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E. coli recovery from antimicrobial hand towels used in rural households in Kenya

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Abstract

An antimicrobial towel designed for repeated use was developed to prevent recontamination of washed hands after drying. This field trial in Kenya found that nearly all antimicrobial hand towels and untreated control towels were contaminated with *E. coli* after household use. The antimicrobial towel did not inactivate *E. coli*.

Keywords

Hand hygiene; Antimicrobial towel; *E. coli*; Kenya

Household activities in developing countries are associated with microbial hand contamination(Pickering et al., 2011) and handwashing with soap has been shown to prevent diarrhea.(Curtis et al., 2000; Curtis and Cairncross, 2003) Hand-drying—an important aspect of hand hygiene because of the potential for recontamination of clean hands—has been inadequately studied.(Huang et al., 2012) Studies have found paper towels to be superior to warm air dryers, and both methods performed better than cloth-roller towels. (Huang et al., 2012) All three methods are costly and impractical in low-resource settings. Shaking and air-drying has been recommended as an alternative, but one study showed that few use this method, preferring the more convenient method of drying hands on clothing. (Person et al., 2013) Effective, low-cost hand-drying strategies are needed.

Vestergaard (vestergaard.com) developed a reusable hand towel with proprietary antimicrobial properties (“treated towel”) with an untreated cloth border (Fig. 1). Laboratory studies have demonstrated that treated towels resist microbial contamination on repeated use, (Gerba et al., 2012) but field studies in rural western Kenya showed that use of the

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Declaration of Competing Interest

The authors declare no conflicts of interest.

treated towel did not reduce hand contamination (Kim et al., 2019) and did not prevent diarrheal, respiratory, or skin infections. (Slayton et al., 2016) To better understand these findings, we conducted a microbiologic analysis of treated and identical untreated towels used by intervention and comparison households, respectively, in the Vestergaard towel trial.

One used, treated towel from each of 119 participating households randomly selected from 12 census enumeration areas(Slayton et al., 2016) and one used, untreated towel from each of 19 comparison households in two, non-trial enumeration areas (numbers limited by budget and logistics) were aseptically collected in sealable plastic bags. At collection, the household head was asked when it was last used, last washed, and where it was hung. Bags were transported on ice to a laboratory operated by the Safe Water and AIDS Project (SWAP), a Kenyan non-governmental organization. Each towel was removed from the bag using sterile forceps and cut in half with sterile scissors, allowing the lower half to drop back into the bag. To determine whether the untreated border cloth could be a source of contamination, the border was removed from the upper half of the towel with sterile scissors and the borderless half was placed in a separate bag.

Next, 150 ml of an elution solution (sterile distilled water containing 0.01% (v/v) polysorbate 80 (to aid in microbial removal), 0.001% (v/v) Antifoam A (to reduce foaming of polysorbate 80), and 0.15% (*w/v*) sodium thiosulfate (in case the proprietary disinfectant was a halogen-based or non-halogen-based oxidizer) was added to each bag. The bag was sealed and the towel was massaged by hand for 90 s, ensuring liquid coverage of both surfaces, then wrung out thoroughly inside the bag. Eluate from heavily soiled towels required dilution to mitigate visual interference with the subsequent assay. Eluate turbidity was measured to determine assay volume: 1 ml (> 100 Nephelometric Turbidity Units [NTU]), 10 ml (10–100 NTU), or 100 ml (1–10 NTU). For 1- and 10-ml volumes, samples were supplemented with 99-ml and 90-ml sterile distilled water, respectively. *Escherichia coli*, an indicator of fecal contamination, was measured in eluate using the IDEXX QuantiTray/2000 (IDEXX.com) most probable number (MPN) methodology. Back-calculation was used to estimate *E. coli* concentration on half towels (i.e., per 150 ml eluate). Towels were assigned into two *E. coli* contamination categories: low (< 150 MPN/150 ml) and high (≥150 MPN/150 ml).

In a sub-analysis to determine the impact of cleaning on treated towel contamination, one used, treated towel was selected from each of 13 randomly selected study households. Each towel was cut in half using the above procedure; one half was assayed directly and the other half was washed for 90 s in 4 l of sterile distilled water containing 45 g of locally-available Ariel washing powder (Proctor & Gamble, Cincinnati, OH, USA), double-rinsed for 90 s in sterile distilled water, and hung to dry in direct sunlight using sterilized clothespins. Each sample was eluted and 10-ml of eluate supplemented with 90-ml of sterile distilled water were assayed as described above; back-calculation was used to estimate *E. coli* concentration.

To examine the association between *E. coli* contamination and towel type, multivariable logistic regression was applied, setting the *E. coli* category as a binary outcome and the

towel type (treated or untreated) as the main exposure variable, adjusting for other characteristics of towel use.

Of 119 treated towels, 110 (92%) were reported last used in the previous 24 h, compared to 9 (47%) of 19 untreated towels ($p < .001$) (Table 1). Thirty-two (27%) treated and 8 (42%) untreated towels were reported to have been washed in the previous 24 h. The most frequently reported towel locations included kitchen (61%) and toilet (17%). There were no differences in the percentages of eluate samples in the low *E. coli* contamination category between treated (59%) and untreated (58%) towels ($p = .94$). In a multivariable analysis, no associations were found between *E. coli* contamination and towel type, adjusting for presence of border cloth, reported last use, reported washing in the previous 24 h, and towel location (Table 2). *E. coli* was not detected (< 15 MPN/150 ml) in eluate samples obtained from all 13 towels washed in soap and water and dried in sunlight compared with 2 (13%) of 13 eluate samples obtained from towels before cleaning.

We found no differences in the occurrence or level of *E. coli* contamination between antimicrobial and untreated towels. These findings are consistent with a study of antimicrobial hospital curtains that became contaminated over time,(Schweizer et al., 2012) demonstrating the difficulty in sustaining cleanliness of treated fabrics in contaminated environments. Study limitations include uncertain effect of disinfectant neutralizing agents in towels with undisclosed proprietary antimicrobial agents, possible uneven contaminant distribution on towel halves, small comparison group, potentially inaccurate *E. coli* concentration estimates due to dilution of eluate from heavily soiled towels. The observation that towels washed with soap and water and dried in the sun exhibited no detectable contamination suggests that multiple-use towels could be an effective, low-cost hand-drying intervention, but the need for frequent washing and drying may be impractical. The methods employed in this study could be used in future efforts to identify feasible and effective hand drying methods.

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Fig. 1.
Antimicrobial (treated) hand towel, 30 cm × 40 cm, with border consisting of untreated binding (untreated towel appeared identical).

Table 1

Characteristics of towel samples with border, N(%), by towel type, Kenya, 2012.

	Total, N = 138	Treated, N=119	Untreated, N=19	[a] p-value
Towel last used ≤ 24h				**< 0.001**
Yes	119 (86.2)	110 (92.4)	9 (47.4)	
No	19 (13.8)	9 (7.6)	10 (52.6)	
Towel last washed ≤24 h				0.17
Yes	40 (29.0)	32 (26.9)	8 (42.1)	
No	98 (71.0)	87 (73.1)	11 (57.9)	
Where often used				0.10
Toilet	23 (16.7)	20 (16.8)	3 (15.8)	
[b] Leso	15 (10.9)	12 (10.1)	3 (15.8)	
Kitchen	84 (60.9)	76 (63.9)	8 (42.1)	
General	16 (11.6)	11 (9.2)	5 (26.3)	
[c] *E. coli*, MPN/150 ml eluate				0.94
≥150 (high)	57 (41.3)	49 (41.2)	8 (42.1)	
<150 (low)	81 (58.7)	70 (58.8)	11 (57.9)	
Breakdown of results classified as low				
Detectable				
1–149	34 (42)	30 (43)	4 (36)	
Non-detectable				
<1.5	16 (20)	12 (17)	4 (36)	
<15	24 (30)	21 (30)	3 (27)	
<150	7 (8)	7 (10)	0 (0)	

MPN: most probable number.

Boldindicates significant at $P \leq 0.05$

[a] Chi-square and Fisher's exact test as appropriate.

[b] Decorated cloth worn over one's clothing.

[c] Eluate from heavily soiled half towels required dilution to mitigate visual interference with assay therefore assay detection limit varied (e.g., non-detectable *E. coli* in 1:10 dilution of eluate sample has a lower detection limit of 15 MPN/150 ml).

Table 2

Adjusted odds ratio (OR) of exhibiting high *E. coli* contamination from a multivariable logistic regression, Kenya, 2012.

	OR (95% CI)	p-value[a]
Towel type		
Treated	0.53 (0.20–1.44)	0.21
Untreated	Ref	
Untreated border attached		
Yes	1.25 (0.95–1.64)	0.11
No	Ref	
Towel last used ≤24 h		
Yes	2.62 (0.77–8.97)	0.12
No	Ref	
Towel last washed ≤24 h		
Yes	1.69 (0.82–3.49)	0.16
No	Ref	
Where often used		
Toilet	2.08 (0.52–8.34)	0.30
Leso	2.67 (0.59–12.04)	0.20
Kitchen	2.35 (0.68–8.10)	0.17
General	Ref	

[a]Generalized estimating equation approach was applied to consider possible correlation between the measurements of the half towels from the same towel.