TROPICAL HEALTH

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EXPANDING THE OWNERSHIP AND USE OF MOSQUITO NETS

Insecticide-treated net (ITN) washing practices – a multi-country secondary data analysis

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August 2025

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Abbreviations

aHR	Adjusted hazard ratio
aOR	Adjusted odds ratio
CI	Confidence interval
DM	Durability monitoring
GEE	Generalized estimating equations
ITN	Insecticide-treated net
NMP	National malaria programme
PH	Proportional hazard
pHI	Proportional hole index
SBC	Social and behaviour change
SBCC	Social and behaviour change communication
WHO	World Health Organization

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1. Background

Reports that insecticide-treated nets (ITNs) are not meeting the three-year standard for efficacy have generated ongoing concern around the physical and insecticidal durability of nets. Durability depends on many factors that span the lifecycle of an ITN and includes the standards used in evaluating a new ITN product, quality assurance processes during manufacturing, and ways in which an ITN is used and cared for in people's homes. Here, we focus on this final component: the use and care of the ITN in people's homes, specifically as it relates to net washing.

Certain washing products and practices can be particularly detrimental to ITNs. The lower the alkalinity of the soap used for washing, the less damaging the process is for the insecticide on the net. Often, bar soap is less harmful than industrial detergents, while bleach is especially harmful not only to the insecticide but also to the textile fibre. The physical process of washing also provides opportunities for holes to form or enlarge, potentially exacerbating existing damage. Drying nets on trees or bushes carries the risk of the net snagging and tearing, and drying nets in the sun exposes the insecticide and fibres to ultraviolet (UV) radiation, which can speed up degradation of the net. To limit the negative impact of washing and drying, social and behaviour change communication (SBCC) messaging advises households that nets should only be washed when dirty, and no more than once every three months, or approximately 12 washes over an assumed three-year lifespan of the net.

According to guidelines from the World Health Organization (WHO), ITNs should retain full insecticidal activity for up to 20 washes. The assumption is that these 20 washes approximate wash resistance over a three-year period of normal use and washing for the net. While the 20 washes specified by the WHO guidelines are not meant to emulate washing in the home environment, in the absence of more specific guidelines, we use 20 washes over three years as an estimate of expected wash frequency, i.e. a frequency that can be expected during normal use and that aligns with the standardized evaluation process for an ITN.

To review assumptions around washing and to characterize washing practices across different settings, we conducted a secondary analysis of data collected during ITN durability monitoring (DM) studies. From the DM data, we estimated net washing frequencies across countries. We examined household factors that may impact washing frequency and what impact, if any, washing has on net survival in households. We also summarized practices relating to the use of soaps and detergents and drying of nets.

2. Methods

Data source

Durability monitoring studies are prospective studies that collect data on cohorts of ITNs at baseline (up to six months post distribution), 12 months, 24 months, and 36 months post distribution. Publicly available DM data sets for 33 study sites in 13 African countries covering 12 ITN brands were downloaded from www.durabilitymonitoring.org. The data represent durability monitoring of ITNs distributed through mass campaigns between 2015 and 2020. The standardized questionnaires used to collect these data include questions on whether the net has ever been washed, how many times the net has been washed in the previous six months, what type of cleaning product (if any) was used to wash the net, and the location where the net was dried.

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Table 1 summarizes the study countries, sites, ITN brands, and the timing of primary study activities, ordered by the year of the mass campaign.

Table 1. Durability monitoring study details for sites included in the secondary analysis

			Year of	
Country	Site	ITN brand	Mass campaign	Endline round
Mozambique	Inhambane	Royal Sentry	2015	2018
Mozambique	Nampula	Royal Sentry	2015	2018
Mozambique	Tete	MAGNet	2015	2018
Nigeria	Ebonyi	DawaPlus 2.0	2015	2018
Nigeria	Zamfara	DawaPlus 2.0	2015	2018
Nigeria	Oyo	DawaPlus 2.0	2016	2018
DRC	Mongala	DawaPlus 2.0	2016	2019
DRC	Ubangi Sud	Duranet	2016	2019
Zanzibar	Pemba	Olyset	2016	2019
Zanzibar	Unguja	PermaNet 2.0	2016	2019
Kenya	Busia	DawaPlus 2.0	2017	2021
Kenya	Kwale	Duranet	2017	2021
Ghana	Nanuba South	Olyset	2018	2021
Ghana	Zabzugu	DawaPlus 2.0	2018	2021
Liberia	Grand Gedeh	Duranet	2018	2021
Liberia	Lofa	Duranet	2018	2021
Madagascar	Bekily	DawaPlus 2.0	2018	2021
Madagascar	Farafangana	DawaPlus 2.0	2018	2021
Madagascar	Fort Dauphin	PermaNet 2.0	2018	2021
Madagascar	Maintirano	DawaPlus 2.0	2018	2021
Niger	Gazaoua	Olyset	2018	2021
Niger	Madaoua	Olyset	2018	2021
Burkina Faso	Banfora	Interceptor G2	2019	2022
Burkina Faso	Gaoua	Interceptor	2019	2022
Burkina Faso	Orodara	PermaNet 3.0	2019	2022
Burundi	Kirundo	PermaNet 3.0	2019	2022
Burundi	Muyinga	Yorkool	2019	2022
Rwanda	Burera	Olyset	2020	2023
Rwanda	Karongi	Interceptor G2	2020	2023
Rwanda	Kicukiro	PermaNet 3.0	2020	2023
Rwanda	Ruhango	Yahe	2020	2023
Sierra Leone	Bo	PermaNet 3.0	2020	2023
Sierra Leone	Moyamba	Olyset Plus	2020	2023

Four rounds of data collection occurred at 29 of the 33 sites. In Oyo, Nigeria and the two sites in Burundi, data collection ended after three rounds (at 24 months); in Fort Dauphin, Madagascar the first round of data collection occurred at 12 months and only three rounds of data were collected.

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Analysis

We first calculated the percentage of nets that had ever been washed, i.e. washed at least once since arriving in the household. We then used the subset of nets that had ever been washed for further analysis of net washing frequency, including calculating median wash frequency over the previous six months by country and by site within each country, and at each survey time point (baseline, 12-months, 24-months, and 36-months post distribution of nets).

Based on the expected wash frequency of 20 washes over three years – or approximately three washes every six months – we classified cases into one of two categories: nets washed more than three times in six months were categorized as "overwashed" (washing frequency exceeds what is expected given normal use and care of the net) and nets washed no more than three times in the previous six months were categorized as "not overwashed". Using these categories, we calculated the percentage of observations by country and by site within each country where the net was overwashed.

We used generalized estimating equations (GEE) with a binary outcome to assess the relationship between the odds of a net being classified as "overwashed" and factors relating to net attributes (e.g. net colour, age), household attributes (e.g. presence of children under five, socioeconomic status calculated from housing characteristics and goods owned by the household), and use and care (e.g. frequency of use, other washing practices). A table of all covariates can be found in the annex (Table 4). The use of GEE accounted for repeated measures of the same net. Unadjusted (univariate) models were run for all covariates and those that were significant in the unadjusted model ($p < 0.05$) were retained in the adjusted (multivariate) model.

To assess the impact of overwashing on net survival, we used Cox proportional hazards (PH) models following the methods from Kilian et al[1]. Nets were classified as "surviving" at a given data collection round if they were still in the household and in serviceable condition, based on the proportionate hole index (pHI). The pHI is a measure of the number of holes, weighted by the surface area of the hole, such that one pHI unit is equivalent to $4cm^2$ of hole surface. If the pHI is under 643, then nets are considered to be in serviceable condition, i.e. not too torn to be used[2]. In addition to washing frequency, other covariates included in the model were those shown by Kilian et al to be significantly associated with net survival[1]. These are socioeconomic status of the household, whether the household reported storing food in rooms used for sleeping, whether the household reported cooking in rooms used for sleeping, a combined measure of SBCC exposure and positive attitudes towards net care, and whether the dominant user(s) of the net were children, adults, or a combination of both. We included three additional covariates based on a recent unpublished extension of the work in Kilian et al. These are household size, presence of children under five in the household, and whether the net was folded up during the day or not.

All statistical models were run in R 4.2.2 with packages "geepack" v. 1.3.9 used for the GEE and the "survival" v. 3.5-5 used for the Cox PH models.

[1] Kilian A, Obi E, Mansiangi P, Abílio AP, Haji KA, Blaufuss S, et al. Variation of physical durability between LLIN products and net use environments: summary of findings from four African countries. Malaria Journal. 2021; 20:26.

[2] World Health Organization. Vector Control Technical Expert Group Report to MPAC September 2013: Estimating functional survival of long-lasting insecticidal nets from field data.

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3. Results

In the data sets, there were 34,595 observations for 13,226 unique nets. Among all observations, 19,277 observations (56 per cent) reported that the net had been washed at least once since it was received by the household. Of the observations where the net was reported to have been washed at least once, there were 1,110 observations with missing data for the number of times the net was washed in the previous six months. Our analysis of net washing frequency is therefore based on the 18,167 observations of 9,180 nets that had been washed at least once during the six months leading up to the data collection period and the number of washes in the previous six months reported.

Frequency of net washing among washed nets

Across all observations, the median number of times a net was washed in the previous six months was two, or approximately 12 washes over a three-year span assuming a constant rate of washing. The median value was lower for observations from the baseline round (one wash in the previous six months) but was consistently two washes in the previous six months when considering the 12-, 24- and 36-month surveys separately. Across all observations, net washing frequency varied by country (Figure 1) and ranged from a median of one (in Sierra Leone) to three (in Ghana, Madagascar and Niger).

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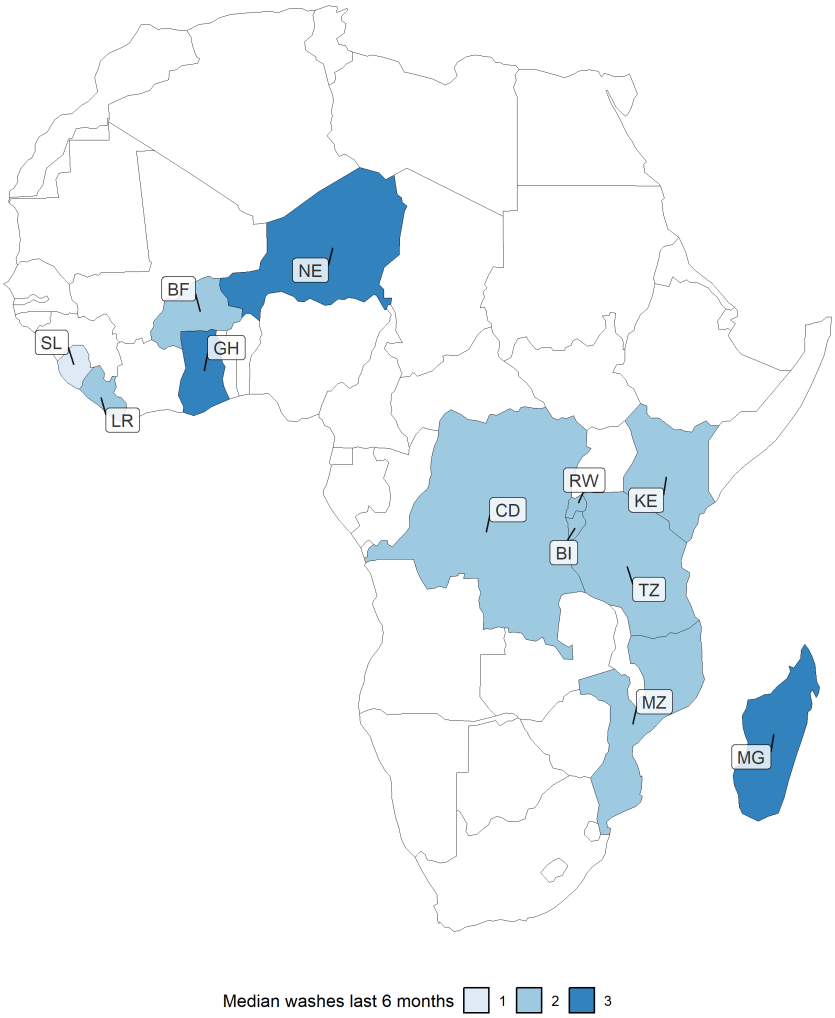
Figure 1. Median wash frequencies for washed ITNs by country; BF (Burkina Faso), BI (Burundi), CD (Democratic Republic of Congo), GH (Ghana), KE (Kenya), LR (Liberia), MG (Madagascar), MZ (Mozambique), NE (Niger), NG (Nigeria), RW (Rwanda), SL (Sierra Leone), TZ (Tanzania)



The spread of reported net washing frequency overall and at each study site is shown in Figure 2. Site-level median net washing frequencies varied from one to three washes in the last six months, but there was variation between sites in the same country and between households at the same site. A small number of substantial outliers were present in the data, with 27 sites including cases reporting 20 or more washes in the previous six months.

Figure 2. Number of times nets were washed in the previous six months by country and site. Boxplots show the median and interquartile range (IQR), as well as minimum (third quartile - 1.5 x IQR), maximum (first quartile + 1.5 x IQR), and potential

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outliers are shown as open points. The colour corresponds to the country, with pooled (all country) results shown in black at the top of the figure.

In total, 2,946 out of 18,167 observations (16 per cent) reported that the net had been washed more than three times in six months (i.e. overwashed). The percentage of nets washed more than three times in six months varied by country, ranging from one per cent of observations recorded in Rwanda to 38 per cent in Niger. The proportion of nets reported to have been washed more than three times in six months is shown by the dark blue segment in Figure 3.

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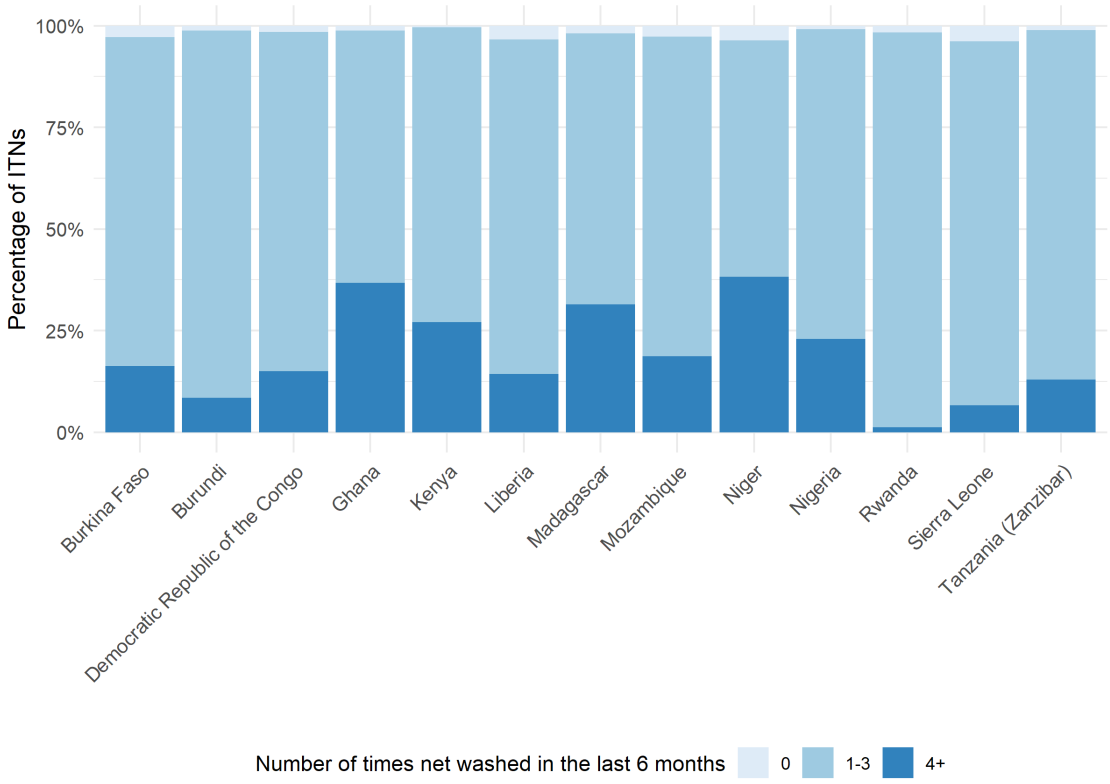
Figure 3. Proportion of ITNs in each wash frequency category (washed 0, 1-3, or 4+ times in past six months) by country



Factors associated with overwashing

The covariates evaluated for an association with overwashing are presented in Table 2, along with the odds ratios, 95 per cent confidence intervals (CI), and p-values for the unadjusted (univariate) and adjusted (multivariate) models.

Table 2. Odds ratios for washing more than three times in six months (overwashing), output of GEE models

Characteristic	Unadjusted OR (95% CI)[1,2]	Adjusted OR (95% CI)[1,2]
Country (reference: Rwanda)		
Burkina Faso	15.0 [11.0, 20.4]***	3.62 [1.24, 10.5]*
Burundi	7.05 [4.88, 10.2]***	7.57 [3.07, 18.7]***
Democratic Republic of the Congo	13.6 [9.77, 18.8]***	6.78 [2.75, 16.7]***
Ghana	44.6 [33.1, 60.2]***	29.0 [11.9, 70.5]***
Kenya	28.4 [21.1, 38.4]***	17.8 [7.30, 43.4]***
Liberia	12.8 [9.20, 17.9]***	9.39 [3.91, 22.5]***
Madagascar	35.2 [26.7, 46.4]***	11.0 [4.44, 27.4]***
Mozambique	17.6 [13.3, 23.3]***	9.38 [3.86, 22.8]***
Niger	47.3 [35.7, 62.8]***	35.1 [14.9, 82.7]***
Nigeria	22.9 [17.2, 30.4]***	17.3 [7.34, 40.6]***
Sierra Leone	5.46 [3.84, 7.79]***	7.03 [2.99, 16.5]***
Tanzania (Zanzibar)	11.4 [8.43, 15.5]***	5.88 [2.43, 14.2]***
Survey timepoint (reference: baseline)		
12m	2.53 [2.15, 2.98]***	2.29 [1.86, 2.82]***
24m	3.68 [3.13, 4.33]***	4.15 [3.36, 5.14]***
36m	4.05 [3.42, 4.80]***	3.90 [3.09, 4.91]***

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Proportionate hole index (pHI) (reference: 0-64)		
65-300	1.57 [1.41, 1.75]***	1.40 [1.21, 1.61]***
301-642	1.66 [1.44, 1.92]***	1.55 [1.28, 1.87]***
643+	1.58 [1.42, 1.76]***	1.37 [1.18, 1.59]***
Net colour (reference: white)		
Blue	1.05 [0.96, 1.16]	1.15 [0.91, 1.45]
Green	0.06 [0.02, 0.14]***	0.03 [0.01, 0.09]***
Other	0.22 [0.15, 0.32]***	1.09 [0.65, 1.82]
Children under five in household (reference: no)		
Yes	1.57 [1.42, 1.74]***	1.27 [1.13, 1.42]***
Wealth tertile (reference: middle)		
Highest	1.02 [0.91, 1.15]	
Lowest	1.07 [0.95, 1.21]	
Frequency of use (reference: every night)		
Most nights	0.95 [0.80, 1.12]	1.19 [0.94, 1.50]
Some nights	0.64 [0.50, 0.82]***	0.64 [0.47, 0.87]**
Not used last week	0.93 [0.81, 1.08]	0.79 [0.61, 1.02]
Net not used at all	0.69 [0.49, 0.97]*	0.92 [0.58, 1.46]
Don't know	2.62 [1.65, 4.15]***	2.22 [1.20, 4.11]*
Location of net (reference: hanging tied up)		
Hanging loose	1.14 [1.05, 1.25]**	0.86 [0.76, 0.97]*
Stored away	1.11 [0.94, 1.32]	0.99 [0.74, 1.32]
Taken down	1.65 [1.42, 1.90]***	1.00 [0.81, 1.23]
Temporarily taken from household	1.06 [0.80, 1.41]	0.62 [0.33, 1.15]
Type of cleaning product used (reference: bar soap)		
Bleach	0.61 [0.21, 1.77]	0.60 [0.19, 1.85]
Detergent	1.62 [1.49, 1.77]***	0.98 [0.86, 1.11]
Mix of products	1.69 [1.31, 2.18]***	1.40 [0.96, 2.03]
No soap used	0.99 [0.61, 1.60]	0.44 [0.21, 0.92]*

[1]*p<0.05; **p<0.01; ***p<0.001
[2]CI = Confidence Interval

Rwanda was used as the reference country because it had the lowest proportion of overwashed nets. In the adjusted model, all other countries had significantly higher odds of overwashing with the adjusted OR (aOR) ranging from 3.6 in Burkina Faso to 35.1 in Niger.

Net attributes

Increasing net age relative to distribution (based on survey timepoint) was strongly associated with overwashing. Compared to nets at baseline, nets at 12 months (aOR = 2.3), 24 months (aOR = 4.2), and 36 months (aOR = 3.9) were all significantly more likely to have been overwashed. Nets with a higher proportionate hole index (pHI) (i.e. nets with more and bigger holes) were also more likely to be overwashed. Relative to nets with a pHI between zero and 64 (classified as good condition), nets with pHI of 65-300 (acceptable condition, some damage; aOR = 1.4), 301-642 (acceptable condition, serious damage; aOR = 1.5) and 643+ (too torn to be serviceable; aOR = 1.4) all had higher odds of having been overwashed. Blue and other coloured nets were equally likely to be overwashed as white nets, but green coloured nets were much less likely to be overwashed than white nets (aOR = 0.03). Almost all (950/1007 or 94 per cent) green nets were from Nigeria. While Nigeria had an aOR = 17, a high risk of overwashing relative to the reference country of Rwanda, it may be that there is a confounding factor associated with net colour that we have not captured in our model.

Household attributes

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Nets in households with children under five years of age were more likely to be overwashed than those in households without children under five years of age (aOR = 1.3). There was no difference between wealth tertiles (a measure of socioeconomic status) in the odds of overwashing in the univariate model, so the variable was not retained in the multivariate model.

Net use and care

For net use and care, we took the recommended practice as the reference level for each covariate; these recommendations include using the net every night, tying up the net during the day, and using bar soap rather than detergent or bleach to wash the net.

Relative to nets used every night, nets used only some nights in the previous week were less likely to be overwashed (aOR = 0.6). There was no difference between nets not used the previous week and nets used every night. Nets that were hanging loose over a sleeping space rather than tied up were less likely to be overwashed than nets that were tied up (aOR = 0.9). There was no difference between nets that were put away and nets that were hanging and tied up. There was also no difference in the odds of overwashing if bleach or detergent were used to wash the net, instead of bar soap. Nets where no cleaning product was reported to have been used did have lower odds of overwashing (aOR = 0.4) relative to those washed with bar soap.

Impact of overwashing on net survival

The results of the Cox regression for determinants of net survival are presented in Table 3. The net-level regression model used 15,206 observations of 8,143 ITNs with 1,830 ITN failures.

When we adjusted for six household factors and two net-level behaviours previously shown to be associated with net survival, there was no significant difference in survival outcomes between overwashed nets compared to those that had not been washed more than three times in the previous six months. Consistent with previous analyses, the other covariates were almost all associated with significant differences in net survival.

Table 3. Hazard ratios for net survival in serviceable condition (output of Cox proportional hazard model)

Characteristic	Adjusted HR[1]	95% CI[1]	p-value
Overwashing (washed more than three times in past six months) (reference: no)			
Yes	1.05	0.94, 1.18	0.391
Household size at baseline (reference: 1 – 3 people)			
4 - 6 people	1.10	0.96, 1.25	0.175
7+ people	1.51	1.31, 1.75	<0.001
Presence of any child under five in household (reference: no)			
Yes	1.23	1.10, 1.38	<0.001
Wealth tertile (reference: highest)			
Lowest	1.35	1.20, 1.52	<0.001
Middle	1.26	1.12, 1.41	<0.001
Store food in sleeping rooms (reference: never)			
Sometimes or always	1.05	0.92, 1.20	0.456
Cook in sleeping rooms (reference: never)			
Sometimes or always	1.26	1.14, 1.39	<0.001
Combined SBC exposure and net care attitudes (reference: SBC never – attitude never)			
SBC any number - attitude once or more	0.73	0.61, 0.88	<0.001
SBC at least once - attitude never	0.72	0.58, 0.90	0.003

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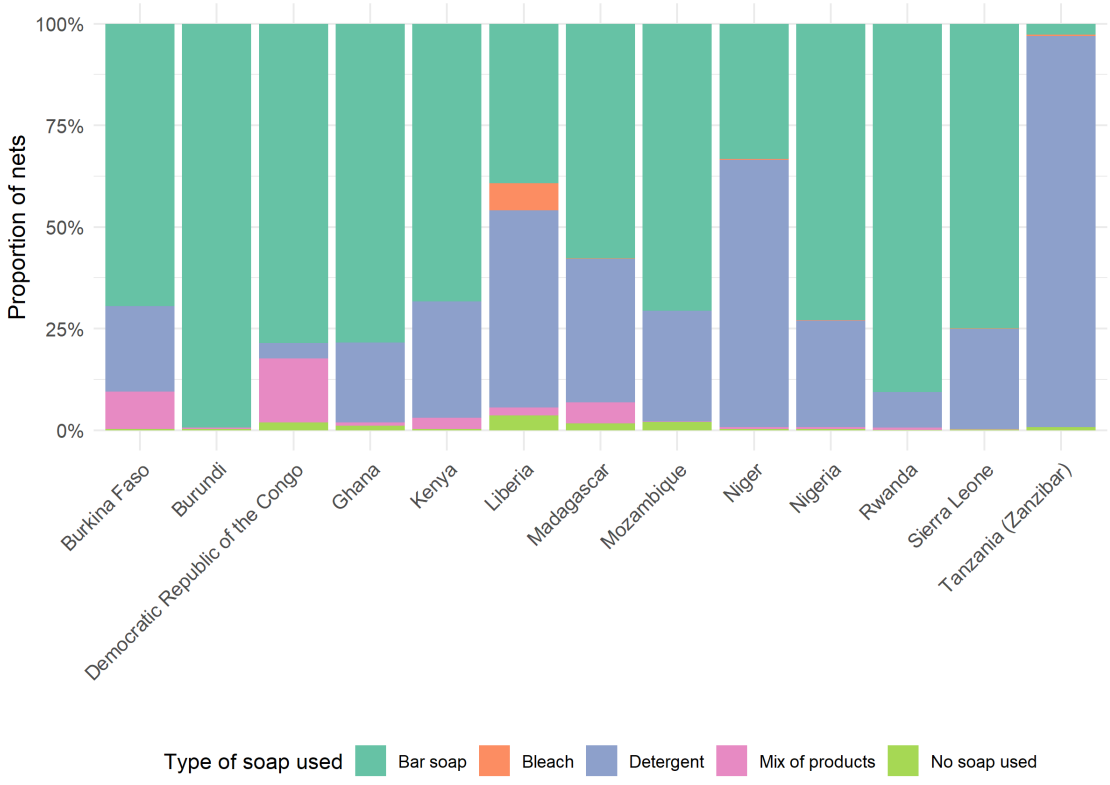
SBC twice or more - attitude twice or more	0.48	0.39, 0.56	<0.001
Dominant net users (reference: adults only)			
Child and adults	1.20	1.08, 1.34	<0.001
Child only	1.33	1.12, 1.57	<0.001
Fold net up during day when hanging (reference: sometimes or always)			
Never	1.53	1.39, 1.69	<0.001
[1]HR = Hazard ratio, CI = Confidence interval			

Other net washing practices

Beyond the frequency of net washing, other washing practices such as the use of soaps, detergent or bleach can impact insecticide retention and physical durability. The use of bleach is particularly detrimental, due to its high level of alkalinity, but its use was rare in the data that we analysed, with fewer than 50 observations reporting the use of bleach, almost entirely from Liberia. Use of detergent is also discouraged in SBCC due to its potential impact on insecticide retention, but its use was reported in more than 20 per cent of observations in every country except Burundi, DRC and Rwanda. Other than in Liberia, Niger and Zanzibar, bar soap was the most frequently reported product used for cleaning nets (Figure 4).

Figure 4. Cleaning product reported to have been used for net washing.



Likewise, certain net drying practices may impact net durability. Exposing a net to full sun can degrade insecticides and fibres, while drying a net on fencing, trees, or bushes can cause the net to snag, forming or enlarging holes. Most nets (57 per cent) were dried outside on a line but drying on a fence or bush was also commonly reported, particularly in Burundi, Madagascar, Mozambique and Niger (Figure 5).

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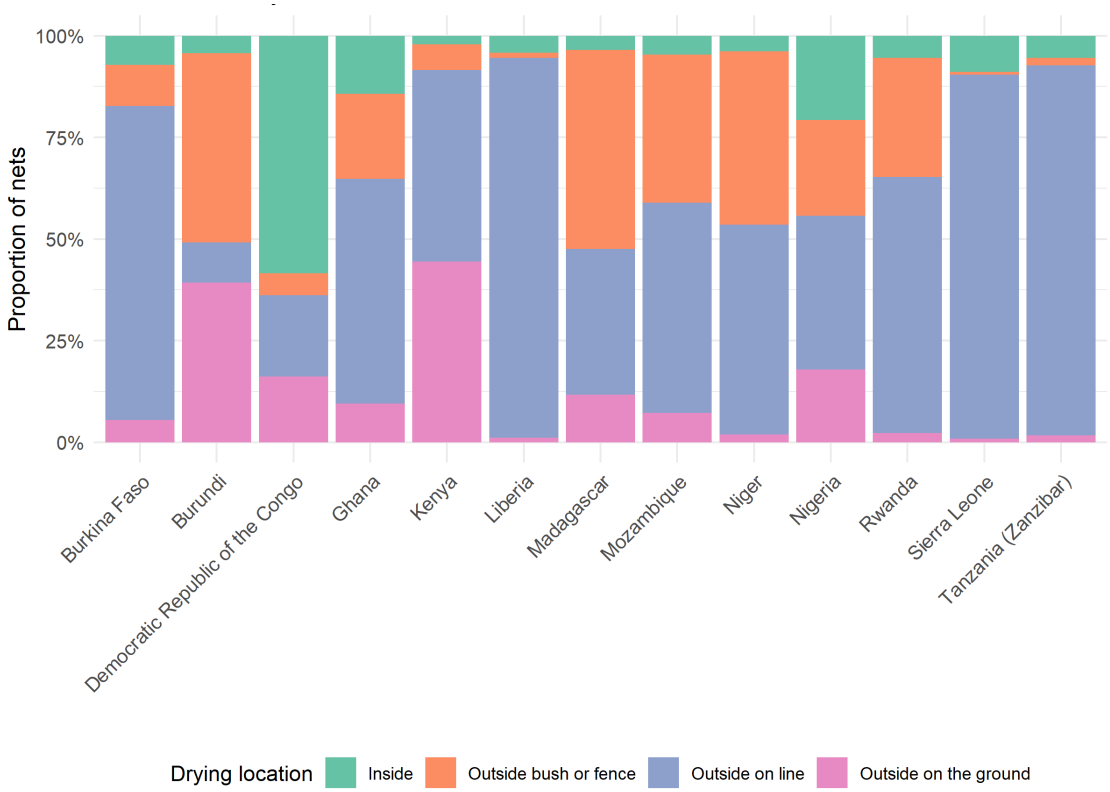
Figure 5. Reported net drying locations.



In a subset of surveys (24- and 36-month surveys in Burkina Faso, Burundi, Ghana, Kenya, Liberia, Madagascar and Niger), households were also asked if the net was dried in the sun or in the shade. Most (68 per cent) observations reported that the net had been dried in the shade, except for Niger where 72 per cent of observations reported that the net had been dried in the sun.

4. Discussion

Based on a secondary analysis of durability monitoring data, we have characterized washing practices, primarily net washing frequency, across 33 sites in 13 African countries. For all the countries included in our analysis, the median number of net washes did not exceed three times in six months (our threshold for overwashing). While median net washing frequency did not exceed three times in the previous six months at the country-level, overwashing did occur – 16 per cent of observations reported that the net had been washed more than three times in the previous six months, ranging from just over one per cent of observations in DRC to 38 per cent in Niger.

We suggest several possible reasons for frequent washing. First, the net is being used in an environment or in a way in which it becomes dirty more quickly. This could be the underlying cause for the significantly increased odds of overwashing that we saw for nets that were used frequently and used in households with young children. Nets left hanging loose over a sleeping space may also become dirty more quickly than those tied up during the day, but in our analysis, nets hanging loose were less likely to be overwashed than those tied up. Other factors that could be considered for further analysis could include household size or household members cooking in rooms used for sleeping. Second, the net may have certain physical properties where people feel that the net becomes dirty more quickly or where dirt or stains are more noticeable. An example of this would be

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white nets showing dirt more than coloured nets: however, we did not find a significant increase in the risk of overwashing for white nets. We did find that older, more damaged nets had a significantly higher risk of overwashing, which could be because these nets are, or are perceived as, dirtier as they age. However, the analysis does not allow us to determine the direction of the relationship between damage and washing. Nets washed more frequently may be subject to more damage while washing, or because nets with holes also happen to be washed more frequently. Net age likely plays a role, as nets accumulate holes over time and older nets are also washed more frequently. Third, households may misremember or forget messaging relating to net care, which they may have received only once at the time when the net was received by the household, if at all. Forgetting care messaging could be another explanation for the association between overwashing and net age.

Significant differences by country remained, even after accounting for these factors in the multivariate GEE model, which reflects that there are unobserved or unmeasured factors that may also be important to understanding why households may have overwashed nets.

Assumptions

Setting the overwashing threshold

WHO guidelines for evaluating long-lasting insecticidal nets (LLINs) call for nets to retain efficacy through 20 washes. The laboratory washes included in the guidelines are not meant to replicate washing in the home but rather act as a proxy for nets retaining efficacy over three years of normal use. In the absence of more specific guidelines, we have used the 20 washes as the basis of our threshold for overwashing in the household. In other words, 20 washes over three years is a frequency of net washing that should not cause excessive wear and tear and is slightly less conservative than what is recommended by SBCC messaging on net care.

Estimating net washing frequency

Because the net washing frequency is reported for the previous six months, we have extrapolated that 20 washes over three years is approximately three washes every six months. This assumes that the 20 washes are consistently distributed over the lifespan of a net, but it may be that nets are washed more or less frequently over time (e.g. older nets are washed more frequently).

In some cases, nets will have been in the household for less than six months because the baseline survey was done less than six months after distribution. In these situations, net washing frequency would be underestimated (e.g. a net reported as washed twice in six months may really have been washed twice over two months).

Effect of washing on net durability

An underlying assumption in our analysis is that washing is a primary cause of wear and tear for nets, contributing to poorer survival outcomes. The impact of overwashing on a net's physical durability may be negligible, particularly in environments where there is a high risk of damage through other mechanisms, for example due to young children playing with the net, the net catching and tearing on a bed frame, abrasions from contact with the wall, or damage from rodents or domesticated animals.

Our survival analysis defines survival according to physical durability and attrition from the household. The benefit of this approach is that there is a clear definition for net survival based on pHI, and DM studies are designed and powered appropriately for this type of analysis. The disadvantage of this approach is that it does not allow us to take into consideration insecticide content or bioefficacy of

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the nets. It should be noted also that the WHO guidelines specifying 20 washes is based primarily on retention of insecticidal activity.

Lastly, in focusing on net washing frequency, there is the assumption that all washing methods are equally destructive to nets when, in actual practice, how you wash a net may matter as much as or more than how often you wash your net.

5. Conclusion

For most nets in the data that we analysed, washing practices were not a cause of concern. Most nets were washed less than three times in six months, were not washed with bleach, and were dried in the shade, all of which could help keep the net in serviceable condition for protection from malaria.

While washing may not be a primary cause of physical damage for nets, ensuring that nets are not washed too frequently may improve the longevity of the insecticidal component. Additionally, given ongoing concerns around physical durability and insecticide longevity for ITNs, it is important to know if washing practices are contributing to the problem. Consistent reporting of net washing practices is an important first step in identifying any potential gaps. Understanding the scale of “overwashing”, where it exists, and the underlying reasons will all inform the best solutions, whether that is strengthening SBCC in a particular context or prioritizing durability to washing as new ITNs are being developed and evaluated.

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6. Annex

Supplementary tables

Table 4 presents the number of observations for covariates included in the unadjusted and adjusted GEE models. Note that many observations from Madagascar, Rwanda and Sierre Leone were dropped from the multivariate model due to missing values, particularly for net colour and children under five in the household.

Table 4. Number of observations by level for each covariate included in the unadjusted (univariate) and adjusted (multivariate) GEE model

Characteristic	N, unadjusted (% of observations)	N, adjusted (% of observations)
Country		
Rwanda	4,655 (26%)	487 (5%)
Burkina Faso	1,083 (6%)	134 (1%)
Burundi	747 (4%)	277 (3%)
Democratic Republic of the Congo	651 (4%)	648 (6%)
Ghana	750 (4%)	746 (7%)
Kenya	875 (5%)	848 (8%)
Liberia	773 (4%)	730 (7%)
Madagascar	1,739 (10%)	235 (2%)
Mozambique	1,814 (10%)	1,799 (17%)
Niger	1,123 (6%)	1,008 (10%)
Nigeria	1,623 (9%)	1,615 (15%)
Sierra Leone	1,021 (6%)	470 (5%)
Tanzania (Zanzibar)	1,432 (8%)	1,427 (14%)
Net colour		
White	7,174 (55%)	4,619 (44%)
Blue	5,084 (39%)	5,027 (48%)
Green	336 (3%)	335 (3%)
Other	530 (4%)	443 (4%)
Proportionate hole index (pHI)		
0-64	10,863 (60%)	6,551 (63%)
65-300	2,828 (16%)	1,613 (15%)
301-642	1,363 (8%)	723 (7%)
643+	2,927 (16%)	1,537 (15%)
Survey timepoint		
Baseline	2,866 (16%)	1,554 (15%)
12m	6,144 (34%)	3,676 (35%)
24m	5,541 (30%)	3,029 (29%)
36m	3,735 (20%)	2,165 (21%)
Frequency of use		
Every night	14,484 (79%)	8,322 (80%)
Most nights	1,096 (6%)	653 (6%)
Some nights	681 (4%)	398 (4%)
Not used last week	1,617 (9%)	829 (8%)
Net not used at all	325 (2%)	169 (2%)

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Don't know	82 (<1%)	53 (1%)
Location of net		
Hanging tied up	7,472 (41%)	3,984 (38%)
Hanging loose	7,911 (43%)	4,842 (46%)
Stored away	1,358 (6%)	624 (6%)
Taken down	1,358 (7%)	870 (8%)
Temporarily taken from household	391 (2%)	104 (1%)
Children under five in household		
No	6,805 (44%)	4,211 (40%)
Yes	8,569 (56%)	6,213 (60%)
Wealth tertile		
Middle	5,214 (34%)	
Highest	5,681 (37%)	
Lowest	4,466 (29%)	
Type of cleaning product used		
Bar soap	12,321 (68%)	6,121 (59%)
Bleach	55 (<1%)	43 (<1%)
Detergent	5,346 (29%)	3,968 (38%)
Mix of products	374 (2%)	183 (2%)
No soap used	151 (1%)	109 (2%)

Internal