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Delivery Unit Costs for Antiretroviral Treatment and Prevention of Mother-to-Child-Transmission of HIV:

A Systematic Review for Low and Middle Income Countries

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Abstract

Background—As antiretroviral treatment (ART) for HIV/AIDS is scaled-up globally, information on per-person costs is critical to improve efficiency in service delivery and maximize coverage and health impact.

Objective—To review studies on delivery unit costs for adult and pediatric ART provision per-patient-year, and prevention of mother-to-child transmission (PMTCT) interventions per mother-infant pair screened or treated, in low- and middle-income countries.

Methods—Systematic review of English, French and Spanish publications from 2001 to 2009, reporting empirical costing that accounted for at least antiretroviral (ARV) medicines, laboratory testing and personnel. Expenditures were analyzed by country income level and cost component. All costs were standardized to 2009 US dollars.

Results—Analyses covered 29 eligible, comprehensive costing studies. In the base case, in low-income countries (LIC), median, ART cost per patient-year was $792 (mean: $839, range: $682-$1089); for lower-middle-income countries (LMIC), the median was $932 (mean: $1246, range: $156-$3904); and for upper-middle-income countries (UMIC) the median was $1454 (mean: $2783, range: $1230-$5667). ARV drugs were largest component of overall ART cost in all settings (62%, 50% and 47% in LIC, LMIC and UMIC respectively). Out of 26 ART studies, 14 report which drug regimes were used, and only one study explicitly reported second line treatment costs. The second cost driver was laboratory cost in LIC and LMIC (14% and 19.5%) whereas it was personnel costs in UMIC (26%). Two studies specified the types of laboratory tests costed, and three studies specifically included above-facility-level personnel costs. Three studies reported detailed PMTCT costs, and two studies reported on pediatric ART.

Conclusions—There is a paucity of data on the full ART and PMTCT delivery unit costs, in particular for low-and middle-income countries. Heterogeneity in activities costed and insufficient

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detail regarding components included in the costing hampers standardization of unit cost measures. Evaluation of program-level unit costs would benefit from international guidance on standardized costing methods, and expenditure categories and definitions. Future work should help elucidate the sources for the large variations in delivery unit costs across settings with similar income and epidemiological characteristics.

Keywords

HIV treatment costs; ART; PMTCT; developing countries; systematic review; meta-analysis

1. Introduction

Cost evaluations support program planning and budgeting, can help to ensure program sustainability, and are a pre-requisite in identifying opportunities for efficiency gains. [1, 2] As global health institutions strive to ensure "value for money," they are committed to supporting countries to measure per-person delivery costs of key services.[3–8] Since 2008, many national HIV/AIDS programs have made an important advance in complying with the bi-annual routine reporting of nationally aggregated expenditures as stated in the 2001 Declaration of Commitment on HIV/AIDS (UNGASS) to UNAIDS.[9] However, UNGASS reporting does not express program expenditures as per-person unit costs, nor does it request a comprehensive break-down of the cost components included in each service area. As of 2010, most HIV/AIDS programs do not routinely assess their cost per person or per unit of service delivery, nor do they have expenditure breakdowns by cost components using standardized methods.

For antiretroviral treatment (ART), scale-up of treatment access in low- and middle-income studies started in 2004–5, when funding increased substantially with new donor funding from the Global Fund to Fight AIDS, Tuberculosis and Malaria, and the U.S. President's Emergency Plan for AIDS Relief (PEPFAR), among others. As of the end of 2009, an estimated 5.2 million HIV-infected people were receiving ART globally; with the WHO's revised 2010 guidelines on HIV treatment in resource-limited settings, the total immediate need is now estimated at 15 million eligible people worldwide.[10] The ongoing scale-up and progress toward *Universal Access* will depend on both total available funding and the delivery cost per patient-year in high-HIV countries.

Previous reviews of ART – facility-level or per-patient – costs found only a very small number of studies from low- and middle-income countries [11, 12] and estimated the cost of antiretroviral (ARV) medicines from manufacturers' procurement price lists, as an average per country income-group.[12] For Prevention of Mother-to-Child Transmission of HIV (PMTCT), (unit) delivery costs have not been reviewed since 2000.[13] The most recent ART costs review [14] included more studies from low- and middle-income countries and presented a scoring system to rate studies' methodological quality – without attempting a quantitative meta-analysis of cost results.

To complement these overviews, we conducted a systematic literature review and a meta-analysis of per-patient unit expenditures on adult and pediatric ART as well as ARV prophylaxis used for PMTCT, using explicit guidelines for systematic reviews, and standardizing data from eligible studies into common service delivery units and cost component categories. Per-patient costs are presented as median, arithmetic average, and ranges across eligible study sites, studies, countries and country-income-level groupings, separately for the most important standardized cost components. We discuss results in the light of information requirements anticipated from National AIDS Programs from major global financiers of HIV/AIDS program scale-up.

2. Methods

2.1. Literature Search

The literature search followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[15] Original articles published in English, French and Spanish from January 2001 to October 2009 were searched using PubMed, EconLit and Cochrane Library, and gray literature through Google Scholar and POPLINE. In addition, websites of international donor organizations such as UNAIDS, WHO, World Bank, PEPFAR, UNICEF were searched. We also screened abstracts from the International AIDS Conferences 2001–2008, International Health Economics Association 2006–2008, American Society for Health Economists 2006–08, International AIDS Economics Network 2008, and PEPFAR Implementer's meetings 2008–09 for contextual information to the published data. References identified as relevant served to track additional studies of interest. Annex A (all annexes available in Supplemental Digital Contents only) details the search terms used on electronic databases. Annex B shows the search commands and number of studies found.

2.1A. Inclusion criteria

- Country-specific, empirical measurement of actual expenditures, from micro-costing or ingredients approach. (If the study used solely a step-down approach it was excluded);
- Study (or study data point) included at least 25 patients;
- Low- and middle-income countries, according to the July 2009 World Bank list of economies[16] with both publication and data collection between January 2001 and October 2009;
- Costing included *at least* antiretroviral drugs (ARVs), laboratory expenses and personnel, as three individually reported expenditure components, or as explicitly named components of a comprehensive but unbundled overall expenditure;
- Economic costs from the health care provider perspective; financial costs included if economic costs were not available. (Economic costs accruing to patients such as waiting time, transportation time, and productivity losses were not considered because of the inherent difficulties associated with assigning opportunity costs in the absence of accurate data on wages and time costs). (A list of excluded studies is available in Annex D).

2.1B. Data extraction—Eligible articles were reviewed for inclusion by at least two independent reviewers (OG and VW or AML), using a pre-determined data extraction form (see Annex C). When the decision was "in doubt", a third or fourth reviewer (YST or AFL) analyzed the article; inclusion was solved by consensus. If the information contained in the full-text article was incomplete, its authors were contacted to obtain missing data.

2.1C. Standardization of data—ART delivery unit cost data were standardized as estimates per patient-year, separately for first-line and second-line ART, or weighed by their local mix of patients. Pediatric ART was distinguished from adult ART using an age cut-off of 15 years. Components of total costs were categorized as follows:

- Antiretroviral medicines (ARVs); including, if available, transport of drugs to point of care, and storage;
- Personnel involved in delivering ART, including education and training, as well as supra-facility level human resources, if specified (such as personnel in distribution

centers or district/provincial/national program management, or monitoring and evaluation);

- Laboratory tests, including CD4 cell counts and viral load, as well as other tests, if specifically mentioned.
- Overhead costs including administration and utilities (electricity, water, phone, rent, maintenance costs, cleaning, security);
- Other components considered and reported as part of delivery unit costs, such as: concomitant medications (for opportunistic infections or prophylaxis such as Septran), other supplies (e.g., cotton, syringes, gloves), staff transport for home visits (i.e., trained field officers visit patients' homes periodically to deliver drugs, clinically monitor participants with a checklist on signs and symptoms of drug toxicity or disease progression, and provide adherence support), depreciated capital costs (medical and non-medical equipment), as well as other recurrent costs, when those breakdowns were available.

For **PMTCT**, reported costs were either per HIV-infected pregnant woman receiving ARV prophylaxis, or per pregnant woman initially tested and counseled for HIV. In each case, costs covered the woman-neonate pair throughout the pregnancy/birth period. Cost components were categorized as follows:

- ARVs given before, during and/or shortly after birth to mother and/or child to prevent transmission (including transport cost of ARVs to point of care and storage);
- Personnel involved in delivering PMTCT, including education and training, as well as supra-facility level personnel, if specified;
- Laboratory tests (including HIV testing, CD4 cell counts and viral load);
- Overhead costs including administration and utilities (electricity, water, phone, rent, maintenance costs, cleaning, security);
- Other components, as listed by specific studies.

We report all costs in October 2009 US dollars (USD), after foreign currency conversion using average annual exchange rates provided by original study authors or from the International Monetary Fund[17] (except, in the case of a study of ART in Lesotho[18], directly from a Central Bank[19] source for lack of the relevant exchange rate from the IMF). Once converted into USD, costs were adjusted for inflation using the U.S. Consumer Price Index (CPI).[20]

2.2. Data aggregation and sensitivity analysis

The analysis focused on economic costs from the perspective of the provider. Specified economic costs to the patient were included only if a monetary transaction took place so that the service would occur (e.g., a co-payment or recuperation fee paid for by the patient); in which case they were added to the overall costs.

Unit costs and unit cost components were summarized as mean, median and range across countries studied (after aggregation across multiple sites, or data points within each country), within country income level groups: low-income countries (LIC), lower-middle-income countries (LMIC), and upper-middle-income countries (UMIC), according to the World Bank's 2009 country classification.[16] This method of aggregation prevented countries with relatively large numbers of data points to skew the results. In sensitivity analyses, we explored the robustness of results against alternative ways of aggregating

results across sites, countries and country-income groupings, and of different study inclusion criteria.

3. Results

Out of 574 abstracts retrieved, 150 full-text studies were assessed for eligibility; of those, 29 were included in analysis: 26 on ART (23 on adult ART, two on adult and pediatric ART[21, 22], and one on pediatric ART only) [23] (tables I, II and III). Table IV provides results for the base case and the sensitivity analysis for ART unit costs, and fig. 2 summarizes the most relevant findings. Three studies for PMTCT are detailed in table V. (Expanded versions of tables with additional information and annexes are available as Supplemental Digital Content).

3.1. Antiretroviral Treatment

Six studies from four low-income countries (LIC) were included (Benin, Ethiopia, Haiti and Uganda); the median cost per patient-year of ART was $792 (mean $839, range $682 to $1,089) (tables I & IV).[22, 24–28] Studies for lower-middle-income countries (LMIC) were found for India[29, 30], Lesotho[18], Morocco[31], Nigeria[32, 33], and Thailand [34]; the median cost of ART was $932 (mean $1,246, range $156 to $3,904) (tables II & IV). In upper-middle-income countries (UMIC), Brazil [23, 35], Mexico [36–38] and South Africa [21, 39–45] the median ART cost was $1,454 (mean $2,783; range $1,230 to $5,667) (tables III & IV).

ART unit costs and its components varied considerably both between countries and studies,– such as South Africa[21, 39–45] – and between sites within one study (e.g., Gupta et al, 2009[29]) (fig. 2). While variations between studies may in part reflect differences in costing methods and definitions, variations within studies point to the existence of real differences in actual cost between sites and/or patient populations.

3.1A. ARV medicines—In all three income groups, ARV medicines were the largest cost component. In low-income countries, they represented 64% of the overall costs, at a median $428 per patient-year (mean: $456 (62%), range: $205–$607 (37% – 78%)) (table I). In lower-middle income countries, ARV medicines represented 50% of overall cost at a median $127 (mean: $463 (54%), range: $46–$3415 (35%–88%)) (table II). In upper-middle income countries, ARV medicines covered 47% of cost, at a median $958 per patient-year (mean: $1473 (53%), range: $104 – $6,024 (4%–96%)) (table III).

3.1B. Laboratory—In LIC and LMIC, laboratory costs were the second most important cost component. In LIC they accounted for 14% of overall costs (median $123; mean: $133 (17%), range: $16 – $242 (6–30%)) (table I). In LMIC laboratory costs corresponded to 20% of overall costs (median cost of $42; mean: $106 (18%), range: <$1 – $462 (<1% – 32%)) (table II). In UMIC, laboratory costs accounted for 10% (median of $223; mean: $319 (14%), range: $40 – $1174 (3% – 41%) of ART cost (table III), being the third largest cost component after personnel.

3.1C. Personnel—In LIC and LMIC, personnel costs were the third most important cost component, corresponding to 3% in LIC [median $22; mean: $66 (9%), range: $12 – $243 (1%–29%)], (table I), and 8% in LMIC [median $12; mean: $82 (13%), range: $7–$391 (6%–38%)], (table II) of overall costs, respectively. In UMIC, in contrast, personnel costs were the second most important cost component at 26% of overall cost [median cost of $383; mean: $535 (24%), range: $6 – $2098 (0.4% – 55%)] (table III).

Most studies for ART (23 out of 26) included the cost of personnel only at the facility level. While types of services costed varied, only seven studies reported details of the types of personnel included [26, 30, 35, 39, 41, 43, 44]. Of these, three costing studies included above-facility level personnel such as human resources at distribution centers or district/provincial/national program management, or monitoring and evaluation in the personnel cost component.[29, 30, 33] (See section 3.1D below).

3.1D. Program-level costs—Three studies included program-level costs associated with ART delivery.[29, 30, 33] Across two urban sites in India [29] program-level costs on medical and administrative personnel other than those directly involved in ART delivery to patients were reported to be about 16% of per patient-year recurrent costs during the first year of the program, falling to about 7% in the second year. Another study in India[30] included a project coordinator working across different health facilities under personnel cost. In urban Nigeria[33], reported above-facility expenses included transport of drugs from federal central facilities to the ARV centers.

3.2. Pediatric ART

We identified two studies reporting costs of ART for patients below 15 years of age. In UMIC Brazil, costs of ART in a university hospital were $2,039 per year for outpatient children [23]; weighed across all children (14% of whom were inpatient), the average yearly cost was $2,826. In LIC Ethiopia [22] a total cost per child-year was found of $961 for new patients (within first 6 month of treatment) and $933 for established patients, with ARVs covering $607 (over 60% of total cost), and laboratory tests $191 (20%) in new or $94 (10%) in established patients.

3.3. PMTCT

Three eligible PMTCT costing studies were analyzed. The cost per mother-neonate pair receiving nevirapine around child delivery was $251 in India[46], $ 209 in South Africa [47] (both middle-income countries), but only $6.4 in Rwanda[48], a LIC (table V). (The large difference in cost in the latter study suggests that not all components were comparable).

The South Africa study[47] presented a thorough costing in already existing facilities, focusing on the added financial costs utilized specifically by the PMTCT program. Across four facilities, the average unit cost per HIV-infected mother-neonate pair receiving prophylactic nevirapine services was $209. This cost included nevirapine to mothers at delivery, as well as provision of nevirapine suspension to the infant and formula milk for the duration of the hospital stay. Additional costs estimated in the study were: $42.4 for the pre-test counseling, and $32.5 for testing costs. The study reported a substantially higher cost for post-discharge follow-up care at $327 per HIV-infected mother/infant pair covering cotrimoxazole and provision of infant formula after birth for the duration of the hospital stay (table V). The unit costs varied according to the denominator unit used (pregnant women screened, women tested, HIV-infected women and neonate pair, number followed) as well as between the four locations according to their economic and epidemiological differences: e.g., a high HIV prevalence, resource-poor setting (Frankfort, Free State) compared to a low-HIV-prevalence, better resourced setting (Paarl, Western Cape).

In Andhra Pradesh, India[46] across 16 PMTCT centers 1,212 HIV-infected pregnant women received PMTCT, out of 125,073 pregnant women counseled and tested. The average economic cost per HIV-infected woman receiving nevirapine around child delivery was $251. Expressed per pregnant women counseled and tested irrespective of HIV status, average unit cost was $2.40. Given the low price of nevirapine, personnel was the major cost

component, at $119 or 47% of overall cost per HIV-infected woman, followed by $37 (15%) on overhead.

In Rwanda[49], the PMTCT unit cost was much lower, at $6.4 for a specific intervention. This marked contrast is in part explained by Rwanda's much lower *per-capita* income level and health worker salaries. Equally important, this unit cost was achieved in a large-scale program in a high-HIV prevalence setting, with the six health centers covering a catchment population of 148,151 persons with a high PMTCT uptake rate of 71.6% that likely achieved significant economies of scale. However, the study does not specify number of pregnant women screened for PMTCT, the number of HIV-infected women, or the number of mother-infant pairs given NVP.

3.4. Sensitivity Analysis

A first sensitivity analysis assessed the effect of aggregating unit cost within country income groups by weighing all data points and sites across studies and countries equally, instead of the base-case model (presented above) that weighed all countries equally irrespective of their number of data points. In this variant model, median unit costs of ART were nearly unchanged for LIC and UMIC: in LIC the median was $797 (compared to $792 in base-case model) and for UMIC 1,397 (compared to $1,454 in base-case model, table IV). For LMIC, however, this alternative aggregation method resulted in a three-fold reduced median cost estimate per patient-year, of $298 compared to $932 in the base-case. This difference reflects an overrepresentation of study sites and data points from India among LMIC, with exceptionally low unit costs reflecting India's uniquely low ARV prices related to the country's important generic ARV industry and resulting strong pharmaceutical negotiation capacity.

A second sensitivity analysis, to further check on representativeness, expanded the data set to include a number of studies which did not include a break-down of cost components, but had data on total ART costs. Adding one study from Kenya[50], the LIC median cost per patient per year became $773 (mean $713, range $211 to $1,089), similar to the original estimate of $ 792. Among LMIC, adding data points from Thailand and India [51–53] did not alter the median cost per patient per year from default of $932 (but the mean increased to $1,314; range $162 to $4212).

Third, we replaced the country income classification according to each country's 2009 income level by a classification using each country's income level in the year of cost data collection (while in both cases applying World Bank's 2009 income thresholds). This shifted five countries that had grown richer between the costing study year and 2009 (Brazil, India, Lesotho, Nigeria, and South Africa) into a lower income category. This country regrouping reduced the median ART per-patient cost among LIC (from $792 to $646), increased the estimate for LMIC (from $932 to $1,454) and decreased the estimate for UMIC (from $1,454 to $1,241).

4. Discussion

Empirical data on ART delivery unit costs in low- and middle-income countries has increased significantly in recent years, as access to ART has expanded. The current review identifies several more good-quality costing studies of both outpatient and home-based ART than earlier reviews [11, 12, 14], and provides cost estimates for the components ARVs, personnel and laboratory costs separately.

The results have several implications for program planning and budgeting, and for seeking efficiency improvement. For ART, within health facilities the key cost drivers are ARV

procurement, laboratory tests, and staff. ARV prices have declined substantially over the last decade, with average declines of 12–39% over 2006–2009 for the first-line regimens most commonly used in low- and middle-income countries.[54] Lacking specification of regimens and drug sources in sites studied, it was not possible to adjust cost estimates for price declines. Only 6 out of the 24 ART costing studies reported whether the program used generic or innovator drugs (see SDC version of tables I, II and III). Of 14 studies that specified ARV regimens, the majority used lamivudine (3TC) + nevirapine (NVP) + stavudine (d4T) as the most common first-line regimen, the regimen for which recent price declines have been smallest: 9–12% per year. [54] The predominance of this regimen may explain why over 2004–2009, the average proportion of overall ART cost covered by ARV drugs was relatively stable, at 48–52% every year, rather than declining.

The observed large variations between countries and sites in laboratory costs point to possible opportunities for efficiency seeking. Part of variations may relate to differing clinical stage of patients and response to treatment [45], with high laboratory costs during the first 6 months after ART initiation.[22] Further, laboratory costs tend to be lower in established programs or in hospitals, for example, $15.7 or 6% of overall cost in Ethiopia in 2004–5 [25], compared to starting programs or clinics that are investing more in laboratory equipment.[26]

Available data (tables I—III) were limited in the specification of laboratory tests performed, test-specific costs as well as in the specification of precise laboratory testing practices and frequencies. We could therefore not analyze whether sites with routine, systematic CD4 and viral load monitoring were more expensive than sites with selective viral load monitoring, sites with only (or less frequent) CD4, or sites with just clinical monitoring, so we cannot estimate the likely savings from shifting testing patterns. In the trial of clinically-driven versus laboratory-guided ART (DART) in Uganda and Zimbabwe, hematology and biochemistry added little benefit; 12-weekly CD4 monitoring improved clinical outcomes from the 2nd year from treatment initiation onwards. Based on minimal lab monitoring (i.e., CD4 12-weekly after the second year), the cost of CD4 testing would have to drop to $3.8 (from current $175) in order to make laboratory monitoring cost-effective. [55] [56]

Another approach to improving ART program efficiency may be personnel task shifting. [57–59] In an NGO-led program in rural Uganda, costs to the provider were similar for clinic-based and home-based ART ($834 and $789 per patient-year, respectively), at comparable patient retention and clinical outcomes [28]. The study suggests an opportunity to scale-up ART access in settings with restrained health system capacity. The markedly higher cost of inpatient compared to outpatient ART (in 2 studies in South Africa, table III) furthermore demonstrates the financial importance of preventing hospitalizations.

4.1 Limitations

This review reflects the state of evidence in the first decade of global ART scale-up. Given the limited number of studies, from selected countries and settings, the available data could hardly claim global representativeness. Despite the recent increase in good-quality studies (as defined in our inclusion criteria), costing information remains extremely limited in South Asia (N=2 studies), Latin America and the Caribbean (N=5) and East Asia and the Pacific (N=1). Also, in sub-Saharan Africa, 8 out of the 16 studies were conducted in South Africa, which by its relatively high income level is the country least representative of the region. The lack of regional representativeness is one reason why our first sensitivity analysis found higher median ART costs in low-income countries compared to lower-middle-income countries, a result that seems contrary to intuition and to observed patterns in ARV prices.[54] Despite the inclusion of studies from the gray literature (of which 7 were found eligible [18, 21, 22, 26, 32, 33, 38]), we cannot exclude the possibility of publication bias in

available costing studies. Several recent, well-executed ART and PMTCT cost studies that are recognized for influencing donor funding policies have not been published in books, peer-reviewed journals, or made otherwise publically available, so were unfortunately not included in our meta-analyses.

Innovative *Monitoring & Evaluation* strategies are needed to address the gaps in good-quality evidence, especially concerning above-facility and program-level costs. We intended to analyze all relevant cost components, including program–level (above-facility-level) activities and expenses including managerial overheads, administration, monitoring and evaluation and training borne at district, province and national levels. Only three ART studies however provided such programmatic costs, without sufficient description of the relevant activities or cost items to analyze the determinants of these potentially significant contributions to overall delivery cost.

Among available costing studies, quality and completeness varied. Many studies did not explicitly report all cost components, missing information on important cost determinants such as ARV drugs, regimens, type and frequency of laboratory testing used. Most studies also lacked details about variation in costs between different types of facilities and patient populations studied (in terms of e.g., age and CD4 cell count at treatment initiation).[22] Basic information on cost components was lacking in many studies; often either capital costs (such as those related to setting up laboratory equipment), or selected recurrent costs (like utilities) were omitted. In particular, definitions of overhead costs varied, with some studies not even including any overheads. Only three studies [32, 33, 35] mentioned explicitly that their data collection instruments had been validated or piloted before application. The best studies reviewed use a micro-costing approach, where expenditures on each component of providing ART or PMTCT delivery are separately listed and costed out. Even when an ingredients approach was utilized, most studies in the last decade do not provide the type of ART used (not even generic vs. patent, or first-line as distinct from second-line). In many studies sample sizes appear to have been driven by clinical outcomes, rather than by costing-related statistical considerations. Sample sizes varied between 209 (median for LIC, range 122–218) and 430 patients (median for UMIC, range 22 to 2,835), which may be considered appropriate for an overall estimate from one single locality. However, convenience sampling limits the precision and power to evaluate costs for relevant strata of sites, patient age groups, treatment regimens and modality and phases of treatment.

Heterogeneity in unit denominators, notably the calculation of patient-years, further complicates comparisons among studies. For illustration, a study in India [29] reported 1,094 clients who “ever started ART” (as average across sites), 939 clients “at the end of study” and 503 clients who had been “on therapy for the entire study period”. These authors selected the corresponding 9,460 client-months of ART as appropriate denominator unit; however the large differences between patients starting and retained illustrates the critical influence that varying denominator calculations will have on unit cost estimates, especially in programs with low patient retention and/or rapid scale-up with many new patients initiating ART.

4.2. Way forwards

The limitations in availability and comparability of existing cost data described above highlight an urgent need for development and dissemination of standardized cost measurement methodologies and for capacity building. Awaiting such guidance and improved data quality and standardization, any cost comparisons between sites and studies should only be done with extreme caution and attention to methodological differences; interpretations on relative efficiency will typically be limited to within-study determinants. Future strategic use of cost data for improving the efficiency of ART delivery will in

particular benefit from more careful costing and reporting of ARV drugs sources and regimens, laboratory costs by type and frequency of tests, and of staff costs by type of personnel including those above the health facility level).

Future assessments should link costs to health outcomes, including cost differentials associated with clinical response[45], drug toxicity and resistance [43]. This is ever more important in view of the WHO's revised 2010 guidelines for adult ART in resource-limited settings, which recommend an expanded access to ART starting at CD4 cell count below 350/uL instead of the former 200/uL. In addition, a gradual phasing-out is now recommended of stavudine (d4T) in first-line regimens, to be replaced by less toxic but more costly efavirenz and/or tenofovir-based first-line regimens [60]. As countries will over coming years gradually adopt and implement the new treatment guidelines, it is imperative that costing studies document the mix of patients evaluated in terms of CD4 cell counts at treatment initiation and regimens used, to facilitate interpretation of cost findings and cost determinants.

To improve the knowledge base on efficient ART and PMTCT delivery, collaboration between countries could be very important: First, to increase costing capacity and resources, and second, to exchange experiences in increasing service efficiency. Multi-country exercises should help to improve and standardize costing methodologies and tools for comprehensive data collection. Economies of scale as apparent in some settings [29] are worth investigating, to establish more clearly if these are achieved merely by allocating fixed costs over a larger number of patients, or by improved technical efficiency (i.e. transformation of inputs to outputs) associated with program maturation and learning.

Whenever possible (conditional on the availability of data on patient wages and other opportunity costs), both financial and economic costs should be collected. Financial costs are relevant for programmatic budgeting, while economic costs (including opportunity costs, productivity losses, transport and out-of-pocket expenditure by patients) will determine cost-effectiveness and prioritization of resource allocations. For example, if an ART service package includes in-kind contributions such as food subsidies or other resources donated from external funding sources, these will influence future planning and sustainability. Ignoring such external assistance would distort the picture of overall costs and incentives structures in which an ART program operates.

5. Conclusion

There is a paucity of information about the delivery unit costs of ART and PMTCT in different HIV/AIDS programs, particularly in low-income countries. Future evaluations of program-level ART and PMTCT unit costs will benefit from international guidance on standardized expenditure definitions and categories, standardized formats for specifying ARV regimen mixes and laboratory testing practices (including type of tests and frequency) and for human resource disaggregation (facility-level vs. above-facility and program-level); as well as standardized service unit denominators (possibly including a component of service quality or of patient retention). The large differences in ART unit costs observed in settings with similar epidemiologic and economic characteristics deserve additional assessments focusing on cost determinants and opportunities for efficiency gain in program implementation and scale-up. To scale-up ART and PMTCT to universal access globally, innovative options are needed to contain costs while maintaining or improving quality and health gain.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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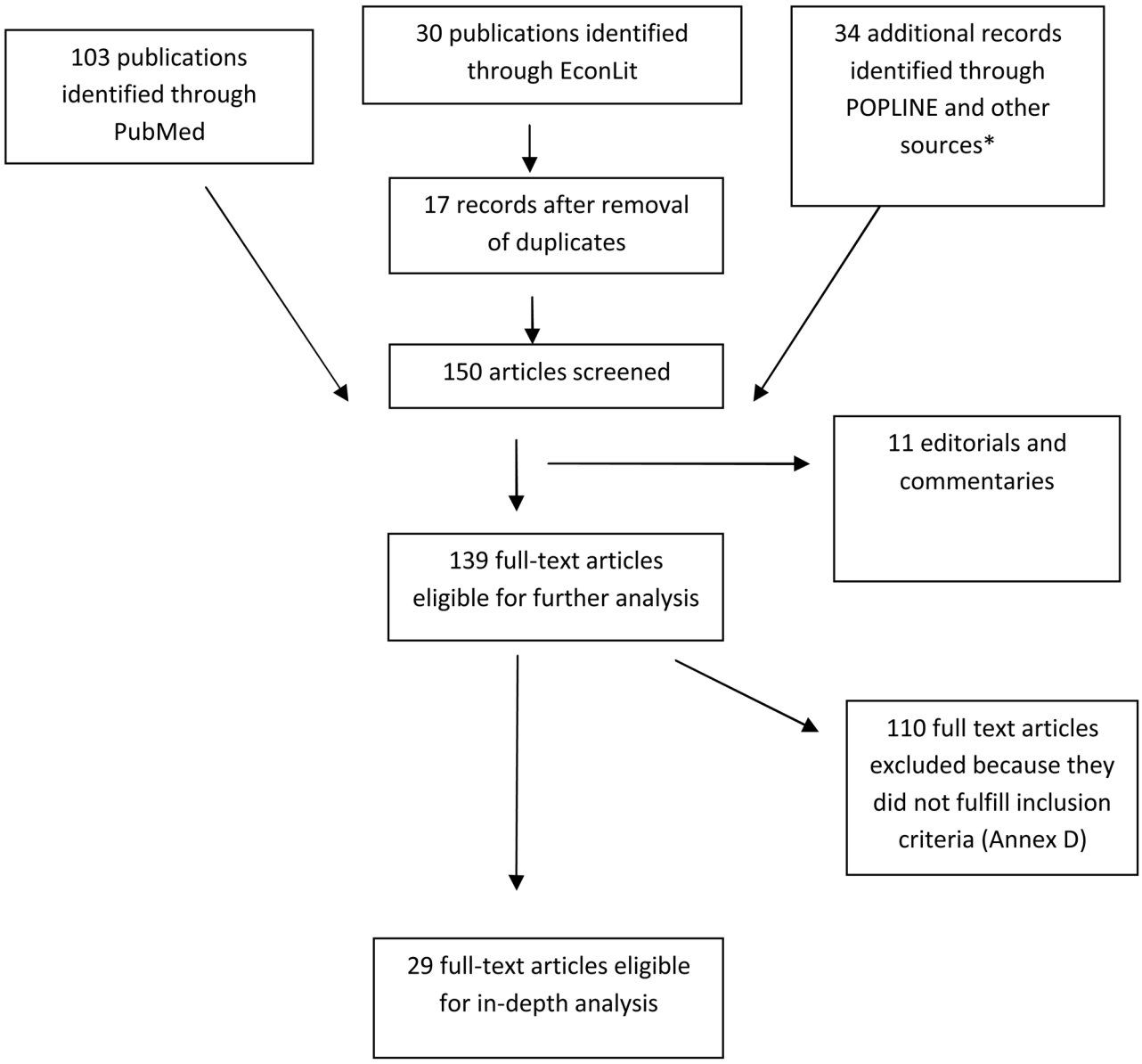

Fig. 1. Literature review on ART and PMTCT per-person year delivery unit costs: flowchart of search and review process

* Seven studies included for in-depth analysis were from the gray literature

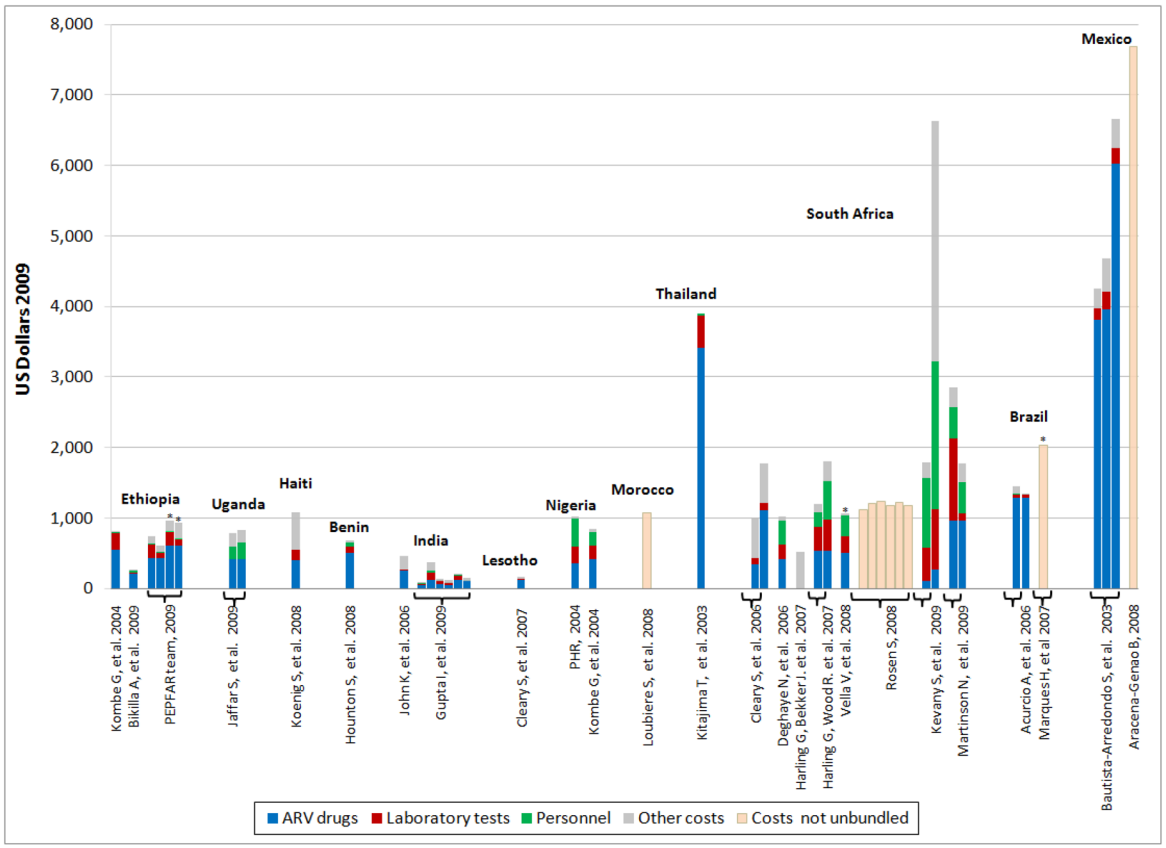

Fig. 2. Delivery unit costs of ART, per patient-year, by cost component, country and site

Countries ranked from left to right according to increasing *per capita* gross national income (GNI) and then by year of study publication. Studies including (or limited to) pediatric ART are indicated with an asterisk (*) over the bar. 'Other costs' refer to components of ART other than ARV medicines, laboratory and personnel costs; 'other costs' are not comparable across studies because they do not contain the same elements. Unbundled costs refer to the overall cost of ART in case the study did not report the separate cost components – but these still included at least the three main components under review. Each bar represents a separate data point within each country or study (e.g., different region, health facility/site, patient type, delivery modality, temporality, etc.). GNI per capita (2009): Ethiopia: $280, Uganda: $420, Haiti: $660, Benin: $690, India: $1,070, Lesotho: $1,080, Nigeria: $1,160, Thailand: $2,840, South Africa: $5,820, Brazil: $7,350, Mexico: $9,980. See tables I, II and III for additional details.

Table I

Delivery Unit Costs of Antiretroviral Treatment, per patient-year, low-income countries

Country	Reference	City/Setting	Scope		Provider type	ART unit costs, in 2009 USD	Costs components, in 2009 USD (% of total cost)				ART Regimen
			Facilities	Patients			ARV drugs	Personnel	Laboratory tests	Overheads	
Benin	Hounton S, et al. 2008[a] [24]	Cotonou/U	1	122 *Outpatients*	Nat/NGO/D	681.9	500.5 (73.4%)	51.4 (7.5%)	99.5 (14.6%)	21.1 (3.1%)	NA
Ethiopia	Bikilla A, et al. 2009[b] [25]	Arba Minch/U	1	209 *Outpatients*	Nat	262.8	205 (78%)	37.8 (14.4%)	15.7 (6%)	Included but not unbundled	(d4T/3TC + NVP) or (AZT + 3TC + NVP) or (d4T/3TC + EFV) or (AZT + 3TC + EFV) *All regimens are first-line treatments*
	Kombe G, et al. 2004 [*] [26]	Nazareth/U; Addis/U; Bahir Dar/U	6	NA	Nat	804.1	548.3 (68.2%)	14.2 (1.8%) *Doctor, nurse, counselor, pharmacist, lab technician*	241.5 (30%) Full blood count, blood chemistry, blood sugar, CD4 count, viral load	Not included	AZT+ d4T + NVP *First-line treatment*
	The PEPFAR ART Costing Project Team, 2009[c, w] [22]	Urban	9	NA *Outpatients*	Nat	741.7 *New adult patients*	428.3 (57.7%)	21.8 (2.9%)	191.1 (25.8%)	59.9 (8%)	NA
						610.8 *Established-adult patients*	428.3 (70.1%)	12 (2%)	80.8 (13.2%)	33.7 (5.5%)	
						960.8 *New pediatric patients*	606.7 63.1%)	21.8 (2.2%)	191.1 (19.9%)	62.7 (6.5%)	
						933.4 *Established pediatric patients*	606.7 (65%)	12.3} (1.3%)	94.5 (10.1%)	39.4 (4.2%)	
Haiti	Koenig S, et al. 2008[d] [27]	Port-au-Prince/U	1	218 *Inpatients-Outpatients*	NGO	1,088.7	402.6 (37%)	Included but not unbundled	147.4 (13.5%)	129.6 (11.9%)	NA
Uganda	Jaffar S, et al. 2009[e] [28]	Jinja/R	1	NA *Outpatients*	NGO	789	416.6 (52.8%)	181.5 (23%)	Included but not unbundled	Included but not unbundled	NA
						833.8	417.7 (50.1%)	242.6 (29.1%)			

General: The tables are ordered alphabetically by country name and then by author. Dollar amounts and proportions of overall costs may not add to 100% due to rounding and because some of costs do not fit into the classifications used. For example, transportation costs to visit patients' homes, non-ARV medicines, OI medicines, and recurrent costs such as cotton, syringes, gloves, etc. are in the "Other" category, which has been excluded from the table (but could be estimated subtracting the current total from 100%). ARV medicine costs include only the costs of antiretrovirals, mostly first-line unless otherwise noted in Regimen type. Personnel costs include human resources expenses incurred in services delivery, including health workers doing patient care and in some studies also administrative personnel. Laboratory costs may include HIV testing, CD4 cell count and viral load measurement. Overheads may include capital costs (medical equipment, computers) and/or recurrent costs (utilities: electricity, water, phone, rent, maintenance costs, storage, cleaning, or security). If the study reviewed provided details about what was included in each category, those details have been incorporated in the tables. Costs were converted into 2009 USD using average exchange rates during the study period (see sources in the Methods section).

City/setting: Refers to the city or area name and the type of location where the study took place, including U= Urban and R= Rural

Facilities: Refers to the number of facilities in which the costs were collected

Patients: Refers to the number of patients for whom cost data were collected for ART delivery

Provider type: Refers to the type of provider delivering ART: Nat=National; D=Donor; NGO= Non-government organization ; FBO= Faith-based organization

Regimen: Refers to the ARV line costed by the study. The acronyms for ARV drugs were taken from the World Health Organization classification: Cotrimoxazole = CTX; Didanosine = ddl; Efavirenz = EFV; Indinavir = IDV; Lamivudine = 3TC; Lopinavir = LPV; Nevirapine = NVP; Ritonavir =RTV; Saquinavir = SQV; Stavudine= d4T; Zidovudine = AZT

NA=Not available in the study reviewed.

[β]The study includes programmatic cost

[*] The costs collected are financial costs.

Specific:

[a] International dollars convert into USD using the purchase power parity conversion factor provided by the U.N. Statistical Office.[61]

[b] Outpatients only. It includes patients who are 15 years old and above.

[c] The study reports the median costs.

[f] Costs calculated using patients retained "at the end of the study" as denominator.

[g] The study reports median costs.

[h] Costs taken were for "first-line, annually thereafter" (i.e., first-line patients only, from their 6th month after ART initiation onwards).

[i] Including patients who started visiting the hospital in 1997, as it was not possible to single-out those patients who initiated ART after 2001.

[k] Public sector only, with patients paying a fixed portion of ART (included in the costs listed).

[l] Annual patient cost derived by multiplying cost per visit with an average number of visits per year. Because the hospital charged an extra 15%, we multiplied reported results obtain the actual cost of ART delivery.

[m] Study does not specify what "other" specialists or what "other" laboratory tests were costed out.

[n] Patients who, every month throughout the study period, received ART. Costs presented cover patients through 2006, with only 41% having started after the year 2000.

[o] Costs include patients who initiated ART in 2000, as it was not possible to single-out those patients who started after 2001.

[p] Costs concern ART given for the treatment occurring between 6–12 months for first-line ART (patient specific) and separately for second-line treatment.

[r] Average between first year and second year of follow-up.

[s] Average between first year and second year of treatment.

[t] Includes patients who are 15 years old or above.

[w] Includes children: patients who are younger than 15 years of age.

For further details see the Supplementary Digital Content version of the tables.

Table II

Delivery Unit Costs of Antiretroviral Treatment, per patient-year, lower-middle-income countries

Country	Reference	City/Setting	Scope		Provider type	ART unit costs, in 2009 USD	Costs components, in 2009 USD (% of total cost)				ART Regimen
			Facilities	Patients			ARV drugs	Personnel	Laboratory tests	Overheads	
India	Gupta I, et al. 2009[f] *β[29]	Chennai/U	1	2,606	Nat	96.7	46.2 (47.8%)	7.1 (7.3%)	18.9 (19.5%)	Not included	d4T + 3TC + NVP *First-line treatment*
		Imphal/U	1	226		377.2	130.3 (34.5%)	33.3 (8.8%)	97.8 (25.9%)		
		Ahmedabad/U	1	1,210		133.2	60.7 (45.5%)	8.5 (6.4%)	42.4 (31.8%)		
		New Delhi/U	2	1,728		120	53.4 (44.5%)	11.4 (9.5%)	20.3 (16.9%)		
		Trivandrum/U	1	498		217.9	118.3 (54.2%)	12.8 (5.9%)	60.3 (27.6%)		
		Thrissur/U	1	308		155.5	101.4 (65.1%)	8.7 (5.6%)	0 (0%)		
	John K, et al. 2006[g] *β[30]*	Bangalore/U	1	25 *Inpatients-Outpatients*	NGO	461.8	257.7 (55.8%)	Included but not unbundled *Project coordinator, medical officer, nurses, laboratory technician, counselors*	17.4 (3.8%)	Included but not unbundled	AZT/d4T + 3TC + NVP *First-line treatment*
Lesotho	Cleary S, et al. 2007[h][18]	Maseru/U	1	271 *Inpatients*	Nat/NGO	161.7	127.4 (78.8%)	Included but not unbundled	15.3 (9.5%)	Included but not unbundled	3TC + d4T + NVP *First-line treatment*
Morocco	Loubiere S, et al. 2008[i][31]	Casa Blanca/U	1	167 *Inpatients-Outpatients*	Nat	1,076.9	Included but not unbundled	Included but not unbundled	Included but not unbundled	Included but not unbundled	NA
Nigeria	Kombe G, et al. 2004 [j] [32]	Lagos/U; Abuja/U	5	NA	Nat	841	420.5 (50%)	185 (22%)	193.4 (23%)	33.6 (4%)	d4T + 3TC + NVP *First-line treatment*
	PHR, 2004[k] *β[33]*	Anambra/U; Bauchi/R; Edo/U; Federal Capital Territory/U; Kano/U; Lagos/U; Nassarawa/U; Rivers/U	66	NA *Inpatients-Outpatients*	Nat/FBO/NGO	1,023.3	362.1 (35.4%)	391.2 (38.2%)	237.5 (23.2%)	18.6 (1.8%)	3TC + d4T + NVP *First-line treatment*

Country	Reference	City/Setting	Scope		Provider type	ART unit costs, in 2009 USD	Costs components, in 2009 USD (% of total cost)				ART Regimen
			Facilities	Patients			ARV drugs	Personnel	Laboratory tests	Overheads	
Thailand	Kitajima T, et al. 2003[f][34]	Khon Kaen/R	2	106 *Outpatients*	Nat	3,903.8	3,415.1 (87.5%)	Included but not unbundled	462 (11.8%)	26.7 (0.7%)	NA

General: The tables are ordered alphabetically by country name and then by author. Dollar amounts and proportions of overall costs may not add to 100% due to rounding and because some of costs do not fit into the classifications used. For example, transportation costs to visit patients' homes, non-ARV medicines, OI medicines, and recurrent costs such as cotton, syringes, gloves, etc. are in the "Other" category, which has been excluded from the table (but could be estimated subtracting the current total from 100%). ARV medicine costs include only the costs of antiretrovirals, mostly first-line unless otherwise noted in Regimen type. Personnel costs include human resources expenses incurred in services delivery, including health workers doing patient care and in some studies also administrative personnel. Laboratory costs may include HIV testing, CD4 cell count and viral load measurement. Overheads may include capital costs (medical equipment, computers) and/or recurrent costs (utilities: electricity, water, phone, rent, maintenance costs, storage, cleaning, or security). If the study reviewed provided details about what was included in each category, those details have been incorporated in the tables. Costs were converted into 2009 USD using average exchange rates during the study period (see sources in the Methods section).

City/setting: Refers to the city or area name and the type of location where the study took place, including U= Urban and R= Rural

Facilities: Refers to the number of facilities in which the costs were collected

Patients: Refers to the number of patients for whom cost data were collected for ART delivery

Provider type: Refers to the type of provider delivering ART: Nat=National; D=Donor; NGO= Non-government organization ; FBO= Faith-based organization

Regimen: Refers to the ARV line costed by the study. The acronyms for ARV drugs were taken from the World Health Organization classification: Cotrimoxazole = CTX; Didanosine = ddl; Efavirenz = EFV; Indinavir = IDV; Lamivudine = 3TC; Lopinavir = LPV; Nevirapine = NVP; Ritonavir =RTV; Saquinavir = SQV; Stavudine= d4T; Zidovudine = AZT

NA=Not available in the study reviewed.

[β]The study includes programmatic cost

[*]The costs collected are financial costs.

Specific:

[a]International dollars convert into USD using the purchase power parity conversion factor provided by the U.N. Statistical Office.[61]

[b]Outpatients only. It includes patients who are 15 years old and above.

[c]The study reports the median costs.

[f]Costs calculated using patients retained "at the end of the study" as denominator.

[g]The study reports median costs.

[h]Costs taken were for "first-line, annually thereafter" (i.e., first-line patients only, from their 6th month after ART initiation onwards).

[i]Including patients who started visiting the hospital in 1997, as it was not possible to single-out those patients who initiated ART after 2001.

[k] Public sector only, with patients paying a fixed portion of ART (included in the costs listed).

[l] Annual patient cost derived by multiplying cost per visit with an average number of visits per year. Because the hospital charged an extra 15%, we multiplied reported results obtain the actual cost of ART delivery.

[m] Study does not specify what "other" specialists or what "other" laboratory tests were costed out.

[n] Patients who, every month throughout the study period, received ART. Costs presented cover patients through 2006, with only 41% having started after the year 2000.

[o] Costs include patients who initiated ART in 2000, as it was not possible to single-out those patients who started after 2001.

[p] Costs concern ART given for the treatment occurring between 6–12 months for first-line ART (patient specific) and separately for second-line treatment.

[r] Average between first year and second year of follow-up.

[s] Average between first year and second year of treatment.

[t] Includes patients who are 15 years old or above.

[w] Includes children: patients who are younger than 15 years of age.

For further details see the Supplementary Digital Content version of the tables.

Table III

Delivery Unit Cost of Antiretroviral Treatment, per patient-year, upper-middle-income countries

Country	Reference	City/Setting	Scope		Provider type	ART unit costs, in 2009 USD	Costs components, in 2009 USD (% of total cost)				ART Regimen
			Facilities	Patients			ARV drugs	Personnel	Laboratory tests	Overheads	
Brazil	Acurcio A, et al. 2006[m] * [35]	Belo Horizonte/U	2	157 *adherents patients*	Nat	1,454	1,290.3 (88.7%)	6.2 (0.4%) *Infectious diseases specialist and other specialists*	45 (3%) *Lymphocyte CD4/CD8, viral load test, other tests*	Not included	NA
				40 *non-adherents patients*		1,340.1	1,290.3 (96.3%)	8.7 (0.6%) *Infectious diseases specialist and other specialists*	39.9 (2.9%) *Lymphocyte CD4/CD8, viral load test, other tests*		
	Marques H, et al. 2007 [w] [23]	Sao Paulo/U	1	140 *Outpatient children*	Nat	2,038.8	Included but not unbundled	Included but not unbundled	Included but not unbundled	Included but not unbundled	RTV+NFV+3CT+ZDV+ddI+IDV
Mexico	Aracena-Genao B, et al. 2008[n] [36]	Mexico City/U	1	80	Nat	7,688	Included but not unbundled	Included but not unbundled	Included but not unbundled	Included but not unbundled	NA
	Bautista-Arredondo S, et al. 2003; Bautista-Arredondo S, et al. 2008[o] [37, 38]	Mexico City/U; Cuernavaca/U; Guadalajara/U	11	902	Nat	6,651.3 *First year after ART treatment*	6,024.4 (90.6%)	Included but not unbundled	223.4 (3.4%)	Included but not unbundled	NA
						4,256.8 *Second year after ART treatment*	3, 809.4 (89.5%)		165.8 (3.9%)		
						4,682.9 *Third year after ART treatment*	3,960.7 (84.6%)		254.6 (5.4%)		
South Africa	Cleary S, et al. 2006[p] [39]	Cape Town/U	3	1,729	Nat	987.3	338.8 (34.3%)	Included but not unbundled	96 (9.7%)	Included but not unbundled	AZT + 3TC+NVP/EFV *First-line Treatment*
						1,774.3	1,108.3 (62.5%)		112 (6.3%)		AZT + ddl + LPV/RTV *Second-line treatment*
	Deghaye N, et al. 2006[q] [40]	Durban/U	2	41	Nat	1,022.3	411 (40.2%)	330 (32.3%)	218.8 (21.4%)	16.4 (1.6%)	d4T + 3TC+ EFV *First-line treatment*
	Harling G, Bekker J, et al 2007[r] [41]	Cape Town/U	1	NT	Nat/D	521.6	Included but not unbundled	Included but not unbundled *Doctor, nurse, counselor, pharmacist*	Included but not unbundled	Included but not unbundled	NT
	Harling G, Wood R. 2007[s] [42]	Cape Town/U	1	172 *outpatients*	Nat/NGO	1,296.5	535.9 (41.3%)	203.3 (15.7%)	341 (26.3%)	25.2 (1.9%)	d4T + 3TC + EFV *First-line treatment*
				129 *inpatients*		1,834.3	535.9 (29.2%)	545.5 (29.7%)	442.1 (24.1%)	212.7 (11.6%)	
	Kevany S, et al. 2009[t] [43]	Cape Town/U	1	48 *outpatients*	Nat	1,795.8	103.9 (5.8%)	988.6 (55.1%) *Consultant, medical officer, nursing sister, medical ward staff*	478.1 (26.6%)	Not included	3TC + d4T + NVP *First-line Treatment*
				25 *inpatients*		6,579.5	271.7 (4.1%)	2,097.8 (31.9%) *Consultant, medical officer, nursing sister, medical ward staff*	847.6 (12.9%)		
	Martinson N, et al. 2009[u] [44]	Soweto/U	1	591	D	2,853.6 *Newly ART patients*	958 (33.6%)	435.5 (15.3%) *Primary health care nurse, pharmacist, medical officer*	1,174.4 (41.2%)	190.5 (6.7%)	d4T + 3TC + NVP
						1,770.4 *Established-ART patients*	958 (54.1%)	435.5 (24.6%)	114.5 (6.5%)	190.5 (10.8%)	

Country	Reference	City/Setting	Scope		Provider type	ART unit costs, in 2009 USD	Costs components, in 2009 USD (% of total cost)				ART Regimen
			Facilities	Patients			ARV drugs	Personnel	Laboratory tests	Overheads	
								Primary health care nurse, pharmacist, medical officer			*First-line treatment*
	Rosen S, et al. 2008[v] [45]	Gauteng/U	2	200	Nat/NGO	1,122.5 *Patient responding*	Included but not unbundled	Included but not unbundled	Included but not unbundled	Included but not unbundled	3TC + d4T + EFV *First-line treatment*
						1,210.3 *Patient not responding*					
		Eastern Cape/U	1	100	NGO	1,241.1 *Patient responding*					
						1,177.3 *Patient not responding*					
		Mpumalanga/R	1	100		1,229.4 *Patient responding*					
						1,182.7 *Patient not responding*					
	Vella V, et al. [21] 2008[w]	KwaZulu-Natal/U	32	2,835	Nat	1,068.1	500 (46.8%)	300 (28.1%)	236 (22.1%)	16.6 (1.5%)	NA

General: The tables are ordered alphabetically by country name and then by author. Dollar amounts and proportions of overall costs may not add to 100% due to rounding and because some of costs do not fit into the classifications used. For example, transportation costs to visit patients' homes, non-ARV medicines, OI medicines, and recurrent costs such as cotton, syringes, gloves, etc. are in the "Other" category, which has been excluded from the table (but could be estimated subtracting the current total from 100%). ARV medicine costs include only the costs of antiretrovirals, mostly first-line unless otherwise noted in Regimen type. Personnel costs include human resources expenses incurred in services delivery, including health workers doing patient care and in some studies also administrative personnel. Laboratory costs may include HIV testing, CD4 cell count and viral load measurement. Overheads may include capital costs (medical equipment, computers) and/or recurrent costs (utilities: electricity, water, phone, rent, maintenance costs, storage, cleaning, or security). If the study reviewed provided details about what was included in each category, those details have been incorporated in the tables. Costs were converted into 2009 USD using average exchange rates during the study period (see sources in the Methods section).

City/setting: Refers to the city or area name and the type of location where the study took place, including U= Urban and R= Rural

Facilities: Refers to the number of facilities in which the costs were collected

Patients: Refers to the number of patients for whom cost data were collected for ART delivery

Provider type: Refers to the type of provider delivering ART: Nat=National; D=Donor; NGO= Non-government organization ; FBO= Faith-based organization

Regimen: Refers to the ARV line costed by the study. The acronyms for ARV drugs were taken from the World Health Organization classification: Cotrimoxazole = CTX; Didanosine = ddl; Efavirenz = EFV; Indinavir = IDV; Lamivudine = 3TC; Lopinavir = LPV; Nevirapine = NVP; Ritonavir =RTV; Saquinavir = SQV; Stavudine= d4T; Zidovudine = AZT

NA=Not available in the study reviewed.

[β]The study includes programmatic cost

[*]The costs collected are financial costs.

Specific:

[a]International dollars convert into USD using the purchase power parity conversion factor provided by the U.N. Statistical Office.[61]

[b]Outpatients only. It includes patients who are 15 years old and above.

[c]The study reports the median costs.

[f] Costs calculated using patients retained “at the end of the study” as denominator.

[g] The study reports median costs.

[h] Costs taken were for “first-line, annually thereafter” (i.e., first-line patients only, from their 6th month after ART initiation onwards).

[i] Including patients who started visiting the hospital in 1997, as it was not possible to single-out those patients who initiated ART after 2001.

[k] Public sector only, with patients paying a fixed portion of ART (included in the costs listed).

[l] Annual patient cost derived by multiplying cost per visit with an average number of visits per year. Because the hospital charged an extra 15%, we multiplied reported results obtain the actual cost of ART delivery.

[m] Study does not specify what “other” specialists or what “other” laboratory tests were costed out.

[n] Patients who, every month throughout the study period, received ART. Costs presented cover patients through 2006, with only 41% having started after the year 2000.

[o] Costs include patients who initiated ART in 2000, as it was not possible to single-out those patients who started after 2001.

[p] Costs concern ART given for the treatment occurring between 6–12 months for first-line ART (patient specific) and separately for second-line treatment.

[r] Average between first year and second year of follow-up.

[s] Average between first year and second year of treatment.

[t] Includes patients who are 15 years old or above.

[w] Includes children: patients who are younger than 15 years of age.

For further details see the Supplementary Digital Content version of the tables.

Table IV

Base Case and Sensitivity Analysis: Delivery Unit Cost (USD 2009) of ART per patient per year, by country income level

		Low income	Lower middle income	Upper middle income	All
Base case	Mean	839	1,246	2,783	1,494
	Median	**792**	**932**	**1,454**	1,005
	SD	175	1,546	2,500	1,628
	Min	682	156	1,230	156
	Max	1,089	3,904	5,667	5,667
	Countries	4	5	3	12
	Studies (N)	6	7	13	26
	Data points/sites (n)	10	12	24	45
1. Weighing all study sites, instead of all countries equally	Mean	770	714	2,366	1,600
	Median	797	298	1,397	1,077
	SD	226	1,067	2	1,772
	Min	263	97	522	97
	Max	1,089	3,904	7,688	7,688
	Countries	4	5	3	12
	Studies (N)	6	7	13	26
	Data points/sites (n)	10	12	24	46
2. Adding studies reporting total unit cost without ARV/lab/HR break-down	Mean	713	1,314	Unchanged from base-case	1,422
	Median	773	932		932
	SD	319	1,637		1,639
	Min	211	162		162
	Max	1,089	4,212		5,667
	Countries	5	5		13
	Studies (N)	7	9		29
	Data points/sites (n)	11	14		48
3. Country income level according to costing year	Mean	565	1,683	3,068	1,496
	Median	646	1,454	1,241	1,073
	SD	346	886	2,537	1,559

	Low income	Lower middle income	Upper middle income	All
Min	97	522	1,068	156
Max	1,089	3,904	7,688	5,667
Countries	7	4	2	12
Studies (N)	11	9	6	26
Data points/sites (n)	20	13	13	45

Notes: The base case aggregates total ART unit costs per person per year (in 2009 USD) by first taking the median within each country. Sensitivity analyses are as follows: 1. All study sites weighted equally, regardless of country or number of sites per country. 2) Expanded dataset to include studies which did not include a break-down of cost components, but had data on total ART costs. 3) Use World Bank GNI per capita data at the time of the study costing, instead of 2009 GNI, to classify countries according to income level. Baseline estimates based on more than 14,765 patients from 26 studies, plus additional studies that did not disaggregate costs by cost component. Twelve studies specifically reported costs for first-line treatment; one study [39] specifically included second-line treatment but those specific costs were excluded. Total data points aggregate to 45 because two studies from Mexico [37, 38] were considered as only one data point as they referred to the same study population, but we needed both sources to obtain all the necessary information. See tables I, II, and III, text and annexes for further details.

Table V

Delivery Unit Cost of Prevention of Mother to Child Transmission of HIV

Country	Reference	City/Setting Costing year	Scope		Provider type	PMTCT unit cost (2009USD)	Cost in 2009 USD (% of total cost)				Regimen
			Facilities	Patients			ARV drugs	Personnel	Laboratory tests	Overheads	
India	Dandona L, et al. 2008 [46]	Andhra Pradesh/U2005–06	16	1,212 [Y]	Nat	2.4 *Post test counseling*	Included but not unbundled	1.1 (47.3%)	Included but not unbundled	0.35 (14.7%)	NVP
						251.1 [#] *Mother neonate pair receiving nevirapine*		118.7 (47.3%)		36.9 (14.7%)	
South Africa	Desmond C, et al. 2004 [47]	Durban/U; Paarl/U; Siloam/R Frankfort/R; 2002	9	709	Nat/D	42.4 *Pretest counseling*	Included but not unbundled	Included but not unbundled	Included but not unbundled	Not included	NVP + CTX
				570		32.5 *Testing*					
				532		23.8 *Post test counseling*					
				117 [Y]		**208.8** [¥] *Mother neonate pair receiving nevirapine*					
				63		327.2 [‡] *Mother neonate pair follow up*					
Rwanda	McMennamin T, Fellow A. 2007 [48]	Gicumbi/R 2005	6	NA	Nat/FBO	6.42 *Specific intervention*	Included but not unbundled	Included but not unbundled	Included but not unbundled	Included but not unbundled	Not reported

NA: not available in the study

Costs have been converted into USD$ of 2009 using average exchange rates during the study period

City/setting: Refers to the city and the type of location: U= Urban; R= Rural

Costing year: Refers to the year for which the study reported the costs

Facilities: Refers to the number of facilities in which the costs were collected

Patients: Refers to the number of patients studied to cost the ART delivery:

[Y] mother-neonate pairs

Provider type: Refers to the type of ART provider: Nat=National; D=Donor; NGO= Non-government organization ; FBO= Faith based organization

Regimen: ARV line costed by the study using acronyms for ARV drugs taken from the World Health Organization classification: Cotrimoxazole = CTX; Nevirapine = NVP

[#] The mother was given one tablet of 200 mg at the onset of labor and the neonate was given 2 mg/kg body weight within 72 hours of birth.

[¥] This cost includes re-issue of nevirapine to mothers, and provision of nevirapine suspension to the child and any formula milk for the duration of the hospital stay.

[‡] PMTCT activities delivered after the mother and infant are discharged from hospital after delivery, including cotrimoxazole and the provision of formula feeding. It does not include infant HIV testing.