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Antimicrobial Copper Effective in Major Urban Transit System

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ABSTRACT

Purpose: To demonstrate reduced bacterial contamination and load on common touch surfaces in urban mass transit vehicles and headquarter outfitted with antimicrobial copper foil as compared to stainless steel surfaces.

Methods: Antimicrobial copper foil containing 99.9% copper was adhered to multiple stanchions, grab rails, door handles, and other common touch surfaces on a bus, a Los Angeles Metro rail car, and headquarter building. After 3 months of regular use by transit riders and office workers, the surfaces were swabbed, immediately placed in medium, and cultured for 24 hours. For control, nearby, comparable stainless steel surfaces were also swabbed and cultured.

Outcome Measure: Rate of contamination and number of bacterial colony forming units (CFU) were measured.

Results: The samples were grouped into Group A (headquarter) and Group B (bus and Metro rail car). The contamination rate was significantly higher in the non-copper (100% Group A and 76.9% Group B) vs. copper group (11.1% Group A and 7.7% Group B) by Fisher's Exact Test ($p = 0.0004$ Group A and 0.001 Group B). The non-copper surfaces also had significantly higher bacterial loads (mean of 12 CFU in Group A and 2.5 CFU in Group B) than the copper surfaces (mean of 0.1 CFU in Group A and 0.1 CFU in Group B) by Kruskal-Wallis test ($p = 0.0002$ for Group A and 0.0004 in Group B).

Conclusion: A method of employing antimicrobial copper reduced bacterial contamination and load on frequently touched surfaces in urban mass transit system used by both mass transit riders and Los Angeles Metro office workers, and may prevent spread of disease.

Background

It is established that copper has antimicrobial effect on bacteria, virus, and fungi [1-3]. When rarely used for its antimicrobial purpose, most facilities use solid copper alloys [4,5]. One study examined contamination rates on copper alloy vs. stainless steel pens used by nurses in a hospital critical care unit [6] and demonstrated significantly lower bacterial load on copper vs. stainless steel pens. Recently, antimicrobial copper foils have become available as a method of resurfacing existing common touch areas. They provide an easy, cost-effective alternative to refurbishing existing structures. We have previously demonstrated the antimicrobial effect and the practicality of this method in a university dorm setting [7]. For this study, we examine the antimicrobial property of antimicrobial copper foils in an urban mass transit system-the Los Angeles Metropolitan Transportation Authority (LA MTA). It is well known that public surfaces harbor significant loads of bacteria, many of which are pathogens. A bacterial load study [8] on buses in Chittagong City, Bangladesh found MRSA and several species of enteric bacteria, many of which were resistant to multiple antibiotics. A study performed on public transit vehicles and a hospital in London, England looked for Staphylococcus aureus only and found 95% contamination rate [9]. Another in Istanbul, Turkey found staphylococcus and enterococcus species [10]. These articles essentially report that public transit surfaces were contaminated with fecal and dangerous antibiotic-resistant bacteria.

We adhered antimicrobial copper foils to stanchions, grab handles on a Los Angeles Metro bus and rail car, as well as to common touch areas in bathrooms and other public areas in the Los Angeles Metropolitan Transportation Authority headquarter for a pilot project to assess feasibility and antimicrobial property. Anti-Covid property of the copper was also assessed by the EPA and will be reported in a separate article. In the present publication, we focus on the anti-bacterial results of the pilot. This method of resurfacing touch areas offered some advantages to the alternative of refurbishing buses, rail cars and other areas, which would require taking the vehicles out of service for a period of time to disassemble existing stainless steel structures and reassemble with copper alloy parts. The copper alloys are usually not up to EPA registered antimicrobial standards [11], as they need to maintain rigidity. Cost of replacement and amount of copper is also very substantial. With thin foils, they only need to be customized to the shape and size of the surfaces and adhered, with savings in time, effort as well as cost.

Methods

This study was approved by the University of California, Los Angeles and LA MTA. Areas of common touch were selected in collaboration with LA MTA staff. The copper foils were provided by Clean Copper, LLC. Adjacent stanchions and grab handles on vehicles were covered with antimicrobial copper in an alternating fashion to allow for swab comparison. Similarly, adjacent areas in LA MTA headquarter bathrooms and call center break area for dispatch operators were alternately covered for comparison. Photographs of the copper-covered areas are shown in Figures 1-3. After installation, the copper and regular surfaces were maintained in the same fashion per routine. LA MTA maintenance crew disinfected vehicles and headquarter per normal protocol with disinfectant spray and wipe at a regular interval. The transit vehicles and headquarter spaces were then used in their normal capacity by transit riders and office workers, albeit during somewhat reduced traffic during the pandemic. No announcement was made to the transit riders of the special coverings. Three months after installation, swabbing of the copper and control surfaces were performed. The bus and rail car were accessed in the maintenance yards. The headquarter was accessed during regular business hours on a weekday. Six each of copper-covered and non-covered areas in LA MTA headquarter men's and women's bathrooms and 3 each of copper-covered and non-covered areas of the call center were swabbed for bacteria. Seven each of copper-covered and non-covered grab handles and stanchions on a bus and 6 each of copper-covered and non-covered areas on a rail car were swabbed. The distal 2 centimeters of the swabs were cut in a touch-less fashion and placed in 2ml of neutralizing solution (D/E neutralizing broth; BD, Franklin Lakes, NJ) and vortexed for 60 seconds. Then 500ul of this solution was inoculated onto the surface of a blood agar plate and incubated aerobically at 37 ^{o}C for 24 hours. All microorganisms were enumerated and identified using standard microbiological techniques.

Figure 1: Antimicrobial copper on LA MTA bathroom handicap grab rail and trash receptacle door.

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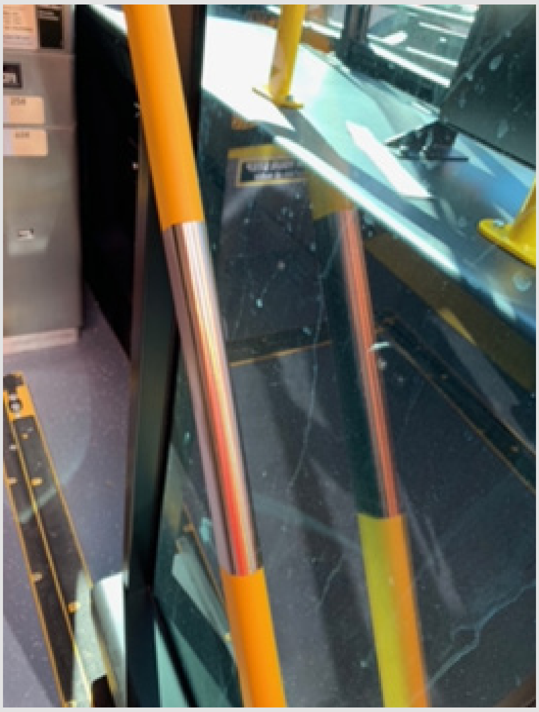

Figure 2: Antimicrobial copper on LA MTA bus entrance grab railing.

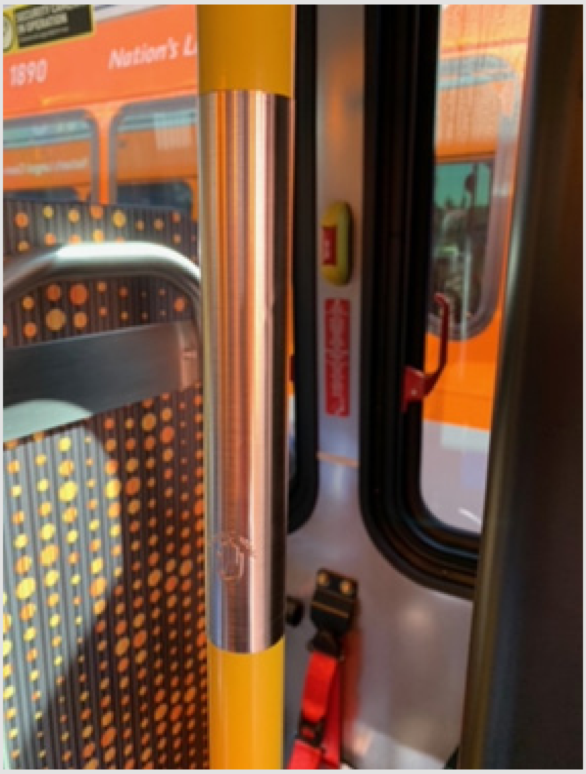

Figure 3: Antimicrobial copper on LA MTA bus stanchion.

Results

Table 1: Group A (LA MTA headquarter bathrooms and call center) copper-covered areas swab results.

Copper Locations	Colony Count	Organisms	No Growth
Women's room toilet flush handle			NG
Women's room toilet stall door			NG
Women's room handicap rail	1	SCN	
Men's room toilet flush handle			NG
Men's room toilet stall door			NG
Men's room handicap rail			NG
Cabinet door handle			NG
Cabinet door handle			NG
Refrigerator door handle			NG

The number of surfaces contaminated with microorganisms and the number of CFU recovered are presented in Tables 1 through 4. The data was divided into two groups. Group A contains the LA MTA headquarter areas, which were 1 men's bathroom, 1 women's bathroom, and the call center break area for dispatch operators. Group B included 1 Metro bus and 1 rail car. Table 1 shows results of Group A copper covered surfaces. Table 2 shows results of Group A non-covered surfaces. Table 3 shows results of Group B copper-covered areas, and Table 4 shows results of Group B non-covered areas. Statistical comparison was made between Tables 1 & 2, and between Tables 3 & 4. In Group A (LA MTA headquarter), the contamination rate on non-copper surfaces (9 of 9 samples = 100%) was statistically higher than copper surfaces (1 of 9 = 11.1%), with a p value of 0.0004 by Fisher's Exact Test. The bacterial load on non-copper surfaces (average 5.1 CFU per surface) was also statistically higher than copper surfaces (average 0.1 CFU per surface) by Kruskal-Wallis test (p = 0.0002). In Group B (LA MTA bus and rail car), the contamination rate on non-copper surfaces (10 of 13 samples = 77.0%) was statistically higher than copper surfaces (1 of 13 samples = 7.7%), with a p value of 0.001 by Fisher's Exact Test. And the bacterial load on non-copper surfaces (average 2.5 CFU per surface) was also statistically higher than copper surfaces (average 0.1 CFU per surface) by Kruskal-Wallis test (p = 0.0004). This is depicted in Tables 5 & 6. The bacteria cultured were staphylococci coagulase negative, diptheroid, and non-cereus or anthracis bacillus species. No antibiotic sensitivity testing was performed since these were commensal organisms. During the month of installation there were no complaints from the riders or staff regarding the copper. The aesthetic appearance was well maintained with the infrequent

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maintenance wipe. Rider and staff activities were not disrupted in any perceivable way.

Table 2: Group A (LA MTA headquarter bathrooms and call center) non-copper-covered areas swab results.

Copper Locations	Colony Count	Organisms	No Growth
Women's room toilet flush handle	2	2 different types of SCN	
Women's room toilet stall door	5	SCN, 2 different types of Bacillus (not cereus of anthracis	
Women's room handicap rail	15	3 different types of SCN	
Men's room toilet flush handle	6	2 different types of Bacillus (not cereus of anthracis)	
Men's room toilet stall door	7	SCN	
Men's room handicap rail	2	SCN	
Cabinet door handle	5	Diptheroids	
Cabinet door handle	1	SCN	
Refrigerator door handle	3	2 different types of SCN	

Table 3: Group B (LA MTA bus and rail car) copper-covered areas swab results.

Copper Locations	Colony Count	Organisms	No Growth
Bus stanchion			NG
Bus stanchion			NG
Bus stanchion	1	SCN	
Bus door handle			NG
Bus door handle			NG
Bus grab bar			NG
Bus grab bar			NG
Rail car stanchion			NG
Rail car stanchion			NG
Rail car stanchion			NG
Rail car stanchion			NG
Rail car stanchion			NG
Rail car stanchion			NG

Table 4: Group B (LA MTA bus and rail car) non-copper-covered areas swab results.

Copper Locations	Colony Count	Organisms	No Growth
Bus stanchion	5	2 different type of SCN	
Bus stanchion	3	SCN	
Bus stanchion	1	SCN	
Bus door handle	7	SCN, diphtheroids	
Bus door handle	6	SCN, 2 different types of Bacillus	
Bus grab bar			NG
Bus grab bar	1	SCN	
Rail car stanchion			NG
Rail car stanchion	2	2 different types of SCN	
Rail car stanchion	1	Bacillus (not cereus of anthracis)	
Rail car stanchion	3	Diptheroids	
Rail car stanchion			NG
Rail car stanchion	4	Diptheroids	

Table 5: Group A contamination rate and bacterial load comparisons.

	Copper Surfaces	Non-Copper Surfaces	P-Value
Contamination rate	11.1%	100%	0.0004
Avg bacterial load	0.1 CFU	5.1 CFU	0.0002

Table 6: Group B contamination rate and bacterial load comparisons.

	Copper Surfaces	Non-Copper Surfaces	P-Value
Contamination rate	0.8%	77%	0.001
Avg bacterial load	0.1 CFU	2.5 CFU	0.0004

Discussion

This is the first known study of antimicrobial copper use in a major metropolitan transportation center. It demonstrated a contamination rate 9 times higher on non-copper vs. copper surfaces in the bathrooms and call center break area of the transit office building, and 10 times higher on non-copper surfaces vs. copper surfaces on grab handles and stanchions in a bus and a rail car. The bacterial load cultured was 51 times higher on non-copper vs. copper surfaces in the bathrooms and call center break area of the transit office building, and 25 times higher on non-copper surfaces vs. copper surfaces on grab handles and stanchions in a bus and a rail car. This clearly demonstrates the antimicrobial activity of the copper vs. stainless steel and plastic surfaces, as corroborated by many other studies [7,12-15]. The copper surface is well adhered and appeared part of the structures in place, however the copper color does differ from the surrounding stainless steel. Neither the cleaning crew nor the riders were informed of the purpose or presence of the copper to minimize bias in use or cleaning of the surfaces. It is possible that riders still avoided touching something unfamiliar, or the cleaning crew paid more attention to the new surfaces. The areas chosen though were ergonomically chosen, e.g. waist to shoulder height location on a stanchion, or common grab areas to encourage regular usage.

It also demonstrated the practicality of using copper foil as an antimicrobial surfacing method. Instead of replacing whole parts in large facilities, which is costly and time-consuming, desired areas of treatment can simply have the antimicrobial copper foil adhered with shortened disruption to work flow. This reduces the amount and consequently the cost of the copper used, and it has the added advantage of being able to use higher concentration of copper (more antimicrobial) due to its material flexibility. The foils withstood 3 months of regular use by the transit-riding public as well as by workers in the headquarter office building. It is reportedly durable for several years at other commercially installed areas. The antimicrobial property of copper has been known for a long time. The first record of it dates back to 1600 BCE in an ancient Egyptian medical text named the Smith Papyrus, in which copper were described as being used to sterilize wounds and drinking water [16]. Modern scientific literature is full of articles on antimicrobial property of copper. With the recent pandemic, interest in its use is increasing. However, copper is still not widely used for this purpose today, most likely due to the expense and impracticality of retrofitting high number of existing fixtures in our environments. There have been innovations into using copper as a spray-on product during manufacturing process, however this still requires retro-fitting existing fixtures. This study suggests antimicrobial copper foil is an attractive and effective alternative.

Even though the bacteria identified in this particular study were all commensal organisms, these can sometimes cause infections as well. This study only sampled small areas in a building, one bus and one rail car. If the entire system was sampled, more harmful pathogens would undoubtedly be found. Studies have shown that dangerous bacteria such as MRSA is found in 30-37% of hospital population and 1.3% of community population [17]. These bacteria are left on touched surfaces, survive for weeks to months [18], then are picked up by other people. Having copper surfaces helps to reduce contamination rate as well as bacterial load. A prospective, randomized study [15] has already demonstrated that just having 6 items of copper in an ICU room can reduce the rate of hospital acquired infection (HAI) by 58%. Even though a urban mass transit setting may not harbor as much dangerous pathogens as a hospital, if copper can be employed in a cost-effective manner, comparable to cost of cleaning regular surfaces, it is worthwhile to provide as hygienic an environment as possible. In conclusion, the present study demonstrated effectiveness and practicality of a method of employing antimicrobial copper in reducing bacterial contamination and load on commonly touched surfaces in a major urban mass transit system.

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