



WATER & WASTE
PROJECT

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Water safety impacts of delegated management of urban water service delivery

a post hoc evaluation in Kisumu, Kenya

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<https://waterandwaste.org/>

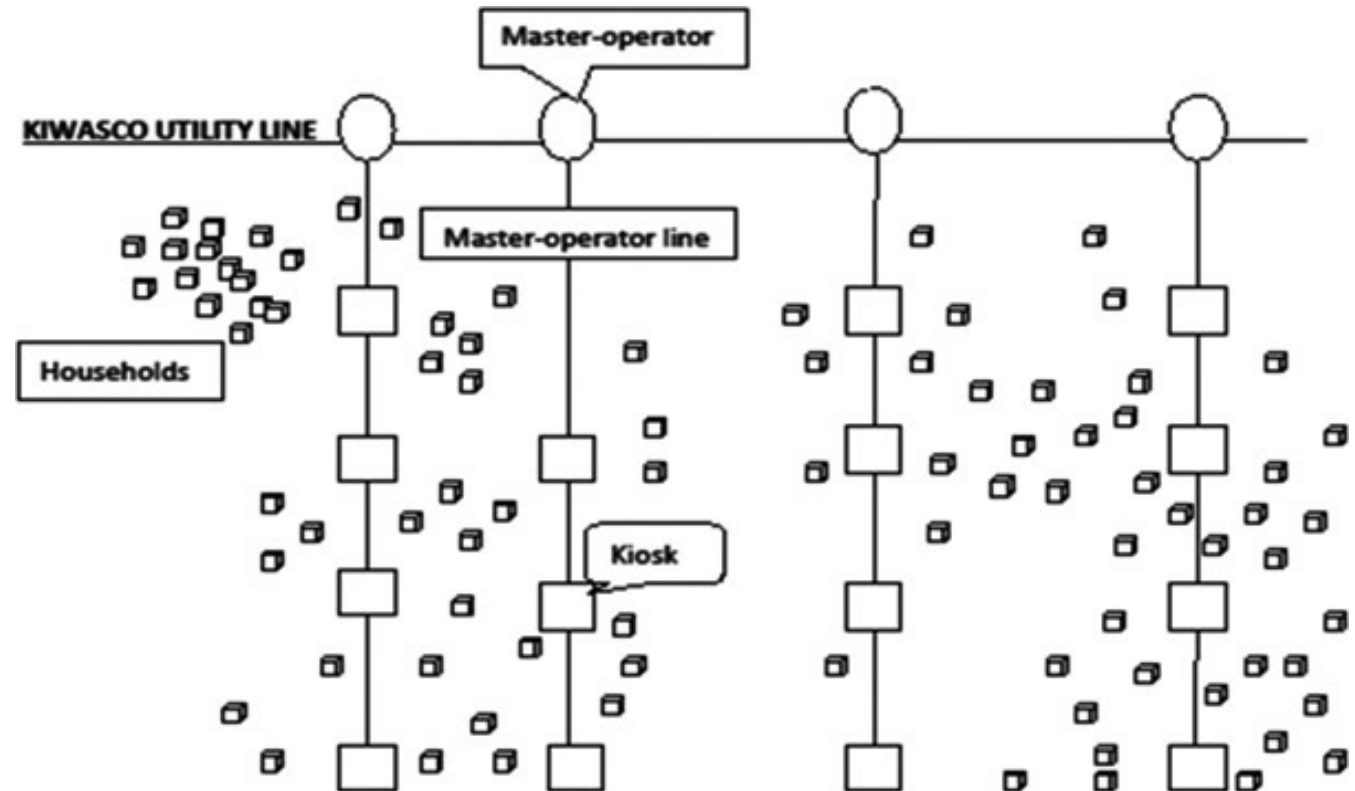


Background

- Under SDG6.1, 2 billion people (26% globally) lacked safely managed drinking-water services in 2020
 - 766 million of these people in Africa in 2020, up from 703 million
 - Safely managed water services: “accessible on premises (accessibility), water available when needed (availability), and **free from contamination** (quality)”
- Utilities adopting pro-poor strategies to address SDG6.1.
- Delegated Management Model (DMM) is one such scheme, adopted in e.g. Arusha, Tanzania; Maputo, Mozambique; Manila, Philippines; **Kisumu, Kenya.**
- Formalisation of micro-enterprises under DMM

Background

- Kisumu Water & Sewerage Company (KIWASCO) DMM scheme in low-income areas since 2007
- Water service delivery delegated to 41 Master Operators (MOs) in 2021
- MOs sell to households & kiosks
- MOs responsible for:
 - Infrastructure maintenance
 - Tariff recovery
 - Network expansion
- Tariffs for bulk water provision & consumers overseen by regulator



Source: Nzengya, D. Development Policy Review, Volume: 36, Issue: 2, Pages: 190-202, First published: 18 December 2017, DOI: (10.1111/dpr.12361)

Background & objective

- Previous studies (Nzengya, 2015, 2018; Schwartz and Sanga, 2010) found DMM:
 - Improved service delivery/professionalization in water management
 - Slightly lowered water costs for consumer
 - Improved revenue for the water utility (KIWASCO through master operators)
 - Generated employment for master operators
- No studies of DMM's water safety impacts
- OBJECTIVE:
 - to assess DMM's impact on point-of-storage water safety among kiosk water consumers in Kisumu, Kenya via a post-hoc evaluation study



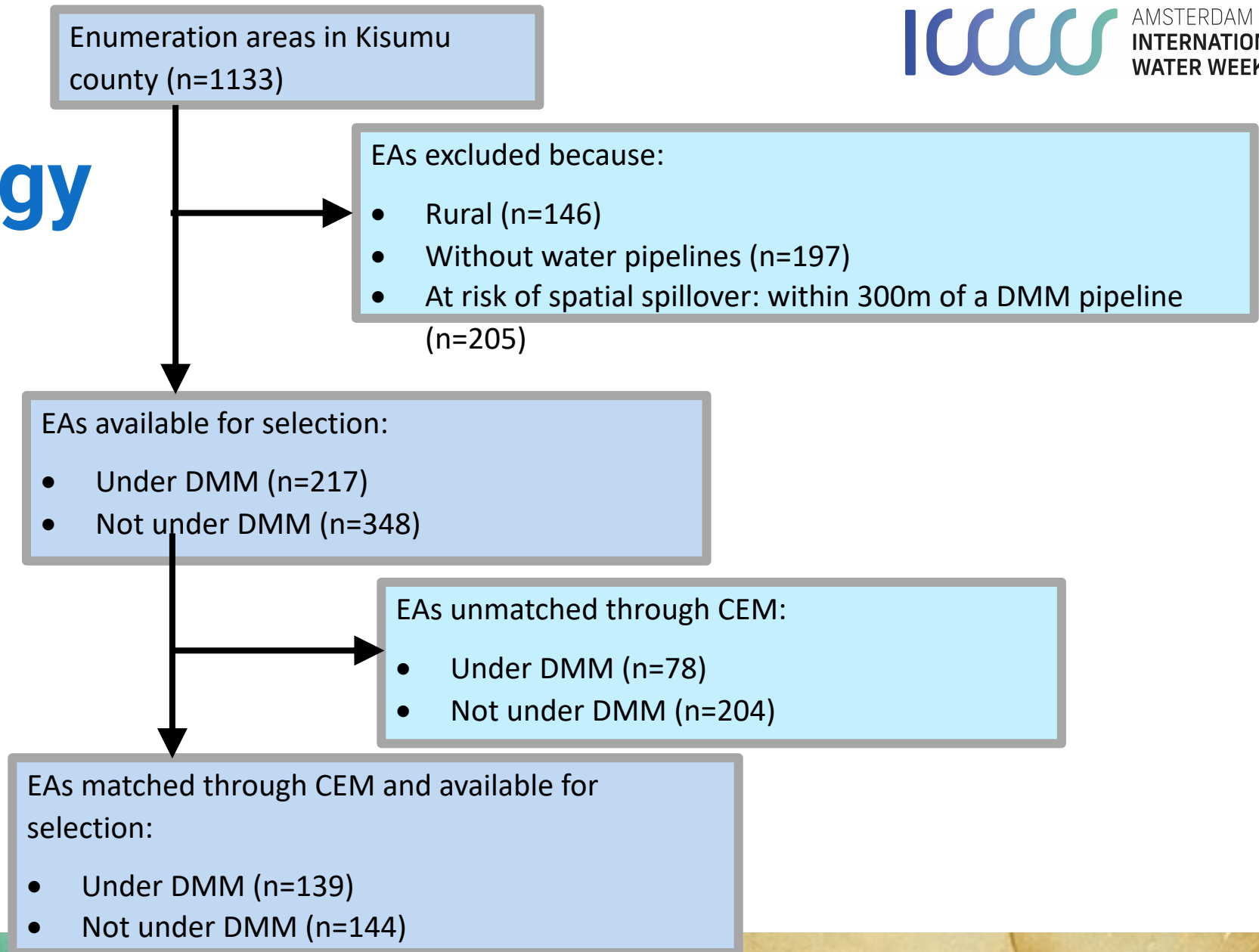
Methodology

- Post hoc impact evaluation:
 - DMM areas matched to similar urban control areas (e.g. for population density, sewerage coverage), avoiding spatial spill-overs
 - Random sample of ten matched intervention & ten control Enumeration Areas selected
- Evaluation:
 - Questionnaire interviews with 'chain': Master Operators, Kiosks, hand-cart vendors, households
 - 100ml sample from each tested for thermotolerant coliform (stored water contamination: primary outcome)

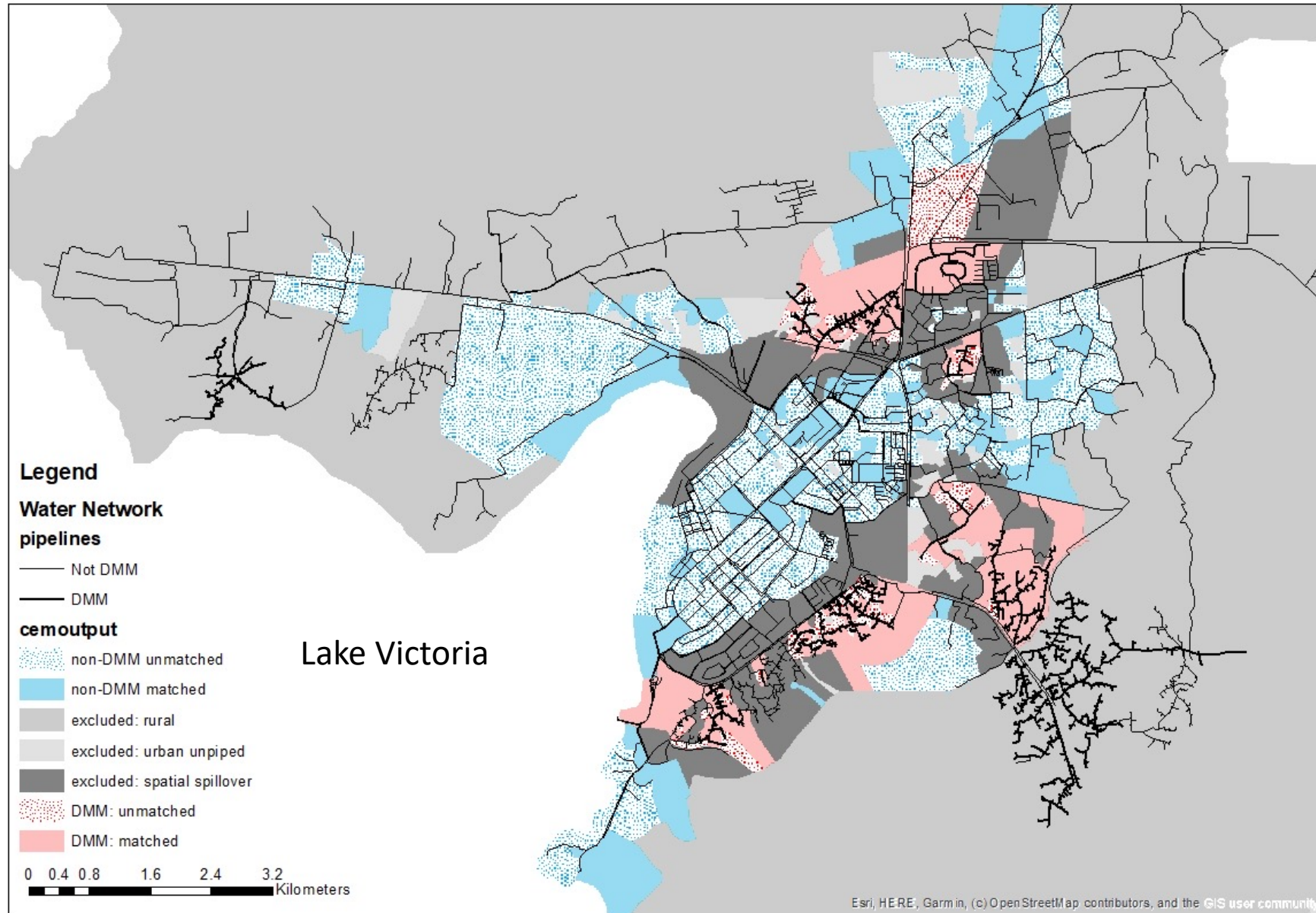


Methodology

- Rural areas excluded
- Lacking piped water excluded
- Coarsened exact matching for remaining areas



Methodology



Methodology

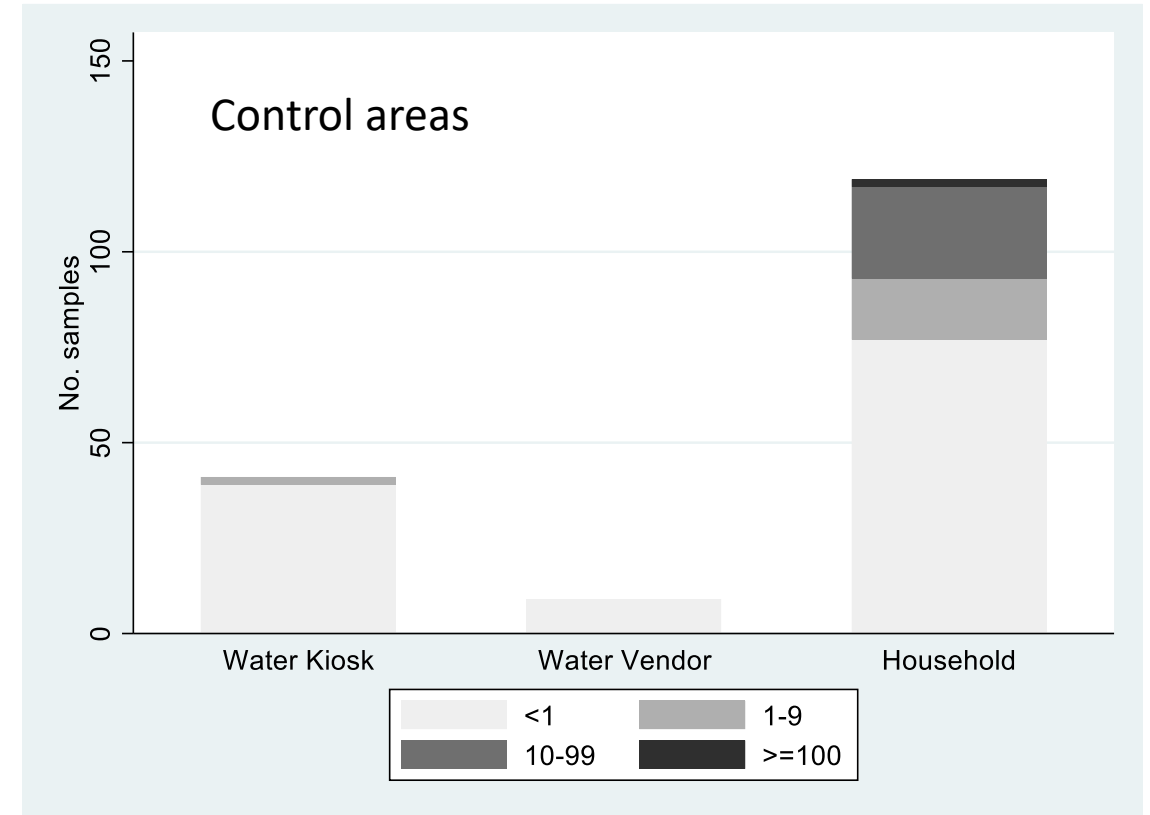
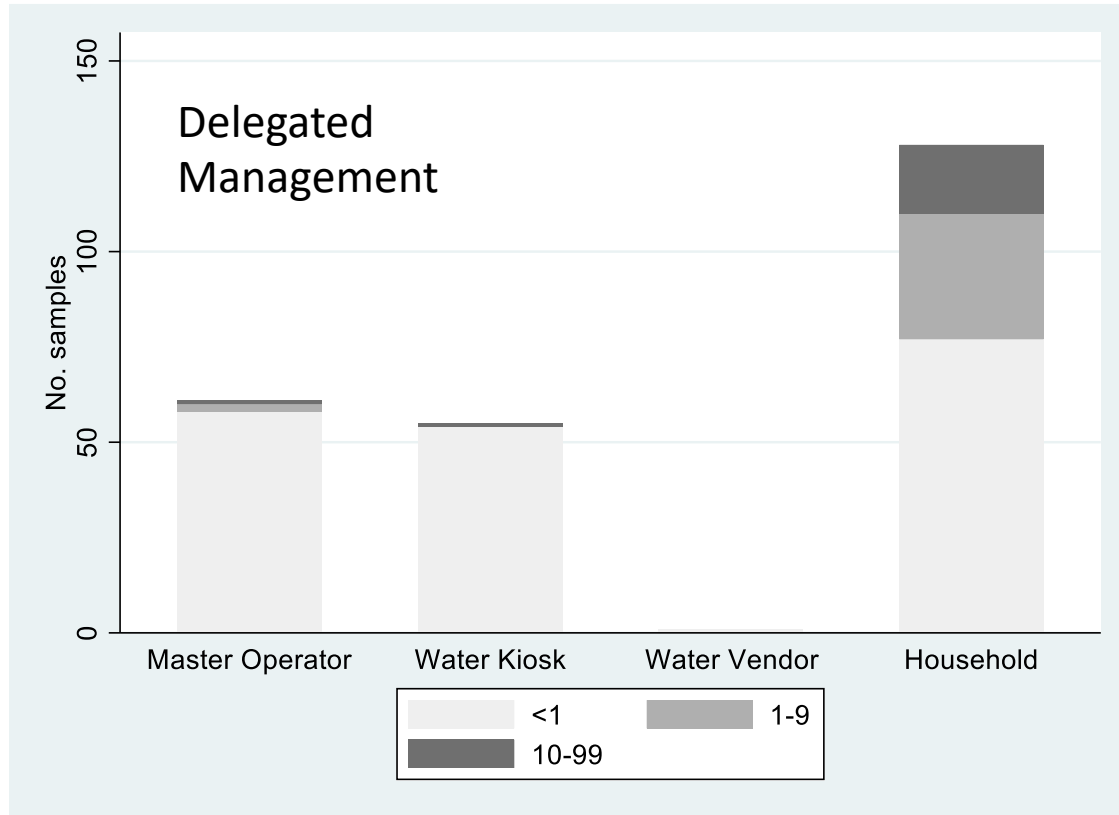
LEVEL OF SAMPLING	No. OF RESPONDENTS SAMPLED IN DMM AREAS	No. OF RESPONDENTS SAMPLED IN NON-DMM AREAS
Master Operators	65	-
Water Kiosks	58	33
Hand Cart Vendors	2	9
Households	118	114

Methodology

- Total & thermotolerant coliform enumeration:
 - Membrane filtration via cellulose acetate membrane pore diameter, 0.45 μm
 - 1mL Ringer's solution added
 - incubated at both 37⁰c and 44⁰c, for 18 – 24 hrs
 - membrane placed on selective medium (Membrane Lauryl Sulphate Broth)
 - yellow colonies 1-3mm diameter counted as thermotolerant coliforms
- STATISTICAL ANALYSIS: Robust logistic regression to test for differences in detectable thermotolerant coliforms between DMM and matched control sites, controlling for contamination risk factors unrelated to DMM



Results



Thermotolerant coliform counts (colony forming units, cfu/100mL) in water samples taken from Master Operator-managed pipelines, water kiosks, water vendors, and household stored water



Results

Risk factor	Detectable thermotolerant coliforms (>0/100mL)		Unadjusted Odds Ratio (CI)	P Value	Adjusted Odds Ratio (CI)	P Value
	Yes n(%)	No n(%)				
Control area (No DMM)	55(45.45)	66(54.55)	0.7(0.421-1.139)	0.148	0.8(0.459-1.291)	0.321
Unimproved sanitation	120(51.06)	115(48.94)	1.7(0.612-4.940)	0.299	1.0(0.286-3.345)	0.971
No Soap/handwashing facility	95(51.91)	88(48.09)	1.3(0.737-2.252)	0.374	1.2(0.666-2.128)	0.557
Overcrowded housing	68(51.91))	63(48.09)	1.2(0.703-1.894)	0.572	1.0(0.612-1.705)	0.936
Non-durable housing	16(64.00)	9(36.00)	1.9(0.795-4.418)	0.151	1.7(0.732-4.162)	0.209
Lack of solid waste services	116(52.49)	105(47.51)	2.2(0.989-4.936)	0.053	2.0(0.814-5.002)	0.130

Unadjusted and adjusted odds ratios for detectable thermotolerant coliforms in household stored water, derived from multivariate logistic regression modelling



Results

Kiosk characteristic	control areas (n, % col)	DMM areas (n, % col)	P value
<i>Water continuity: Water always available</i>	7 (21.2%)	3 (5.6%)	
Water available most of the time	21 (63.6%)	31 (57.4%)	
Water available some of the time	5 (15.2%)	19 (35.2%)	
Water rarely available	0 (0.0%)	1 (1.9%)	0.04¹
<i>water supply in a typical week:</i>			
24 hours/day	1 (3.0%)	4 (7.4%)	
18-23 hours/day	27 (81.8%)	32 (59.3%)	
12-17 hours/day	5 (15.2%)	10 (18.5%)	
6-11 hours/day	0 (0.0%)	4 (7.4%)	
<6 hours/day	0 (0.0%)	4 (7.4%)	0.15 ¹
Has water storage tank	6 (18.2%)	8 (14.8%)	0.68 ²
Treats water (all via chlorination)	1 (3.0%)	5 (9.4%)	0.25 ¹
Mean residual free chlorine in kiosk water (ppm, mg/L)	0.05	0.12	0.02³
Reported price of 20L of kiosk-vended water (KSh)	4.03	3.80	0.55 ³

Household Characteristic	control areas(n, % of col)	DMM areas (n, % of col)	P value
Lacking solid waste services	99 (82.5%)	120 (92.3%)	0.02
<i>UN Habitat slum criteria</i>			
Overcrowded housing	29 (24.2%)	40 (30.8%)	0.24
Non-durable housing	18 (15.0%)	30 (23.1%)	0.11 ²
Unimproved sanitation	23 (19.2%)	56 (43.1%)	<0.001
Mean residual free chlorine in household stored water (ppm, mg/L)	0.09	0.03	<0.001
Reported price of 20L of kiosk-vended water (KSh)	4.32 (\$0.03)	5.18	0.004

Characteristics of kiosks and households in Delegated Management Model areas versus control areas
 (1Fisher's exact test; 2Chi square; 3linear regression)

Conclusions

- Post-collection contamination of stored water equally high in both delegated management and control areas
- DMM almost completely eliminated hand-cart vendors, a potential water safety hazard
- DMM delivered connections to 7,988 households & kiosks, likely reducing risk of post-collection contamination for households
- Long-term improvement in water safety, relative to previous studies
- Signals that tariff subsidy and affordability of DMM has declined since inception – ongoing implementation science study



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