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COVID-19 AND THE EMERGENCE OF INDUSTRIAL GRADE TRAVEL-RELATED SANITIZATION APPLICATIONS USING ULTRAVIOLET LIGHT:THE CASE OF STERIBIN LLC

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ABSTRACT

Knowledge regarding the power of ultraviolet light to kill various bacteria and viruses has existed for some time. Even prior to the onslaught of the Covid-19 virus, scientists were busy studying various types of UV light and how it might be applied to a wide variety of sanitization applications. Initially driven by the desire to effectively apply UV light to quickly sanitize airport security bins, Steribin was founded prior to the emergence of the Covid pandemic. It has since expanded into a number of sanitization applications, utilizing all of forms of UV technology, with a primary focus on sanitization needs in travel-related applications.

1. INTRODUCTION

Michael Christensen, Chief Operations & Maintenance Officer for LAWA (Los Angeles World Airports) recently stated (May, 2023), "It's clear to see the significant impact the COVID-19 pandemic had on our traffic (along with revenue, employment, and schedules). We still haven't completely recovered, with our traffic projections this summer being around 87% of 2019 levels. It's important to note that this pandemic wasn't the first one we've experienced at LAX, and we don't believe it will be the last. As evidence of this outlook, LAX has obtained and is maintaining the two available industry-accepted health accreditations, ACI (Airport Council International) and GBAC (Global Biorisk Advisory Council), to be sure we maintain industry best practices for cleaning and sanitizing our passenger terminals." LAWA/LAX has more origin & destination (O&D) passengers than any other airport in the USA, and it is clear they believe that cleanliness of their facilities, and the health safety of their passengers, are major concerns; before, during, and after the Covid-19 pandemic.

The health safety of travelers was emphasized by the Covid-19 pandemic, but dangers have always, and will always, exist. The purpose of this article is to specifically address the emergence of UV (ultraviolet) light technologies in the sanitization of highly contaminated surfaces that virtually all travelers come into contact with.

This paper presents a case analysis of Steribin, LLC, a startup company first-to-market in designing, testing, and offering UV lights for the sanitization of airport security bins, and other applications. The purpose of this case analysis is to evaluate the viability of the commercial use of UV lights to improve the safety and health of people using highly congested public spaces (e.g., airports, hotels, hospitals, malls, etc.) and coming in frequent contact with surfaces and objects that are likely to be contaminated with viruses and bacteria. This paper discusses the evolution of Steribin (Section 5), its business model, and the reaction of people and organizations to the use of UV lights used to sanitize highly contaminated surfaces. Strengths and weaknesses are explored, and recommendations given for future applications and improvements.

Finally, recommendations for future improvements are offered based on the findings of the case analysis. These recommendations focus not only on Steribin itself, but also on the travel industry and its acceptance and use of UV technologies to protect the public from exposure to unhealthy viruses and bacteria transmitted through contact with contaminated surfaces.

Overall, this case analysis provides valuable insights into the Steribin's business model and strategies, as well as the entire UV sanitization market, particularly as it relates to travel. The findings and recommendations presented in this paper can be used to guide future decision-making and help further protect the traveling public and

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those employed in businesses with frequent and close contact with contaminated surfaces.

In 2018, researchers from the University of Nottingham were working with Finland's Department of Health and Safety when they discovered airport security bins used by passengers were 18 times filthier than airport toilets when swabbed for "influenza A and B viruses, respiratory syncytial virus, adenovirus, rhinovirus and coronaviruses" (Ikohen et al., 2018, para 2). Seeing a very real issue at hand, inventors Wayne Provost and William Christensen of Utah Tech University in Utah began looking for a solution that would thoroughly disinfect security bins while not affecting airport security's effectiveness or increasing the time passengers would need to wait in line. Christensen and Provost began researching Pulsed Ultraviolet (PUV) light disinfection to determine which method would be the most efficient and effective for airport security bins. [1]

Today, with the challenges of COVID-19, this technology is even more valuable considering its potential to reduce the spread of bacteria and viruses while allowing people to resume travel safely under pandemic conditions. "Safety" in the current situation can be seen in both physical and psychological aspects. Especially when it comes to things so small that we cannot see them (e.g., bacteria and viruses), perception is critical. In this regard, perception of cleanliness is, for many, even more important than actual cleanliness. Even before COVID-19, a third of airport travelers took "active measures during air travel to prevent themselves from becoming sick" (Park & Almanza, 2020). Because of COVID-19, not only are passengers looking to see (not just be told) things are being disinfected, they're also looking to turn to other methods of travel due to concerns about the safety of air travel (Stimac et al. 2020). Strategically, the inventors believed that installing the machine at the front of airport security lines would be most effective in convincing travelers their luggage bins were sanitized and make them feel more secure in their decision to travel by air. Several designs were created, all to provide a disinfection rate greater than 99.999%, while being compatible with current security lines and allowing passengers to be the first people to touch the sanitized bin.

We suggest that Steribin's disinfecting technology and attention to travelers' perception of safety result in a device that is not only scientifically effective but also psychologically beneficial for users. If implemented on a mass scale, Steribin, or a similar technology, has the potential to ease travel anxiety during pandemic times and beyond.

2. METHODOLOGY

To conduct this case analysis, the authors conducted a comprehensive review of the historical application of UV technology. This includes the evolution of UV technology, and the introduction of UV sanitization of highly contaminated surfaces frequently contacted by travelers and the public (e.g., airport security bins). The emergence of various UV market opportunities and the development of Steribin is also discussed. Data was collected from various sources including previous research, news reports, press releases, industry publications, and interviews with key stakeholders.

3. HISTORY AND BACKGROUND

3.1 History of UV Light for Disinfection

UV-C light has a long history of being an effective disinfectant in multiple settings. As Reed (2010) points out, by 1845, scientists knew microorganisms responded to light and in 1877, Downes and Blunt discovered "the ability of sunlight to prevent microbial growth" with "test tubes remain[ing] bacteria-free for several months." They also discovered sunlight's ability to "neutralize bacteria was dependent on intensity, duration and wavelength" (16). This is one of the reasons Provost and Christensen turned to this technology. Having a well-documented record of effectiveness for the disinfecting component of their device was of paramount importance to the inventors. Since Downes and Blunt's discovery in the late-1800s, UV-C disinfection has been readily accepted and utilized in water treatment, hospitals, and now airport security bins.

3.2. UV-C Light as a Disinfectant in Water Treatment

UV-C light as a disinfectant in water treatment plants is relatively new. Qualls et al. (1989) released their ground-breaking study on UV-light disinfection water treatment, finding that both exposure time and intensity determined the survival rates of organisms with either DNA or RNA-based genetic material. This study, and others released around the same time, contributed to the rise in UV light disinfection

For example, Kruithof et al., (1992) released their findings on nine locations from around the Netherlands with UV disinfection installations, saying the systems were utilized for "(a) the destruction of E. coli and Aeromonas bacteria or a decrease in colony counts in groundwater; (b) a decrease in colony counts in bank-filtered water following GAC filtration; and (c) the replacement of post-chlorination in extensively pre-treated surface water" (88). While UV disinfection systems for drinking water had been utilized since 1955 around Europe, the 1980s saw a steep rise in both the literature being produced in the scientific community and the use of UV disinfection in water treatment plants. This was seen in the rapid increase in the number of UV plants in countries like Switzerland, Austria, and Norway—with the latter building 400 plants between 1975-1985 (Kruithof, Leer and Hinjen, 1992: 89).

The United States has been relatively slow in accepting UV-C water disinfection systems. While Europe hosts over 2,000 systems (Oram, 2020, para. 2), the number of systems in the United States is not even published. One must wonder why the system has seemingly been rejected in the United States. There are a few theories for the US' reluctance to accept the system, with Oram (2020) pointing out, "it was used for drinking water disinfection and treatment in the early 1900s but was abandoned due to high operating costs, unreliable equipment, and the expanding popularity of disinfection by chlorination" (para. 1). However, given the increasing use in other countries, it is assumed that US officials will eventually begin to accept UV-C light disinfection plants as a viable method for cleaning water.

One example of this is Walwick, New Jersey's Northwest Bergen County Utility Authority Wastewater Treatment Plan changing from a chlorination system to a UV-C light system in 1989 due to concerns for public safety and "recent findings and concerns over the environmental impact of chemical releases and spills" relating to chlorine leaking into the environment (EPA, 1999, 4). UV-C light systems have no known environmental or public risks due to the system

requiring no chemicals and being in a fully contained environment and are more reliable in their disinfection than chlorination techniques. As long as UV sensors and the source are properly set up UV-C light can kill a host of viruses and bacteria in a matter of seconds. including Hepatitis B, Rotavirus SA 11, Influenza, Salmonella, Streptococcus, and Tuberculosis (Oram, 2020, Table 1). In addition to its security bin sanitization system, Steribin is also developing systems for water treatment, using PUV, which is proving to be the most effective and fastest method of UV light disinfection. PUV lights strike each security bin with three seconds of pulsed lighting, offering more than enough time to kill the most common pathogens found on bins. The difference between PUV and constant UV can be easily explained using the metaphor of a hammer and nail. Constant, or regular UV light is analogous to trying to place the head of a hammer on a nail and pushing the nail in. That requires a lot of time and force. On the other hand, PUV is like striking the nail with the hammer numerous times, and we know how much more effective that is.

UV-C water disinfection system technology is constantly advancing as well. Bohrerova et al. (2008) discovered that pulsed UV-C lighting is more effective than continuous lighting, especially regarding deactivating e-coli (2980). Researchers believe this may be due to bacteria weakening more with each hit versus exposure to a continuous stream of light.

3.3. UV-C Disinfection Systems in Hospitals

Hospitals have begun to utilize pulsed UV-C light systems for disinfection over the past decade. Just like in water treatment plants, pulsed UV-C lighting has been found to have greater success than continuous light streams. Nerandzic et al. (2015) discovered that pulsed UV-C

lighting "resulted in statistically significant reductions in the percentages of sites positive for MRSA, C. difficile, and VRE with the exception of glass surfaces, which benefit more from continuous light streams" (194). These results match those found by Bohrerova et al. (2008) on pulsed lighting's effectiveness in water treatment plants. Furthermore, Villacis (2019) found pulsed lighting to be more effective than manual disinfection after examining 17 rooms in an Ecuadorian hospital. Using PUV-C light allows hospitals to sterilize rooms in a matter of minutes without the risk of contamination that is seen in rooms cleaned by staff.

Re-contamination post disinfection is a real problem faced by hospitals today. Casini et al. (2020) tested 345 sample sites around a teaching hospital. Only 18% of samples that had been treated with UV-C light tested positive for bacteria compared to 63% of samples that had been cleaned following standard operating protocol (SOP); furthermore, only 11% of samples following SOP met the hygienic standards put forth by the Italian Works Compensation Authority. While UV light cannot physically clean or remove material, therefore meaning it will never fully replace those who complete manual cleaning, its use as a tool—especially after cleaning staff have left the room—is routinely shown to be the most effective method to ensure sanitization and disinfection of high-traffic and high-touch areas in medical settings.

4. COVID-19 AND AIRPORT SECURITY BINS

In 2020, the COVID-19 pandemic forced scientists to examine the disinfectant qualities of UV-C light against the virus. At the time of writing, only one study has been conducted on UV-C light concerning airport security bin disinfection and SARS-CoV-2 (COVID-19). Cadnum (2020), points out how airport security bins are the perfect surface for UV-C decontamination due to it being a "hard, smooth surface that can be placed close to UV-C bulbs" (para. 2) and found that with 30 seconds of exposure (albeit not in an enclosed area), 99.9% of bacteria were killed, including MRSA (para. 10). However, Cadnum (2020) also acknowledges that a sterilization machine would need to be contained to protect passengers from UV-C exposure in addition to automated movements so foot traffic in security lines would not be held up.

A challenge of sanitizing airport security bins with UV light is that to maintain passenger flow, disinfection must occur within 3-6 seconds. With the effectiveness and speed of pulsed UV lights, they provide the best solution to this challenge. Nevertheless, clusters of mercury UV lights and dense bundles of LED UV lights can also provide log1 (99.9%) kill rates. Although perhaps acceptable in some applications, this does not compare to the log6 (99.9999%) kill rates possible with pulsed UV lights within only a few seconds. When one considers the billions of bacteria and viruses that may reside on a security bin, even a 99.9% kill may leave millions of live contaminants on the bin. Although able to utilize any of the UV lights sources (e.g., pulsed, mercury, and LED), Steribin's development has focused on the use of high-intensity pulsed UV lighting because of its superior effectiveness in killing bacteria and viruses. Steribin researchers are planning additional tests to support the effectiveness of pulsed UV light disinfection with short time exposures.

On March 16, 2021, the Transportation Security Administration (TSA) announced they were testing UV-C disinfection technology for airport security bins with two checkpoints at Ronald Reagan Washington National Airport (DCA) to provide a safer environment for travelers. TSA Federal Security Director Scott T. Johnson stated, "We are excited to test technologies that might prove effective in disinfecting checkpoint bins and eventually provide another layer of protection against viral and bacterial spread" (para. 2). The technology used at DCA was a competing brand; however, Steribin was used at LAX in November 2020 and is currently working with a number of domestic and international airports regarding use of its equipment in security lines.

4.1. Customer Psychology Related to Perceptions of Contamination and Disinfection

Before COVID-19, disinfection tended to happen behind closed doors, minus the occasional table wipe down in restaurants. Today, proper disinfection happens right in front of people's eyes, and customers believe it's imperative they see the disinfection process. In fact, when researchers surveyed grocery store customers' thoughts on disinfection, they rated it both positive and significant during their shopping experience (Rukuni and Maziriri, 2020). This isn't limited to grocery stores either. When Ecolab (2021) found 95% of customers wanted "to see as much or more cleaning and sanitation practices at the places they eat, stay and shop." Understanding that for most people "perception is reality," Christensen and Provost created a system that allows travelers to see the airport security bin being disinfected, and have no one touch the bin after disinfection before they utilize it.

5. DEVELOPMENT OF STERIBIN

Although UV light is not a new technology, the application of UV light technologies in travel-related applications was virtually unheard of until recently. In 2018, seeing that a disinfection system was needed for airport security bins, the founders of Steribin looked to create a system that could disinfect security bins quickly and efficiently without needing a large amount of space, in addition to being fully contained. Their first prototype machine was cloaked in stainless steel, featured 360-degree UV-C disinfection

lighting, and housed a carbon ozone filter to capture any emissions produced by the UV-C. Bins were fed manually into the machine. See Figure 1.

Figure 1. Steribin Prototype. Copyright: Steribin

To combat concerns about a disinfection system holding up foot traffic in security areas, Steribin's machines are designed to take up very little space so that they can be placed at the front of a security line and require very little change to a security line layout. Being able to thoroughly sanitize a bin in about 5 seconds allows a throughput of over 720 passengers per hour, which is more than sufficient to allow normal flow rates. This meets or exceeds TSA's (2021) objective that, "the equipment will have no impact on passenger screening times or the efficiency of the checkpoint screening process" (para. 5).

In addition to time and space constraints, Steribin faced challenges related to the cost of UV lighting. Although significantly more effective than other forms of UV lighting, PUV is also more expensive. However, having established a collaborative working relationship with a U.S. pulsed light manufacturer, Steribin was able to lower the cost and use more suitable light designs that will make this superior lighting technology competitive with other less-efficient UV light technologies.[2] Nevertheless, Steribin has also recognized the need to supply systems at various price levels and in accordance with various customer specifications, so their designs can also easily accommodate other UV light types (e.g., LED and mercury).

Steribin continues to refine its designs for airport security bin sanitization and is working with partners around the world to bring this technology to airports and air travelers everywhere. Their latest design incorporates a proprietary auto-feed system in which a stack of bins is placed on the machine, and the machine auto-feeds the bins through the UV light chamber, one bin at a time, with a cycle time of about 6 seconds. See Figure 2.

Figure 2. Steribin updated design. Copyright Steribin

5.1. Steribin beyond Airport Security

In addition to equipment for use in the sanitization of airport security bins, a number of other travel-related UV applications have been developed by Steribin, and a host of other developers. These applications include things such as whole-room low-level UV lighting (e.g., used in some restroom applications); UV scrubbing of escalator hand rails; UV cleaning of touch screens used by passengers; Robotic UV sanitization of aircraft interiors between flights; and kiosks available to passengers for self-use UV cleaning of cell phones, tablets, and other small personal items (note: Steribin has such a kiosk device on test at a local airport).

6. CONCLUSION

According to The Brookings Institution, a leading non-profit public policy organization in the US, "The COVID crisis has led to a collapse in international travel." Relying on data from the World Tourism Organization, Brookings reports that "international tourist arrivals declined globally by 73 percent in 2020, with 1 billion fewer travelers compared to 2019, putting in jeopardy between 100 and 120 million direct tourism jobs." The impact on tourist-dependent economies is hard to overestimate as the pandemic brought about the collapse of export and import industries in many places and jeopardized transportation services in general (Milesi-Ferretti 2021).

Traveler perceptions and fear of health risks related to bacteria and viruses have profound implications for travel providers. Travel providers would be well advised to understand both the realities of contamination and sanitization, as well as traveler perceptions, and to whatever degree possible, address both through the effective use of sanitization methods, including UV, to create and maintain a clear perception of that reality. Along with value-adding amenities and services, successful travel providers will need to provide additional value by creating real perceptions of cleanliness and health safety in order to effectively compete in a post-Covid-19 travel environment.

The world will not quickly recover from the global Covid-19 pandemic, so concerns related to cleanliness will likely linger long after this pandemic is gone. In retrospect, the cleanliness of contaminated surfaces encountered regularly in public spaces should have been something addressed long ago. Steribin provides an easy to implement solution for air travelers that uses scientifically proven technology to sanitize airport security bins. The advantage of Steribin technology is in the use of UV light, a disinfecting mechanism known for decades for its efficiency and ease of use. Although UV light technologies have existed for some time, the more recent innovations lie in using UV light in travel-related applications. More specifically, Covid-19 has highlighted the need to respond to travelers' desires to witness the sanitization process rather than simply being assured that it took place. Ultimately, Steribin is one example of a startup company that is working to apply UV and PUV light technology to some of the most prevalent situations in which we encounter highly contaminated surfaces, helping to bring "peace of mind at the speed of light" ©.

Yet, despite the proven effectiveness of UV technology and Steribin's equipment, airports, especially in the U.S., have been extremely slow to address the need to sanitize common surfaces (e.g., security bins). Reasons for this include the lack of funding, a seemingly disinterested bureaucracy, pandemic burnout, and the politicization of Covid-19. Steribin saw the need to improve traveler health safety well before the Covid-19 pandemic. Although it seems reasonable to assume that the Covid-19 pandemic would have accelerated the widespread adoption of sanitization technologies, such as UV, in fact, the opposite seems to have occurred. That is, for all the reasons stated above, the recent pandemic seems to have dulled concerns regarding traveler health and safety, and slowed the adoption of UV sanitization technologies to protect the traveling public. Although this is not universally true, the United States seems to have become the largest and most powerful denier of the hazards of harmful viruses and bacteria, and the slowest to adopt helpful change, including UV sanitization technologies.

Failure of governments and the travel industry to use whatever tools (e.g., Steribin UV devices) become available to increase the perception and reality of safer travel, surely increases economic policy uncertainty (EPU) indices. Such increases have been shown to have a negative impact on international tourism, thus exacerbating a quick return to pre-pandemic travel levels (Işık et al. 2020).

As economies, supply chains, and travel industry recover from the ill-effects of the pandemic, it will be necessary to implement higher standards of cleanliness, including sanitization of contaminated surfaces, and for governments to support industry efforts and set standards and guidelines to improve the safety and health of the traveling public and those working in the travel industry. The need for better sanitization and traveler health safety is great and urgent. However, just like the need to prepare for any natural disaster is great and urgent, it is, unfortunately, too often ignored until it is too late. Hopefully, governments and the travel industry will not forget the lessons of Covid-19 and will continue to prepare and improve the reality and the perception of traveler health safety, including greater use of proven UV light technologies.

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[1] UV light is a form of electromagnetic radiation. The sun emits three different types of UV light: UV-A, UV-B, and UV-C; however, only UV-A and UV-B waves reach the Earth's surface. UV-C light, which must be created artificially via lamps and bulbs, produces the best results for sterilization (Reed, 2010; FDA, 2020). UVC light kills microorganisms, including strains of coronavirus, by both destroying nucleic acids and damaging the RNA or DNA (Buonanno, Welch, Shuryak, & Brenner, 2020).

[2] Xenon UV-C produces high-quality bulbs specifically chosen by Steribin creators due to their longevity and proven track record of disinfection. For example, in 2020, Kitagawa et al. examined the effects of pulsed Xenon bulbs in conjunction with manual cleaning on high-touch surfaces in a hospital in Japan and found that UV-C disinfection decreased instances of MRSA on hard surfaces by a further 72.1% versus manual cleaning alone (141). With further development of systems to utilize these bulbs, it's very likely manual human disinfection will be used much more rarely in the future.

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