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ABSTRACT

Background: In 2003, World Health Organization recommendations to scale up the use of malaria rapid tests in resource-limited settings were accompanied by identification of key operational research needs to assess the factors that affect the implementation or expansion of use of malaria rapid tests at the national level. Such research findings can help guide the scale-up process and ensure high-quality testing. To date, there is limited literature assessing factors affecting the adoption of simple diagnostic technologies in resource-limited settings at the macro-level.

Objective: This study evaluated the health facility characteristics associated with the early adoption of malaria rapid tests in Rwanda, Tanzania and Uganda.

Methods: We used data from the MEASURE DHS Service Provision Assessment (SPA) surveys conducted in Rwanda (2007), Tanzania (2006) and Uganda (2007). The surveys included a total of 538 facilities in Rwanda, 611 in Tanzania and 491 in Uganda. We conducted univariable and multivariate logistic regression analysis to evaluate the impact of organizational and contextual factors on malaria rapid test use among health facilities with malaria diagnostic capacity.

Results: Our analysis included 482 facilities in Rwanda, 233 in Tanzania and 157 in Uganda. In Rwanda 9% of facilities used rapid tests, in Tanzania 6% and in Uganda 9%. In Rwanda and Uganda malaria rapid tests were more likely to be used in capital city regions, while in Tanzania test use was not associated with region. In Tanzania malaria rapid tests were more likely to be used in private health facilities than in government facilities, while in Rwanda and Uganda there was little difference in test use between private and government facilities.

Conclusion: Study findings suggest that region and operating authority are influential factors in the adoption of simple health technology devices in resource-limited settings. However, the extent to which these factors are important varies by country. Further analysis is recommended to find out why types of facilities identified in this study adopted malaria rapid tests and to develop adoption indicators applicable to resource-limited settings.

BACKGROUND

In 2001, the World Health Organization (WHO) issued guidelines that encouraged artemisinin combination therapy (ACT) as the first line treatment for uncomplicated malaria in endemic areas, due to the increased resistance of the malaria parasite to chloroquine-based therapies (WHO 2001). The new treatment policy brought the need to improve upon the less accurate clinical diagnostic methods used in resource-limited settings that lack access to laboratory diagnostic capacity. More accurate diagnoses would in turn prevent the unnecessary prescription of costly ACT and discourage the development of resistance to the new drug (WHO 2003).

While microscopy was (and still is) the gold standard in the diagnosis of malaria, its use was largely limited by its expense and by the inadequate number of skilled technicians in resource-poor health facilities. Malaria rapid tests were becoming a popular alternative to microscopy in areas with limited diagnostic capacity, due to their simplicity and ability to provide results quickly and hence to ensure appropriate and timely treatment of patients (WHO 2003).

In 2003 WHO‟s Training in Tropical Diseases group (TDR) identified key operational research gaps concerning malaria rapid test use, such as the need to better understand the factors that affect the implementation or expansion of use of rapid tests at the national level (WHO 2003). In furthering knowledge in this area, one approach includes the identification of health facilities that are likely to be early adopters of malaria rapid tests. Typically in resource-limited settings such as Rwanda, Tanzania and Uganda, wide-scale adoption to a new technology by health facilities is contingent upon approval of the technology by an international agency, such as WHO, policy development for technology use at the national level, and adequate funding for technology procurement (Free 2004). Some facilities adopt new technologies before or during the early stages of national policy development.

Knowledge of early adopters can help to identify health facilities where the new technology can be evaluated, to assess the quality of the new technology and determine whether it is being applied correctly in the clinical setting, to identify an initial market for other upcoming technologies and, based on the facility‟s catchment area and patient profile, to understand the characteristics and proportion of the population with access to the new technology. Early adopters can provide information that can assist in developing guidelines for technology use and, in addition, encourage the adoption of the technology by other health facilities (Berwick 2003; Free 2004).

To date, few studies have evaluated the characteristics of facilities that are early adopters of simple diagnostic technologies in resource-limited settings. In a working paper aimed at determining the impact of new diagnostic technologies, Girosi and colleagues suggested that when new technologies are introduced into a country they are initially accessible to higher-level health facilities with the best infrastructure (Girosi, Olmsted et al. 2006). Previous reports and qualitative studies also have suggested that key factors that facilitate adoption of technologies by facilities in resource-limited settings include proximity to a supply/distribution chain, affiliation with non-governmental organizations (NGOs) or donor agencies/partnerships, and private sector affiliation (Peeling 2007; Singer, Berndtson et al. 2007; Kamau 2008).

Our study seeks to evaluate the association between health facility characteristics and the adoption of malaria rapid tests, as an example of a simple diagnostic technology in resource-limited settings. In our study, adoption is defined as reported use of the diagnostic technology.

We use data from health facility surveys conducted in Tanzania in 2006, and in Uganda and Rwanda in 2007. At the time of the surveys, malaria rapid test policy guidelines in Uganda, Rwanda and Tanzania were still in their infancy, while some health facilities already had begun to adopt rapid tests independent of a formal policy framework (Lynch et al 2006). Given the timeframe in which the surveys were conducted, their findings are likely to depict an informal or unplanned adoption process, as opposed to one characterized by formal policies and scientific methods (Greenhalgh, Robert et al. 2004).

METHODS

Study Design

We used data from the MEASURE DHS Service Provision Assessment (SPA) surveys conducted in Rwanda (2007), Tanzania (2006) and Uganda (2007). The SPA surveys are cross-sectional health-facility-based surveys, typically conducted over a four to five month period to assess the type and quality of health care infrastructure and services offered by a sample of representative facilities in a country.

In the Tanzania and Uganda surveys, health facilities were selected by facility type from a sampling frame of functioning health facilities in each country. Facilities accounting for a small proportion of facilities in the country were oversampled, whereas those accounting for a large proportion were undersampled. Therefore, all government hospitals in Tanzania were included in the survey, because they account for a small proportion of the total number of health facilities. Health centers, dispensaries, stand-alone facilities and private hospitals were selected so that they were representative of facilities at the national level and zonal level. Zones are unofficial groupings of regions in Tanzania that are used by the Ministry of Health and Social Welfare. In Uganda, all hospitals and half of all Health Centre IVs were included in the survey. Health Centre Is, IIs and IIIs were selected to be representative of facilities at the national and regional levels. Each facility was weighted by facility type so that it represented that actual number of that type of facility in the country. Because Rwanda has fewer health facilities than the other two countries, almost all facilities (97%) were included in the Rwanda survey. The study sample was not weighted, because it was representative of the health facilities in the country.

A total of 538 facilities were included in the survey in Rwanda, 611 in Tanzania and 491 in Uganda. Further details of the survey design have been described elsewhere (Tanzania NBS and Macro 2007; Rwanda MOH, Macro et al. 2008; Uganda MOH and Macro 2008).

In our study, we conducted a secondary data analysis using variables from the facility checklist, laboratory and pharmacy datasets, to evaluate the association between health facility characteristics and the type of malaria test used. The final study sample included health facilities that were reported to have a malaria test (microscopy, rapid test or other) available in the laboratory dataset. The study was exempted from approval by the University Hospitals of Cleveland Institutional Review Board.

Conceptual Framework

The factors associated with the adoption of health technologies can be characterized as individual, organizational and contextual. Individual factors are the characteristics of authoritative figures in the organization or health facility. Organizational factors describe how the health facility is structured and operates. Contextual factors are characteristics of the policy and regional environment in which the health facility is located (Kimberly and Evanisko 1981). We focus on the organizational and contextual factors that are associated with the adoption of malaria rapid tests, because the SPA surveys collected this type of information.

Study Outcome

The main outcome measure was a dichotomous variable indicating whether the facility used malaria rapid tests in a laboratory unit, or in at least one of its laboratory units if it had more than one laboratory. In each laboratory unit in which a survey was conducted, the provider was asked whether malaria rapid tests were used and whether they were available, recorded as „observed", „reported, not seen" or „normally available, not today". If the response to whether the malaria rapid test was used in at least one laboratory unit was „yes", we categorized the facility as one that uses rapid tests, and vice versa.

Independent Variables

Organizational factors

Health facilities in our study samples follow a tiered structure in which hospitals are classified as the highest level, followed by health centers and dispensaries or stand-alone facilities. Unique to Uganda is the classification of health centers, from Health Centre I (HCI) to Health Centre IV (HCIV), with HCI being the lowest level. Higher-level health facilities tend to serve larger populations and to be more autonomous. The type of facility has been suggested as a factor influencing the adoption of diagnostic technologies (Girosi, Olmsted et al. 2006). We included "type of facility" as recorded in the facility checklist dataset as a variable in our analysis.

Previous reports have suggested that malaria rapid test use is more common in the private sector than in the public sector (Kamau 2008). We included "managing authority"

from the facility checklist as a variable in our analysis. Facilities operated by the government included public facilities and, in Tanzania, parastatal facilities. Private health facilities included private-for-profit health facilities, not-for profit health facilities (faith-based organizations, community-based organizations) and government-assisted facilities. Government-assisted facilities are not-for-profit health facilities, in Rwanda, that have similar management structures to public health facilities.

Health facility size has been shown to be an influential factor in the adoption of health technologies in high income countries and can be reliably estimated by the total number of health workers (Kimberly and Evanisko 1981). We calculated the total number of health workers in each health facility by summing the "actual number in post" in Tanzania, and the "actual number of full-time and part-time males and females" in Rwanda and Uganda, as observed in the facility checklist.

Because malaria rapid test use was recommended following the introduction of ACT (or Coartem), we included "Coartem availability" as a variable in our analysis. Coartem was considered to be available in the health facility if it was recorded as „all valid", „at least one valid" or „available but none valid" in at least one pharmacy unit in the pharmacy dataset. The use of routine user fees by health facilities has been associated with improved quality of care. We used the variable "facility charges routine user fees" from the facility checklist dataset.

To explore the potential effect of additional revenue resources and NGO affiliation on test adoption, we used variables in the analysis specific to the Uganda facility checklist dataset indicating whether the facility received any funding from NGOs/donors or out of pocket revenue from clients in the 2006/2007 financial year. At the time of the survey, malaria diagnosis and clinical guidelines in Uganda discouraged routine use of malaria rapid tests, due to uncertainty about their accuracy. We therefore evaluated the association between test use and guideline availability in at least one inpatient or outpatient unit, using data from the inpatient and outpatient datasets.

Contextual factors

Geographic location is likely to influence health technology adoption, because location affects proximity to infrastructure, supply chain and financial resources (Hikmet, Bhattacherjee et al. 2008). We used the regions, or zones in the case of Tanzania, identified in the facility checklist to represent geographic location. The nine regions in Uganda were

regrouped to create four regions: Kampala, Central and Eastern (East and East Central), Northern (North Central, West Nile, Northeast) and Western (Western and Southwestern).

Analytic Strategy

We conducted separate analyses for each country. The facility served as the unit of analysis in this study. In the descriptive analysis we calculated the weighted distribution (Tanzania and Uganda) or unweighted distribution (Rwanda) of the total sample of facilities by facility characteristic. We conducted univariate logistic regressions to evaluate the association between facility characteristics and malaria rapid test use. All variables were included in the multivariable logistic model to estimate the adjusted odds of malaria rapid test use by facility characteristic. Data were analysed using SAS Software for Windows, version 9.2 (SAS Institute Inc. Cary, NC, USA) and STATA Software for Windows, version 10.1 (StataCorp, TX, USA).

RESULTS

Study Sample Characteristics and Test Use

The analysis included a total of 482 facilities in Rwanda, 233 in Tanzania and 157 in Uganda (see Tables 1a, 1b and 1c). As the tables show, at the time of each survey 9% of facilities in Rwanda used malaria rapid tests, 6% in Tanzania and 9% in Uganda. The majority of health facilities had coartem therapy available in Rwanda (78%) and Uganda (81%), while the proportion of facilities with coartem availability was much lower in Tanzania (13%). In Rwanda 96% of facilities charged routine user fees, and 91% in Tanzania, while in Uganda only 47% of facilities charged routine user fees. In Uganda malaria management guidelines were available in 73% of health facilities, and clinical guidelines were available in 82%. In Rwanda and Uganda, malaria rapid test use was more common in the capital cities (Kigali City, 16%; Kampala, 33%) than in other regions of the countries. In Tanzania, however, test use was highest in the lake zone (11%), surpassing the eastern zone (6%) in which the capital city, Dar es Salaam, is situated. In all three countries studied, rapid test use was highest among hospitals and declined as health facility level decreased. In Uganda, however, malaria rapid test use among Health Centre IIs (13%) was slightly higher than among Health Centre IVs (10%).

Table 1a: Distribution of Rwandan study sample and test use by facility characteristic

Facility characteristic	Number	Percent	Percentage with malaria rapid test
Region			
Kigali City	77	16.0	16.9
Northern	80	16.6	8.8
Southern	109	22.6	9.2
Eastern	102	21.2	2.9
Western	114	23.7	7.0
Facility Type			
Hospital	39	8.1	10.3
Health Center, Polyclinic	360	74.7	8.6
Dispensary/Health Post/Clinic	83	17.2	7.2
Total Number of Health Workers			
<= 25	377	78.1	6.9
25 - 75	73	15.1	17.8
> 75	33	6.8	6.1
Managing Authority			
Public	284	58.9	6.7
Agrees/Private/NGO/Community	198	41.1	11.1
Coartem availability[a]			
Yes	378	78.4	8.5
No/Unknown	104	21.6	8.7
Facility charges routine user fees			
Yes	464	96.3	8.6
No	18	3.7	5.6
Total	482	100.0	

[a] Represents first line therapy availability in at least one unit in the health facility.

Table 1b: Distribution of Tanzanian study sample and test use by facility characteristic

Facility characteristic	Number[a]	Percent	Percentage with malaria rapid test
Region			
Western	26	11.2	0.0
Northern	53	22.7	5.6
Central	6	2.5	1.9
Southern Highlands	25	10.9	9.3
Lake	29	12.4	11.2
Eastern	63	26.9	6.4
Southern	20	8.5	1.3
Zanzibar	12	5.0	1.9
Facility Type			
Hospital	25	10.5	15.2
Health Centre	44	18.7	12.1
Dispensary/Stand-Alone	165	70.8	2.5
Total Number of Health Workers			
<= 20	199	85.4	3.6
> 20	34	14.6	17.9
Managing Authority			
Government/Parastatal	71	30.5	3.2
Non-Government	162	69.5	6.7
Coartem availability[b]			
Yes	31	13.3	13.7
No	202	86.7	4.4
Facility charges routine user fees			
Yes	212	91.0	6.2
No	21	9.0	0.0
Total	233	100.0	

[a] Weighted

[b] Represents first line therapy availability in at least one unit in the health facility.

Table 1c: Distribution of Ugandan study sample and test use by facility characteristic

Facility characteristic	Number[a]	Percent	Percentage with malaria rapid test
Region			
Kampala	7	4.6	32.8
Central and Eastern	63	40.3	8.3
Northern	38	24.3	1.7
Western	48	30.8	12.2
Facility type			
Hospital	19	12.0	14.8
Health Centre IV	25	16.0	10.1
Health Centre III	70	44.9	4.9
Health Centre II	42	27.0	12.7
Total number of health workers			
<= 20	112	71.6	8.6
> 20	44	28.4	10.2
Managing authority			
Government Public	88	56.2	7.2
Private	69	43.8	11.4
Received any funding from donor agencies/NGOs in 2006/2007 financial year			
Yes	33	21.0	3.9
No/Unknown	124	79.0	10.4
Received any funding from out of pocket revenue (client charges) in 2006/2007 financial year			
Yes	53	33.7	5.9
No/Unknown	104	66.3	7.7
Coartem availability[b]			
Yes	125	80.1	10.3
No	31	19.9	4.1
Management of uncomplicated malaria guideline availability[c]			
Yes	115	73.7	8.0
No	41	26.3	11.8
Uganda clinical guidelines availability[c]			
Yes	129	82.3	8.6
No	28	17.7	11.1
Facility charges routine user fees			
Yes	74	47.1	10.5
No	83	53.0	7.7
Total	157	100.0	

[a] Weighted

[b] Represents first line therapy availability in at least one unit in the health facility.

[c] Represents guideline availability in at least one unit (inpatient or outpatient) in the health facility.

Univariate and Multivariable Analyses

Tables 2a, 2b and 2c present results of the univariate and multivariable analyses. In the univariate analysis, the odds of test use were lower in Rwanda‟s Eastern (OR = 0.15; p <0.01) and Western (OR = 0.37; p<0.05) regions compared to Kigali City. In Uganda the odds of test use were significantly lower across all regions compared to Kampala. In Rwanda the odds of test use were higher among health facilities with 25 to 70 health workers compared to facilities with 25 or fewer health workers (OR = 2.92; p<0.01).

In the multivariable analyses, test use remained associated with region in the study samples from Rwanda and Uganda. In Uganda, the odds of test use were lower among Health Centre IIIs compared to hospitals (OR = 0.22; p <0.05). In the study sample from Tanzania, the odds of test use among private facilities increased by twofold and became statistically significant (OR = 2.88; p = 0.045). Test use was not associated with the total number of health workers in the three study samples.

Table 2a: The association of health facility characteristics with malaria rapid test use in the Rwandan study sample

	Unadjusted model				Adjusted model			
Variable	Odds ratio	p-value	95% Lower CI	95% Upper CI	Odds ratio	p-value	95% Lower CI	95% Upper CI
Region								
Kigali City	1.00	—	—	—	1.00	—	—	—
Northern	0.47	0.13	0.18	1.26	0.34	0.05	0.11	0.99
Southern	0.50	0.12	0.21	1.20	0.32	0.03	0.12	0.87
Eastern	0.15	0.00	0.04	0.54	0.11	0.00	0.03	0.45
Western	0.37	0.04	0.15	0.95	0.24	0.01	0.09	0.68
Facility type								
Hospital	1.00	—	—	—	1.00	—	—	—
Health Center, Polyclinic	0.82	0.73	0.27	2.47	0.38	0.29	0.06	2.25
Dispensary/Health Post/Clinic	0.68	0.57	0.18	2.57	0.20	0.18	0.02	2.11
Total number of health workers								
<= 25	1.00	—	—	—	1.00	—	—	—
25 - 75	2.92	0.00	1.42	5.99	1.94	0.15	0.78	4.80
> 75	0.87	0.85	0.20	3.83	0.24	0.24	0.02	2.57
Managing authority								
Public	1.00	—	—	—	1.00	—	—	—
Agrees/Private/NGO /Community	1.74	0.09	0.92	3.32	1.54	0.25	0.73	3.22
Coartem availability[a]								
Yes	1.00	—	—	—	1.00	—	—	—
No/Unknown	1.02	0.95	0.47	2.22	0.70	0.49	0.26	1.92
Facility charges routine user fees								
Yes	1.00	—	—	—	1.00	—	—	—
No	0.62	0.65	0.08	4.81	0.89	0.92	0.10	7.74

[a] Represents first line therapy availability in at least one unit in the health facility.

Table 2b: The association of health facility characteristics with malaria rapid test use in the Tanzanian study sample

	Unadjusted model				Adjusted model			
Variable	**Odds ratio**	**p-value**	**95% Lower CI**	**95% Upper CI**	**Odds ratio**	**p-value**	**95% Lower CI**	**95% Upper CI**
Region								
Northern	1.00	—	—	—	1.00	—	—	—
Western	—	—	—	—	—	—	—	—
Central	0.85	0.88	0.09	7.76	1.23	0.86	0.12	12.60
Southern Highlands	0.60	0.55	0.11	3.16	0.61	0.57	0.11	3.41
Lake	1.70	0.39	0.51	5.69	1.63	0.47	0.44	6.03
Eastern	0.85	0.80	0.24	2.94	0.90	0.88	0.23	3.53
Southern	0.75	0.73	0.14	3.96	0.90	0.90	0.15	5.28
Zanzibar	0.23	0.19	0.03	2.01	0.33	0.36	0.03	3.55
Facility type								
Hospital	1.00	—	—	—	1.00	—	—	—
Health Centre	0.93	0.90	0.29	2.97	1.16	0.88	0.17	7.93
Dispensary/Stand-Alone	0.15	0.00	0.04	0.52	0.14	0.12	0.01	1.61
Total number of health workers								
<= 20	1.00	—	—	—	1.00	—	—	—
> 20	3.61	0.01	1.38	9.43	1.59	0.68	0.19	13.19
Managing authority								
Government/Parastatal	1.00	—	—	—	1.00	—	—	—
Non-Government	1.49	0.37	0.62	3.56	2.88	0.05	1.02	8.08
Coartem availability[a]								
Yes	1.00	—	—	—	1.00	—	—	—
No	0.58	0.30	0.20	1.65	2.77	0.13	0.75	10.31
Facility charges routine user fees								
Yes	—	—	—	—	—	—	—	—
No	—	—	—	—	—	—	—	—

[a] Represents first line therapy availability in at least one unit in the health facility.

Table 2c: The association of health facility characteristics with malaria rapid test use in the Ugandan study sample

	Unadjusted model				Adjusted model			
Variable	**Odds ratio**	**p-value**	**95% Lower CI**	**95% Upper CI**	**Odds ratio**	**p-value**	**95% Lower CI**	**95% Upper CI**
Region								
Kampala	1.00	—	—	—	1.00	—	—	—
Central and Eastern	0.14	<0.0001	0.05	0.39	0.13	0.00	0.04	0.43
Northern	0.08	<0.0001	0.02	0.30	0.07	<0.0001	0.02	0.31
Western	0.37	0.04	0.14	0.94	0.31	0.04	0.10	0.94
Facility type								
Hospital	1.00	—	—	—	1.00	—	—	—
Health Centre IV	0.69	0.41	0.28	1.69	0.57	0.35	0.17	1.88
Health Centre III	0.51	0.22	0.18	1.47	0.22	0.04	0.05	0.94
Health Centre II	0.96	0.95	0.30	3.12	0.46	0.34	0.09	2.27
Total number of health workers								
<= 20	1.00	—	—	—	1.00	—	—	—
> 20	1.39	0.41	0.64	3.05	1.35	0.61	0.42	4.33
Managing authority								
Government Public	1.00	—	—	—	1.00	—	—	—
Private	1.50	0.27	0.73	3.10	1.38	0.64	0.35	5.49
Received any funding from donor agencies/NGOs in 2006/2007 financial year								
Yes	1.00	—	—	—	1.00	—	—	—
No/Unknown	2.01	0.12	0.84	4.81	2.10	0.15	0.78	5.68
Received funding from out of pocket revenue (client charges) in 2006/2007 financial year								
Yes	1.00	—	—	—	1.00	—	—	—
No/Unknown	0.62	0.19	0.30	1.28	0.73	0.64	0.20	2.69
Coartem availability[a]								
Yes	1.00	—	—	—	1.00	—	—	—
No/Unknown	1.24	0.65	0.48	3.22	1.03	0.96	0.34	3.11
Management of uncomplicated malaria guideline availability								
Yes	1.00	—	—	—	1.00	—	—	—
No	1.09	0.85	0.47	2.54	0.86	0.79	0.28	2.65
Uganda clinical guidelines availability								
Yes	1.00	—	—	—	1.00	—	—	—
No	2.01	0.14	0.80	5.04	0.68	0.20	0.66	7.11
Facility charges routine user fees								
Yes	1.00	—	—	—	1.00	—	—	—
No	0.79	0.52	0.38	1.62	1.69	0.51	0.35	8.19

[a] Represents first line therapy availability in at least one unit in the health facility.

Other Analyses

We collapsed the region variable into two categories, capital region and other region, because test use was comparatively low across regions outside of the capital cities in Rwanda and Uganda. In a multivariable logistic regression analysis adjusting for managing authority, facility type and total number of health workers, the odds of test use were greater in Kigali City (OR = 3.55; p = 0.004; 95% CI = 1.49, 8.48) and Kampala (OR = 7.51; p < 0.0001; 95% CI = 2.87, 19.63) compared to other regions. In a multivariable logistic regression analysis stratified by managing authority, the odds of test use were greater in Kampala compared to other regions (OR = 4.91; p = 0.052; 95% CI = 0.99, 24.49). The overall model was not statistically significant (p = 0.29). Among private facilities, the odds of test use were greater in Kampala compared to other regions (OR = 11.36; p<0.0001; 95% CI = 3.08, 41.90), and the overall model was statistically significant (p <0.01) (Results not shown).

We also conducted a stratified regression analysis using the study sample from Rwanda. However, we collapsed the variable facility type to two categories, hospital and other health facility, because there were too few observations for analysis for the dispensary/health post/clinic category. We dropped the total number of health workers variable from the analysis, because it was strongly correlated with facility type in this study sample. Among government facilities, the odds of test use were greater in Kigali City compared to other regions (OR = 5.13; p = 0.005; 95% CI = 1.63, 16.16), and the overall model was statistically significant (p <0.05). Among private facilities, the odds of test use were not associated with region (OR = 1.83; p = 0.22; 95% CI = 0.70, 4.77), and the overall model was not statistically significant (p = 0.31) (Results not shown).

DISCUSSION

Findings from this study provide quantitative evidence for the association between health facility characteristics and the adoption of malaria rapid tests in study samples from Rwanda, Tanzania and Uganda. The findings suggest important associations between test use and geographic region in Rwanda and Uganda, at the time of the surveys. While there was no association between geographic region and test use in Tanzania, private health facilities in Tanzania were more likely than public facilities to use malaria rapid tests.

When new health technologies are introduced in countries similar to those in our study sample, it is expected that the technologies will first become available to capital city regions, due to better accessibility to the distribution chain. However, the lack of significant regional disparity in test use among health facilities in Tanzania may reflect a more equitable distribution of per capita income and resources across the country than in Rwanda and Uganda, where resources tend to be concentrated in capital city regions (BJ Ndulu and CK Mutalemwa 2002).

It is also expected that new technologies are more likely to become available first to the private sector. Study findings confirm this hypothesis in Tanzania, but not in Rwanda and Uganda. The slower adoption of malaria rapid tests among public compared to private health facilities in Tanzania might be attributed to the notably centralized decision-making process in the country‟s public health sector (DELIVER 2007). However, in Rwanda and Uganda public health facilities may have demonstrated minimal disparities in test adoption compared to their private counterparts due to a greater degree of autonomy in the public sector. In Rwanda this autonomy may stem from a decentralized system in which public facilities set their own user-fee levels and determine how revenue is spent (Soeters, Habineza et al. 2006). In Uganda, despite a no user-fee policy in the decentralized public health system, increased affiliations with non-governmental agencies and research institutions may have facilitated the decision to adopt malaria rapid tests. The general difference in outcomes observed in Tanzania might reflect an earlier stage of the adoption process, given that at the time of survey Tanzania had not officially adopted the ACT treatment policy, whereas Uganda and Rwanda and Uganda had adopted the policy (PMI 2006; PMI 2007; PMI 2007).

Further analysis of the effect of managing authority on test adoption in Rwanda and Uganda suggests that this variable modifies the association between region and test use. In Uganda a stronger estimate of association between region and test use was observed among

private facilities compared to government facilities, although the confidence limits around these estimates were considerably wider. The wide confidence limits might be attributed to the fewer number of cases per variable in the regression analysis. A stronger association between region and test use in private facilities may be an indication of the greater opportunity and incentive for the private sector to provide services in Kampala, due to the higher income per capita compared to other regions of the country. Conversely, in Rwanda a stronger estimate of association between region and test use was observed among government health facilities compared to private facilities. This difference could be a result of the fact that the private sector played a limited role in health services delivery at the time of the survey.

While the total number of health workers, a measure of health facility size and proxy for resource availability, has been a particularly important variable associated with adoption of health technologies in high income countries, our study found that facilities with more health workers were not more likely to use malaria rapid tests. We hypothesize that there are other factors in addition to facility size that need to be accounted for to better reflect resource availability in resource-limited settings. Such factors may include availability of electricity, clean water, trained laboratory technicians and decently equipped laboratories, which are commonly observed among higher-level health facilities, such as hospitals (Girosi, Olmsted et al. 2006). „Type of facility" might therefore be a better measure of resource availability than the number of health workers. Our findings showed that hospitals were more likely than other health facilities to use rapid tests, although this result was not statistically significant.

There are several limitations in this study. First, the small sample of facilities using malaria rapid tests may have prevented the detection and precision of important associations in the regression analysis. Therefore, we acknowledge that the study findings are only suggestive of the associations that exist between facility characteristics and test use in resource-limited settings. Second, given the cross-sectional nature of the survey design, timing of adoption was not captured in the study, a factor that can help distinguish between the "early-early adopters" and the "late-early adopters," which may have different characteristics (Berwick 2003).

Also, in our study malaria rapid test use was only captured in the laboratory setting, while the simple nature of these devices means that they could potentially be used outside of this setting. Moreover, additional individual-level factors that may affect test use, such as the educational level, age and „cosmopolitanism" (having outside professional contacts) of the facility decision-makers, were not included in the study (Kimberly and Evanisko 1981).

It is also important to acknowledge that our study samples are limited to facilities with malaria diagnostic capacity, with the majority of these facilities already using microscopy. Therefore, the decision to adopt a malaria rapid test may have been influenced by factors that reflect an improvement over microscopy-based diagnosis, for example reduced patient waiting time in high-volume facilities. Similarly, the decision not to adopt rapid tests may have been influenced by factors that would have reduced the effectiveness of this testing method, such as frequent stock-outs of laboratory reagents and lack of finances to procure test kits. Further evaluation of the group of early adopters at the qualitative level can provide more insight into why health facilities chose to adopt malaria rapid tests.

CONCLUSIONS

This study has demonstrated that region and operating authority are influential factors in the adoption of simple health technology devices in resource-limited settings. However, the extent to which these factors are important depends on the country in question, possibly as result of differences in the decision-making context and/or the structure and influence of the private and public sectors in health service delivery. Accounting for interactions among these factors might better explain their association with test adoption.

To our knowledge, this study is one of the few that provide quantitative evidence at the macro-level for test device adoption patterns in resource-limited settings. To better evaluate the association between health technology adoption and health facility characteristics in resource-limited settings, we recommend longitudinal and more comprehensive collection of facility-level data. As a follow-up to this study, we recommend a more detailed analysis of the facilities adopting the malaria rapid tests and their associated decision-makers in the respective countries. The follow-up can help to explain the adoption patterns suggested in this study and can provide guidance on additional relevant indicators of adoption that can be collected in upcoming SPA surveys. In order to allow for the inclusion of larger sample sizes in subsequent analyses, collection of similar adoption indicators across countries will allow more efficient pooling of data, in the event that independent country analyses depict similar findings.

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