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COVER IMAGE: a city skyline with several large water pipes above ground by Gratuit. http://www.freeimageslive.co.uk/free_stock_image/water-pumping-jpg. Creative Commons Attribution 3.0 Unported License.

Showerheads experience: Statistical analysis of the individual behaviour of the users

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ABSTRACT

The water user embodies different physical, social and psychological factors, which in turn inform their water behaviours and the extent to which they engage with solutions aimed at water efficiency. Therefore, products designed to be resource efficient, such as the showerhead, needs to consider the affordances of user interactions and experience in order to ensure that their design, performance and environmental intents are achieved.

This paper sits within a wider body of work which aims to understand the technical efficiency of showerheads as well as the extent to which it is efficient-in-use based on other qualitative metrics such as the user, perceptual and experiential factors. The work presented in this paper uses statistical methods to investigate the correlations and differences between water use factors such as duration and volume (discharge), against user and water efficient showerhead types.

The significant findings are that while users may adjust the duration of their shower events according to the volume discharge of the showerhead, increasing the duration slightly with decreasing discharge, this does not hinder the water savings potential from the discharge reduction. Further, the showerheads discharge is the underlying motivation for the water consumptions differences between males and females. Bearing in mind the limitations of the sample, the female participants were found to consume more water on average than the male participants in these cases, indicating distinct gender behaviour change relative to the showerhead discharge. However, the sample size limits extensive statistical conclusions and needs to be further explored for conclusive results.

Still the initial findings in this paper contributes insights into how quantitative methods and analysis are beneficial for understanding the qualitative implications of water efficiency interventions; such the tendency for users to make behavioural adjustments according to the perceived performance of water efficient products.

Keywords: shower duration, showerhead discharge, water efficiency, water user behaviour

1. INTRODUCTION

The drivers for indoor use include household composition, presence of water saving devices and a range of socio-economic factors [1]. Jorgensen *et al.* [1] therefore proposed a model which suggests that demographics, dwelling characteristics (including house size, water using appliances and type) and household composition (number of people and ages) impact directly on consumption, conservation intention, trust and perceived behavioural control and on the range of attitudes, perceptions and habits. They found this to be in keeping with other studies

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findings where housing type and size has been found to have the largest influence on water use, along with the direct impact of climate and seasonal factors.

This aligns with previous studies, like [2, 3], which found that the user's decisions, behaviours and habits have a major effect on resource use be it energy or water. Berk *et al.* [4] also found people with a higher income, more education and a higher status job were more likely to engage in water saving practices. Although, it was further found that this could be linked to being able to afford the purchase and use of water saving technologies rather than behaviours per se. Conversely, Lee *et al.* [5] found location, function, and personal preferences are major factors in determining water demand.

Residential water demand can be classified as indoor and outdoor water use. Lee *et al.* [5] found that, approximately, 50 percent of the residential water demand in Miami is for indoor use. As study by Beal *et al.* [6] and [7] found that shower use contributes an average of around 30% of the total household consumption in Australia and UK. If indoor and outdoor water demand proportion may vary substantially with location, the relative proportion of shower water consumption is more consistent in developed countries. Beal *et al.* [6] also found a trend toward greater water use in showers amongst older, smaller households and younger, larger families. This makes engineered/ higher efficiency water using devices such as water efficient showerheads an important strategy for delivering effective reductions in water consumption [8]. Most 'water saver' showers achieve savings by introducing air or atomising the water drops to improve wetting for a given flow rate. For the user, the experience is not entirely compromised, as it is similar to that of a 'power shower' but with less water used per minute compared to 12-20 litres from non-efficient showers [9].

This paper sits within a wider body of work which aims to understand the technical efficiency of showerheads as well as the extent to which it is efficient-in-use based on other qualitative metrics such as the user, perceptual and experiential factors. The work presented in this paper uses statistical methods to investigate the correlations and differences between water use factors such as duration and volume (discharge), against user and water efficient showerhead types. In addition to the statistical findings, this paper is significant because it provides insights into how quantitative methods and analysis can be beneficial for understanding the qualitative implications of water efficiency interventions; such the tendency for users to make behavioural adjustments according to the perceived performance of water efficient products.

2. METHODOLOGY

A statistical approach was adopted to analyse the user data collected and explored in a showerhead study during which users' trialled 10 showerheads in 10 weeks and filling up a water diary (Table 1). Other aspects, including subjective comfort related information, were elicited from the users and further detail can be found in Adeyeye et al. [10]. Statistical tests were applied to evaluate:

i) If there are differences in the shower event durations and amounts of water used as a result of using the different showerheads.
ii) The possible explanations underlying the distinct behaviours from the various users when using the same showerhead.

In the first option, each user is considered independent, while in the second, each showerhead is analysed separately. The methodology comprises the following steps:

i) Data preparation, including the codification of the non-numerical information in the dataset.
ii) Preliminary data analysis and assumption checking.
iii) Testing the difference between the shower events durations and volumes changes.

The results of the tests were evaluated using the usual 0.05 significance level and all non-significant cases are highlighted in italic on the tables. As any mathematical tool, the statistical tests required that non-numerical characteristics have to be converted into numeric. This conversion will have influence in the results, particularly when the classes are ordinal and not

categorical. Even regarding the later, if the continuous variable reveal an order between the categories, that may affect the results.
Herein, Tables 1 and 2 were used to code the non-numerical information in the dataset collected by Adeyeye *et al.* [10]. This coding process was done using an expert approach whilst respecting the order of the classes whenever applicable. The users, the showerheads, the days of the week and the weeks were also coded sequentially, but not shown herein due to space constraints.

Table 1. User characteristics coding.

Gender		Weight		Relationship	
Female	1	51-55kg	1	Single, never married	1
Male	2	56-60kg	2	Cohabiting	2
Age		66-70kg	3	Divorced	3
25 - 34	1	71-75kg	4	Married or domestic partnership	4
35 - 44	2	76-80kg	5	**Employment**	
45 - 54	3	90kg +	6	Student	1
Ethnicity		**Height**		Employed (part -time)	2
Asian/Asian British	1	151-155cm (to 5ft 1inches)	1	Employed and student	3
Mixed/Multiple ethnic groups	2	156-160cm (to 5ft 3inches)	2	Employed (full-time)	4
Polish Catholic & Jewish	3	166-170cm (to 5ft7inches)	3	**Income**	
White	4	171-175cm (to 5ft 9 inches)	4	£20,000 - £29,999	1
Education		176-180cm (to 5ft 11inches)	5	£30,000 - £39,999	2
Currently studying	1	180cm and more (6ft +)	6	£40,000 - £49,999	3
Professional qualification	2	**Religion**		£50,000 - £59,999	4
Further Education/ College	3	All	1	£60,000 or more	5
Bachelor Degree	4	No religion	2		
Postgraduate degree	5	Christian (all denominations)	3		

Table 2. Showerhead and shower events characteristics coding.

Shape		Colour		Purpose	
Rectangular	1	Chrome	1	Refresh	1
Round	2	Grey & Chrome	2	Relax/ Refresh	1
Oblong	3	White & Chrome	3	Hygiene	2
Curved rectangular	4	**Height**		Hygiene/ Refresh	2
Sprout		135-150	1	Hygiene/Other	2
Protruding single	1	151-170	2	Relax	3
Recessed twin	2	171-200	3	Hygiene/ Refresh/ Relax	3
Spray		**Distance**		Hygiene/ Relax	3
Colliding twin jet	1	0-20	1	**Time of the day**	
With air	2	21-50	2	Morning	1
		51-75	3	Afternoon	2
		76-150	4	Evening	3

Tables 3 and 4 present the mean duration and water consumption of the shower events for each user and showerhead tested. It is noticeable that only one user experienced all showerheads. Therefore, the sample size and composition varies for each user or showerhead.

Table 3. Mean duration (min) of the shower events for each user and showerhead.

User	S-01	S-02	S-03	S-04	S-05	S-06	S-07	S-08	S-09	S-10	Mean
1		4.43	5.58	5.67	5.43		6.00	6.67	8.14	4.60	**5.81**
2	6.60	6.50		6.17	6.00	5.67		6.00	6.00	6.00	**6.12**
3					30.00	8.60		8.60			**15.73**
4	35.67	29.29	32.00		27.56	27.50		33.33		32.50	**31.12**
5	14.50	27.50	21.17	31.43	26.67	27.14		27.14	28.33	27.50	**25.71**
6	4.68	4.31	4.64	4.05	4.68		4.00	4.69	4.43	4.40	**4.43**
7		7.56		8.83		9.83	8.33	9.00	9.14		**8.78**
8	8.17	8.92	9.00	8.86	9.50	7.13	8.75	18.07		9.14	**9.73**
9	11.14	7.43	8.00	8.29	7.57	9.17	7.50	9.50	7.43	9.29	**8.53**
10	4.10		4.00	4.29	3.68	4.40	4.63		4.29	6.57	**4.49**
11	9.00	9.00		10.25	8.60		6.20	10.25	8.71	9.25	**8.91**

User	S-01	S-02	S-03	S-04	S-05	S-06	S-07	S-08	S-09	S-10	Mean
12	7.80	7.00	6.80	6.80	5.80	6.80	7.67	5.50		9.00	**7.02**
Mean	**11.29**	**11.19**	**11.40**	**9.46**	**12.32**	**11.80**	**6.64**	**12.61**	**9.56**	**11.83**	**10.81**

Table 4. Mean water consumption (l) of the shower events for each user and showerhead.

User	S-01	S-02	S-03	S-04	S-05	S-06	S-07	S-08	S-09	S-10	Mean
1		31.89	40.20	52.13	47.23		70.20	48.00	65.96	44.16	**49.31**
2	67.98	46.80		56.73	52.20	28.90		43.20	48.60	57.60	**51.25**
3					261.00	43.86		61.92			**87.58**
4	367.37	210.86	230.40		239.73	140.25		240.00		312.00	**250.72**
5	149.35	198.00	152.40	289.14	232.00	138.43		195.43	229.50	264.00	**205.56**
6	48.15	31.04	33.44	37.26	40.72		45.20	33.74	35.87	42.24	**38.39**
7		54.45		81.27		50.15	94.17	64.80	74.06		**66.64**
8	84.12	64.20	64.80	81.49	82.65	36.34	98.88	130.08		87.77	**84.97**
9	114.77	53.49	57.60	76.23	65.87	46.75	84.75	68.40	60.17	89.14	**71.34**
10	42.23		28.80	39.43	32.00	22.44	52.36		34.71	63.09	**44.85**
11	92.70	64.80		94.30	74.82		70.06	73.80	70.59	88.80	**77.32**
12	80.34	50.40	48.96	62.56	50.46	34.68	86.63	39.60		86.40	**57.84**
Mean	**115.18**	**75.95**	**66.48**	**87.82**	**99.88**	**61.10**	**73.28**	**98.68**	**73.75**	**103.60**	**86.85**

Assuming the shower events as independent cases allows the use of the totality of the 621 observations to the assess differences in means. This implies that the intrinsic habit of the users is less relevant to explain the shower events than the other characteristics recorded.

3. RESULTS AND DISCUSSION

Parametric or non-parametric tests were carried out in order to compare if the mean values between two distributions are statistically distinct. An important aspect of the selection of parametric or non-parametric tests is checking if the data meets the assumptions underlying the former. Parametric tests are considered more powerful than non-parametric, but require the data to be normally distributed across each group and to be without outliers.

The usual parametric tests to compare means are the T-test, for comparing only two groups, and the Analysis of Variance (ANOVA), for comparing three or more groups. However, both the Shapiro-Wilk and Kolmogorov-Smirnov (more adequate for our case since the sample size in category is less than 50) tests reveal that the duration and the water consumption of the shower events are not normally distributed for several users and showerheads. Tables 5 and 6 present the results for user 1 and showerhead 1.

Table 5. Duration and water consumption normality test results for user 1.

Variable	Showerhead	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Duration (min)	2	0.360	7	0.007	0.664	7	0.001
	3	0.484	12	0.000	0.465	12	0.000
	4	*0.293*	*6*	*0.117*	*0.915*	*6*	*0.473*
	5	0.421	7	0.000	0.646	7	0.001
	7	0.414	7	0.001	0.630	7	0.001
	8	*0.285*	*6*	*0.140*	0.711	6	0.008
	9	0.504	7	0.000	0.453	7	0.000
	10	0.367	5	0.026	0.684	5	0.006
Water consumption (l)	2	0.360	7	0.007	0.664	7	0.001
	3	0.484	12	0.000	0.465	12	0.000
	4	*0.293*	*6*	*0.117*	*0.915*	*6*	*0.473*
	5	0.421	7	0.000	0.646	7	0.001
	7	0.414	7	0.001	0.630	7	0.001
	8	*0.285*	*6*	*0.140*	0.711	6	0.008
	9	0.504	7	0.000	0.453	7	0.000
	10	0.367	5	0.026	0.684	5	0.006

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 6. Duration and water consumption normality test results for showerhead 1.

Variable	User	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Duration (min)	2	0.367	5	0.026	0.684	5	0.006
	4	*0.268*	*6*	*,200**	*0.862*	*6*	*0.197*
	5	0.322	8	0.014	0.753	8	0.009
	6	*0.251*	*8*	*0.148*	*0.924*	*8*	*0.459*
	8	0.492	6	0.000	0.496	6	0.000
	9	*0.228*	*7*	*,200**	*0.934*	*7*	*0.582*
	10	*0.192*	*8*	*,200**	*0.926*	*8*	*0.477*
	11	*0.175*	*3*		*1.000*	*3*	*1.000*
	12	*0.233*	*5*	*,200**	*0.884*	*5*	*0.329*
Water consumption (l)	2	0.367	5	0.026	0.684	5	0.006
	4	*0.268*	*6*	*,200**	*0.862*	*6*	*0.197*
	5	0.322	8	0.014	0.753	8	0.009
	6	*0.251*	*8*	*0.148*	*0.924*	*8*	*0.459*
	8	0.492	6	0.000	0.496	6	0.000
	9	*0.228*	*7*	*,200**	*0.934*	*7*	*0.582*
	10	*0.192*	*8*	*,200**	*0.926*	*8*	*0.477*
	11	*0.175*	*3*		*1.000*	*3*	*1.000*
	12	*0.233*	*5*	*,200**	*0.884*	*5*	*0.329*

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

As such, only non-parametric tests were used in the analysis, namely the Mann-Whitney U test, for comparing two groups, and the Kruskal-Wallis test, for comparing three or more groups.

3.1 Analysing each user separately

The user profiles are as shown in Table 7. Kruskal-Wallis test reveal that for the different showerheads, the duration and water consumption are statistically distinct for users 1, 2, 5, 8 and 10. For users 4, 6, 7, 9 and 12 the duration is not statistically distinct but the water consumption is. No statistically significant difference was found either for duration or water consumption for users 3 and 11 (Table 8). Some of these results require due consideration of the sample size and composition, namely the case of user 3 which only tested 3 of the showerheads divided by 12 shower events.

The results regarding the duration are the most relevant, since the water consumption is estimated based on the reported duration of the shower events. Since the water pressure at the shower may be distinct from what was assumed, the actual value of the water consumption may be biased. Still, this bias is constant for all showerheads tested by each user, meaning the water consumption difference is correct. Therefore, since we are testing if there are statistically significant differences, the results are valid nevertheless.

Focusing on the duration results, it is observed that the majority of the users do not change their showering pattern, enabling the lower discharge showerheads to produce a statistically significant reduction in water consumption. The sample size is limited for generalization purposes, but these results are indications that these water efficient devices provide most users an equivalent level of comfort so that they do not change their showering habits.

Table 7. User profile

Users	Gender	Age	Highest qualification	Height	Weight	Income	Ethnicity	Relationship	Religious beliefs	Employment
1	Female	35 - 44	PG degree, Doctorate	156-160cm (to 5ft 3inches)	51-55kg	£40,000 - £49,1003	Polish Catholic & Jewish	Married or domestic partnership	All	Employed (full-time)
2	Female	25 - 34	Bachelor Degree	151-155cm (to 5ft 1inches)	51-55kg	£20,000 - £29,1004	White	Married or domestic partnership	No religion	Employed (full-time)
3	Female	35 - 44	PG degree, Doctorate	171-175cm (to 5ft 9 inches)	71-75kg	£60,000 or more	White	Married or domestic partnership	No religion	Employed (full-time)
4	Female	35 - 44	PG degree, Doctorate	151-155cm (to 5ft 1inches)	56-60kg	£20,000 - £29,1003	White	Single, never married	No religion	Employed (full-time)
5	Female	45 - 54	PG degree, Doctorate	156-160cm (to 5ft 3inches)	56-60kg	£20,000 - £29,1000	White	Divorced	No religion	Employed (part -time)
6	Female	25 - 34	PG degree, Doctorate	151-155cm (to 5ft 1inches)	90Kg +	£30,000 - £39,999	White	Married or domestic partnership	No religion	Employed and studying (part - time)
7	Male	35 - 44	PG degree, Doctorate	171-175cm (to 5ft 9 inches)	76-80kg	£60,000 or more	Mixed/Multiple ethnic groups	Married or domestic partnership	Christian	Employed (full-time)
8	Male	25 - 34	PG degree, Doctorate	180cm and more (6ft +)	76-80kg	£20,000 - £29,999	White	Single, never married	Christian	Employed (full-time)
9	Male	25 - 34	Currently studying	166-170cm (to 5ft7inches)	76-80kg	£20,000 - £29,1001	White	Married or domestic partnership	No religion	Student
10	Male	45 - 54	Professional qualification	166-170cm (to 5ft7inches)	71-75kg	£60,000 or more	White	Married or domestic partnership	No religion	Employed (full-time)
11	Male	35 - 44	Professional qualification	171-175cm (to 5ft 9 inches)	66-70kg	£60,000 or more	Asian/Asian British	Married or domestic partnership	No religion	Employed (full-time)
12	Male	35 - 44	Further Education/ College	176-180cm (to 5ft 11inches)	66-70kg	£50,000 - £59,999	White	Married or domestic partnership	No religion	Employed (full-time)

Table 8. Kruskal-Wallis test results assessing the influence of the showerhead on the duration and water consumption of the shower events for each user.

User	Variable	Duration (min)	Water consumption (l)
1	Total N	57	57
	Test Statistic	25,342[a]	33,561[a]
	Degree Of Freedom	7	7
	Asymptotic Sig.(2-sided test)	0.001	0.000
2	Total N	47	47
	Test Statistic	19,303[a]	43,429[a]
	Degree Of Freedom	7	7
	Asymptotic Sig.(2-sided test)	0.007	0.000
3	*Total N*	*12*	*12*
	Test Statistic	*4,780*[a,b]	*5,313*[a,b]
	Degree Of Freedom	*2*	*2*
	Asymptotic Sig.(2-sided test)	*0.092*	*0.070*
4	Total N	39	39
	Test Statistic	*11,354*[a,b]	25,457[a]
	Degree Of Freedom	*6*	6
	Asymptotic Sig.(2-sided test)	*0.078*	0.000
5	Total N	61	61
	Test Statistic	29,373[a]	42,383[a]
	Degree Of Freedom	8	8
	Asymptotic Sig.(2-sided test)	0.000	0.000
6	Total N	*67*	67
	Test Statistic	*6,190*[a,b]	23,105[a]
	Degree Of Freedom	*8*	8
	Asymptotic Sig.(2-sided test)	*0.626*	0.003
7	Total N	*47*	47
	Test Statistic	*5,865*[a,b]	20,133[a]
	Degree Of Freedom	*5*	5
	Asymptotic Sig.(2-sided test)	*0.320*	0.001
8	Total N	77	77
	Test Statistic	25,939[a]	43,775[a]
	Degree Of Freedom	8	8
	Asymptotic Sig.(2-sided test)	0.001	0.000
9	Total N	*66*	66
	Test Statistic	*8,460*[a,b]	24,729[a]
	Degree Of Freedom	*9*	9
	Asymptotic Sig.(2-sided test)	*0.489*	0.003
10	Total N	67	67
	Test Statistic	15,754[a]	34,394[a]
	Degree Of Freedom	7	7
	Asymptotic Sig.(2-sided test)	0.027	0.000
11	*Total N*	*36*	*36*
	Test Statistic	*12,177*[a,b]	*13,817*[a,b]
	Degree Of Freedom	*7*	*7*
	Asymptotic Sig.(2-sided test)	*0.095*	*0.055*
12	Total N	*45*	45
	Test Statistic	*11,416*[a,b]	26,542[a]
	Degree Of Freedom	*8*	8
	Asymptotic Sig.(2-sided test)	*0.179*	0.001

a. The test statistic is adjusted for ties.
b. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

3.2 Analysing each showerhead separately

Against the showerhead types (Table 9); the Mann-Whitney U test reveal that the duration and water consumption for males and females are statistically distinct for showerheads 1, 4, 6, 9 and 10. No statistically distinct water consumption was found for showerheads 2, 3, 5, 7 and 8 (Table 10). The fact that both the duration and water consumption results are the same for all showerheads is explained by the perfect correlation between duration and water consumption (water consumption is equal to the duration times the showerhead discharge). As such, if one is statistically distinct the other will be also and vice-versa. Both results were presented here just for consistence with the presentation of the results in the previous section.

Table 9. Showerhead types

Ref No.	S-01	S-02	S-03	S-04	S-05	S-06	S-07	S-08	S-09	S-10
Shape	Round	Oblong	Round	Round	Round	Round	Round	Rectangle	Curved rectangle	Round
Height (mm)	90	157	106	100	100	106	135	67	65	135
Width (mm)	90	82	106	100	100	106	135	182	120	135
Height incl. handle (mm)	215	270	239	230	230	239	246	227	219	246
Regulated flow rate @ 2 bar pressure (L/m)	8.7	8.7	7.9	13.2	12.9	5.1	7.6	7.4	8.3	7.6
Number of functions	1	4	1	3	1	1	2	2	1	2
Image										

As in the previous section, some of the results have to be looked with due consideration regarding the sample size and composition for each showerhead. Particularly showerhead 7, which was only used by two females and all the males. This bias explains the contradiction with the results obtained for showerhead 10, for which the only difference is the colour.

Table 10. Mann-Whitney U test results assessing the influence of the users gender on the duration and water consumption of the shower events with each showerhead.

Showerhead	Variable	Duration (min)	Water consumption (l)
1	Total N	56	56
	Mann-Whitney U	142.000	142.000
	Test Statistic	142.000	142.000
	Standard Error	56.811	56.811
	Standardized Test Statistic	-3.520	-3.520
	Asymptotic Sig.(2-sided test)	0.000	0.000
2	Total N	*78*	*78*
	Mann-Whitney U	*792.500*	*792.500*
	Test Statistic	*792.500*	*792.500*
	Standard Error	*99.576*	*99.576*
	Standardized Test Statistic	*0.326*	*0.326*
	Asymptotic Sig.(2-sided test)	*0.744*	*0.744*
3	Total N	*55*	*55*
	Mann-Whitney U	*297.000*	*297.000*
	Test Statistic	*297.000*	*297.000*
	Standard Error	*58.693*	*58.693*
	Standardized Test Statistic	*-1.363*	*-1.363*
	Asymptotic Sig.(2-sided test)	*0.173*	*0.173*
4	Total N	63	63
	Mann-Whitney U	207.000	207.000
	Test Statistic	207.000	207.000
	Standard Error	72.226	72.226
	Standardized Test Statistic	-3.987	-3.987
	Asymptotic Sig.(2-sided test)	0.000	0.000
5	Total N	*71*	*71*
	Mann-Whitney U	*476.000*	*476.000*
	Test Statistic	*476.000*	*476.000*
	Standard Error	*83.846*	*83.846*
	Standardized Test Statistic	*-1.407*	*-1.407*
	Asymptotic Sig.(2-sided test)	*0.159*	*0.159*

Showerhead	Variable	Duration (min)	Water consumption (l)
6	Total N	49	49
	Mann-Whitney U	143.500	143.500
	Wilcoxon W	468.500	468.500
	Test Statistic	143.500	143.500
	Standard Error	49.488	49.488
	Standardized Test Statistic	-3.162	-3.162
	Asymptotic Sig.(2-sided test)	0.002	0.002
7	*Total N*	*48*	*48*
	Mann-Whitney U	*223.500*	*217.500*
	Test Statistic	*223.500*	*217.500*
	Standard Error	*47.919*	*48.101*
	Standardized Test Statistic	*-1.304*	*-1.424*
	Asymptotic Sig.(2-sided test)	*0.192*	*0.154*
8	Total N	*72*	*72*
	Mann-Whitney U	*577.500*	*577.500*
	Test Statistic	*577.500*	*577.500*
	Standard Error	*88.102*	*88.102*
	Standardized Test Statistic	*-0.778*	*-0.778*
	Asymptotic Sig.(2-sided test)	*0.437*	*0.437*
9	Total N	57	57
	Mann-Whitney U	52.500	52.500
	Test Statistic	52.500	52.500
	Standard Error	60.777	60.777
	Standardized Test Statistic	-5.570	-5.570
	Asymptotic Sig.(2-sided test)	0.000	0.000
10	Total N	72	72
	Mann-Whitney U	379.000	379.000
	Test Statistic	379.000	379.000
	Standard Error	83.128	83.128
	Standardized Test Statistic	-2.370	-2.370
	Asymptotic Sig.(2-sided test)	0.018	0.018

5. CONCLUSION

This paper uses statistical methods to investigate the correlations and differences between water use factors such as duration and volume, against user and water efficient showerhead types.

Some of the users (5 in 12) were found to adjust the duration of their shower events to the volume discharge of the showerhead; increasing the duration slightly with decreasing discharge. Still, the p-values of the duration were always found to be larger than for the discharging, indicating that the more water efficient showerheads still resulted in statistically significant water savings. This was further strengthened by the fact that the shower events of another 5 out of the 12 was not statistically distinct for the various showerheads, indicating that the potential water savings could be effectively achieved in almost its full potential. The remaining 2 users, for which neither the duration nor the water consumption was found statistically distinct for the various showerheads, one case (user 3) is explained by the fact that it only used three of the showerheads and the other (user 11) presents non-statistically significant results for the water consumption by a very small margin (p-value=0.055). Applying a less stringent significance criteria to user 11 (e.g., 10% error - p-value=0.1), both the duration and water consumption differences would be classified has statistically significant.

The trends in the analysis for each showerhead are less noticeable. Apparently, the showerheads discharge is the underlying motivation for water consumptions differences between males and females, with higher and lower discharges (extremes) resulting in statistically significant mean values. Bearing in mind the limitations of the sample, females were found to consume more water in average than males in these case, indicating distinct gender behaviour change to the showerhead discharge. Still, other factors may play a role, for instance comparing showerheads 1 and 2 one could hypothesize the influence of the shape, but the sample size limits the statistical conclusions.

Water savings are possible using water efficient showerheads for the large majority of users, since the eventual duration adjustment from behavioural change may affect but do not hinder the potential savings completely. There seems to be distinct behaviour from males and females to the different showerheads, particularly when the discharge is high or low, but this needs to be further explored in the future for conclusive results.

The findings need to be regarded as preliminary due to the dataset limitation (sample size), but they provide useful insights into how quantitative methods and analysis are beneficial for understanding the qualitative implications of water efficiency interventions; such the tendency for users to make behavioural adjustments according to the perceived performance of water efficient products.

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