Healthcare Delivery in Rwanda, Uganda, and Tanzania: Applying the Service Delivery Underperformance Index to the Healthcare Sector

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The Service Delivery Underperformance Index (SDUI) is used to analyze healthcare delivery in Rwanda, Uganda and Tanzania using data from Demographic and Health Surveys Service Provision Assessment. A cross-country ranking of healthcare delivery is done for these countries, where it is found that Rwanda has the best performing healthcare delivery despite being ranked below Tanzania and Uganda in terms of some health outcomes. A more extensive analysis of healthcare delivery in Rwanda shows that there are significant disparities in the performance of different types of healthcare facilities. An analysis is done of healthcare delivery in facilities that did and did not participate in policies intended to improve healthcare delivery. It is found that facilities that participated in community involvement performed significantly better than facilities that did not. This observation calls for future work to be done using the SDUI as an impact evaluation tool to analyze how policies impact underperforming healthcare delivery.

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1. Introduction

Allwine and Foster (2014) introduced the Service Delivery Underperformance Index (SDUI), a new approach to the measurement of service delivery. This index measures the underperformance, or multiple inadequacies, in service delivery, focusing on the healthcare and education sectors. Using Sen's theory of development and Foster and Handy (2008*a*)'s definition of external capabilities, education and healthcare facilities are described as providing capabilities, or freedoms, to potential patients in the communities that they serve. Implying that if development is the expansion of capabilities, there should be a focus on facilities that deprive people of multiple capabilities.

The index uses the Alkire and Foster (2011) methodology (used for poverty measurement) to aggregate indicators of poor service delivery. This allows the

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index to satisfy numerous properties, including focusing only on underperforming facilities. Taking into account the breadth of inadequacies experienced by facilities through dimensional monotonicity. Decomposability by the multiple dimensions and indicators of underperforming healthcare delivery. Allowing for ordinal variables.

This paper uses the SDUI to analyze the healthcare sectors in Rwanda, Uganda, and Tanzania using DHS:SPA survey data. Each of these countries has seen a stagnation in the improvement of health variables since the announcement of the MDGs and each is unlikely to meet many of the health related MDGs despite an increase in funding for the healthcare sector.

The three countries are ranked by their performance in delivering healthcare services. It is found that Rwanda has the best delivery of healthcare services, despite being ranked below Uganda and Tanzania for some health variables. This result is statistically significant at the 1% level and is robust to a change in the underperformance threshold, adequacy thresholds, and weights. Though a cross-country ranking does not aid countries in terms of policy responses to underperforming healthcare delivery, this ranking will draw attention to those countries that are not providing adequate delivery of healthcare services to people in order to ensure the improvement of the delivery of healthcare services.

An in-depth analysis of healthcare delivery in Rwanda is done by decomposing the SDUI results for Rwanda by the type of facility, governing authority of facilities, and province where facilities are located. It is found that health posts, dispensaries, and clinics are the worst at delivering healthcare services, while hospitals are the best. This result is statistically significant and is robust to a change in the underperformance threshold, adequacy thresholds, and weights. The rankings by governing authority and province are not robust. However, regressions are run to determine what are the determinants of the index, i.e. what characteristics are significantly correlated with the index, and it is found that the provinces of Enga and Kigali City have a significant negative relation to the number of inadequacies experienced by facilities as well as whether a facility is classified as underperforming.

A comparison of healthcare delivery for facilities that did and did not participate in three policies that have been used in many countries to improve the delivery of healthcare services is done using the SDUI. This is done not to show that the policy had an impact on healthcare delivery or causation in any way, but to show the SDUI could be used as a policy tool for impact evaluations of these policies. It is found that for community involvement, there is better healthcare delivery for facilities that implement the policy. This result is robust to changes in the underperformance cutoff, adequacy cutoffs, and weights.

The layout of the rest of this paper is as follows. Section 2 gives a literature review for the measurement of healthcare services and healthcare in each of countries analyzed here. Section 3 summarizes the SDUI and how it is applied to the healthcare sector. Section 4 describes the Demographic and Health Surveys:

Service Provision Assessment data used in the application of the index. Section 5 describes how the data is used to calculate the SDUI. Section 6 presents the results of the cross-country ranking. Section 7 presents the results of the in-depth analysis of Rwanda's healthcare delivery. Section 8 compares healthcare delivery for facilities that did and did not participate in three policies intended to improve the delivery of healthcare services. Section 9 concludes.

2. Literature Review

1. The Measurement of Healthcare Delivery

There are many measures of the quality of healthcare. The OECD Health Care Quality Indicators Project uses indicators of mortality and screening rates for specific illnesses to compare the quality of healthcare across countries. Some measures of the quality of healthcare depend on the purpose of the measure. For instance, Bruce (1990) measures the quality of care for family planning. Nicolucci, Greenfield and Mattke (2006) measures the quality of care for diabetes.

Many measures of healthcare quality can be found in research where a measure, or numerous indicators of quality, are used to determine the impact of quality on the dependent variable of interest. Hong, Montana and Mishra (2006) using the 2003 Egypt Interim Demographic and Health Survey construct an index of the quality of family planning services at the facility level made up of the availability of supplies used in family planning visits (such as spotlights and speculums) as well as healthcare delivery indicators such as training availability, supervision of providers, and updating of family planning registers. Authors find that IUD use among women was significantly positively associated with quality of family planning services, independent of characteristics of the facility and women surveyed. This held for women that received their IUD from a public facility, but not from a private facility.

Peabody, Gertler and Leibowitz (1998) use data from a national sample of randomly selected households and a concurrent facility survey of the public health clinics in Jamaica to analyze the relationship between infant birth weight and inputs and indicators of quality of healthcare and healthcare delivery (taking into account characteristics of facilities and mothers). They find that women who had access to facilities that did a more complete clinical examination, had infants who weighed, on average, 128 g more than those without access.

Gage and Zomahoun (2012) use data from health facility and household surveys in five states in Nigeria to examine the association of family planning service delivery and contraceptive outcomes. They use a multilevel logit model and find that there is a strong positive association of the knowledge of contraceptive methods and the use of quality assurance systems by family planning health facilities in the local government area (LGA). Health worker training in family planning services had a positive association with the odds of both lifetime use and current use of a modern method. The quality of provider-client interaction

in family planning in the LGA was positively associated with current use of a modern method of contraception as well as the odds of currently using a modern method for men and women.

Healthcare delivery indicators have also been used to analyze the impact that policies such as community involvement and pay for performance have on health. Bjorkman and Svensson (2009) analyze a project that introduced community involvement in Nigeria and found that the introduction of community involvement resulted in a decrease in absenteeism, increase in the correct use of equipment, the appropriate provision of supplements and vaccines for children, the quality of information provided to patients, and the cleanliness of facilities.

Basinga et al. (2010) evaluates the introduction of pay for performance for centers in Rwanda and finds that pay for performance has a significant impact on the share of clinical content items from first prenatal visits as well as a significant impact on utilization of maternal and child services.

There are also numerous papers that have discussed the specific indicators of healthcare delivery. Some of these include Banerjee, Deaton and Duflo (2004), Chaudhury et al. (2004), Chaudhury et al. (2006), and Das et al. (2005) which analyze absenteeism. Lindelow, Reinikka and Svensson (2003) and Leonard and Masatu (2010) analyze provider performance. Gauthier and Wane (2009) look at the impact of leakages of budgeted funds for facilities to explain the relationship between healthcare expenditure and utilization of services.

Note that measures of quality vary depending on the indicators used. Some include measures of basic inputs available and utilization rates of services. This paper focuses on those indicators of quality that reflect the poor performance, or underperformance, of the delivery of services. For instance, as indicators of quality of healthcare Hong, Montana and Mishra (2006) include the supervision of healthcare providers and updating of family planning registers to construct an index of the quality of family planning services at the facility level. These are measures of the delivery of services.Bjorkman and Svensson (2009) use cleanliness of the facility as an indicator of the quality of healthcare provision when analyzing the impact of increasing community involvement on the quality of healthcare. This is also a measure of the delivery of services.

2. Healthcare in Rwanda, Uganda, and Tanzania

The three countries in the analysis below have all had difficulties in meeting the health-related MDGs. None of the countries are on track to meet the goal of reducing maternal mortality by three-quarters. Only Tanzania is on track to reduce child mortality rates by two-thirds. Uganda has seen a increase in the spread of HIV/AIDS. However, in all three countries, expenditure on healthcare has increased, putting more emphasis on the delivery of healthcare services and measuring the problems in each country associated with the delivery of healthcare services.

These countries also have some of the lowest levels of GDP per capita, ranking

in the bottom 20 countries in the World Bank ranking. They are also in the bottom 20 countries in the ranking by the Multidimensional Poverty Index. It is for countries like these that a better understanding of why an increase in health expenditures is not yielding larger benefits to the health of citizens is critical.

3. Summary of the Theory and Computation of the SDUI

The theoretical reasoning for development of the SDUI is directly from Sen's capability approach. This approach measures a person's well-being by the capabilities, or freedoms, available to him or her to lead the kind of life he or she values. Therefore, development is measured as an expansion of peoples capabilities, or freedoms. (Sen (1999)) If development is an expansion of a person's capabilities, then poverty is a lack of capabilities. This is the approach taken in the measurement of poverty in the Alkire and Foster (2011) methodology and its application by Alkire and Santos (2011) in the Multidimensional Poverty Index.

Expanding on Foster and Handy (2008*b*)'s definition of external capabilities as the capabilities that are conferred to individuals through their "direct connection or relationship with another person" (Foster and Handy (2008*b*),1), education and healthcare facilities can be thought of as providing capabilities to individuals in the community that they serve. A high quality healthcare facility in the area allows a person to live a healthier life by providing adequate services such as checkups and vaccinations by quality personnel and the appropriate treatment for illnesses. Poor quality facilities deprive people of these capabilities. Therefore, we should focus on those facilities that are depriving people of multiple capabilities. These are classified as the worst performing facilities.

To compute the SDUI, first dimensions and indicators of underperforming service delivery must be chosen. A summarizing framework of the indicators that have been used in previous research to reflect underperforming service delivery are listed in Table 1 of Allwine and Foster (2014) and are copied below.[1]

To aggregate these indicators into an index, the Alkire and Foster (2011) methodology is used. First, the indicators chosen must be measured and applied to the facility level. For the purpose of this index, the facility will be the level at which each of the indicators will be represented. This is because, as mentioned above, facilities are considered to be giving individuals external capabilities. We are concerned with those individuals who are deprived of these capabilities. However, the indicators above are not only measured at the facility level. Any indicator that is not measured at the facility level needs to be transformed to a facility level indicator.

Financial accountability of the state to the sector is measured at the state level. Depending on the financial structure of the sector, this could mean that

[1]Examples of these indicators from the health sector are given in Allwine and Foster (2014).

[2]The difference between payroll roster and number of actual providers working

[3]Portion of providers claiming illegal payments were made to influence managerial decisions- including hiring and assignments

Table 1—Dimensions and Indicators that can be used to populate the SDUI

Dimension	Indicators
Financing and Resources:	- Financial accountability of the state to the sector. - Supervision and monitoring of financing and resources (including budget and supply leakages and payroll irregularities[2]).
Infrastructure:	- Adherence to quality assurance activities - Maintaining the physical condition of the facility. -Patient satisfaction ratings.
Providers:	- Provider absenteeism - Provider performance - Provider education and training - Corruption (such as job purchasing[3] and informal payments) - Patient satisfaction ratings.

each facility within the state receives the same value for this indicator. This would be the case where all facilities rely on financing from the government. However, if private facilities are not reliant upon the government for financing, or only receive a small portion of funding from financing, then the indicator could be evaluated separately for public and private facilities. Though measuring an indicator for the facility at the state level conveys less about differences in service delivery within a country then indicators measured at the facility and provider level, it gives us critical information on differences in service delivery across countries. A similar approach is taken for poverty analyses using the MPI. Village level variables reflecting infrastructure, such as the availability of roads to individuals, have been discussed in the MPI.

Supervision and monitoring of financing and resources, adherence to quality assurance activities and maintaining the physical condition of the facility are measured at the facility level. Provider performance, absenteeism, education and training, and corruption of the provider are all measured at the provider level. The provider level indicators are then aggregated to the facility level. For instance, taking the share of providers with adequate performance or the share of providers without the basic education requirements being met. Patient satisfaction ratings are measured at the patient level and then must be aggregated to the facility level, again using using share of patients who are satisfied.

These indicators will then be represented in a matrix of facilities achievements. Using similar notation as Alkire and Santos (2011), let $y = [y_{ij}]$ denote the $n \times d$ matrix of achievements for facility i in dimension j, where each value within the matrix (y_{ij}) represents an achievement y for facility i in dimension j and each row of the matrix represents the achievements of a facility i in all of the dimensions.

Next, a weighting scheme must be chosen for the dimensions such that each dimension receives a weight w_j and all weights sum to the number of dimensions $(\sum_{j=1}^{d}(w_j) = d)$.

Now we must identify those facilities that are underperforming (i.e. those facilities that have multiple inadequacies), as these are the facilities we want the index to capture and monitor. First, an adequacy threshold must be chosen for each dimension, call this z_j. z_j is chosen such that if the value of the dimension for a facility y_{ij} falls below the threshold z_j, a facility is considered inadequate in this dimension. Achievements of each facility in each of the dimensions are evaluated according to the threshold, and a matrix of inadequacies ($g = [g_{ij}]$) is generated by replacing each element of y (y_{ij}) with a value of 1 if $y_{ij} < z_j$ and 0 if $y_{ij} \geq z_j$.

From the matrix g a matrix of inadequacy counts (i.e. the weighted number of inadequacies a facility experiences) is calculated by calculating a weighted summation of each of the rows in matrix g. In mathematical notation, vector $c = [c_i]$ where $c_i = \sum_{j=1}^{d}(w_j \times g_{ij})$ and c is therefore a $n \times 1$ vector representing the weighted number of inadequacies each facility experiences.

To identify facilities that are underperforming, a underperformance threshold K must be chosen to represent the weighted number of dimensions a facility must be inadequate in to be considered underperforming. Generate a vector ρ that replaces each value in vector c in the following way. Let $\rho_i = 0$ if $c_i < K$ and let $\rho_i = 1$ if $c_i \geq K$. This vector ρ identifies which facilities are classified as underperforming.

Construct a second matrix $g(K)$ called the censored inadequacy matrix that sets all values of g to 0 when a facility is not classified as underperforming. In mathematical terms $g_{ij}(K) = 0$ if $\rho_i = 0$ else $g_{ij}(k) = g_{ij}$. From the censored inadequacy matrix a censored inadequacy counts vector can be calculated as simply the sum of each of the rows of $g(K)$ or $c(K) = [c(K)_i]$ where $c(K)_i = \sum_{j=1}^{d}(w_j \times g(K)_{ij})$.

There are numerous ways to calculate the SDUI from this information. First, one can simply calculate the average of the censored inadequacy matrix $g(K)$, meaning that $SDUI = \mu(g(K)) = (1/n)(1/D)\sum_{i=1}^{n}\sum_{j=1}^{d}(g(K)_{ij})$. This is the same as simply multiplying the share of facilities classified as underperforming by the average share of inadequacies that underperforming facilities experience. The share of facilities that are classified as underperforming can simply be calculated as the average of the vector ρ. This is called the facility count ratio, or FCR. The average share of inadequacies that a underperforming facility experiences is calculated by simply dividing each entry of vector $c(K)$ by the number of dimensions, d, and taking the average of the vector for all facilities classified as underperforming. In mathematical terms $A = (1/d)(1/q)\sum_{i=1}^{n}(c(K)_{ij})$. It is clear from this approach that the SDUI takes into account not only the incidence of underperforming facilities, but also the intensity of inadequacies within underperforming facilities.

To test statistical significance of rankings, one can simply run the usual t-test for each of the rankings of interest. To test the robustness of the results to a change in the underperformance cutoff (K), one can check the ordering implied

by the index for plausible values. Dominance of the resulting ordering is implied by a lower value of the index for all values of K (Foster and Shorrocks (1988)). However this can be a strict requirement and if a comparison is being made across more than 2 groups then another test of robustness may be needed.

To test the robustness of the underperformance cutoff (K), weights, and adequacy cutoffs (z_j) one can compare robustness of rankings to different specifications by computing rank correlation coefficients using Spearman's Rho, Kendall's Tau, and Pearson. Pearson's rank correlation coefficient simply calculates the percentage of pair-wise comparisons that are robust when different specifications are used. Kendall's Tau compares each pair within the group to determine if the ranking of the pair is concordant (implying that the ranking is the same as the original ranking) or discordant (implying that the ranking does not hold under the new specification). Kendall Tau's rank correlation coefficient is then simply the number of concordant pairwise ranks (C) minus the number of discordant pairwise ranks (D) divided by the total number of concordant pairwise ranks ($\tau = (C - D)/(C + D)$). Spearman's rank correlation is computed by ranking all groups under the original and new specification and for each country calculating the difference in the two ranks (r_i) for each group i. Then Spearman's Rho is simply $\rho = 1 - (1/n(n^2 - 1))6 \sum_{i=1}^{n} r_i^2$.

4. Data

Data on the delivery of healthcare services has recently become available from the Demographic and Health Surveys: Service Provision Assessment (DHS: SPA). The DHS: SPA is a nationally representative, facility based survey that uses facility questionnaires to management, healthcare providers, and patients, as well as observations of healthcare providers in their interactions with patients, in order to "obtain information on the capacity of facilities to provide quality services and the existence of functioning systems to support quality services." (National Institute of Statistics Rwanda, Ministry of Health Rwanda, and Macro International Inc. (2008), xxvii) The DHS: SPA has been implemented across fifteen countries: Kenya(1999 and 2004 and 2010), Rwanda(2001 and 2007), Uganda(2007), Bangladesh(1999 and 2014), Egypt(2002 and 2004), Tanzania (2006 and 2014), Ethiopia (2014), Zambia (2005) Namibia (209 and 2014), Senegal (2012/13 and 2014) Mexico (2000), Ghana(2002), Guyana (2004), Guatemala (1997), and Haiti (2013). The application below uses Rwanda (2007), Uganda (2007), and Tanzania (2006) because significant disparities exist across the DHS:SPA in different countries and these three surveys have the most consistency in questions asked yielding the largest number of indicators for calculation of the SDUI.

The Rwanda Services Provision Assessment was conducted in 538 health facilities, covering all public facilities and 61% of private facilities with three or more

staff.[4][5] The Uganda Services Provision Assessment surveyed 490 health facilities, covering approximately 16% of facilities.[6] The Tanzania Services Provision Assessment surveyed 611 health facilities, covering approximately 10% of facilities in the mainland and 36% of facilities in Zanzibar.[7]

To calculate the SDUI using the DHS:SPA data, the same core dimensions of healthcare delivery from Allwine and Foster (2014) are used. These are the effective use of: 1. Financing and Resources, 2. Infrastructure, and 3. Providers. Indicators used to reflect these dimensions are those used in previous research to reflect the poor delivery of healthcare services as well as data availability in the survey. These are listed in Table 2 below along with adequacy thresholds and weights for each indicator. There are 4 indicators for Infrastructure as well as Providers and 3 for Financing and Resources. A summary of why each indicator and adequacy threshold was chosen is located below the table. In many cases the adequacy cutoff was stipulated within the DHS:SPA survey material. Wherever this was not the case, robustness tests were done changing the adequacy cutoff chosen in the appendix.

The state is accountable to its people for efficiently financing the health sector. Part of the adequate financing of the health sector is ensuring that a large enough portion of the budget is being dedicated to the health sector. The WHO has set a suggested national budget share of 8% minimum. While this does not fully capture the efficiency with which the sector is financed, as could be done if Public Expenditure and Financial Accountability indicators (which assesses whether a country has the tools to deliver fiscal discipline, strategic resource allocation, and the efficient use of resources for service delivery) were applied to the health sector, it does proxy for the value the country places on healthcare.

Supervision and monitoring of financing and resources is necessary for an adequately functioning health sector. This includes monitoring finances intended to reach healthcare facilities to ensure that there is no funds lost to capture, as well as the monitoring of supplies (including medicine) that has been dedicated to the facility. Though there is no data available on the monitoring of finances, there is two variables that reflect the monitoring of resources. The DHS:SPA asks for the frequency with which supplies ordered are received. The response is given as the following: the facility received the amount of supplies ordered always, always but not often, or almost never over the past 6 months. The adequacy cutoff was not stipulated by the DHS, so it is set at always, such that if a facility received an order not always but often, or almost never the facility it is deemed inadequate in this indicator. As a robustness check for this cutoff, the SDUI is recalcu-

[4]Public facilities include government and government assisted facilities, approximately 74% of total facilities in Rwanda (National Institute of Statistics Rwanda, Ministry of Health Rwanda, and Macro International Inc. (2008))

[5]4 facilities were omitted because no provider data was given, resulting in a sample of 40 hospitals, 389 health centers and polyclinics, and 105 health posts, dispensaries, and clinics.

[6]5 facilities were omitted for missing healthcare provider data, resulting in a weighted sample of 19 hospitals, 283 health center ii's, 154 health center iii's, and 27 health center iv's.

[7]Resulting in a weighted sample of 25 hospitals, 55 health centers, and 522 dispensaries.

Table 2—Indicators and Sub-Indicators of the SDUI for Healthcare

Dimension	Indicator	Adequate if:	Weights
Financing and Resources:	Percentage of the national budget designated for healthcare	Government designates at least 8% of the national budget to healthcare sector	1/3
	Stock card is used to record receipt and use of medicine	Stock card observed	1/3
	Frequency with which supplies ordered are received	Always received	1/3
Infrastructure:	Quality assurance activities	Evidence of any quality assurance activities	1/4
	Frequency of managerial meetings	Record of meetings held at least every 6 months.	1/4
	Cleanliness of the facility	No areas of the facility were unclean	1/4
	Infrastructure of the facility	No areas of the facility were damaged	1/4
Providers:	Vignette on safety procedures for needlestick injury	Correctly answered safety procedures	1/4
	Education level of provider	All providers have at least basic training	1/4
	Availability of training classes	More than half of listed classes are available	1/4
	User fees posted	User fees clearly posted	1/4

lated changing the adequacy cutoff to not always but often, such that a facility is deemed inadequate only if medicine is almost never received in the appendix. The rankings remain robust.

The second variable reflecting supply leakages is the use of a stock card by a facility to record the receipt and use of medicine. This is very important as it is necessary that once medicine is received that it is actually used for patients and not on ghost patients. The leakage of drug supplies (including the presence of ghost patients) and mismanagement of revenues has been found to have a negative impact on healthcare utilization, as presented in McPake et al. (1999). There is a clear cutoff for this variable as the stock card is either observed, or not.

Quality assurance activities are used to maintain the quality of healthcare in facilities. Quality assurance activities may include supervisory check lists of equipment, medications, healthcare providers (such as observation checklists), supervision of healthcare providers, updating of records, facility reviews of mortality, and audits of medical records. These are some of the quality assurance activities listed in the DHS Service Provision Assessment survey. The DHS:SPA asks facility management if the facility uses any of a list of quality assurance activities. Gage and Zomahoun (2012) use data from health facility and household surveys in five states in Nigeria to examine the association of family planning service delivery and contraceptive outcomes. They find that there is a strong positive association of the knowledge of contraceptive methods and the use of quality as-

surance systems by family planning health facilities in the local government area (LGA). There is a clear adequacy cutoff here, such that if there is no evidence of any quality assurance activities, then the facility is deemed inadequate in this indicator.

The above variable representing quality assurance does not ask about the frequency of quality assurance activities, and it is important that managerial meetings are held frequently to ensure the efficient running of the healthcare facility. Gage and Zomahoun (2012) use whether official staff meetings have been held with a supervisor in their index representing quality family planning. They find that there was a positive association between having systems that were supportive of quality family planning services and the current contraceptive use rate. The DHS SPA asks for the frequency of meetings held by managerial staff, and adequacy is stipulated as being held at least every 6 months.

Maintaing the cleanliness of the facility is imperative to the usefulness of the facility to improve the health of patients. The DHS:SPA uses observations of cleanliness of all areas of the hospital (including whether the sharps container was overflowing or was pierced or broken, if bandages and non-sharps infectious waste was observed outside of a covered trash container) and a facility is deemed inadequate in cleanliness if any of the areas do not satisfy these basic observations of cleanliness. Cleanliness of the facility is one of the indicators used by Bjorkman and Svensson (2009) to represent quality of healthcare provision.

That patients are protected from weather elements is also critical to whether the facility can be effectively used to treat patients. The DHS:SPA asks if there was major damage to the walls or roof. A facility is deemed inadequate if there is major damage to either. This is a relatively clear cutoff as major damage will have serious effects on whether providers can serve patients.

The performance of healthcare providers can mean the difference between life and death for patients. Das and Hammer (2005) find that in India among the top 20% of providers, there was still a more than 50% chance that providers would harm patients with their lack of knowledge in the case of viral diarrhea and an over 25% chance for patients with preeclampsia. Das and Hammer (2005) shows that vignettes are the best way to ascertain provider performance. The DHS:SPA asks providers to detail what should be done in the case of a sharps or needlestick injury. The correct knowledge of this should proxy for the knowledge that providers have and would use in their interactions with patients.

Provider education is commonly used as a measure of provider quality. DHS asks for the year providers were given their technical qualifications (based off of the technical qualifications they were documented to have in the survey). All providers are required to have received the technical qualification for the position they are practicing at.

Training of providers has been used as a measure of quality in Hong, Montana and Mishra (2006) where authors find that IUD use among women was significantly positively associated with quality of family planning services. Gage and

Zomahoun (2012) also use training of providers as a measure of quality of healthcare. They find that health worker training in family planning services had a positive association with the odds of both lifetime use and current use of a modern method. The DHS lists 5 basic training courses that should be offered in an adequate facility. Adequacy requires that at least half of these training courses be offered, as it is possible that none of the providers interviewed were managers, and one of the courses was directly related to managerial duties. A course was deemed available to providers if any of the interviewed providers partook in the class. Robustness to this adequacy cutoff is checked in the appendix.

To proxy for corruption, the posting of user fees is used. Over 95% of facilities charge user fees in Rwanda. However, in the DHS supporting material it discusses the importance of posting fees in a visible way so that patients know how much they should be charged. If not, there is a higher likelihood that they will be charged informally above what the formal fee is. If fees are not visibly posted for patients then the facility was deemed inadequate in this indicator.

Though patient satisfaction levels are available in the data, they are not used to create the index as Aldana, Piechulek and Al-Sabir (2001) find that patient satisfaction ratings may not reflect quality, and that patient satisfaction ratings may have more to do with the cultural background of people than actual quality.

The weights given to each of the dimensions above is 1 and the weight for each indicator within each dimension is split equally. Robustness tests for these specifications are done in the appendix. To test the robustness of the weights, rank correlation coefficients are computed using Spearman's Rho, Kendall's Tau, and Pearson.

K is set at a plausible value of 1.5. Plausible values of K are between 1 and 2, as when K is set above 2 the facility count ratio drops significantly for all three countries to below 5% and the SDUI is essentially zero, which is highly implausible for these countries, and when K is set below 1 the facility count ratio increases to above 95%. A similar analysis to determine plausible cutoff values was done in Alkire and Santos (2011). This implies that a facility is deemed underperforming in healthcare delivery if the weighted indicators in which it is inadequate sum to 1.5 out of the 3 dimensions, or 50% of the weighted indicators. So for a facility to be classified as underperforming, it must be classified as inadequate in at least 1 dimension and half of another dimension, or a combination of indicators that yield a weighted sum of inadequacies of at least 1.5. Robustness tests are then done for all possible values of K in the appendix using Foster and Shorrocks (1988) dominance of the resulting ordering, which is implied by a lower value of the index for all values of K.

A weight of 1 is given to each facility. The DHS:SPA did ask facility managers for their catchment area, however there is a nonresponse rate for this question of 20% for Rwanda, 35% for Uganda and 28% for Tanzania, and it is for this reason that the results are calculated giving each facility the relative weight based off of the catchment area in the appendix.

5. Cross-Country Ranking

Table 3 below displays the cross-country ranking by SDUI for Rwanda, Uganda, and Tanzania using the DHS: SPA data. Rwanda has the lowest SDUI of .268, implying that Rwanda has the best delivery of healthcare services of these three countries. Table 3 also gives the components of the SDUI: the FCR (facility count ratio, or incidence of underperformance) and A (the average share of inadequate indicators within underperforming facilities, or the intensity of inadequacies within underperforming facilities). In Rwanda, A is 60%, implying that on average underperforming facilities in Rwanda are inadequate in 1.8 of the weighted indicators measured. The FCR for Rwanda is 45%, implying that 45% of facilities are underperforming in the provision of healthcare services in Rwanda in comparison to 57% in Uganda and 67% in Tanzania. The table also contains the standard error of each value calculated which are used to calculate statistical significance of the rankings. All rankings by FCR are statistically significant at the 1% level. Rankings by the average inadequacy share are statistically significant for all rankings at the 1% level except the ranking between Uganda and Tanzania. The ranking by SDUI is statistically significant for all rankings at the 1% level, except for the ranking between Uganda and Tanzania which is statistically significant at the 10% level. The rankings are also robust to a change in the underperformance cutoff and adequacy thresholds chosen (as can be seen in the appendix). The rankings are relatively robust to a change in weights, yet this result depends on the rank correlation coefficient used.

Table 3—Cross-Country SDUI Ranking

Country	Year	Facility Count Ratio (FCR)	A	SDUI	SDUI Rank
Rwanda	2007	.45	.6	.268	1
		(.022)	(.005)	(.013)	
Uganda	2007	.57	.63	.357	2
		(.028)	(.006)	(.018)	
Tanzania	2006	.67	.62	.417	3
		(.021)	(.005)	(.014)	

Setting
K=1.5

Table 4 compares the ranking of these three countries by SDUI to the ranking by a range of health outcomes from the World Bank Indicators, including the under-5 mortality rate, maternal mortality ratio, life expectancy at birth as well as rankings by healthcare utilization including % of birth attended by a skilled

health provider and % of women receiving prenatal care.[8] The ranking by health varies significantly for these countries depending on the variable used and also differs from the ranking of the SDUI. The implication being that rankings by health outcomes such as the under-5 mortality rate, maternal mortality ratio, and life expectancy as well as rankings by by healthcare utilization such as the % of births attended by a skilled health provider and % of women receiving prenatal care can be misleading if used to judge healthcare delivery, because these outcomes are not solely impacted by healthcare delivery, but also peoples characteristics and behavior.

Table 4—SDUI Ranking versus Health Outcomes Ranking

Country	SDUI Rank	Under-5 Mortality Rate (per 1,000 live births)	Maternal Mortality Ratio in 2005 per 10,000 live births	Life Expectancy at birth (total years)	% of Births Attended by Skilled Health Provider in 2005	% of Women Receiving Prenatal Care
Rwanda	1	85	610	59	39	94
Uganda	2	95	510	55	42	94
Tanzania	3	84	610	55	43	78

Setting
K=1.5

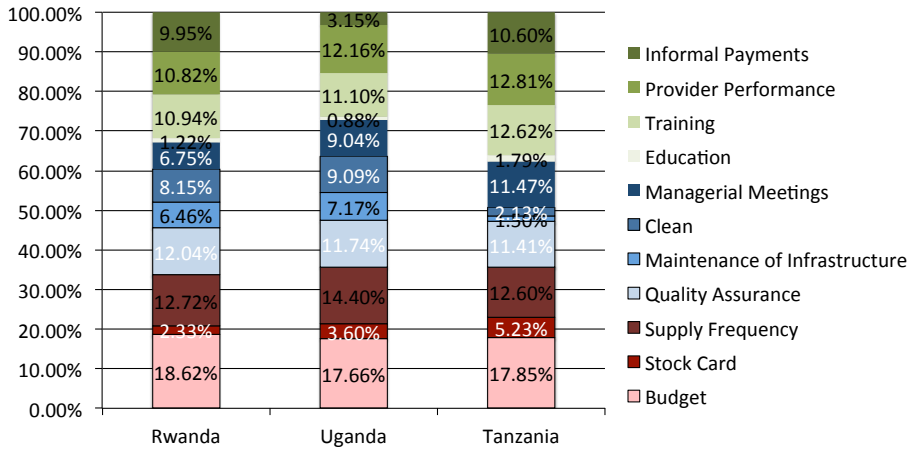
The results from Table 3 can be decomposed to find the percentage contribution of each indicator to the SDUI. This is done in Figure 1. The composition of underperformance varies considerably across these three countries. Uganda has a low contribution from Informal Payments to overall underperformance in the delivery of healthcare services. The cleanliness indicator has a small contribution to the SDUI in Tanzania. That Provider Performance has a much larger contribution than Provider Education for all three countries may seem surprising; however this gives reinforcement to the argument made in Leonard and Masatu (2010) that though healthcare providers are qualified to give a certain amount of treatment, they do not perform with this same quality unless under "intense scrutiny".

Policy implications are relatively limited from cross-country rankings, and it is for this reason that in Section 6 an in-depth analysis of healthcare delivery is done for Rwanda. However, the measurement and ranking of the poor delivery of healthcare services will likely bring attention to it and instill motivation for governments and institutions to invest and research ways to make improvements in the delivery of healthcare services.

Also, the ranking of these countries could be taken into account when calculating lending rates on investments in healthcare as the poor delivery of healthcare

[8]Variables where a year was not specified are measured in the year the survey was done or the closet year where data was available.

Figure 1. Contribution of Each Indicator to the SDUI



services dampens the impact of investments in healthcare, implying that countries with a lower index value will likely yield better returns on healthcare investments.

6. Healthcare Delivery in Rwanda

Rwanda's Public Health System is decentralized into health districts, where each health district has at least one hospital and numerous health centers and health posts. Health posts are generally located in more rural areas, far from health centers, and provide a narrow range of services. Health centers are located in more urban areas and provide a wider range of services than health posts. District hospitals serve patients that have been referred by primary health centers within its district (National Institute of Statistics Rwanda, Ministry of Health Rwanda, and Macro International Inc. (2008)). Private facilities in Rwanda also serve the community. Private facilities include polyclinics, which fulfill similar functions as health clinics in the public sector, as well as clinics and dispensaries, which fulfill similar functions as health posts, and hospitals.

Table 5 decomposes Rwanda's SDUI by facility type[9], managing authority[10], and province. Health posts, dispensaries, and clinics are found to have the worst provision of healthcare services of all three types of facilities, as demonstrated by a SDUI of .367.[11] It is not surprising that healthcare provision at the health

[9]Facility type groups facilities by similar functioning (including both public and private facilities).

[10]Managing authority includes government managed facilities and non-government managed facilities, where non-government managed facilities includes private and government assisted facilities. "[t]he government assisted facilities have a formal agreement to follow the policies of the MOH." (National Institute of Statistics Rwanda, Ministry of Health Rwanda, and Macro International Inc. (2008), 4) Unfortunately private and government assisted facilities cannot be separated due to contractual obligations of DHS to countries surveyed.

[11]It could be argued that adequacy cutoffs should differ between types of facilities, which is not done

posts, dispensaries, and clinic level is inefficient, as accountability and supervision are likely to be less prevalent in rural areas.

Standard errors are listed below each of the values calculated and statistical significance results are calculated based off of these. The ranking by SDUI for all three types of facilities is statistically significant at the 1% level for all rankings. Decomposing the SDUI into it's two components shows that the ranking of facility types is not only due to the higher percentage of facilities providing inefficient services for each type of facility, but also to the increasing average intensity of inadequacies across facility type. The ranking by facility count ratio is statistically significant across facility types at he 1% level, while the ranking by average intensity of inadequacies is not. The ranking by SDUI is robust to a change in the weighting scheme and adequacy thresholds as can be seen in the appendix.

Table 5—Decomposition of Rwanda's SDUI by Facility Type, Managing Authority, and Province

	FCR	A	SDUI	SDUI Rank
Facility Type				
Hospital	.15	.58	.087	1
	(.057)	(.027)	(.033)	
Health Center and Polyclinic	.44	.59	.259	2
	(.025)	(.005)	(.015)	
Health Post, Dispensary, and Clinic	.6	.61	.367	3
	(.053)	(.014)	(.034)	
Managing Authority				
Government	.43	.59	.26	1
	(.028)	(.006)	(.017)	
Non-government	.45	.6	.279	2
	(.034)	(.008)	(.021)	
Province				
North	.3	.6	.181	1
	(.05)	(.014)	(.031)	
South	.42	.59	.245	2
	(.046)	(.008)	(.027)	
East	.5	.61	.302	4
	(.048)	(.01)	(.029)	
West	.43	.58	.248	3
	(.045)	(.011)	(.027)	
Kigali City	.57	.6	.341	5
	(.055)	(.012)	(.033)	

Setting K=1.5

Non-government facilities are inferior to government facilities in the provision of

here but could be done if adequate survey data to determine cutoffs for each type of facility was available.

healthcare services, with a SDUI of .335 versus .279.[12] Again, standard errors are listed below the FCR, A and SDUI and are used to calculate statistical significance results. This ranking is not statistically significant.

That there is no significant difference across different managerial authorities is interesting as theoretically accountability should be less problematic in non-government facilities; however asymmetric information has been shown to yield numerous problems in non-government health facilities. This can be seen in Banerjee, Deaton and Duflo (2004) where the authors found that private providers in rural Udaipur, India underperformed their public counterparts, and Das and Hammer (2005) where it was found that private providers in poor areas of India performed worse than their public counterparts.

Out of all five provinces, Kigali City has the poorest provision of healthcare services, while the North has the best. This is interesting as Kigali City is considered to be an urban hub for Rwanda where many providers are likely to want to be stationed, whereas the North is considerably more rural.

The ranking is not statistically significant across all pairwise rankings of provinces, however the ranking between the North and East as well as the North and Kigali City is statistically significant for both the facility count ratio, the average share of inadequacies, and the SDUI. The ranking for the North and East remains consistent when changing the weighting scheme. Though the ranking for the North and Kigali City does not, as when 50% weight is put on financing and resources Kigali City becomes the best at delivering healthcare services. However, this is likely due to it's central location. Therefore we can only definitively state based off of statistical significance and robustness that the North has better delivery of healthcare services than the East.

However, note that Kigali City and the East have a higher portion of health posts, dispensaries, and clinics than any other province, implying that this result may be driven by the composition of types of facilities within these provinces. It is for this reason that regressions are run to determine the most important characteristics to determining whether a facility is classified as underperforming and the number of inadequacies they experiences. A summary table of characteristics of facilities is given in Table 6 below. Results from the regression of characteristics on whether a facility is classified as underperforming is in Table 7. Results from the regression of characteristics on the number of inadequacies experienced by facilities is in Table 8. There are numerous omitted variables that we would like to include in these regression, including but not limited to the poverty level in the area that the facility serves, how rural the area is where the facility is located, and the value of fees charged by facilities. This will likely lead to some omitted variables bias in the results following.

The average number of providers at a facility are 25 and the average share of

[12]There is a possibility that this result is due to specific indicators omitted in the application, as it is likely that absenteeism will be worse in government facilities than non-government facilities, as is seen in Banerjee, Deaton and Duflo (2004).

Table 6—Summary of Characteristics

Variable	Mean	Std Dev	Min	Max
Total Providers	25	43	2	526
Share of Female Providers	.54	.17	0	1
Number of Days Open	6.9	.4	3	7
Number of Beds	31	54	0	512
Share of List of Medications Available	.36	.13	.01	.78
Share of List of Medications Out of Stock in Past 6 Months	.11	.22	0	1
Share of List of Supplies Available	.64	.18	.13	1
Computer Available	.45	.5	0	1
Available Working Phone or Radio	.87	.34	0	1
Shortage of Water	.53	.5	0	1

female providers is 54%. Most facilities are open 7 days a week. The average number of beds that facilities have are 31. DHS gives a list of 90 general medications that all facilities should have and interviewers then observe whether these medications are available. On average, facilities have only 36% of these medications with some facilities only having 1% of the general medications listed and others having 78%. Of these general medications listed by DHS, on average 11% have been out of stock in the past 6 months, with some facilities having no stock outs while others having a stock out of all of the medications listed. DHS gives a list of basic supplies that all facilities should have (including supplies such as sharps and sharp boxes). On average, facilities have 64% of these supplies and again there is a wide range with some facilities only having 18% of the basic supplies and others having all of them. 45% of facilities have a computer available and 87% have a working phone or radio to communicate. 53% of facilities have experienced a shortage of water.

Probit results show that facilities with a larger share of female providers have a lower probability of being classified as underperforming. Facilities with a larger share of the listed general medications available have a lower probability of being classified as underperforming. Facilities with a computer available have a 10% lower probability of being classified as underperforming. Having a working phone or radio decreases the probability of being classified as underperforming by 13%. Facilities from the North East, and West provinces are all significantly less likely to be classified as underperforming than facilities in Kigali City. Therefore facilities in Kigali City have a significantly higher probability than these 3 provinces of being classified as underperforming. Hospitals are 34% less likely to be classified as underperforming than health posts, dispensaries, and clinics. Government facilities are 39% less likely than non-government facilities to be classified as underperforming.

Though these results do not follow exactly our rankings above they are very close. However, it is important to remember that the SDUI takes into account

Table 7—Regression Results of Characteristics Related to whether a Facility is Deemed Underperforming

Characteristics	Marginal Effect	Standard Error
Total Providers	.0004	.001
Share of Female Providers	-.28*	.15
Number of Days Facility is Open	.13	.09
Number of Beds	.002	.001
Share of List of Medications Available	-.47*	.29
Share of List of Supplies Available	.1	.15
Share of List of Medications Out of Stock in Past 6 Months	.13	.11
Computer Available	-.1*	.05
Available Working Phone or Radio	-.13*	.08
Shortage of Water in Past 6 Months	-.03	.05
North Province	-.44***	.08
South Province	-.16	.13
East Province	-.25*	.14
West Province	-.27***	.11
Hospital	-.34**	.13
Health Center	-.14	.12
Government	-.39**	.18
North Province*Government	.47***	.15
South Province*Government	.25	.18
East Province*Government	.37**	.18
West Province*Government	.4***	.15
Hospital*Government	-.31*	.18
Health Center*Government	.11	.17

the incidence of underperformance as well as the intensity, so the above regression is simply telling us the characteristics that are important in describing whether a facility is classified as underperforming. These characteristics include the share of female providers, the share of general medications available, availability of a computer and working phone/radio, province where the facility is located, type of facility, and managing authority of the facility.

Table 8—Regression Results of Characteristics Related to the Number of Inadequacies Experienced by Facilities

Characteristics	Marginal Effect	Standard Error
Total Providers	.0002	.0006
Share of Female Providers	-.09	.1
Number of Days Facility is Open	.1	.07
Number of Beds	.0004	.0005
Share of List of Medications Available	-.36*	.2
Share of List of Supplies Available	.02	.11
Share of List of Medications Out of Stock in Past 6 Months	.01	.07
Computer Available	-.1***	.04
Available Working Phone or Radio	-.12**	.05
Shortage of Water in Past 6 Months	-.02	.04
North Province	-.41***	.08
South Province	-.1	.11
East Province	-.15	.12
West Province	-.15	.1
Hospital	-.14	.15
Health Center	-.16*	.09
Government	-.25*	.14
North Province*Government	.39**	.17
South Province*Government	.18	.15
East Province*Government	.28*	.16
West Province*Government	.25*	.14
Hospital*Government	-.24*	.16
Health Center*Government	.02	.12
constant	1.402***	..51
R Squared	.18	
F (23, 455)	4.78***	

Table 8 presents the results from the regression of characteristics on the number of inadequacies experienced by facilities. OLS is used, adjusting for heteroskedasticity by using robust standard errors. Robust standard errors are used as whites test of heteroskedasticity rejected homoskedasticity. Increasing the share of listed general medications available at a facility is associated with a smaller number of inadequacies by .36 (or one Financing and Resources indicator). Having a computer available is associated with a smaller the number of inadequate indicators. Having a working phone or radio is negatively correlated with the number of inadequate indicators. Again, these results are similar to what was found when comparing rankings of the SDUI.

Which province a facility is located in has a significant amount of explanatory power for the number of inadequacies a facility experiences. Considering that the health sector is decentralized in Rwanda this is not surprising. Facilities from the north have .4 less inadequacies than facilities from Kigali City (this amounts to one indicator of the Financing and Resources dimensions or 1 and a half indicators of the Providers and Infrastructure dimensions). Government

facilities have significantly less inadequacies than non-government facilities.

As is done above for the cross-country ranking, the SDUI results found in Table 5 can be decomposed to find the percentage contribution of each indicator to the SDUI. This is done in Figures 2, 3, 4, and 5. The composition of underperformance varies greatly when comparing across facility types. Stock card use and managerial meeting frequencies have a larger contribution for health posts, dispensaries, and clinics. The composition varies only slightly across government and non-government facilities.[13] The composition of underperformance varies across provinces when comparing the East, Kigali City, and the North. Though the East has significantly and robust worse delivery of healthcare services than the North, the contributions from each indicator are relatively similar. Yet, contributions from Kigali City and the North are very different, where Kigali City has a larger contribution from the Providers dimension (shades of green) and a lower contribution from the Financing and Resources dimension (shades of red).

Through this analysis, policy implications can be made to improve the delivery of healthcare services in Rwanda. According to the theory in Allwine and Foster (2014), facilities that are multiply inadequate should be targeted for the purposes of development in order to expand peoples capabilities through their local facilities. The provision of healthcare services is the poorest in health posts, dispensaries, and clinics which is robust to a change in the adequacy cutoff, a change in weights, and is statistically significant. These facilities could be targeted to effectively improve healthcare delivery in Rwanda, increase the external capabilities experienced by people living in rural areas who use these facilities and therefore spur development. This strategy could also act as an effective tool to reduce the impacts of poverty as this type of facility is generally located in more rural areas where the poor are more likely to be located.

Assuming that equal weights on dimension, and indicators, reflects underperforming healthcare delivery and that an underperformance cutoff of 1.5 correctly defines the minimum standard of performance of healthcare delivery, the indicators: Budget, Quality Assurance, and Managerial Meetings should be targeted within health posts, dispensaries, and clinics as these indicators have the largest contributions to the SDUI.

As the healthcare system is decentralized in Rwanda, provincial government may be interested in ways in which they can improve healthcare delivery for their own province specifically. The SDUI allows for this, as the results from Table 5 by province can be further decomposed by facility type and managing authority. Table 9 demonstrates that in Kigali City non-government facilities perform much worse than their government counterparts; while in the East, North and West provinces government facilities perform worse than non-government facilities. [14] The implication from this analysis is that it may be necessary to employ a different

[13]It is possible that there would be a greater difference in composition among public and private facilities, as "non-government facilities" includes government assisted facilities.

[14]Statistical significance tests and robustness tests can also be done on these results but are not done here as this is strictly meant as an example.

Figure 2. Contribution of Each Indicator to the SDUI by Facility Type

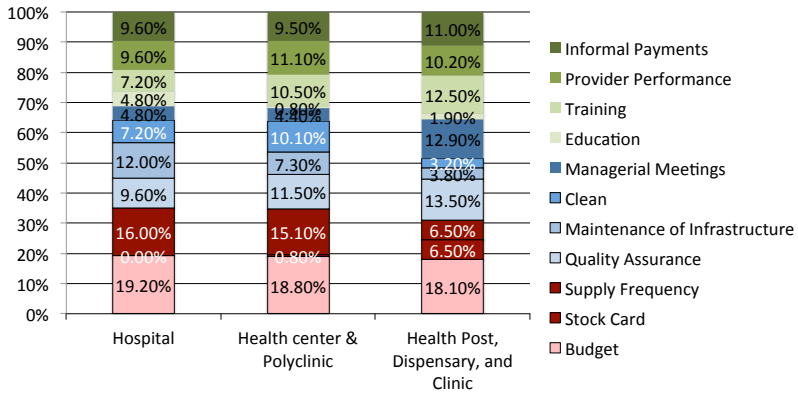


Figure 3. Contribution of Each Indicator to the SDUI by Managing Authority

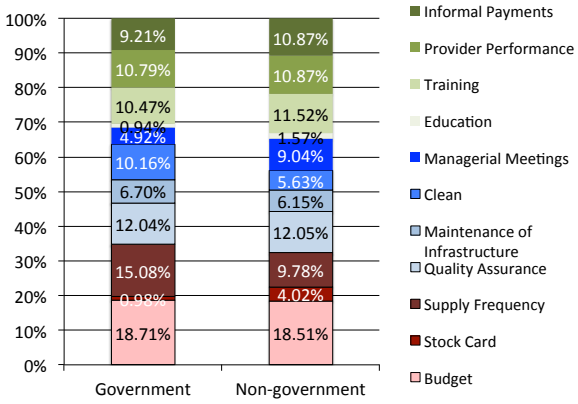


Figure 4. Contribution of Each Indicator to the SDUI by Province: Kigali City and North Provinces

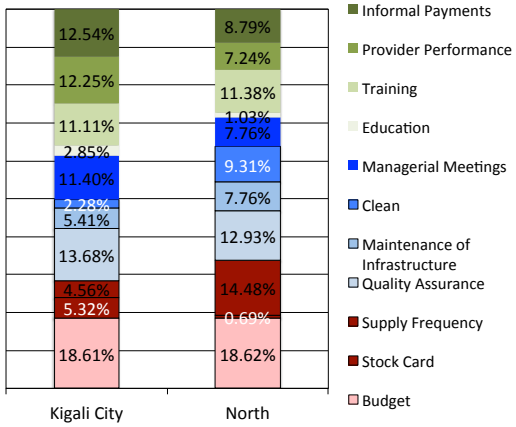
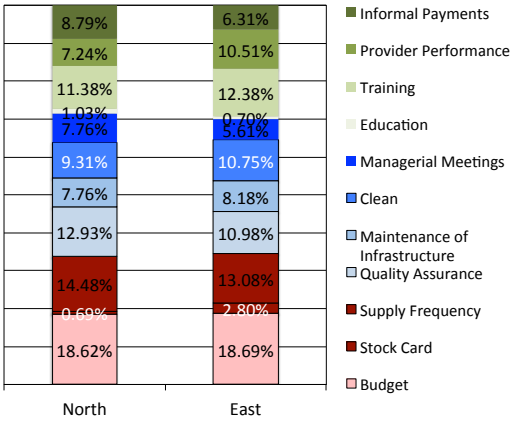


Figure 5. Contribution of Each Indicator to the SDUI by Province: East and North Provinces



combination of policies in different provinces. One can also think of this analysis as a tool for increasing accountability of local government not only to citizens but to the national government.

7. SDUI Comparison Across Policies

A comparison of facilities that took part in three policies intended to improve healthcare delivery is done below. This is strictly a comparison of these facilities healthcare delivery and does not imply causation, meaning that one cannot state that introducing these policies will yield any impact on healthcare delivery as measured by the SDUI. The policies evaluated here are: increased community involvement, health worker pay for performance, and giving health workers the opportunity for advancement in their career.

Increasing the involvement of the community is a common tool for improving accountability in the healthcare system as well as the education system. It has been found to have positive impacts on indicators of healthcare delivery such as cleanliness of the facility, absenteeism, correct use of equipment by providers, appropriate provision of supplements and vaccines by providers, and the quality of information providers give to patients, as well as healthcare utilization as can be seen in Bjorkman and Svensson (2009) in Uganda.

Community involvement has been used in Rwanda for many years, as can be seen in the Lusaka Declaration introduced in 1985. In 1995 the Ministry of Health renewed its dedication to the Lusaka Declaration and increased community participation in the management and financing of services (Government of Rwanda (2005)). The Ministry of Health developed a community health policy for implementing health care services at the community level which recommends ac-

Table 9—Decomposition of Rwanda's SDUI within Provinces

Province		FCR	A	SDUI	Province		FCR	A	SDUI	Province		FCR	A	SDUI
Kigali City	Facility Type				East	Facility Type				North	Facility Type			
	Hospital	.2	.53	.106		Hospital	0	0	0		Hospital	0	0	0
	Health Center and Polyclinic	.5	.6	.3		Health Center and Polyclinic	.53	.6	.318		Health Center and Polyclinic	.32	.61	.194
	Health Post, Dispensary, and Clinic	.66	.6	.394		Health Post, Dispensary, and Clinic	.54	.69	.37		Health Post, Dispensary, and Clinic	.33	.53	.176
	Managing Authority					Managing Authority					Managing Authority			
	Government	.31	.58	.178		Government	.52	.61	.317		Government	.36	.59	.214
	Non-government	.69	.6	.418		Non-government	.417	.59	.246		Non-government	.18	.62	.11
West	Facility Type				South	Facility Type								
	Hospital	.08	.55	.046		Hospital	.4	.6	.24					
	Health Center and Polyclinic	.45	.57	.258		Health Center and Polyclinic	.41	.59	.24					
	Health Post, Dispensary, and Clinic	.64	.66	.422		Health Post, Dispensary, and Clinic	.63	.55	.344					
	Managing Authority													
	Government	.48	.6	.276		Government	.42	.59	.247					
	Non-government	.44	.58	.264		Non-government	.42	.59	.247					

Setting K=1.5

tive participation of the population in planning, implementation, monitoring and evaluation of programs and projects, and strongly encourages community recommendations and feedback. The community is thus responsible for its participation in the management of healthcare facilities. Here the extent of the community's participation in the management of healthcare facilities is measured by managers' response to whether the facility partook in community involvement and had official records of meetings between facility staff and community members. 54% of facilities had official records of meetings between facility staff and community members.

Pay for performance, or performance based financing, has been used as a tool in many developing countries for motivating providers to meet pre-specified performance indicators. In Rwanda, pay for performance financing was introduced nationally in both public and nonprofit health centers and hospitals starting in June of 2006. It was introduced in a randomized format so that evaluation of the impact on healthcare utilization and quality could be done. It was introduced to treatment facilities in June-September of 2006 (with no impact on control facilities) and two years later, in April of 2008 it was introduced in the control facilities. The data from the DHS:SPA was collected between June 16, 2007 and was completed August 31, 2007.

Facilities were given payments equal to fees assigned for a list of common services provided multiplied by the quantity of those services provided in the facility multiplied by a quality score. The quality score included indicators of healthcare delivery. Facilities then used these payments in their own discretion. 77% of facilities used this to increase personnel compensation resulting in a 38% increase in staff salaries. The program's benefits for child and maternity services was evaluated in Basinga et al. (2010).

Unfortunately, the DHS:SPA did not ask whether the facility was in the treatment or control group and there is no data available on the district that each facility is located in to determine which facilities were in treatment and control.[15] However, the survey does ask if providers receive any money outside of their routine salary that is related to their work in the facility. This will capture those facilities that partake in performance based financing at the time and passed their earnings onto providers as well as facilities that adopted their own performance based financing. Therefore, nothing can be stated as to the impact of introducing pay for performance financing. At the time of the survey, 77% of facilities gave providers an additional payment related to their services.

Giving healthcare workers the opportunity for advancement is not as popular of a policy as those mentioned above, but coincides with a policy of non-monetary incentives. Theoretically, providers having the opportunity to advance their career should give an incentive for providing better services.[16] Each facility decides

[15]DHS was contacted to see if this data was available but it was not.

[16]Opportunity for advancement for providers was advocated for by Dr. Lewis at her presentation at ODI.

on the opportunities they will make available for healthcare providers. Each provider's response to whether he or she has any opportunities for promotion in his or her current job is used to measure whether healthcare providers are given the opportunity to advance their career within the facility. If a majority of providers interviewed state that they have the opportunity to advance their career then the facility is deemed to give providers the opportunity for advancement.

Table 10 gives the decomposition of Rwanda's SDUI for facilities that participated in the respective policy and facilities that did not at the time of the survey. For each of the policies listed, the SDUI is higher, and consequentially the provision of healthcare services is worse, for facilities that did not participate in the respective policy. Rankings by Community Involvement and pay for performance by SDUI and FCR are statistically significant at the 1% level. For community involvement, the ranking by average intensity of inadequacies is statistically significant at the 1% level. Rankings for community involvement and pay for performance are also robust to a change in the underperformance cutoff, as can be seen in the appendix. Rankings for community involvement and opportunity for advancement are robust to a change in weights. The ranking for monetary incentive is not robust to a change in weights, as when a weight of 50% is put on Financing and Resources the ranking reverses.

Table 10—Decomposition of Rwanda's SDUI by Policy Solution

	FCR	A	SDUI
Community Involvement			
Participate	.4	.58	.229
	(.028)	(.005)	(.017)
Do not participate	.51	.61	.314
	(.033)	(.008)	(.012)
Health Worker Pay for Performance			
Participate	.42	.59	.246
	(.024)	(.005)	(.015)
Do not participate	.56	.61	.31
	(.046)	(.01)	(.028)
Health Worker Opportunity for Advancement			
Participate	.44	.6	.26
	(.038)	(.008)	(.023)
Do not participate	.45	.6	.27
	(.027)	(.006)	(.016)

Setting K=1.5

To see if the policies explain the classification of whether facilities are underperforming as well as the number of inadequacies experienced by facilities the same regressions are run as before including these three policies as explanatory

variables.

Table 11—Summary of Policy Participation

Variable	Mean	Std Dev	Min	Max
Community Involvement	.54	.5	0	1
Monetary Incentive	.77	.42	0	1
Opportunity for Advancement	.34	.47	0	1

Table 11 gives a summary of policy participation for the three policies. 54% of facilities have records of meeting with the community and 77% of facilities have more than half of providers receiving monetary incentives linked to their performance. In only 34% of facilities do at least half of providers report that they have the opportunity to advance in their career.

Table 12—Regression Results of Characteristics Related to whether a Facility is Deemed Underperforming

Characteristics	Marginal Effect	Standard Error
Community	.11	.1
Monetary Incentive	-.06	.08
Opportunity for Advancement	-.02	.05
Total Providers	.0005	.001
Share of Female Providers	-.31*	.15
Number of Days Facility is Open	.12	.09
Number of Beds	.002	.001
Share of List of Medications Available	-.45	.29
Share of List of Supplies Available	.16	.16
Share of List of Medications Out of Stock in Past 6 Months	.13	.12
Computer Available	-.11**	.05
Available Working Phone or Radio	-.13*	.08
Shortage of Water in Past 6 Months	-.02	.05
North Province	-.45***	.08
South Province	-.17	.13
East Province	-.26*	.14
West Province	-.28**	.11
Hospital	-.33**	.13
Health Center	-.11	.13
Government	-.38**	.18
North Province*Government	.48***	.15
South Province*Government	.27	.18
East Province*Government	.39**	.17
West Province*Government	.42***	.14
Hospital*Government	-.34**	.15
Health Center*Government	.09	.17

From Table 12 none of the policies explains whether facilities are classified as underperforming. Other characteristics are similar to what was found in the previous probit regression.

Table 13—Regression Results of Characteristics Related to the Number of Inadequacies Experienced by Facilities

Characteristics	Marginal Effect	Standard Error
Community	-.11***	.04
Monetary Incentive	-.02	.05
Opportunity for Advancement	-.006	.04
Total Providers	.00006	.00006
Share of Female Providers	-.12	.1
Number of Days Facility is Open	.1	.07
Number of Beds	.0004	.0005
Share of List of Medications Available	-.31	.2
Share of List of Supplies Available	.07	.11
Share of List of Medications Out of Stock in Past 6 Months	-.007	.08
Computer Available	-.11***	.04
Available Working Phone or Radio	-.12**	.05
Shortage of Water in Past 6 Months	-.01	.04
North Province	-.38***	.14
South Province	-.1	.11
East Province	-.12	.13
West Province	-.11	.11
Hospital	-.11	.15
Health Center	-.11	.09
Government	-.23	.14
North Province*Government	.36**	.17
South Province*Government	.17	.15
East Province*Government	.27*	.16
West Province*Government	.23	.15
Hospital*Government	-.27*	.16
Health Center*Government	.02	.12
constant	1.34***	.51
R Squared	.2	
F (26, 452)	4.78***	

Running the same OLS regression as before including the three policies, facilities that take part in community involvement have .11 less inadequacies than those that do not. Other characteristics are similar to what was found in the previous OLS regression.

Though it is shown that the performance of healthcare delivery is significantly and robustly better for community involvement, this does not imply causation just correlation. We cannot rule out that the choice of adopting the policy is endogenous to healthcare delivery of facilities.

8. Conclusion

This paper used the SDUI that was introduced in Allwine and Foster (2014) to analyze healthcare delivery in Rwanda, Uganda, and Tanzania using data from Demographic and Health Surveys Service Provision Assessment survey. Though

there has been much work that has discussed indicators of inadequate healthcare delivery and how these inadequacies impact health outcomes, no single measure of underperforming healthcare delivery has been used to analyze healthcare delivery.

A cross-country ranking of healthcare delivery was done for Rwanda, Uganda, and Tanzania and it was found that Rwanda had the best delivery of healthcare services, despite being ranked below Uganda and Tanzania for some health variables. This result was found to be statistically significant at the 1% level and robust to a change in the underperformance threshold, adequacy thresholds, and weights. The benefit of this type of analysis is that a cross-country ranking will draw attention to those countries that are not delivering adequate healthcare services to people so that healthcare delivery can be improved.

An in-depth analysis of healthcare delivery was done for Rwanda by the type of facility, governing authority of facilities, and province where facilities are located. It was found that health posts, dispensaries, and clinics are the worst at delivering healthcare services in Rwanda, while hospitals are the best. This result is statistically significant and is robust to a change in the underperformance threshold, adequacy thresholds, and weights. The rankings by governing authority and province were not robust. However, regressions were run to determine what the determinants of the index are, i.e. what characteristics are significantly correlated with the index, and it was found that the managing authority and province where a facility are located are both determinants of whether a facility is classified as underperforming and the number of inadequacies a facility experiences.

A comparison was done of healthcare delivery for facilities that did and did not participate in three policies that have been used in many countries to improve the delivery of healthcare services. This was not done to show whether the policy had an impact on healthcare delivery, but to suggest the usefulness of the SDUI as a impact evaluation tool for policies intended to improve healthcare delivery. It was found that for each of the policies, there was better healthcare delivery for facilities that partook in the policy. However, this result is only robust to changes in the underperformance cutoff, adequacy cutoffs, and weights for community involvement. Hopefully this results will act as an incentive for future research to use the SDUI for the purpose of evaluating the impact of community involvement on healthcare delivery.

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Appendix

A1. Robustness to Change in Underperformance Threshold

Figure A1 to A7 show the robustness of the rankings to a change in the underperformance threshold (or cutoff). The cross-country ranking is robust to a change in the threshold. The ranking for facility types and governing authority in the analysis for Rwanda are also robust to a change in the threshold. The ranking between the North and all other provinces is robust, such that the North outperforms all other provinces for all possible underperformance cutoffs. The ranking by participation in a given policy is robust to a change in the underperformance threshold for community involvement and health worker pay for performance. However, the ranking is not robust for health worker opportunity for advancement.

Figure A1. Robustness of Cross-Country SDUI Ranking to the Underperformance Cutoff

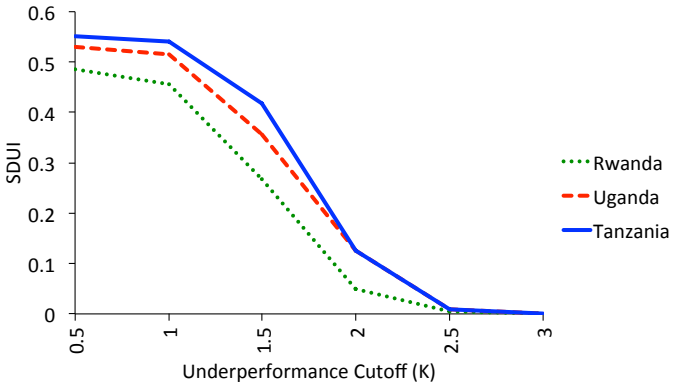


Figure A2. Robustness of SDUI Ranking by Facility Type to the Underperformance Cutoff

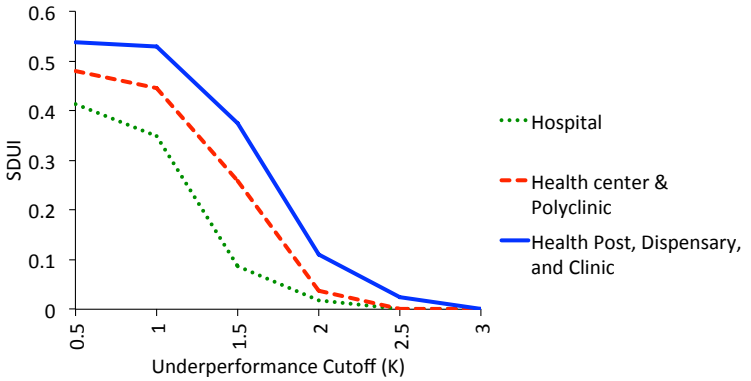


Figure A3. Robustness of SDUI Ranking by Managing Authority to the Underperformance Cutoff

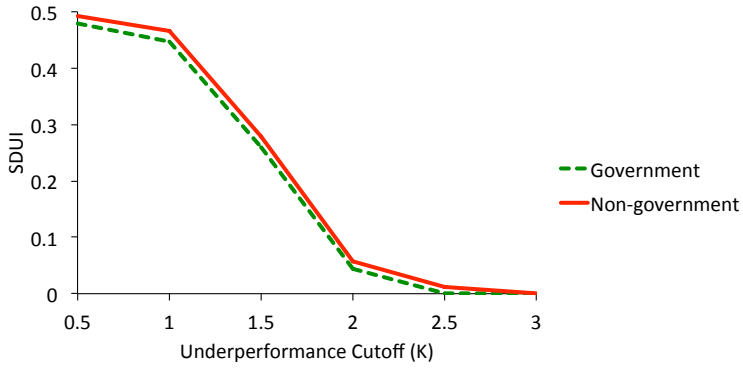


Figure A4. Robustness of SDUI Ranking by Province to the Underperformance Cutoff

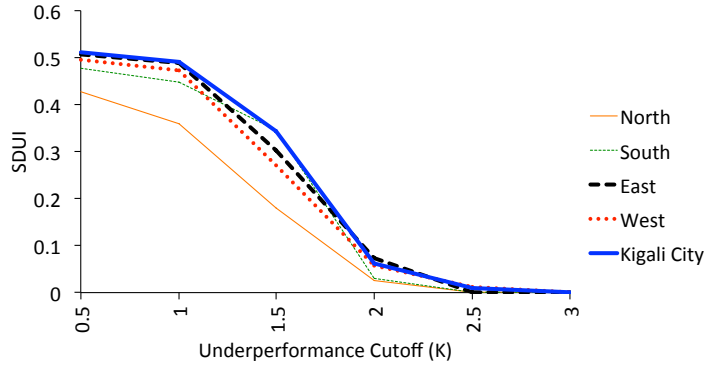


Figure A5. Robustness of SDUI Ranking by Participation in Community Involvement to the Underperformance Cutoff

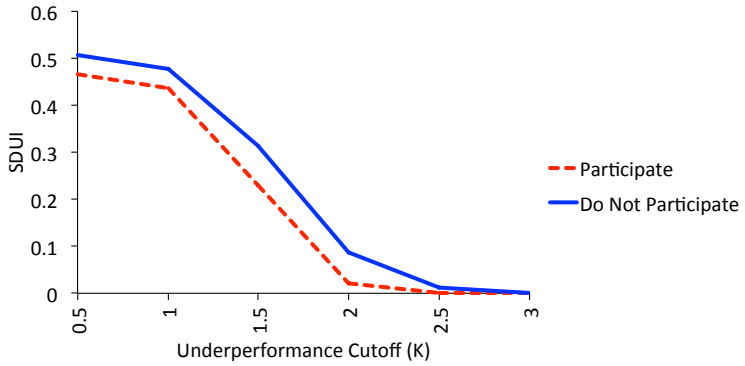


Figure A6. Robustness of SDUI Ranking by Participation in Health Worker Pay for Performance to the Underperformance Cutoff

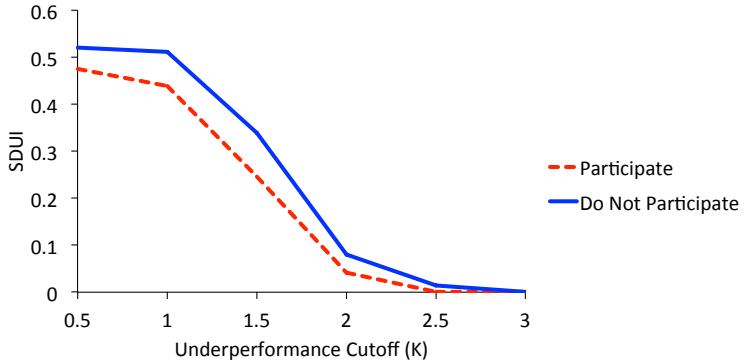
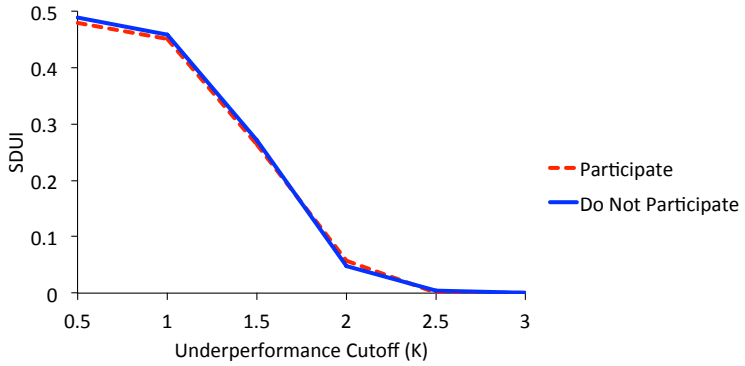


Figure A7. Robustness of SDUI Ranking by Participation in Health Worker Opportunity for Advancement to the Underperformance Cutoff



A2. Robustness to Change in Weights

The statistically significant rankings are now tested for their robustness to a change in weights. The different weighting schemes are the same as specified in Alkire and Santos, where a weight of 50% is put on each respective dimension and the other dimensions receive equal weights. In this way, the dimension with a weight of 50% receives twice the weight as the other dimensions. So when a weight of 50% is put on funding and resources, this implies that effective use of funding and resources is weighted as two times as important as the effective use of infrastructure and the effective use of providers.

Table A1—Cross-Country SDUI Ranking- Robustness to Changing Weights

Pairwise Comparison	Pearson's Correlation Coefficient	Spearman's Correlation Coefficient	Kendall's Tau Correlation Coefficient
Equal Weights and 50% Weight on Funding and Resources	1	1	1
Equal Weights and 50% Weight on Infrastructure	.82	.5	.33
Equal Weights and 50% Weight on Providers	1	1	1

Setting K=1.5

The cross-country ranking is relatively robust to the changing of weights. Where the ranking is less robust is when a weight of 50% is put on the Infrastructure dimension. When this occurs, the ranking between Uganda and Tanzania reverses, though the ranking for Rwanda and Uganda and Rwanda and Tanzania remains consistent such that Rwanda outperforms both countries. For this reason, one can conclude that the results that Rwanda outperforms both countries is robust to a change in weights, but one cannot conclude that Tanzania performs the worst out of all countries. The reason for this can be seen in Uganda and Tanzania's compositions of underperformance. Uganda has a much larger contribution from Institutions than Tanzania, and so by placing more weight on this dimension the ranking changes.

The ranking by facility type in Rwanda is robust to a change in the weighting scheme. The ranking does not change for any of the types of facilities no matter the weighting scheme used. The rankings by province and managing authority in Rwanda are not checked here as they are not statistically significant or robust to a change in the underperformance threshold.

Table A2—SDUI Ranking by Facility Type in Rwanda- Robustness to Changing Weights

Pairwise Comparison	Pearson's Correlation Coefficient	Spearman's Correlation Coefficient	Kendall's Tau Correlation Coefficient
Equal Weights and 50% Weight on Funding and Resources	.95	1	1
Equal Weights and 50% Weight on Infrastructure	1	1	1
Equal Weights and 50% Weight on Providers	.98	1	1

Setting K=1.5

A3. Robustness to Change in Adequacy Thresholds

The frequency with which supplies are received uses whether the facility received the amount of medicine ordered always, always but not often, or almost never over the past 6 months as an indicator. The adequacy cutoff was not stipulated by the DHS, so in the above analysis it was set at always, such that if a facility received an order not always but often, or almost never the facility was deemed inadequate in this indicator. As a robustness check for this cutoff, Table A3 and A4 calculate the rank coefficients when the adequacy cutoff is not always but often, such that a facility is deemed inadequate only if medicine is almost never received.

For training available to providers, the DHS lists 5 basic training courses that should be offered in an adequate facility. Adequacy requires that at least half of these training courses be offered, as it is possible that none of the providers interviewed were managers, and one of the courses was directly related to managerial duties. A course was deemed available to providers if any of the interviewed providers partook in the class. As a robustness check to this adequacy cutoff Tables A3 and A4 calculate the rank coefficients changing the adequacy cutoff to that specified by the DHS, that if over half of the providers partook in any of the training courses, the facility was deemed adequate.

Tables A3 and A4 change the adequacy cutoffs in the way stipulated above and it is found that the ranking remains robust for both the cross-country ranking and the ranking by facility type in Rwanda.

Table A3—Cross-Country SDUI Ranking- Robustness to Change in Adequacy Threshold

Pairwise Comparison	Pearson's Correlation Coefficient	Spearman's Correlation Coefficient	Kendall's Tau Correlation Coefficient
Supply Frequency "Not always but often"	.98	1	1
Training "Over half partake in any training course"	.99	1	1
Both Supply Frequency and Training cutoff changes	.99	1	1

Setting K=1.5

Table A4—SDUI Ranking by Facility Type in Rwanda- Robustness to Change in Adequacy Threshold

Pairwise Comparison	Pearson's Correlation Coefficient	Spearman's Correlation Coefficient	Kendall's Tau Correlation Coefficient
Supply Frequency "Not always but often"	1	1	1
Training "Over half partake in any training course"	1	1	1
Both Supply Frequency and Training cutoff changes	.99	1	1

Setting K=1.5

A4. SDUI Results When Weights Reflect The Catchment Area of a Facility

As is mentioned above, information on the catchment area of a facility is only available for 80% of the facilities in Rwanda, 65% of the facilities in Uganda, and 72 % of facilities in Tanzania. The resulting cross-country ranking from changing weights are given in Table A5 below. Results for the in-depth analysis of healthcare delivery in Rwanda are given in Table A6 below.

Table A5—Cross-Country SDUI Ranking Changing Weights by Catchment Population

Country	SDUI	SDUI Rank
Rwanda	.266	3
	(.08)	
Uganda	.168	1
	(.03)	
Tanzania	.209	2
	(.04)	
Setting		
K=1.5		

Though the cross-country ranking changes significantly, it is not statistically significant for any of the pairs of countries. Though the ranking changes for facility type, it is also not statistically significant. The ranking remains consistent for managing authority, but again is not statistically significant. The ranking by province changes a great deal. Though the North remains the best performing facility, the South becomes the worst performing facility and this ranking (and only this pairwise ranking among provinces) is statistically significant.

Table A6—Decomposition of Rwanda's SDUI by Facility Type, Managing Authority, and Province Changing Weights by Catchment Population

	SDUI	SDUI Rank
Facility Type		
Hospital	.288	3
	(.132)	
Health Center and Polyclinic	.242	2
	(.017)	
Health Post, Dispensary, and Clinic	.166	1
	(.08)	
Managing Authority		
Government	.163	1
	(.017)	
Non-government	.351	2
	(.021)	
Province		
North	.098	1
	(.031)	
South	.409	5
	(.09)	
East	.171	4
	(.04)	
West	.167	3
	(.04)	
Kigali City	.159	2
	(.07)	

Setting K=1.5