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The effectiveness of disinfection protocols in osteopathic family medicine offices

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Abstract

Context: Healthcare-associated infections (HAIs) pose a substantial public health threat. Despite significant strides to curb HAIs in hospital environments, outpatient settings have not received the same degree of attention. Given their emphasis on holistic, patient-centered care, osteopathic family medicine offices are pivotal in both disease prevention and comprehensive patient treatment. The importance of simple yet effective disinfection protocols, such as thorough cleaning between patient appointments, cannot be overstated in these settings because they are integral to minimizing disease transmission.

Objectives: This study aims to assess the effectiveness of the current disinfection protocols in osteopathic family medicine offices.

Methods: A cross-sectional study evaluating disinfection practices on 18 examination tables in an osteopathic family medicine office was conducted. Two high-touch surfaces (midtorso region and table edge) were examined. Initial swab samples were collected after morning disinfection by Environmental Services, and terminal swab samples were gathered after day's-end disinfection by the medical staff. Adenosine triphosphate (ATP) bioluminescence assays were performed utilizing AccuPoint Advanced HC Reader, which quantified ATP, indicating contamination levels in the samples. The higher the ATP levels found in a sample, the greater the amount of biological contamination. All samplers were handled and

tested as per manufacturer's instructions. A preliminary trial was conducted to confirm the internal validity of ATP bioluminescence measurements. The statistical analysis involved Shapiro–Wilk and Wilcoxon signed-rank tests, with significance set at $p < 0.05$. Cohen's d test was utilized to calculate the effect size, identifying meaningful differences in initial and terminal swab sample relative light units (RLUs).

Results: The midtorso region demonstrated an 11.1% increase in failure rate after terminal disinfection when compared to initial disinfection. A Wilcoxon signed-rank test revealed a median estimated pathogen level for the midtorso region that was higher after terminal disinfection (median, 193 RLUs; range, 1–690 RLUs; $n=18$) compared to initial disinfection (median, 134 RLUs; range, 4–946 RLUs; $n=18$). However, this increase was not statistically significant, $p=0.9124$, with a small effect size, $d=0.04$. The edge showed no change in failure rate after terminal disinfection, maintaining a 100% failure rate both before and after disinfection. However, the Wilcoxon signed-rank test revealed a slight reduction in the median estimated pathogen levels after terminal disinfection (median, 2095 RLUs; range, 891–5,540 RLUs; $n=18$) compared to before disinfection (median, 2,257 RLUs; range, 932–5,825 RLUs; $n=18$). However, this reduction was not statistically significant, $p=0.61$, with a small effect size, $d=0.12$.

Conclusions: The findings from this study reveal a substantial disparity in outcomes between the two sample locations, midtorso and edge. The midtorso demonstrated a relatively low failure rate in both initial and terminal swab samples, indicating successful outcomes. In contrast, the edge consistently displayed a 100% failure rate, emphasizing the need for more care and attention when cleaning the edge of the examination to ensure better outcomes. By prioritizing adequate disinfection protocols, including thorough cleaning between patients, osteopathic family medicine offices can more effectively prevent disease transmission and promote patient safety.

Keywords: adenosine triphosphate bioluminescence; cleaning; disinfection; education; family medicine; infection

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Infections acquired within medical care settings, often referred to as healthcare-associated infections (HAIs) or nosocomial infections, represent a significant public health concern [1]. These infections can be transmitted in various medical settings including hospitals, outpatient clinics, surgical centers, and long-term care facilities [1]. HAIs are associated with patient mortality and morbidity across the United States, with approximately 1.7 million infections and 99,000 deaths annually [2]. Implementing and enforcing effective disinfection protocols in healthcare settings may be crucial in reducing the risk of HAIs through minimizing microbial contamination [3].

The COVID-19 pandemic has emphasized the importance of thorough disinfection procedures in all healthcare establishments, leading to our recent study examining disinfection protocols in osteopathic manipulative medicine (OMM) lab [4]. This study revealed significant discrepancies between accepted infection control standards and existing disinfection practices, suggesting the potential for increased risk of infection among peers due to higher contamination levels. This highlights the necessity of evaluating the disinfection protocols in other healthcare settings, such as family medicine. Family medicine offices serve a diverse patient population spanning all age groups and health conditions, making them critical junctions in the healthcare system with high-risk HAIs [5, 6]. Moreover, with the regular close interactions between the family medicine staff and patients, maintaining optimal hygiene in these offices is paramount [6].

Additionally, the recent pandemic and annual flu seasons have highlighted the importance of disinfecting outpatient offices. A recent study conducted by Neprash et al. [7] shed light on the potential for respiratory infection transmission in doctor's offices. The study analyzed a vast dataset of 105,462,600 outpatient visits across 6,709 office-based primary care practices between 2016 and 2017. The findings revealed that if a patient visited the outpatient office within 90 min after another patient with an influenza-like illness, the adjusted absolute difference in their likelihood of returning within 2 weeks with a similar illness increased by 0.7 per 1,000 patients compared to nonexposed patients. This study underscores the significance of infection control measures in outpatient offices and highlights the potential threat of HAIs in outpatient settings.

Unfortunately, compared to inpatient acute care settings, outpatient settings such as the family medicine offices suffer from a significant lack of infrastructure and resources to support infection prevention and surveillance activities [8–11]. This lack of focused research could potentially overlook unique challenges present in family medicine offices. This gap necessitates a targeted study to explore and address the hygiene needs of these unique healthcare settings. Therefore, this study aims to fill this research gap and

shed light on the effectiveness of the current cleaning protocols in family medicine offices, offering invaluable insights for improving patient safety in these critical healthcare environments.

Methods

Study design

A nonrandomized cross-sectional study was conducted between June 2022 and July 2022, involving 18 actively utilized family medicine examination tables in an osteopathic family medicine office. The tables were selected based on their high turnover rates to ensure a diverse range of patient interactions. To minimize behavioral changes, the study was performed without previous discussion with Environmental Services or medical staff.

The study focused on two high-touch surfaces, location A and location B (Figure 1). Location A referred to the midtorso region, positioned 50 cm below the face cradle. Location B represented the edge of the examination table, specifically the centerfold. Data collection involved obtaining initial swab samples in the morning after disinfection by Environmental Services, and terminal swab samples were collected at the end of the day after the Family Medicine staff had completed disinfection of the examination room.

The current cleaning practices encompassed the use of disinfectant chemicals for high-touch areas such as examination room tables, doorknobs, light switches, stools/chairs, and scales. However, specific instructions on how each high-touch area should be disinfected were not provided. Personnel responsible for room cleaning received training on the established examination room cleaning protocol, following the current techniques in place.

AccuPoint advanced HC – ATP bioluminescence

The adenosine triphosphate (ATP) bioluminescence assays were performed utilizing AccuPoint Advanced HC Reader (Neogen Corporation, Lansing, MI) [11]. 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 [11]. The resulting bioluminescent reaction is as follows [12]:

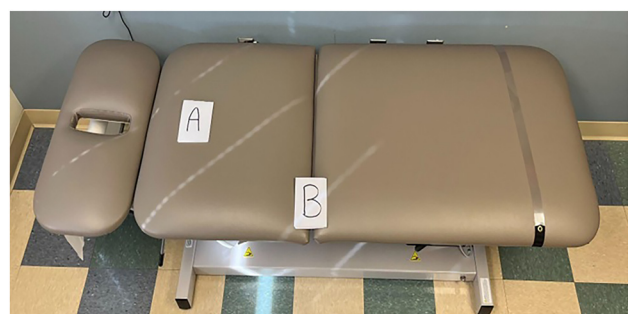
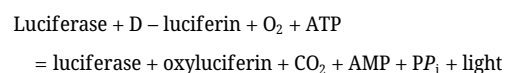


Figure 1: An outpatient examination table, identifying locations A and B.



Figure 2: AccuPoint Advanced HC system with sampler (A) and zigzag swabbing technique for swabbing location A and location B (B).

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

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

ATP, adenosine triphosphate; RLU, relative light unit.

The level of ATP present serves as an indicator of organic material or contamination in the sample. A higher ATP level therefore denotes a greater degree of biological contamination. As per manufacturer’s recommendation [11], to prepare for sample collection, the sampler cartridges were removed from the refrigerator and warmed to room temperature 1 h prior to use. We utilized Dacron swabs, for their superior material compatibility with the AccuPoint Advanced HC system. The collection media within the cartridge is a proprietary blend developed by Neogen Corporation, designed specifically to facilitate ATP extraction. When collecting samples, the sampler was removed from the cartridge by the handle while 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 and B (Figure 1) by swabbing in a zigzag pattern, creating a grid formation (Figure 2).

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 [11]. The threshold value being utilized for interpretation is an ATP level of 500 RLU/100 cm² (Table 1), a standard benchmark threshold [11, 13, 14]. After analysis, the sampler and cartridge were removed from the sample compartment and disposed of according to manufacturer recommendations.

Medical validity

In our previous study, we performed an internal validity trial to ensure that 500 RLUs was a proper indication of disinfection [4]. To ensure the internal validity of the current study, a parallel baseline trial was

Table 2: Failure rates in the initial and terminal samples.

	Initial samples (n=18)			Terminal samples (n=18)		
	Passes	Fails	% Fails	Passes	Fails	% Fails
Location A (midtorso)	17	1	5.6	15	3	16.7
Location B (edge)	0	18	100	0	18	100

conducted to assess the reliability of ATP bioluminescence measurements. Predata collection was performed on 18 family medicine examination tables after a full day of patient office visits but before the family medicine staff completed their disinfection routine after the last patient. The same data collection protocol outlined in the study design section was followed during this set of data collection. The tables were then disinfected utilizing standard examination table cleaning products (CaviCide). The disinfection process involved spraying each section of the examination table with three sprays of the cleaner and wiping the entire surface with a paper towel. Special attention was given to ensuring thorough disinfection of the edges and torso. To prevent cross-contamination, a clean paper towel was utilized for each section of the table to avoid spreading particles across the entire surface. After the disinfection process, the examination tables were left to dry for approximately 10 min before the postdata collection. This drying period reduced the risk of any potential interference from the cleaner and allowed sufficient time for the cleaner to effectively eliminate any pathogens. By implementing these measures, the potential bias from the cleaning process was minimized, thereby improving the reliability and validity of the data collected.

Statistical analysis

ATP values of less than 500 RLUs were considered passing, whereas AP values of 500 or more were considered a failure. All statistical tests were performed utilizing Microsoft Excel 2021 by HP and RP. A Shapiro–Wilk test was conducted to test for normality. A nonparametric Wilcoxon

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

	Initial samples (n=18)		Terminal samples (n=18)		z value	p-Value	Effect size Cohen's <i>d</i>
	Median, RLU	Range, RLU	Median, RLU	Range, RLU			
Location A	134	4–946	193	1–690	0.11	0.9124 ^a	0.04
Location B	2,257	932–5,825	2095	891–5,540	–0.57	0.61 ^b	0.12

^a*P* value calculated from Wilcoxon signed-rank test for the initial and terminal samples in location A. ^b*P* value calculated from Wilcoxon signed-rank test for the initial and terminal samples in location B. RLU, relative light unit.

signed-rank test was then utilized to compare the RLU values of the initial and terminal swab 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 RLU values of the initial and terminal swab samples. A large effect size was classified as $d > 0.80$.

Results

A total of 72 surfaces were sampled, consisting of 36 initial swab samples and 36 terminal swab samples split evenly between location A (n=18) and location B (n=18). RLUs <500 was considered passing, indicating that the sampled surface was adequately disinfected. RLUs ≥ 500 was considered a failure, indicating that the sampled surface was not properly disinfected.

Location A: midtorso

In the initial swab sample, 17 of the 18 samples showed RLU values <500 (94.4 % pass rate) (Table 2). Additionally, 1 of the 18 samples showed RLUs ≥ 500 (5.6 % failure rate) (Table 2). In the terminal swab sample, 15 of the 18 samples showed RLU values <500 (83.3 % pass rate). Additionally, 3 of the 18 samples showed RLUs ≥ 500 (16.7 % failure rate) (Table 2). The terminal swab samples showed an 11.1 % increase, from 1 to 3 failures when compared to the initial swab samples. The Shapiro–Wilk test showed a nonparametric distribution. A Wilcoxon signed-rank test revealed that for the midtorso, the estimated pathogen levels measured in the terminal swab samples (median, 193 RLU; range, 1–690 RLUs; n=18) was not statistically significantly different ($p = 0.9124$) than the levels measured in the initial swab samples (median, 134 RLUs; range, 4–946 RLUs; n=18), $z = 0.11$, $p = 0.9124$ with a small effect size, $d = 0.04$ (Table 3).

Location B: edge

In the initial swab sample, none of the 18 samples showed RLU values <500 (0 % pass rate) (Table 2). All of the 18 samples showed RLUs ≥ 500 (100 % failure rate) (Table 2). In the

terminal swab sample, the results remained the same: none of the 18 samples showed RLU values <500 (0 % pass rate), and all samples showed RLUs ≥ 500 (100 % failure rate) (Table 2). The Shapiro–Wilk test showed a nonparametric distribution. A Wilcoxon signed-rank test revealed that for the edge, the estimated pathogen levels measured in the terminal swab samples (median, 2095 RLUs; range, 891–5,540; n=18) was not statistically significantly different ($p = 0.61$) than the levels measured in initial swab samples (median, 2,257 RLUs; range, 932–5,825 RLUs; n=18), $z = -0.57$, $p = 0.61$ with a small effect size, $d = 0.12$ (Table 3).

Measurement validity trial

A total of 72 surfaces were sampled, 36 before disinfection samples and 36 after disinfection samples split evenly between location A (n=18) and location B (n=18).

Location A: midtorso

The Shapiro–Wilk test showed a nonparametric distribution. A Wilcoxon signed-rank test revealed that for the midtorso, the estimated pathogen levels measured in the before-disinfection samples (median, 2,250 RLUs; range, 551–5,900 RLUs; n=18) were statistically significantly higher ($p < 0.00001$) than the levels measured in the after-disinfection samples (median, 175.5 RLUs; range, 3–391 RLUs; n=18), $z = 5.40$, $p < 0.00001$ (Table 4).

Location B: edge

The Shapiro–Wilk test showed a nonparametric distribution. A Wilcoxon signed-rank test revealed that for the edge, the estimated pathogen levels measured in the before-disinfection samples (median, 2,225 RLUs; range, 701–7,201 RLUs; n=18) was statistically significantly higher ($p < 0.00001$) than the levels measured in the after-disinfection samples (median, 221 RLUs; range, 5–530 RLUs; n=18), $z = 5.40$, $p < 0.00001$ (Table 4).

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

	Initial samples (n=18)		Terminal samples (n=18)		z value	p-Value
	Median, RLU	Range, RLU	Median, RLU	Range, RLU		
Location A	2,250	551–5,900	175.5	3–391	5.40	<0.00001 ^a
Location B	2,225	701–7,201	221	5–530	5.40	<0.00001 ^b

^aP value calculated from Wilcoxon signed-rank test for the initial and terminal samples in location A. ^bP value calculated from Wilcoxon signed-rank test for the initial and terminal samples in location B. RLU, relative light unit.

Discussion

Our study prioritized the establishment of internal validity to corroborate a clear correlation between the implementation of disinfection protocols and their corresponding impact on pathogen levels found on examination tables. We aimed to ensure that the observed effects were directly attributed to our disinfection protocols and not confounded by extraneous factors, including potential limitations associated with ATP bioluminescence readings. Ensuring internal validity would enable us to make reliable inferences about the correlation between the disinfection procedures and the pathogen levels on the examination tables.

To demarcate between disinfected and contaminated examination tables, we opted for an RLU level of 500. This benchmark was informed by existing research, which deemed this value acceptable for determining surface cleanliness [4, 12, 15, 16]. However, acknowledging the unique nature of our study, we conducted a parallel trial involving the same 18 family medicine examination tables to validate the applicability of the 500 RLU level within the confines of a family medicine setting. Our findings aligned with prior research, corroborating the effectiveness of the 500 RLU level in distinguishing between clean and contaminated examination tables. This confirmation of robust internal validity allowed us to continue with our main data collection with more confidence.

The midtorso area, Location A, consistently registered high pass rates during both the initial cleaning conducted by the environmental service and the terminal cleaning by the family medicine staff. The failure rates in this region only showed a marginal increase of 12%, which was not statistically significant ($p=0.04$). We hypothesize that the positive outcome in the midtorso region may be due to the deployment of disposable examination table paper, a recommended practice in healthcare settings to promote cleanliness and reduce cross-contamination risk between patients [17]. The examination table paper, serving as a protective barrier between the patient's body and the table surface, prevents direct contact and mitigates potential pathogen transfer between individuals. However, it is

important to underscore that relying exclusively on examination table paper is insufficient to eradicate the risk of disease transmission completely. The table paper's integrity can be compromised through tearing or manipulation by the patient, thereby reducing its effectiveness as a protective barrier. Therefore, in conjunction with the use of examination table paper, rigorous disinfection of the examination table is essential to ensure a comprehensive strategy in reducing disease transmission risk. The revised protocol should still accentuate the necessity of sanitizing the table surface between each patient, in addition to changing the examination table paper, fostering a comprehensive and effective disease prevention approach.

The 100% failure rate at Location B (edge) during both the initial cleaning by the environmental service and the terminal cleaning by the family medicine staff raises substantial concerns. This high failure rate may be due to the absence of examination table paper and the misconception that patients do not engage with the edge of the examination tables. Several studies have elucidated the importance of cleaning the edges and the potential for pathogen transmission from contaminated surfaces to hands. A study conducted by Kramer et al. [18] investigated the transfer of a model virus, bacteriophage MS2, from a contaminated surface to the hands. The findings revealed that the virus could be transferred to fingertips within 5–30 s of contact with the contaminated surface [18]. Similarly, Barker et al. [19] conducted a study on the transfer of norovirus, a common cause of gastrointestinal illness, from surfaces to hands. The study demonstrated that transfer could occur within 10 s of contact with a contaminated surface. Given that patients often utilize the edge of the examination table to assist in getting on and off the table, it becomes imperative to thoroughly clean these edges to forestall potential pathogen transmission. Given this 100% failure rate and the risks linked with unclean edges, immediate revisions to the cleaning protocols are imperative. Introducing measures to ensure meticulous cleaning of the edges on the examination tables will markedly reduce cross-contamination risk and enhance patient safety.

Considering these insights, it is essential to prioritize infection control practices in outpatient offices, particularly

given the limited research and public awareness concerning these settings. Implementing robust disinfection protocols, advocating proper hand hygiene, and maintaining a clean environment are pivotal steps to minimize the risk of HAIs in outpatient settings. By raising awareness and implementing effective infection control measures, we can enhance patient safety and curtail the transmission of respiratory infections in outpatient offices.

Limitations

Our study possesses several limitations. Our study was primarily conducted within a single medical school, potentially constraining the extrapolation of our results. To reinforce our findings, future studies should consider a larger sample size drawn from multiple institutions.

Another limitation is that although ATP measurements denote the presence of organic matter, they fail to distinguish between pathogenic and nonpathogenic microorganisms. This attribute may lead to an overestimation of contamination risk, because high ATP levels do not always equate to the presence of harmful pathogens. Various factors, such as examination table characteristics and the existence of chemical residues, could also skew the ATP readings, potentially influencing our conclusions. This is a limitation that is also expressed in the study by Patrizio et al. [4]; however, the internal validity trial in the previous study and the current study help to mitigate the likelihood of such contamination affecting our results, although we cannot fully eliminate this as an extraneous variable.

Additionally, our study did not delve into the distinction between nonpathogenic and pathogenic organisms, which is a critical aspect in understanding contamination risks. However, as discussed in Patrizio et al., [4] the presence of even nonpathogenic organisms on a surface could signal potential contamination with the pathogenic organisms, contributing to disease transmission. Furthermore, nonpathogenic organisms can mutate into opportunistic pathogens when an individual's immune system is compromised due to underlying medical conditions or external stressors [20]. In such scenarios, the line between nonpathogenic and pathogenic organisms blurs, with both types posing potential infection risks. This emphasizes the importance of maintaining rigorous hygiene and sanitation practices to mitigate infection risks from all microorganisms.

In light of our research findings, our data assertively emphasize the importance of revising the existing sanitization measures in outpatient family medicine practices.

This refinement needs to incorporate a comprehensive disinfection of all high-contact areas, such as the edges of examination tables, which should be performed by both the Environmental Services and family medicine staff. Despite the limitations faced, our study represents a crucial progression toward refining disinfection protocols and, consequently, enhancing patient safety within medical facilities. In our continued effort to enhance these practices, we are now working on developing a more stringent disinfection protocol. This protocol aims to address the concerns and findings identified in our study. Following the approval of this enhanced protocol, we plan to conduct a subsequent study in the same family medicine clinic to assess the efficacy and practical implementation of our suggested modifications.

Conclusions

In conclusion, this study emphasizes the urgent need to reevaluate and enhance current disinfection protocols in family medicine offices to ensure comprehensive surface cleaning, with a particular focus on the edge areas of examination tables, especially in hands-on fields such as osteopathic medicine. Although the torso region appeared adequately disinfected, our findings revealed a consistent pattern of insufficient cleaning of table edges by both the medical staff and Environmental Services. This highlights a clear opportunity for improvement. Addressing this neglected area and implementing necessary changes to the cleaning procedures will significantly enhance safety in outpatient family medicine offices. This is particularly important in a medical school environment where effective, stringent cleaning protocols should be an integral part of the educational curriculum, instilling the best practices among future healthcare professionals and cultivating an atmosphere of heightened patient safety and care.

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Informed consent: Not applicable.

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