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The effectiveness of disinfection protocols in medical school osteopathic manipulative medicine labs.

Harrison A. Patrizio
Rowan University

Riley Phyu
Rowan University

Thomas Boyle
Rowan University

Todd Schachter
Rowan University

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Harrison A. Patrizio*, BS, Riley Phyu, BS, Thomas Boyle, MS and Todd Schachter, DO

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Abstract

Context: In light of the COVID-19 pandemic, healthcare-associated infections have taken center stage. Healthcare has adjusted workflows to accommodate for more robust disinfecting regiments to help protect the community. This has resulted in the need for medical institutions to reevaluate the current disinfection protocols down to the student level. The osteopathic manipulative medicine (OMM) laboratory provides an optimal avenue for assessing the effectiveness of medical students' ability to clean examination tables. With OMM laboratories having a high level of interaction, adequate disinfection is important for the health and safety of students and teaching faculties.

Objectives: This study will evaluate the effectiveness of the current disinfection protocols in the medical school OMM labs.

Methods: A cross-sectional, nonrandomized study was performed on 20 OMM examination tables utilized for osteopathic training. Tables were chosen based on their close proximity to the podium. Close proximity was utilized as a criteria to increase the probability of utilization by students. The sampled tables were observed to ensure their use by students during class. Initial samples were collected in the morning after disinfection by Environmental Services. Terminal samples were collected after Osteopathic medical students utilized and disinfected the OMM examination tables. Samples were collected from the face-cradle and midtorso regions and analyzed utilizing adenosine triphosphate (ATP) bioluminescence assays with an AccuPoint Advanced HC Reader. This reader provides a digital readout of the quantity of light measured in relative light units (RLUs), which is directly correlated to the amount of ATP present in the sample, providing an estimated pathogen count. For statistical analysis, a Wilcoxon signed-rank test was utilized to find statistical differences in RLUs in samples after initial and terminal disinfection.

Results: The face cradle showed a 40 % increase in failure rate in samples after terminal disinfection when samples were compared after initial disinfection. A Wilcoxon signed-rank test revealed an estimated pathogen level for face cradle that was significantly higher after terminal disinfection (median, 4,295 RLUs; range, 2,269–12919 RLUs; n=20) compared to initial disinfection (median, 769 RLUs; range, 29–2,422 RLUs; n=20), z=−3.8, p=0.00008, with a large effect size, d=2.2. The midtorso region showed a 75 % increase in samples after terminal disinfection when samples were compared after initial disinfection. A Wilcoxon signed-rank test revealed that the estimated pathogen levels for midtorso were significantly higher after terminal disinfecting (median, 656 RLUs; range, 112–1,922 RLUs; n=20) compared to initial disinfecting (median, 128 RLUs; range, 1–335 RLUs; n=20), z=−3.9, p=0.00012, with a large effect size, d=1.8.

Conclusions: This study suggests that medical students frequently failed to disinfect high-touch regions on examination tables, such as the midtorso and the face cradle. It is recommended that the current OMM lab disinfection protocol be modified to include the disinfection of high-touch regions in order to reduce the possibility of pathogen transmission. Further research should explore the effectiveness of disinfection protocols in clinical settings such as outpatient offices.

Keywords: COVID-19; disinfection; environment services; healthcare associated infection (HAI); infection; medical education; medical students; osteopathic manipulative medicine (OMM); pathogen transmission; patient safety.

***Corresponding author: Harrison A. Patrizio**, BS, Rowan University School of Osteopathic Medicine, 1 Medical Center Dr, Stratford, NJ 08084-1501, USA, E-mail: patrizioh2@rowan.edu
Riley Phyu, BS, Rowan University School of Osteopathic Medicine, Stratford, NJ, USA
Thomas Boyle, MS, Department of Employee Health, Rowan University School of Osteopathic Medicine, Stratford, NJ, USA
Todd Schachter, DO, Department of Family Medicine, Rowan University School of Osteopathic Medicine, Stratford, NJ, USA

Healthcare-associated infections (HAIs), also known as "nosocomial infections," are infections transmitted while receiving treatment in healthcare settings [1]. HAIs occur in all healthcare settings such as hospitals, ambulatory clinics, surgical centers, and long-term care facilities [1]. The prevalence of these infections is concerning because they are a major cause of patient mortality and morbidity in the United States [2]. Klevens et al. [3] reported that in 2002, there were approximately 1.7 million HAIs, resulting in approximately 99,000 annual deaths. Thus, proper and adequate disinfection of contaminated surfaces in healthcare settings may be important for reducing microbial contamination of surfaces and subsequent risk for HAIs.

In light of the COVID-19 pandemic, disinfection in healthcare has become increasingly important [4]. Healthcare has adjusted workflows to accommodate more robust disinfecting regiments to help protect the community [4]. This has resulted in the need for medical institutions to reevaluate the current disinfection protocols down to the student level. A study by Lima de Miranda et al. [5] shows that in a study of 155 medical students, 70.0 % of them, on average, assumed that their hand-hygiene compliance rate is much higher than the actual performance, where the hand-hygiene compliance is only approximately 50.0 %. The study concluded that medical students' overconfidence in their hand hygiene resulted in lower-than-desired hygiene compliance in hospital settings [5]. This conclusion was echoed by Pittet et al. showing that intervention was important for improvement in hand hygiene compliance [6]. These observations are concerning due to medical students' frequent interaction with patients and their future role as physicians. The osteopathic manipulative medicine (OMM) lab provides an optimal avenue for assessing the effectiveness of a medical student's ability to clean examination tables. With OMM labs being an activity with a high level of interaction, the adequate disinfection of examination tables is important for the health and safety of students and teaching faculties.

Adenosine triphosphate (ATP) bioluminescence has been commonly utilized to audit the effectiveness of healthcare disinfection [7]. Overall, this method provides an objective, real-time assessment of the degree of contamination [8]. ATP is present in all types of organic materials and can be quantified by utilizing the ATP bioluminescence assays, providing an estimate of pathogenic contamination levels [9]. To our knowledge, ATP bioluminescence has not been previously conducted in an osteopathic medical school setting to evaluate the effectiveness of the OMM lab disinfection protocol. This study aims to evaluate the effectiveness of the current disinfection protocols in osteopathic medical school OMM labs.

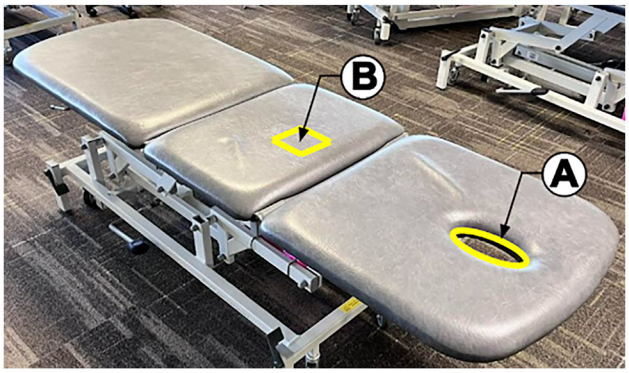

Figure 1: Osteopathic manipulative medicine (OMM) examination table with locations A (face cradle) and B (midtorso region) labeled.

Methods

Study design

A cross-sectional, nonrandomized study was performed on 20 OMM examination tables actively utilized for osteopathic training between June 2022 and July 2022. Tables were chosen based on their proximity to the podium. Proximity to the podium was utilized as a criterion based on the increased probability of use by students. The sampled tables were observed to ensure their use by students during class. Inactive examination tables during class were excluded from data analysis. The study was conducted without discussion with Environmental Services or medical students to minimize behavioral changes.

Two high-touch surfaces, locations A and B (Figure 1), were chosen for data collection on the examination tables. The face cradle, where students rest their face while lying prone, was labeled as location A (Figure 1). The midtorso region, measured 50 cm inferior to the face cradle, was labeled as location B (Figure 1). Initial samples were collected in the morning after disinfection by Environmental Services. Terminal samples were collected after the first-year Osteopathic medical students utilized and disinfected the examination tables after Osteopathic training. Currently, there is no written protocol provided to the students on how to disinfect the examination table. Instead, students are orally instructed to disinfect the OMM tables by spraying and wiping with disinfectant chemicals and clean paper towels.

AccuPoint advanced HC: ATP bioluminescence

The ATP bioluminescence assays were performed utilizing the AccuPoint Advanced HC Reader (Neogen Corporation, Lansing, MI) [10]. The reader provides a digital readout of the quantity of light measured in relative light units (RLUs), which is directly correlated to the amount of ATP present in the sample [10]. All organic matter contains ATP, which allows the reader to show the total quantity of contamination found in the sample utilizing the reaction below [8].

$$\text{Luciferase} + \text{D} - \text{luciferin} + O_2 + \text{ATP} = \text{luciferase} + \text{oxyluciferin} + CO_2 + \text{AMP} + PP_i + \text{light}$$

According to the manufacturer's recommendation [10], to prepare for sample collection, the sampler cartridges were removed from the refrigerator and warmed to room temperature 1 h prior to use.

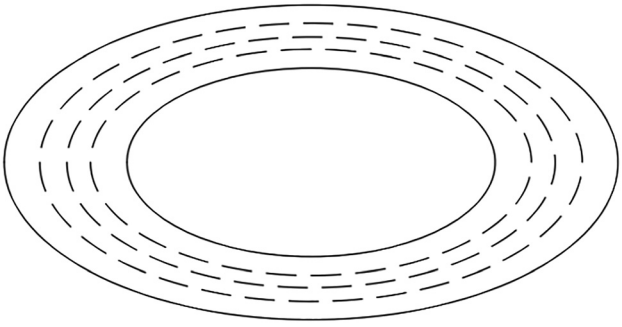

Figure 2: Circular pattern tracing the circumference of the face cradle (location A).

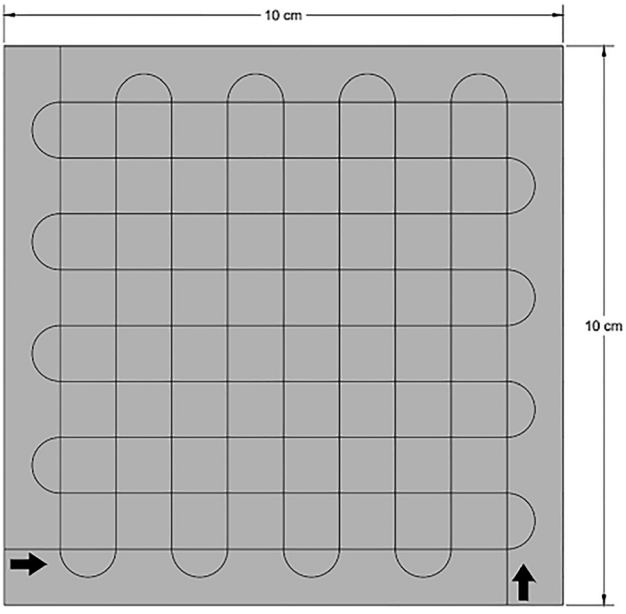

Figure 3: Zigzag pattern protocol for swabbing the midtorso region (location B).

When collecting samples, the sampler was removed from the cartridge by the handle, exercising caution not to touch the tip of the sampler or let the tip touch any other surface prior to testing. Data were collected at location A (Figure 1) by swabbing the entire inner circumference of the face cradle, 2 inches above the seam down to the seam in a circular pattern (Figure 2). Data were collected at location B in a zigzag pattern creating a grid formation (Figure 3).

After collecting the sample, the sampler was reinserted into its cartridge and fully depressed. The sampler along with the cartridge were swirled in a clockwise manner for 2 s and placed into the sampler compartment of the AccuPoint Advanced HC Reader for analysis [10]. The threshold value being utilized for interpretation is an ATP level of 11, 12, RLU/100 cm^2 (Table 1), a standard benchmark threshold [11–13]. After analysis, the sampler and cartridge were removed from the sample compartment and disposed of according to the manufacturer's recommendations.

Measurement reliability

Although ATP bioluminescence has been utilized in other industries, this method is not as widely utilized in the medical field [14–16].

Table 1: RLU criteria utilized for pass/fail criteria.

Assessment of cleanliness	Result	Interpretation
ATP bioluminescence	<500 RLU	Pass
	≥500 RLU	Fail

ATP, adenosine triphosphate; RLU, relative light unit.

Table 2: Failure rates in initial and terminal samples.

	Initial samples (n=20)			Terminal samples (n=20)		
	Passes	Fails	% fails	Passes	Fails	% fails
Location A (face cradle)	8	12	60.0	0	20	100
Location B (midtorso)	20	0	0	5	15	75.0

Therefore, we conducted a separate baseline trial to improve the internal validity of the study. Predata was collected from 10 OMM examination tables after an OMM session before disinfection of the examination table. The data collection protocol outlined in the study design section was also followed during this set of data collection. The tables were then disinfected utilizing standard examination table cleaning products. Disinfection included spraying each section of the examination table with three sprays of the cleaner and wiping the entire surface with a paper towel. Extra care was taken to ensure the edges and face cradle were adequately disinfected. A clean paper towel was utilized on each section of the examination table to ensure that the particles were not spread across the entire surface. After disinfection, the examination tables were left to dry for approximately 10 min before the postdata was collected. This reduced the risk of the cleaner skewing our results and allowed the cleaner to kill any potential pathogens.

Statistical analysis

ATP values of less than 500 RLUs were considered a pass, whereas the AP values of 500 or more were considered a failure. All statistical tests were performed utilizing Microsoft Excel 2021 by HP and RP. The Shapiro-Wilk test was conducted to test for normality. A nonparametric Wilcoxon signed-rank test was then utilized to compare the RLU values of initial and terminal samples. Significance was set at $p<0.05$. Additionally, the effect size was calculated utilizing a Cohen's d test to determine the magnitude of differences in the RLU values of initial and terminal samples. A large effect size was classified as $d>0.80$.

Results

A total of 80 surfaces were sampled, consisting of 40 initial samples and 40 terminal samples split evenly between location A (n=20) and location B (n=20). RLU <500 was considered pass, indicating the sampled surface was adequately disinfected. RLU ≥500 was considered a failure, indicating the sampled surface was not properly disinfected.

Table 3: Median RLU and range of RLU data points of initial and terminal samples.

	Initial samples (n=20)		Terminal samples (n=20)		*z* value	p-Value	Effect size Cohen's *d*
	Median, RLU	Range, RLU	Median, RLU	Range, RLU			
Location A	769	29–2,422	4,295	2,269–12,919	−3.80	0.00008[a]	2.20
Location B	128	1–335	656	112–1,922	−3.90	0.00012[b]	1.80

[a]p value calculated from Wilcoxon signed-rank test for location A initial and terminal samples. [b]p value calculated from Wilcoxon signed-rank test for location B initial and terminal samples. RLU, relative light unit.

Table 4: Measurement validity: median RLU and range of RLU data points of initial and terminal samples.

	Before disinfection samples (n=10)		After disinfection samples (n=10)		*z* value	p-Value
	Median, RLU	Range, RLU	Median, RLU	Range, RLU		
Location A	2,307.5	839–4,830	127	2–430	5.40	<0.00001[a]
Location B	2,165	528–5,814	137.5	9–444	5.40	<0.00001[b]

[a]p value calculated from Wilcoxon signed-rank test for location A initial and terminal samples. [b]p value calculated from Wilcoxon signed-rank test for location B initial and terminal samples.

Location A

In the initial sample, 8 of the 20 samples showed RLU values <500 (40.0 % pass rate) (Tables 1 and 2). Additionally, 12 of the 20 samples showed RLUs ≥500 (60.0 % failure rate) (Tables 1 and 2). In the terminal sample, none of the 20 samples showed RLU values <500 (0 % pass rate). Additionally, all of the 20 samples showed RLUs ≥500 (100 % failure rate) (Tables 1 and 2). The terminal samples of the face cradle showed a 40.0 % increase, from 12 to 20 failures when compared to the face cradle of initial samples. The Shapiro-Wilk test showed a nonparametric distribution. A Wilcoxon signed-rank test revealed that for the face cradle, the estimated pathogen levels measured in the terminal samples (median, 4,295 RLU; range, 2,269–12,919 RLU; n=20) was statistically significantly higher (p<0.00008) than the levels measured in initial samples (median, 769 RLU; range, 29–2,422 RLU; n=20), z=−3.80, p=0.00008 with a large effect size, d=2.20 (Table 3).

Location B

In the initial sample, all of the 20 samples showed RLU values <500 (100 % pass rate) (Tables 1 and 2). Additionally, none of the 20 samples showed RLUs ≥500 (0 % failure rate) (Tables 1 and 2). In the terminal sample, 5 of the 20 samples showed RLU values <500 (25.0 % pass rate). Additionally, 15 of the 20 samples showed RLUs ≥500 (75.0 % failure rate) (Tables 1 and 2). The terminal samples of the midtorso showed a 75.0 % increase from 0 to 15 failures when compared to the midtorso of initial samples. The Shapiro-Wilk test showed a nonparametric distribution. A Wilcoxon signed-rank test revealed that for the face cradle, the estimated pathogen levels measured in the terminal samples (median, 656 RLU; range, 112–1,922; n=20) was statistically significantly higher (p<0.000012) than the levels measured in initial samples (median, 128 RLUs; range, 1–335 RLUs; n=20), z=−3.90, p=0.00008 with a large effect size, d=1.80 (Table 3).

Measurement validity trial

A total of 40 surfaces were sampled, 20 before disinfection samples and 20 after disinfection samples split evenly between location A (n=10) and location B (n=10).

Location A

The Shapiro-Wilk test showed a nonparametric distribution. A Wilcoxon signed-rank test revealed that for the face cradle, the estimated pathogen levels measured in the before-disinfection samples (median, 2,307.5 RLUs; range, 839–4,830 RLUs; n=10) were statistically significantly higher (p<0.00001) than the levels measured in the after-disinfection samples (median, 127 RLUs; range, 2–430 RLUs; n=10), z=5.40, p<0.00001 (Table 4).

Location B

The Shapiro-Wilk test showed a nonparametric distribution. A Wilcoxon signed-rank test revealed that for the face cradle,

the estimated pathogen levels measured in the before-disinfection samples (median, 2,165 RLU; range=528–5,814 RLUs; n=10) was statistically significantly higher ($p<0.00001$) than the levels measured in the after-disinfection samples (median, 137.5 RLUs; range, 9–444 RLUs; n=10), $z=5.40$, $p<0.00001$ (Table 4).

Discussion

In our study, it was essential to establish internal validity to confirm that the observed effects were genuinely caused by the disinfection protocols and not influenced by extraneous factors, including potential limitations associated with ATP bioluminescence readings. Verifying internal validity enabled us to draw reliable conclusions about the relationship between disinfection protocols and pathogen levels on examination tables.

We selected an RLU level of 500 as the cutoff between clean and contaminated examination tables, based on previous literature that identified this range as acceptable for determining cleanliness on surfaces. Considering the unique nature of our study, we also carried out a small trial of 10 OMM examination tables to determine the validity of these levels specifically for OMM examination tables. Fortunately, we discovered that the 500 RLU level offers a satisfactory separation between clean and contaminated examination tables, which is consistent with previous research [11–13]. This conclusion was drawn from the observation that the RLU values in the contaminated dataset were consistently above the 500 RLU cutoff, whereas those in the clean dataset were below the cutoff.

As a result of the strengthened internal validity, we can more confidently suggest modifications to the OMM lab disinfection protocols to better protect the health and safety of students and faculty, while acknowledging the potential presence and risks associated with both pathogenic and nonpathogenic microorganisms. Proper hygiene and sanitation practices are essential for minimizing infection risks in this context.

The 75.0 % increase in failure rates for the midtorso region suggests a significant increase in pathogen presence after student disinfection ($p=0.00012$). These results were surprising due to the natural tendency to wipe down the midtorso region even in minimal wipe downs. This may be explained by students simply forgetting to wipe down the examination table after use or performing the task poorly. A previous study of 25 third-year medical students by Cresswell and Monrouxe [17] qualitatively showed that proper hygiene behaviors had been "forgotten," leading to lower levels of compliance. Additionally, these findings may also be explained by medical students' misperception of the OMM table's low pathogen transmission risk or an overconfidence in their ability to clean. This was supported by studies by Lima de Miranda et al. [5] and Pittet et al. [6] on medical students' perception on their hand-hygiene compliance rate and their actual compliance performance.

The 40.0 % increase in failure rates for the face cradle region suggests that samples after terminal disinfection have a statistically marked increase in pathogen presence ($p=0.00008$) These data show that medical students failed to properly disinfect the edges like the face cradle (location A) in addition to missing the large surface area like the midtorso (location B). High pathogen presence in areas like the face cradle is concerning due to this region's extensive direct skin contact and the increased potential pathogen infection given the proximity to the nose and mouth. The lack of any written disinfecting protocol for medical students may contribute to the current inadequate disinfection. Modifications to current verbal disinfection protocols should include detailed instructions for proper disinfection, especially the face cradle. An incidental finding was also observed in the face-cradle region regarding the initial samples. Even though Environmental Services cleaned the face cradle statistically better than the medical students did ($p=0.0008$), the data showed that Environmental Services still did not adequately disinfect the face cradle. There was a 60.0 % failure rate, 12 out of 20 samples failed, emphasizing a need to further assess the institution's disinfection protocols across multiple departments. This is concerning because the responsibility for disinfecting all areas of the building, such as patient offices, largely falls upon Environmental Services. Therefore, further research may uncover that high-touch areas, such as the face cradle, are not being adequately disinfected across the institution.

Overall, this study shows the need to modify how medical students are trained to disinfect the OMM examination tables. Most importantly, students should be given access to written protocols that are readily available during class. These protocols should be easy to understand and adequately describe how to disinfect all surfaces. This may be best supplemented by images of wiping patterns superimposed on examination tables. Additionally, students should be tested on their knowledge of disinfection protocols before being allowed to participate in OMM training. One possibility is to have students watch a prerecorded video and conduct a written postexamination to ensure understanding. The prerecorded video should include the results of this study, emphasizing the estimated pathogen level that they may be exposed to during OMM training without proper disinfection. Finally, although

verbal reminders to disinfect examination tables have shown to be inadequate in this study, continuing to remind students verbally to disinfect during class may improve adherence to the updated protocol.

Limitations

This study has several limitations. First, the data were collected from only one medical school, which may limit the generalizability of the results. A larger sample size across multiple institutions is recommended to reinforce our findings. Second, potential environmental contamination may have impacted the results. One of the main concerns is the limitations of ATP bioluminescence measurements. Although ATP measurements are correlated to the presence of organic matter, they cannot differentiate between pathogenic and nonpathogenic microorganisms [18]. This means that high ATP levels do not necessarily indicate the presence of harmful pathogens, and thus the results may overestimate the risk of contamination. Furthermore, various factors, such as examination table characteristics and the presence of chemical residues, can interfere with the accuracy of ATP readings, potentially affecting the study's conclusions. Luckily, the possibility of unwanted contamination skewing our results was reduced by the results of our measurement validity check. However, this cannot be fully ruled out as an extraneous variable.

One variable that was not fully explored with this internal validity trial was the distinction between nonpathogenic and pathogenic organisms. However, even the presence of nonpathogenic organisms on a surface can still be concerning, because it may signal that the surface is also contaminated with pathogenic organisms leading to the transmission of disease. Additionally, nonpathogenic organisms can become opportunistic pathogens when the host's immune system is compromised, either due to an underlying medical condition or external factors such as stress or poor nutrition [19]. In such cases, the distinction between nonpathogenic and pathogenic organisms becomes less relevant, because both types can potentially cause infection. Therefore, maintaining proper hygiene and sanitation practices is crucial in minimizing the risk of infection from both pathogenic and nonpathogenic microorganisms. Therefore, the data still highlight the need to revise the existing disinfection protocol to ensure that all high-touch areas, including the face cradle, are thoroughly disinfected by both Environmental Services and medical students.

Conclusions

The data provide evidence for the need to update current disinfection protocols to include disinfecting surfaces, such as the face cradle, for both medical students and Environmental Services. Our research found that the students failed to adequately clean both the midtorso and the face cradle after use, while Environmental Services adequately cleaned the midtorso but failed to properly clean the face cradle. The improved understanding and education of disinfection among medical students may play a role in curbing transmission of peer-to-peer pathogen transmission and future HAIs.

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