature, is applied consistently. • EPP: Spectrum provides EPP with adjusted ART totals by sex through the .ep4 file. No further adjustments required. • Shiny90 and CSAVR: Review whether any software changes are required to ensure region reallocation is incorporated in ART totals. • R implementation of EPP-ASM and Shiny90: Requires update to address region re-allocation [not used in Spectrum; required for Naomi]. • Naomi: Ensure that Naomi ART calibrations are implemented consistently with Spectrum reallocations. Review subnational ART region allocation in Spectrum files and Naomi fitted results for broad consistency in Ethiopia, Kenya, and Zimbabwe.		
Session 7: Age distribution of New Infections (chair: Leigh Johnson) **Objective:** • **Review validation plots in the incidence rate ratio fitting tool**		
Although there have been useful suggestions to add further validation plots, there is also concern that too many validation plots might overwhelm users, so that they don't do validation at all (or get confused about what to prioritize). Two possible ways forward: 1. Add a 'Guidance' button, which automatically pops up with information on validation plots that look suspicious/worrying, depending on 'goodness of fit' metrics. 2. Provide a recommended sequence for going through the validation plots. The recommendation is to test both possible approaches with a few countries.	Avenir Health	Nov 2024

Appendix B

Participants

Name	Organization
Adam Trickey	Bristol University
Ajay Rangaraj	WHO
Andreas Jahn	MoH Malawi
Anna Yakusik	UNAIDS
Ard van Sighem	Amsterdam UMC
Avi Hakim	CDC
Cari van Schalkwyk	SACEMA
Carl Corcoran	CDC
Danielle Payne	CDC
David Boulware	University of Minnesota
Eleanor Gouws	UNAIDS
Elfriede Agyemang	CDC
Eline Louise Korenromp	UNAIDS
Eleni Seyoum	UNAIDS
Guy Mahiane	Avenir Health Inc
Hmwe Kyu	IHME UW
Ian Fellows	CDC
Ian Wanyeki	UNAIDS
Jeffrey Imai-Eaton	Harvard University
John Stover	Avenir Health Inc
Joseph Jarvis	LSHTM
Keith Sabin	UNAIDS
Kelsey Case	UNAIDS consultant
Laura Porter	CDC
Le Bao	PSU
Leigh Johnson	University of Cape Town
Mary Mahy	UNAIDS
Mary-Anne Davies	University of Cape Town
Mathieu Maheu-Giroux	McGill University
Melissa Arons	CDC
Michelle Selim	PEPFAR
Morris Ogero	MoH Kenya
Nancy Tahmo	University of Toronto
Nandita Sugandhi	WHO
Nathan Ford	WHO
Nikos Pantazis	University of Athens
Oli Stevens	Imperial College London
Parviez Hosseini	PEPFAR
Rachel Esra	Avenir Health Inc
Ray Shiraishi	CDC

Reshma Bhattacharjee	USAID
Reshma Kassanjee	University of Cape Town
Rob Glaubius	Avenir Health Inc
Italia Rolle	UNAIDS
Sharmistha Mishra	University of Toronto
Tim Brown	East West Center
Vania Wang	CENSUS
Wiwat Peerapatanapokin	East West Center
Wolfgang Hladik	CDC
Yuri Munsamy	SACEMA

Appendix C

Agenda

Day 1: Wednesday, 16 October

Time	Duration (mins)	Topic	Presenter(s)/ Lead Discussant
14.00	20	Welcome and introductions; 2024/25 estimates workshops and timelines	Mary Mahy
14.20	5	Meeting objectives and recommendation review	Cari van Schalkwyk
Session 1: Advanced HIV Disease (chair: Leigh Johnson) **Objective:** • Review proposed updates to methods to estimate AHD in Spectrum			
14.25	20	• Proportion with CD4 <200 among those on ART with unsuppressed VL and suppressed VL, by duration on ART • Comparison of Spectrum CD4 < 100 prevalence among diagnosed but untreated PLHIV with PHIA data • Comparison of Spectrum AHD prevalence among diagnosed but untreated PLHIV with PHIA data • Comparison of Spectrum AHD prevalence when including untreated PLHIV with CD4 counts 200-249 as having AHD with PHIA data	Oli Stevens
14.45	10	• Compare CSAVR's CD4 at diagnosis and Spectrum's CD4 at ART initiation	Guy Mahiane
14.55	10	New Spectrum AHD input editors and outputs	John Stover
15.05	45	Discussion	
15.50	10	BREAK	
Session 2: Cryptococcal meningitis (chair: Cari van Schalkwyk) **Objective:** • Review implementation of CM cases and deaths calculation in Spectrum			
16.00	20	Review implementation of Minnesota model in Spectrum, informed by AHD cascade data through new editor	John Stover
16.20	30	Discussion	
Session 3: Key population size estimates in sub-Saharan Africa (chair: Sharmistha Mishra) **Objectives:** • Review key population workbook timeline and process • Review proposed use of Triangulator tool for PSE data synthesis in 2025 key population workbooks			
16.50	10	Proposal for key population workbook process timeline, including review and UNAIDS validation	Keith Sabin
17.00	20	Triangulator: implementation in key population workbook	Oli Stevens/ Carl Corcoran
17.20	40	Discussion	
18.00		CLOSE	

Day 2: Thursday, 17 October

Time	Duration (mins)	Topic	Presenter(s)/ Lead Discussant
Session 4: Excess mortality among PLHIV (chair: Eline Korenromp) **Objective:** • Review revision of method to address unexpected pattern that more excess deaths are due to non-AIDS causes at lower CD4 categories			
14.00	15	Non-AIDS excess deaths in high income countries: Revision of method	Rob Glaubius
14.15	20	Discussion	
Session 5: Sub-national estimates (chair: Tim Brown) **Objectives:** • Review proposed updates to sub-national demographics • Review impact of moving away from urban/rural stratification on changes to key estimates in pre-data period			
14.35	20	Demographic inputs: subnational PJNZ files and subnational EPP stratifications	Rob Glaubius
14.55	10	Removing sub-national EPP stratification: impact on key estimates	Jeff Imai-Eaton
15.05	45	Discussion	
15.50	10	BREAK	
Session 6: ART coverage data discrepancies (chair: Jeff Eaton) **Objective:** • Review Spectrum validation and input updates to support review and triangulation of ART coverage data discrepancies			
16.00	10	Spectrum Program Statistics inputs editor, default ART numbers adjustment specification, and validation visualisations	John Stover
16.10	50	Discussion Guidance on steps for ART data review and adjustments	
Session 7: Age distribution of new infections (chair: Leigh Johnson) **Objective:** • Review validation plots in the incidence rate ratio fitting tool			
17.00	10	Consolidate validation plots for multiple data sources about prevalence and PLHIV by age, in the IRR fitting tool	John Stover
17.10	20	Discussion	
17.30		CLOSE	