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Portable UV-C Light Sterilization Cabinet

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Abstract
The use of Ultraviolet C Tape kills the DNA and RNA molecules on many microbes and prevents the proliferation of microorganisms. Contaminations (contamination of disease-causing substances) on materials that come into contact with more than one patient during the day increase the risk of disease. Inadequately disinfected products, on the other hand, pass from patient to patient, increasing the risk of cross-infection. The main purpose of this study is to minimize the possibility of microbial disease spreading of materials that are used in routine treatments and whose sterilization is neglected. In addition, this portable study is suitable for use in examination rooms.

Keywords: *Ultraviolet C Band, Contamination, DNA, RNA*

1. Introduction
Inadequate disinfection of many materials used by doctors for diagnosis or treatment in daily life increases the risk of infection among patients [3]. For example, if the materials used in the Dental Clinic are not sterilized, Herpes viruses (herpes) remain on the material and cause the virus to spread by being carried to the patient. It can also cause a serious microbial skin disease, depending on the person's immunity. With the UV-C Lamp, it plays with the DNA and RNA of the viruses and microbes on the products, making them largely ineffective. Ultraviolet radiation is divided into three classes. These; It is in the form of UV-A, UV-B and UV-C. The electrical efficiency of the UV-C lamp is quite high [1-2]. UV-C light tests destroy

99% of microorganisms on materials in the cabin. These rates vary according to the size of the material placed in the cabinet and the distance between the lamp and the product.

2. Cabinet Design and Method with SolidWorks
The 3D design of the cabin, of which the technical drawing was carried out, was carried out in the SolidWorks Program. Figure 1 and Figure 2 contain 3D images. As the material, DIN 14057 Stainless Steel was assigned. The main reason for choosing this material is its resistance to light and high temperature, resistance to corrosion and abrasion.

The sterilization rate decreases according to the frequency of use of the medical equipment used in the hospital environment. This increases the amount of micro-bacteria on the materials. Inadequately sterilized materials also cause cross-infection.

The study consists of three parts. The circuit we created with Arduino consists of the circuit we set up to light the UV-C lamp and the cabinet where we can sterilize the products. Our aim in the study is to perform sterilization as long as the cabinet door is closed. By covering the cabinet part where we place the product with aluminum foil, the incoming light is distributed evenly over the whole area. A time adjustment of 5 minutes was made in the coding. In order to control the progress of the sterilization and to check the correct operability of the code and circuit elements, a short period of 5 minutes was preferred. Time can be changed in the code.

Thus, the time can be adjusted according to the multiplicity of products. When the cabin is first started, the UV-C lamp does not light directly because the light has harmful effects in general. In this way, direct contact with the user is prevented. In the meantime, the circuit also makes itself ready for operation. It is provided to observe the sterilization time in a way that counts down through the LCD Screen. The green LED placed next to the LCD Screen lights up during sterilization so that the cabinet can visually inform the user while sterilizing. If the cabinet

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door is opened before the sterilization is completed, it receives the warning thanks to the motion sensor, and the buzzer starts to beep by giving an audible warning to the user. The red LED placed next to the LCD lights up and provides a visual warning to the user. Thus, the user was warned in two ways. Thanks to the relay, in case of opening the lid before sterilization is completed, the energy to the lamp is cut off. The UV-C Lamp will turn itself off and the LCD will display "UV-C OFF!" displays the text.

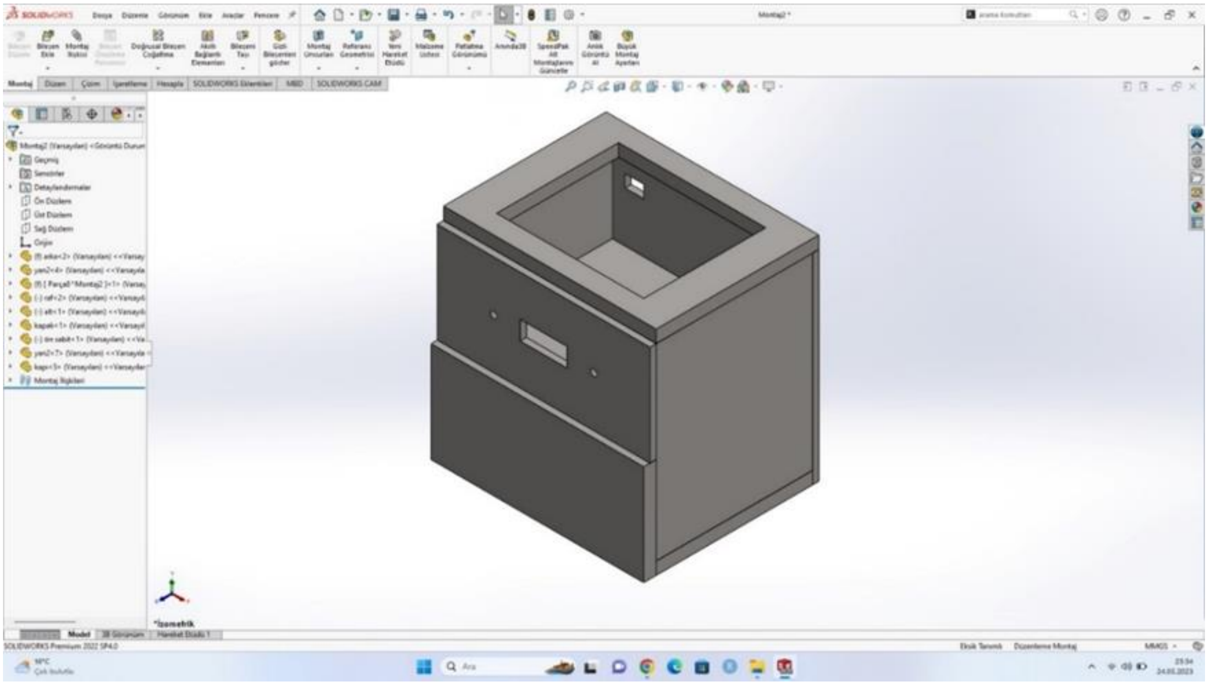

Figure 1. SolidWorks Cabinet

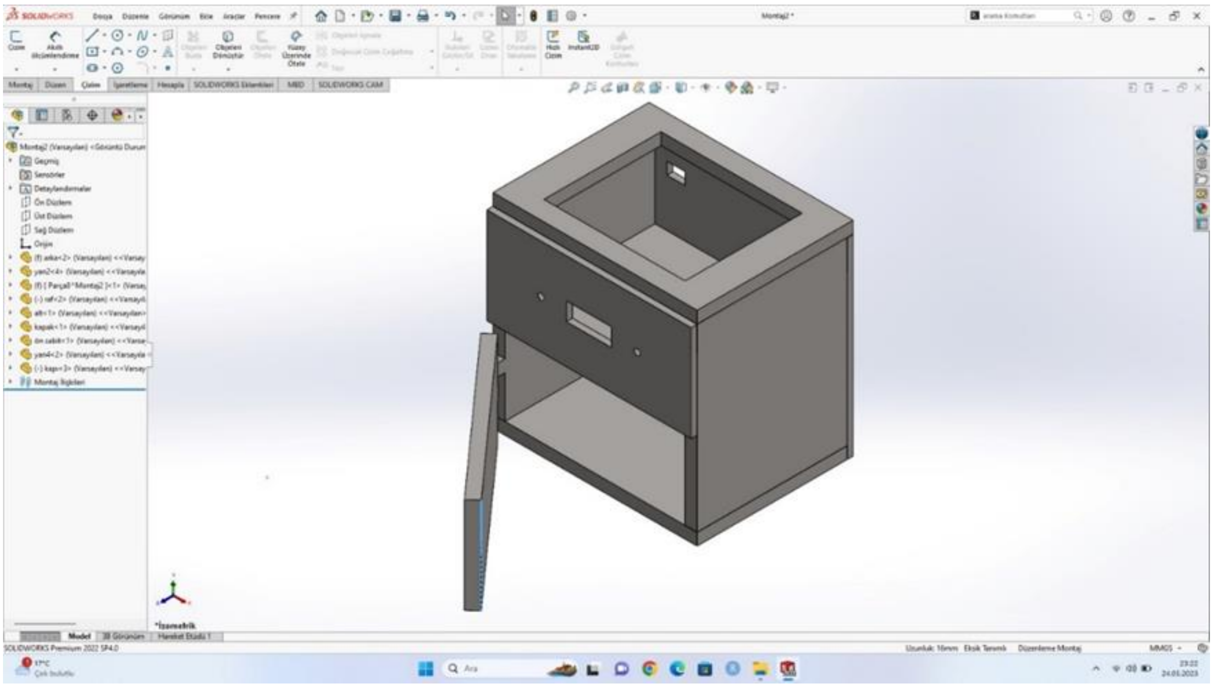

Figure 2. Car Door working principle designed with SolidWorks

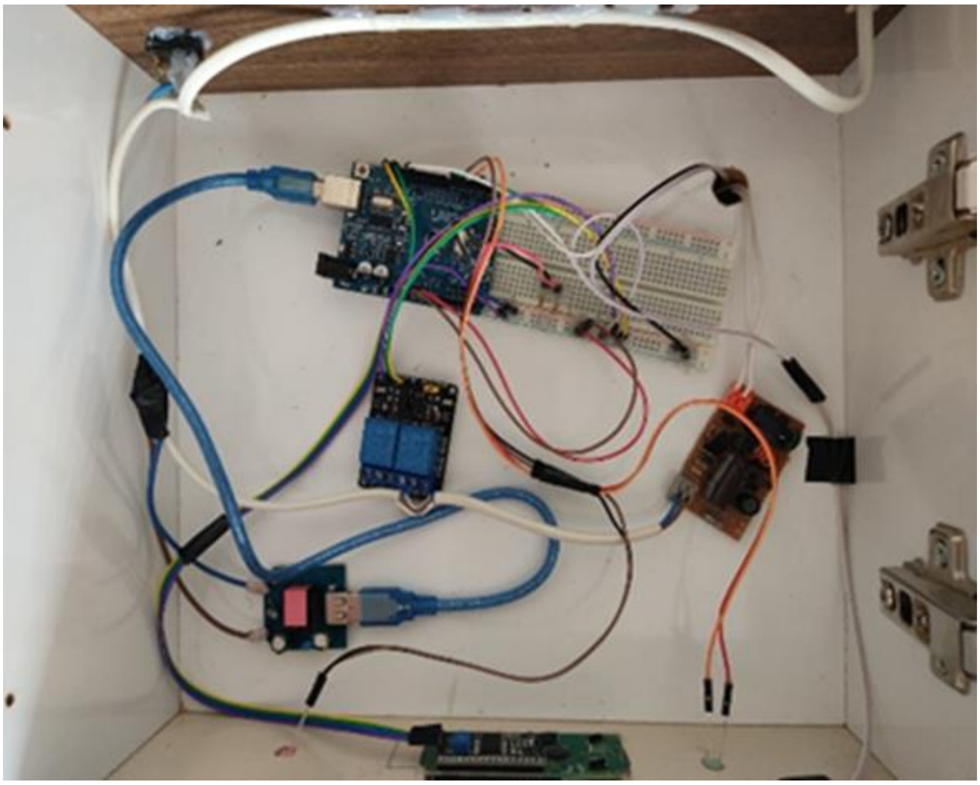

Figure 3. Circuit View

Figure 4. Cabin View

3. Other literature data

In the UVGI decontamination room and D25 UV Light System cabinets, the user should wear precautionary personal protective equipment as sterilization continues if the lid is opened while the lamp is operating. Otherwise, damage to the user may occur. As an advantage, in this study, if the cover is opened, the lamp can turn itself off [4-5]. When i-Robot detects something moving around in the UV-C device, it can automatically turn off the lamps. This device detects motion using a motion sensor, as well as detects motion with the sensor on the cover in our study [6].

There are many alternative methods in the use of UV-C Lamps.
These;
• Handheld
• Robot Type
• Cabin Type
• Embedded System
• Portable UV-C lamp is used for the room.
There are two main types for sterilization. These; They are UV-C Led and UV-C Lamps.
Type preference varies according to the sterilization purpose and the place to be used. For example, UV-C LEDs are preferred in water treatment systems, but they are used less because of their cost [7].

Stibich et al. compare UV-C lamps and pulsed xenon systems for healthcare-associated contamination reduction in hospital rooms [8] Song et al used continuous and pulsed xenon UV to inactivate microbes in ambulances. They concluded that there is no need to use chemicals in the device and that it reduces E. coli, Staphylococcus albus and environmental pathogens by 90% in 30 minutes. UV-C mercury lamps continue to be preferred because of their low cost [9].

In Table 1 below, a table has been created in order to better understand the difference between mercury vapor lamps and led lamps. In the table; types, wavelength, the effect of temperature on its performance, ozone production and environmental friendliness are compared.

Table 1. Comparison of UV-C Led and Lamp [10-11-12]

Variable	Mercury Vapor Lamps	Led Lamps
Species	LP MP HP	-
Dalga Boyu	LP: 254 nm (185nm) MP: 220-580 nm HP: 220-1000 nm	light emission peak 255-275nm uses a value between
Effect of temperature on performance	High	Low
Ozone Production	Possibility	None
Eco-Friendly	No	Yes

LP: Low Pressure, MP: Medium Pressure, HP: High Pressure.

UV-C is automatic disinfection. It is a preferred alternative method for disinfection as it takes less time than the commonly used manual or chemical disinfections, leaves no harmful residues and is environmentally friendly (if mercury vapor lamps are not used). However, it also has limitations, which can be found in Table 2. with the (partial) solutions proposed [14-15] .
In Table 2, a comparison with a similar study is made. Thus, we indicate the original aspects of our work.

Table 2. Limitations/Solutions [16-17]

Limitations	Answers	Our Achieved Solution
Dirt on the object or surface	Pre-cleaning	Pre-cleaning
Shading	Reflective room, ozone generation	Aluminum Coating
Material UV-C Degradation	Low UV-C	Low UV-C Dose
Human Health risks		
Eyes/Skin	Protective Equipment	Motion sensor/ Relay cutting off Lamp energy Protective Equipment

It was determined that 104 out of 120 medical devices tested were bacterially contaminated after use on patients. Stethoscope also showed the highest mean virus value with 90%, then nystagmus glasses showed virus value with an average of 64%. 43% of tuning forks and reflex hammers showed the same values on average. 18 of 20 bandage scissors contain 14% virus, the other two culture media were completely grown with bacterial grass and therefore could not be evaluated quantitatively. While both culture media were grown with Pseudomonas aeruginosa and Staphylococcus species, Enterococcus faecium was also found in one of the two culture media. The lowest mean contamination was found in vascular tourniquets with an average of 12% [3]. A detailed assessment of bacterial contamination is shown in the table in Figure 5.

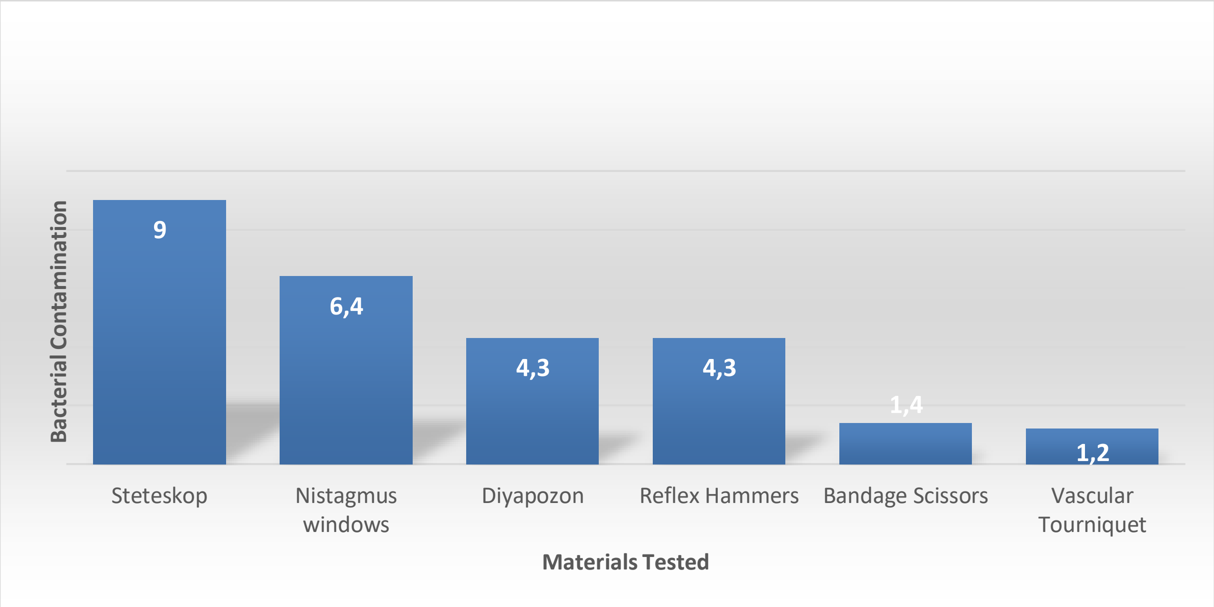

Figure 5. Bacterial contamination

3. Discussion

There are a few articles that indicate that medical devices that do not appear to be critical can cause cross-infection by harboring bacteria due to their potential [4-5-6]. Until now, there is no successful country that can completely control these cross-infections [3]. The main cause of cross infection is thought to be due to insufficient disinfection of materials [18]. According to studies, 12-47% of hospital staff said that they did not sterilize their stethoscopes and only cleaned them once a year [19]. According to the survey conducted among medical students studying at a university abroad, 94% said that they did not sterilize the stethoscopes they used [20].

By performing the sterilization of the products they use with a fast and simple method, the risk of infection among patients can be reduced and more hygienic product use can be realized.

There is information on the use of disinfectant wipes for the sterilization of frequently used materials. This method is known to be sterile at a low rate [21]. Therefore, we conducted a study aiming to reduce the rate of disease by minimizing the risk of cross-infection with the cabinet working with a portable UV-C lamp.

4. Conclusion

Even medical supplies classified as 'Non-Critical' can cause infection after use on the patient. With our study, the amount of contamination will be reduced with the UV-C-based sterilization method. In this study, it has been seen that it works successfully in the tests made by modeling in the digital environment and in the circuits we have created manually. The circuit is installed on the cabinet that we have created as a portable. It has been observed that when we run the circuit, the lamp lights up and if the door in the cabin is opened, it turns off the lamp to protect the user. In case the lamp goes out, it also informs the user that the sterilization process is stopped, via the LCD screen. With the aluminum foil we have covered the inside of the cabinet, the UV-C rays are reflected and evenly distributed to every point in the cabinet. In this way, it is aimed that the light goes to every part of the products placed inside. It is important that an equal amount of light goes out, because while the viruses in the irradiated part will die, the virus will not have decreased in the low or non-vision parts, which indicates that the disinfection has not taken place successfully. An unsuccessful disinfection also leads to the re-transmission of diseases. In our portable study, disinfection was carried out by placing a lamp inside the cabinet so that it does not affect human health due to the dangers of the UV-C lamp. If it is to be used as handheld rather than cabin type, personal protective equipment and glasses must be used, otherwise it may cause serious skin disorders and eye damage. The success of UV-C lamps on bacteria and viruses has been confirmed by many sources. The model tests were carried out successfully. This study will guide similar studies.

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