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ARTICLE

Assessing Occupational Exposure to Surface Contaminants in Kuwaiti Educational Buildings

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ABSTRACT

The prevalence of surface contaminants, such as potentially harmful bacteria, within building environments in the State of Kuwait is not known. To the authors' knowledge, this article is the first of such a report. A total of 342 stool samples were collected from 46 secondary schools to evaluate indoor occurrences of *E. coli* bacteria within selected lavatory surfaces. After microbiological testing, the results for the spread of the *E. coli* bacteria were categorized by total count, sampling location dependency, contamination level comparison between genders, and lavatory fixtures (i.e. seat and squat toilets). The results revealed that 7 schools have a bacterial contamination problem, there is cross-contamination between surfaces in the lavatory stalls, the boys' lavatories were less sanitary than the girls', and that the squat-style toilets are more contaminated than the seat-style. The results suggest that there is significant risk of spread of bacterial infection among students via contaminated hands and surfaces in the lavatory area in some schools. Thus, this study emphasizes the need to improve environmental hygiene and enhanced sanitation in these schools. In addition, conclusions can be drawn as to the effectiveness of the janitorial staff employed by the schools and the efficacy of the cleaning regime used in the lavatories. Furthermore, based on the findings, there are architectural design consequences as squat-style toilets might be excluded in lavatories designed for schools to be constructed in the future.

1. Introduction

Little is known about the complex microbial ecosystems found in the built environment. This is especially true for the State of Kuwait where the microbiology of the built environment is a new field of scientific inquiry. With no such studies conducted in Kuwait, investigating this topic will provide an indication as to the hygienic safety in public buildings and will provide

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a baseline for future investigations. With surrounding countries having similar schools, gender segregated education, culture, climate, customs, and hygienic practices, the findings in this study could be applicable to a larger audience.

Sanitary conditions in public places have always been a major problem universally, especially in lavatories which are suitable environments for bacterial growth. Mendes and Lynch[1] in a bacteriological survey of institutional toilets and washrooms found evidence of substantial contamination with bacteria of fecal origin. There is indication that even daily disinfection can be inadequate for such toilets[2], especially when bacteria are becoming increasingly antibiotic resistant in the restrooms[3,4]. Even with modern sanitation management of public lavatories, a recent bacteriological investigation in South Korea implied there was a need for improvement[5]. Furthermore, there are obvious concerns for the potential of cross infection risks from such contamination.

Schools, having a high-density occupation, should especially be required to provide a safe environment for their students. Nonetheless, there is increasing teacher and parental concerns regarding the possible roles hygiene and bacterial contaminants have in school buildings[6]. A recent study for school-age children in the USA established that gastrointestinal symptoms are frequent somatic grievances among children[7]. Several studies have examined the prevalence of diarrheal diseases in schools and university campus settings, attributing it to the microbial contamination of hands, surfaces, and objects[8,9]. High bacterial contamination was detected in 52.9% of student's hands in Crete schools, with boys exhibiting higher levels of contamination than girls[10]. Therefore, these areas of concern need to be continually checked for cleanliness in order to prevent the spread of infections and disease.

E. coli (*Escherichia coli*) is an indicator bacterium whose presence is used to indicate the presence of a potential health risk. Some strains of the bacterium are potentially deadly in which people can infect each other through a fecal-oral route and by person-to-person contact. Moreover, *E. coli* also has a low infectious dose and is somewhat difficult to kill[11]. Furthermore, it has been stated that 80% of infectious diseases are spread by touch[12]. Therefore, infectious transmission from *E. coli* becomes even more likely in high human density settings such as schools.

Lavatories are especially vulnerable to bacterial contamination. Since bacteria require moisture to proliferate, standing water, water-damaged materials, or wet surfaces in lavatories can serve as a breeding ground for contamination. Since Bacteria adhere more readily to wet hands, there is an increased risk of cross-contamination in lavatories[13]. In one study, Khan[14] has illustrated the role of inadequate hygiene in school toilets in helping spread dysentery among students. Another study has shown that bacteria such as *E. coli* can subsist on the toilet seats for an indefinite period[15]. Molotch and Norén[16] have shown that a toilet seat typically can have on average more than 7 bacteria per square centimeter.

1.1 School Cleaning Routine

The cleaning and disinfecting of lavatories in public schools in Kuwait are out-sourced to the private sector. Through a contract tendered by the Ministry of Education in Kuwait, the cleaning contractor is required to perform a daily cleaning operation. The observed cleaning operation involved two people equipped with the required tools, detergents, and antiseptics. The cleaning operation lasted about 30 minutes for one lavatory facility. The operation took place early in the morning before classes commenced.

A written or approved cleaning procedure to be followed by the custodial crews performing the cleaning operation at the schools was not found by the investigators. It was common practice for both the cleaning staff supervisor and the school deputy principal, acting as a quality control team, to make a daily inspection of the lavatories to ascertain whether the cleaning operation satisfied the subjective quality level.

1.2 School Building Architecture

There are 132 gender segregated public secondary schools in Kuwait. These schools can accommodate between 400 and 750 pupils each. The architecture of the schools reveals two-floor buildings with lavatory facilities containing three to five toilet cubicles on each floor. The door handles in the cubicles were found, generally, be either broken or missing. The toilets are either of European (seat) or Asian (squat) style (Figure 1a, b). Single exhaust fans vented to the outdoors were found in each stall, but in general, were not functioning.

Figure1. A typical European seat style toilet (a) and an Asian squat style toilet (b) found in one of the schools

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Private schools in Kuwait are more varied in architecture and are mostly co-educational. Since these schools are comparatively small in number and differ in structure, they were not considered for this study.

1.3 Research Objectives

In the current investigation, assessment of the prevalence of *E. coli* bacterial contamination and the adequacy of cleanliness of the lavatories in public school buildings in Kuwait are conducted.

Since skin-to-surface contact is inevitable within the lavatory environment, there is the opportunity for bacterial spread. Thus, expected bacteria hotspots in the lavatories were investigated and the dependency of cross-contamination of the surfaces within the toilet area due to the frequency of skin-to-surface contact.

There is some discrepancy in the literature as to whether girls or boys are more susceptible to bacterial infection in schools. In one report, boys exhibited higher levels of contamination[10]. In another report, the prevalence rate of bacterial infection among boys and girls of school age were 16.9% and 22.0% respectively, with *E. coli* (30.8%) being the most common type of infection[17]. Therefore, a further objective of this research will investigate the contamination level between the genders based on the cleanliness of their respective lavatories.

Finally, a contamination level comparison is assessed between lavatory fixtures (i.e. seat and squat toilets). The sampling results are statistically analyzed to determine if one type of fixture is actually more sanitary than the other.

2. Materials and Methods

2.1 Sampling

Of the 132 high schools in Kuwait, 46 gender segregated high schools were chosen as a sampling size for this research. The number of schools chosen signified a suitable statistical number (or above 30% of the total number of schools). Figure 2 shows the sites of these schools, which are located throughout all the urban locations in Kuwait. Of the schools selected, 24 were for females and 22 were for males. The schools chosen differed in age with the oldest school being constructed in 1959 and the most recent school built in 2010. Table 1 shows some relevant data regarding high schools in the State of Kuwait.

Notes: (1) Labeed Iben Rabeea'a, (2) Um Al-Hakam Bent Aby Sufyan, (3) Abdulateef Thnyan Al-Ghanim, (4) Anas Iben Malek, (5) Abraq Kheetan, (6) Ruzainah, (7) Al-Rabee'a bent Mua'aawath, (8) Al-Kendy, (10) Al-Ahmadi, (11) Al-Retqqa, (12) Al-Zoor, (13) Fatema Al-Hashemyah, (14) Sabah Al-Salem, (15) Sabah Al-Salem, (16) Mohammed AL-Meheani. (17) Al-Jahra, (18) Um Al-Hareth Al-Anssaryah, (19) Al-Nawar Bent Malek, (20) Salwa, (21) Al-Jabryah, (22) Jaber Al-Ahmad Al-Sabah, (23) Abdullah Abdulateef Al-Rejeeb, (24) Fatema Al-Sara'awy, (25) Nasser Abdul. AL-Saeed (26) Saad Ben Rabeea' (27) Abdullah Al-Jaber Al-Sabah, (28) Lateefa Al-Shemali, (29) Suaad Bent Salamh, (30) Yousef Ben Essa, (31) Al-Jazae'r, (32) Al-Mansouryah, (33) Al-Yarmouk, (34) Sabah Al-Salem, (35) Jahra, (36) Al-Emam Malek, (37) Al-Mubarakeyah, (39) Balat Al-Shuhada'a (40) Fatema Bent Asad (41) Omar Ben Al-Khata (42) Al-Shargeyah, (43) Falasteen, (44) Al-Furdous, (45) Um Al-Heaman, (46) Al-Jazae'r

Figure 2. The localities of the 46 schools in Kuwait employed in the present research are shown with chosen schools are limited to urbanized areas (about 11% of the country)

Table 1. Relevant statistical data for some components of the high school educational system in the State of Kuwait[18]

Category	Total
High schools in Kuwait	132
High schools for girls	69
High schools for boys	63
Female high school students	40119
Male high school students	31129
Female high school staff members	6669
Male high school staff members	5352

In advance of the testing, each school was visited by a member of the research team in order to both familiarize

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the school administration with the study and to expedite the research undertaking. Beforehand, an official letter from the Ministry of Education was sent to the administration of all the chosen schools with a request of assistance for the research team.

2.2 Microbiological Testing

Bacterial detection was performed with swab samples taken from the lavatories. The swabs were collected during an interval from October 2017 to May 2018. Testing of the swabs was performed using the MicroSnap *E. coli* test system, manufactured by Hygiena International Limited. Briefly, MicroSnap *E. coli* is a swift test for revealing and enumeration of *E. coli* bacteria. The test incorporates two different phases; the first phase is an enrichment of the specimen in a nutrient-rich broth apparatus at 37±0.5°C. After 8 hours, an aliquot is removed from the enrichment apparatus and inserted into the Coliform Detection Device, which is then assayed in a bioluminogenic (light-producing) substrate after 10 min of incubation at 37±0.5°C. Specimens testing positive in the Coliform Detection Device can be then assessed precisely for *E. coli* by means of the *E. coli* Detection Device. The results from this testing system have been previously validated by Meighan[19] for the detection of *E. coli* at very low levels and in a variety of sample types. The MicroSnap device was previously calibrated and prepared for use by the manufacturer. The readings were retrieved from the device with outputs in CFU (Colony Forming Units)/ml (Table 2). To exclude any errors, an average reading for the 3 swabs from each surface was recorded to ascertain the level of contamination.

Table 2. Equivalence readings between RLU units values of *E. coli* bacteria obtained by MicroSnap kit and the colony forming units (CFU)

RLU values	Equivalence colony forming units (CFU)
	EnSUR
≤10	≤40
30	125
100	300
300	800
1000	2,000
3000	5,500
10,000	15,000
30,000	Above display range
100,000	Above display range
300,000	Above display range
1,000,000	Above display range

Data collection using the MicroSnap kit for a selected lavatory took approximately 20 minutes and was conducted mid-day during school operating hours after the early morning custodial cleaning. In accordance with the test kit's instructions, three duplicate swab samples were aseptically collected from three surfaces in each lavatory to test for *E. coli* bacteria prevalence. This resulted in a total of nine samples taken per lavatory. The surfaces in the lavatory selected for the swab samples were decided upon based on the surfaces most commonly coming into human contact (hotspots) and what style of toilet was found.

The lavatory facilities allocated to pupils in the school buildings were randomly selected for the microbiological testing while ensuring that at least one lavatory was selected on each floor level. The researcher first noted whether the lavatory facility had European or Asian type toilets. In the case an Asian style toilet was encountered, three duplicate swabs were each taken from the flushing handle and the bidet shower handle (as shown in Fig. 3), in addition to the sink taps. When a European style toilet was encountered, three duplicate swabs were each taken from each of the flushing handle, the bidet shower handle, and from the toilet seat as illustrated in Fig. 4.

Figure 3. An Asian style toilet indicating where the swab samples were taken

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Figure 4. A seat style toilet showing the three locations where swab samples were taken

2.3 Statistical Analysis

IBM SPSS (version 22) statistical analytical software was used for the research data analysis. A Chi-square test was implemented to ascertain the dependency among the selected data. In addition, F-test and T-statistics were used to compare two independent sample means for unequal and equal variances, respectively.

3. Results and Discussion

The sampling results are shown in Table 3 for each corresponding school. The results showed *E. coli* was non-existent in 85% of the schools tested, while 15% of the schools tested, showed the existence of *E. coli* with varying concentrations. Also, from the 46 sample points tested, 15.2% showed the presence of *E. coli*. This result can be compared to the previously mentioned study by Mohamed et al.[4] which showed that 18% of their samples indicated *E. coli* in public lavatories found in a U.S. metropolitan city.

Table 3. *E. coli* bacteria prevalence in 46 high schools which were randomly selected with 3 duplicate swab samples aseptically collected from 3 surfaces (flush handle, shower bidet, and seat) in each lavatory

No.	School Name	Flush Handle Reading (RLU)	Bidet shower Reading (RLU)	Seat Reading (RLU)
1	Al-Mansouryah	0	0	0
2	Essa Ahmed Al-Hamad	0	0	0
3	Lateefa Al-Shemali	0	0	0
4	Saad Ben Rabeea'a	0	0	0
5	Abdullah Al-Jaber Al-Sabah	0	0	0
6	Al-Jazae'r	0	0	0
7	Yousef Ben Essa	0	0	0
8	Al-Yarmouk	0	0	0
9	Jaber Al-Ahmad Al-Sabah	0	0	0
10	Abdullah Abdulateef Al-Rejeeb	0	0	0
11	Salwa	0	0	0
12	Falasteen*	1	1	4
13	Al-Jabryah	0	0	0
14	Fatema Al-Sara'awy	0	0	0
15	Nasser Abdulmuhsen AL-Saeed	0	0	0
16	Al-Kendy	0	0	0
17	Al-Zoor	0	0	0
18	Fatema Bent Asad	0	0	0
19	Um Al-Heaman	0	0	0
20	Lateefa Al-Fares	0	0	0
21	Al-Ahmadi	0	0	0
22	Balat Al-Shuhada'a	0	0	0
23	Omar Ben Al-Khatab	0	0	0
24	Al-Retqqa	0	0	0
25	Al-Emam Malek	0	0	0
26	Abdullah Mubarak Al-Sabah*	1	2	1
27	Fatema Al-Hashemyah	0	0	0
28	Sabah Al-Salem	0	0	0
29	Al-Shargeyah	0	0	0
30	Sabah Al-Salem	0	0	0
31	Abraq Kheetan	0	0	0
32	Al-Mubarakeyah	0	0	0
33	Ruzainah	0	0	0
34	AnasIbenMalek	0	0	0
35	Labeed Iben Rabeea'a*	26	27	20
36	Abdulateef Thnyan Al-Ghanim*	25	28	22
37	Al-Rabee'a bent Mua'aawath	0	0	0
38	Um Al-Hakam Bent Aby Sufyan	0	0	0
39	Al-Furdous	0	0	0
40	Al-Jahra*	2	1	0
41	Al-Nawar Bent Malek**	2	3	1
42	Mohammed AL-Meheani	0	0	0
43	Um Al-Hareth Al-Anssaryah	0	0	0
44	Al-Jahra	0	0	0
45	Jaber Abdullah Al-Sabah*	2	5	2
46	Suaad Bent Selameh	0	0	0

Notes: *Boys' schools with *E. coli* bacteria prevalence with various values.

**Girls' schools with *E. coli* prevalence for its 3 tested contact surfaces.

The results depict two main observations; first, out of the 7 schools, only 2 schools indicated considerably high values with respect to other schools. Unlike the rest of the schools, it was observed that the sampling results for

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the flush handle, shower bidet, and seat were in the higher range (20-30 RLU). Second, 6 schools were for boys, while only a single school was for girls. Fig. 5 shows the three duplicate swab results for the flush handle, shower bidet, and seat in each lavatory of the 7 schools with high *E. coli* bacteria prevalence. For instance, the sampling results for Abdulateef Thnyan Al-Ghanim male high school had *E. coli* concentration values for flush handle, washing bidet, and toilet seat of 25, 28, and 22 RLU, respectively.

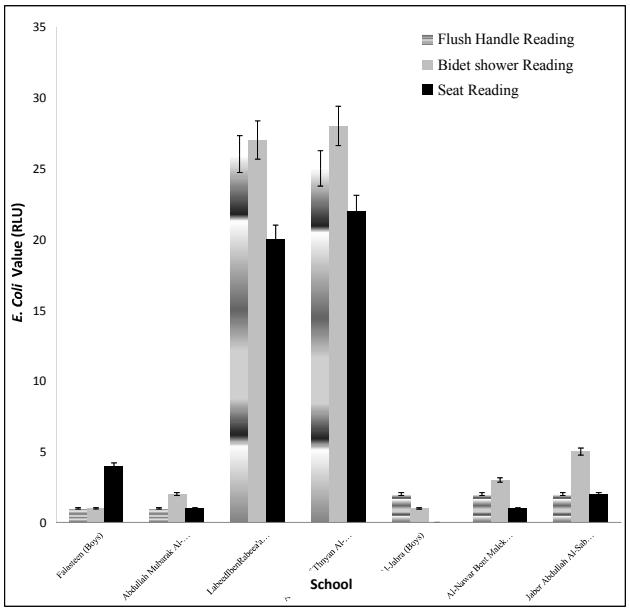

Figure 5. *E. coli* bacteria results of three sampling contact points (flush handle, shower bidet, and seat) in RLU units for 7 schools (representing about 15%) out of 46 schools.

3.1 Dependency Relation of the Three Sampling Surface Points

In order to answer the question of whether there is a difference between the sampling locations (hotspots), namely the Flush Handle, Washing Bidet and Seat, within the same methodology or otherwise, a correlation and Chi-squared tests were used to ascertain such a hypothesis. The Chi-squared test of independence variables was applied to resolve the question of whether the influences of one variable depend on the value of another variable. Therefore, a correlation between the three sampling locations in a sequence manner was implemented as shown in Table 4.

Table 4. Statistical correlation test among the three sampling surfaces (flush handle, shower bidet, and seat) in each lavatory to test the prevalence of *E. coli* bacteria in 46 schools with correlation significant at the 0.01 level (2-tailed)

Correlations		Washing Bidet		
		Flush Handle Readings (RLU)	Readings (RLU)	Seat Readings (RLU)
Flush Handle Readings (RLU)	Pearson Correlation	1	.996*	.990*
	Sig. (2-tailed)		.000	.000
	N	46	46	46
Washing Bidet Readings (RLU)	Pearson Correlation	.996*	1	.990*
	Sig. (2-tailed)	.000		.000
	N	46	46	46
Seat Readings (RLU)	Pearson Correlation	.990*	.990*	1
	Sig. (2-tailed)	.000	.000	
	N	46	46	46

The statistical results depicted in Table 4 show a high correlation of Pearson Correlation "r" with more than 0.99 between the three surfaces under consideration. The correlation between Flush Handle and both Washing Bidet and Seat recorded "r" equal to 0.996 and 0.990, respectively. Similarly, the correlation between Washing Bidet and both flush Handle and Seat revealed a high correlation of 0.996 and 0.990, respectively. In addition, the correlation of Seat and both flush Handle and Washing Bidet showed "r" to be equal to 0.990 for both readings, which indicated a high correlation.

In an attempt to thoroughly verify if one surface sampling represented the rest of the sampling points, a Chi-squared test was implemented. The Chi-squared test of independence variables is used to answer the question of whether the effects of one variable depend on the value of another variable.

Investigating the correlation between Flush Handle and Washing Bidet readings, a null hypothesis (H0:) indicated that the readings of "Flush Handle" and "Washing Bidet" were independent of each other [H0: $\Sigma\Sigma(O - E)2 = 0$], where "O" and "E" represent the actual observation and expected reading value respectively of the mentioned variables. The hypothesis (H1:) indicated the opposite. In other words, readings of "Flush Handle" and "Washing Bidet" were not independent of each other. Therefore, readings in "Washing Bidet" is dependent on readings in "Flush Handle" [H1: $\Sigma\Sigma(O - E)2 \neq 0$]. The value of the Chi-squared statistics shown in Table 5 is presented in $\chi^2 = 164.8$ with a p-value of less than 0.001. Consequently, the

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decision was to reject the null hypothesis (H_0:) at a significance level of less than 1% (α=0.001). As a result, the readings of "Flush Handle" and "Washing Bidet" are dependent and represent each other significantly. Therefore, according to the data and the results, if *E. coli* exists on the "Flush Handle", it is expected to be also existent on the "Washing Handle" as well and vice versa.

Table 5. Chi-square test table representing the dependency correlation between the "Flush Handle" and the "Washing Bidet" readings

Title	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.648E2*	24	.000
Likelihood Ratio	54.340	24	.000
Linear-by-Linear Association	44.601	1	.000
N of Valid Cases	46		

Notes: *Has 34 cells according to the statistical package (SPSS) representing 97.1% with an expected count less than 5 and the minimum expected count is 0.02

In addition, a similar hypothesis was suggested for the correlation between Flush Handle and Toilet Seat readings. Again, the null hypothesis is (H0:) for this scenario and indicated that the readings of "Flush Handle" and "Toilet seat " are independent of each other. The values of the Chi-squared statistic, as indicated in Table 6, shows that χ^2= 148.7 with a p-value less than 0.001. As a result, the decision was to reject the null hypothesis (H0:) at a significant level less than 1%. Hence, the readings of "Flush Handle" and "Toilet Seat" are dependent on each other.

Table 6. The Chi-square test represents the dependency correlation between the "Flush Handle" and the "Toilet seat" readings

Title	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.487E2*	20	.000
Likelihood Ratio	44.988	20	.001
Linear-by-Linear Association	44.085	1	.000
N of Valid Cases	46		

Notes: *Has 34 cells according to the statistical package (SPSS) representing 97.1% with an expected count less than 5 and the minimum expected count is 0.02

For the third and last comparison, a hypothesis was questioned between the "Washing Bidet" and the "Toilet Seat" Readings. The null hypotheses (H0:) for this scenario stated that the readings of the "Washing Bidet" and the "Toilet seat" were independent of each other. The value of the Chi-squared statistic, as indicated in Table 7, shows that χ^2= 206.4 with a p-value less than 0.001. As a result, the decision was to reject the null hypothesis. Therefore, the analysis rejected the null hypotheses (H0:) at a significant level less than 1%. Consequently, the readings of the "Washing Bidet" and the "Toilet seat" are dependent on each other.

Table 7. The Chi-square test represents the dependency correlation between the "Washing Bidet" and the "Toilet seat" readings

Title	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.064E2*	30	.000
Likelihood Ratio	51.579	30	.008
Linear-by-Linear Association	44.103	1	.000
N of Valid Cases	46		

Notes: *Has 34 cells according to the statistical package (SPSS) representing 97.1% with an expected count less than 5 and the minimum expected count is 0.02

Accordingly, it can be stated with high confidence that the three sampling locations (flush handle, shower bidet, and toilet seat) are dependent and highly correlated with not less than a 99% confidence level. Thus, taking samples from any one of the aforementioned "hotspot" locations obviates the other two. This would reduce researcher cost, effort, and time for data gathering procedures.

3.2 Correlation of Male and Female Readings

The previous section addressed the dependency of the three sampling points, where it was concluded that one sampling point could represent other sampling points. Therefore, the researcher could implement sufficiently the correlation of male and female readings analysis using only the "Flush handle" data.

To ascertain the correlation between the readings of both genders and the readings of the tested data, a comparison of the *E. coli* bacteria data for two independent samples, namely male and female, were tested. A tested hypothesis (H_0:) was included if the toilets in the male and female schools had a similar reading. Table 8 depicts the test for equality of variances. According to the F-test, male and female readings have unequal variance since the significant P-value is 0.002, which is less than the significant level 0.01. Therefore, the F-test indicates that the male and female readings have unequal variances. As a result, the t-statistics of equal variances is not assumed. Results indicated that Sig. (2-tailed) is equal to 0.129, which indicates accepting the null hypothesis. Therefore, it was concluded that male and female data could have equal readings.

In a further analysis to test whether male toilets read-

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Table 8. Independent Samples analysis of variance of E. coli concentration readings between male and female lavatories

		Levene's Test for Equality of Variances		*t*-test for Equality of Means						
		F	Sig.	*t*	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Flush handle RLU	Equal variances assumed	10.325	.002	1.650	44	.106	2.50758	1.52019	-.55618	5.57133
	Equal variances not assumed			1.578	21.116	.129	2.50758	1.58901	-.79585	5.81100

ings had less or equal prevalence of *E. coli*, a null hypothesis was tested. The Null hypothesis (H_0:) projected whether male toilets had less than or equal readings to female toilet readings [H_0:$\mu_{male} \leq \mu_{female}$]. Analytical results from Table 8 showed that male and female readings have unequal variance. Therefore, the decision is to reject the hypothesis at the 10% level of significance ({0.129/2= 0.0645} < 0.1). In other words, it is concluded that male toilets readings have greater *E. coli* prevalence than female toilets readings at only a 10% level of significance.

Table 9 shows male and female means significantly different, however their readings could also be equal. Such a fact is supported by the salient readings of *E. coli* bacteria with no prevalence. However, as previously observed, the male toilets readings have greater *E. coli* concentration than Female toilets readings at only a 10% level of significance. Such a result supports the findings in the study previously done by Kyriacou et al.[10].

Table 9. Group statistics for the measured data of 22 male and 24 female lavatories

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Flush handle RLU	Male	22	2.5909	7.44286	1.58682
	Female	24	.0833	.40825	.08333

3.3 Data Variance of European "Seat" and Asian "Squat" Type Toilets

In an effort to test the differences in data between European seat and Asian squat style toilets, the readings were tabulated and analyzed. Descriptive data statistics of the two styles of toilets are presented in Table 10.

Table 10. Group statistics for the measured data of 23 Asian squat and 23 European seat toilets irrespective of gender

	Sampling position	N	Mean	Std. Deviation	Std. Error Mean
Toilet Seat RLU	Asian "squat"	23	2.0000	6.02268	1.25582
	European "seat"	23	.1739	.83406	.17391

Equality of Variances for the data gathered from the European seat and Asian squat toilets were tested as illustrated in Table 11. According to the F-test, European seat and Asian squat toilets had unequal variance since the "seat" readings P-value was 0.007, where it is less than the significant level (0.01). Consequently, in this case, t-statistics of "Equal Variances is not assumed" had to be implemented. Accordingly, the null hypothesis was not rejected. Therefore, the analytical conclusion indicated that there was probably no difference between European seat or Asian squat toilets. However, Asian squat toilets could have greater readings than the European seat toilet at only a 10% level of significance.

4. Conclusions

Since schools should be obligated to provide a safe environment for their students, the present research has been conducted on the prevalence of *E. coli* in 46 public schools in Kuwait. The study involved microbiological testing of 342 stool samples collected from selected lav-

Table 11. Independent samples analysis of variance table testing Asian "Squat" and European "Seat" toilets of E. coli bacteria prevalence for male and female lavatories

		Levene's Test for Equality of Variances		*t*-test for Equality of Means						
		F	Sig.	*t*	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Seat Readings RLU	Equal variances assumed	7.984	.007	1.440	44	.157	1.82609	1.26780	-72900	4.38117
	Equal variances not assumed			1.440	22.844	.163	1.82609	1.26780	-79755	4.44973

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atory surfaces. The results of the testing for the spread of the *E. coli* bacteria were categorized by total count, sampling location dependency, contamination level comparison between genders, and lavatory fixtures (i.e. seat and squat toilets) supported by applying appropriate statistical analysis.

The sampling results indicated some contamination concerns. A total of seven schools showed the existence of *E. coli* (or 15% of the schools tested) with varying concentrations. Of these seven schools, two schools indicated considerably high values with respect to the other schools.

The results also revealed, with the aid of statistical analysis, cross-contamination between surfaces in the lavatory stalls, and thus, sampling location dependency. Therefore, it can be stated with high confidence that the three sampling areas (flush handle, shower bidet, and toilet seat) are dependent. As a result, taking any sampling position obviates the other two areas. This would reduce researcher cost, effort, and time for data gathering procedures.

In addition, analytical results showed that the boys' lavatory readings have greater *E. coli* prevalence than the girls' toilets, and thus, are less sanitary.

Finally, it was determined from the data gathered that the Asian squat style toilets are more contaminated than the European seat style. It might be prudent to reconsider the use of squat style toilets in the architectural layout of any future school building.

The results suggest some schools in Kuwait have a contamination problem and that there is a threat of bacterial infection that can spread among students via contaminated hands and surfaces in the lavatory areas. Therefore, improved environmental hygiene and enhanced sanitation are needed in these "problem" schools and the daily cleaning operation at these schools is not sufficient.

5. Recommendations

Certain schools investigated in this research have *E. coli* levels high enough to create health concerns for students. This information necessitates improving public health hygiene through a multi-level approach to the prevention of *E. coli* exposure. The suggested policies and methods would be remedial by way of additional research, education, and an administrative program.

By regulating the relative humidity level in a lavatory, the growth of bacteria can be reduced. A relative humidity of 30 to 50 percent is suggested and satisfactory ventilation would introduce sufficient outdoor air to assist in the decrease of humidity, especially in a hot-arid climate like the one found in Kuwait. Therefore, the lavatory exhaust fans need to be properly maintained and functioning.

It is recommended as a result of this research to increase the frequency of the current cleaning routine of once per day to twice or more per day during school operating hours, especially for the boys' lavatories. The Ministry of Education should also adopt a written cleaning standard that is implemented by the hired cleaning contractors in order to improve hygiene in the schools. The standard should include, in addition to cleaning frequency, the provision of adequate infection controls and accepted anti-bacterial detergent usage.

Other methods of effective cleaning could also possibly be introduced. For example, a continuous-release hypochlorite disinfectant system may be utilized. The continuous release system can produce a considerable and continuous reduction in contamination of the toilet and surrounding areas[2].

Also, the outcomes of this research are a task for legislators. Numerous countries have health laws that entail school inspections to safeguard hygiene quality measures. Some of these laws dictate that local health agencies to perform the inspections. The State of Kuwait is still deficient in such health laws for implementing satisfactory hygiene measures for schools. This is a chance for policymakers to become promoters for the safeguard of children's environments and prevention of exposure to bacterial contamination.

At the school level, grasping the significance of good hygiene is imperative in establishing a successful health program. Health and environment specialists have a part to play in helping school administrators understand how bacterial complications progress, the significance of suitable hygiene, and its effect on students and staff. School nurses should be prepared and qualified to identify situations of bacterial exposure.

Long-term testing and sampling during school hours was not conceivable in this study owing to the disruption it would have caused to the schools. However, when the population studied is a sensitive group, there is a certain necessity to test continuously. Thus, the several schools tested to have elevated *E. coli* measurements are candidates for long-term monitoring.

Additional analyses are also required to establish the reasons for the measured divergences between the schools and to conclude if the initial school sites used in this study are illustrative of actual exposures in other surrounding schools that were not tested in this study. Discrepancies might also be present in other educational facilities such as university, middle, and primary school buildings and this is a topic for further study.

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