



PHILIPPINE DERMATOLOGICAL SOCIETY PHOTODERMATOLOGY SUBSPECIALTY CORE GROUP

GUIDELINES ON UV DISINFECTION

INTRODUCTION

With the advent of the COVID-19 Pandemic, Ultraviolet Germicidal Irradiation (UVGI) has received renewed interest after years of underutilization. But with renewed interest comes questions about its usage, safety and efficacy. However, since SARS-CoV-2 is a novel virus, the standards for its use against this virus have not been set. Studies all over the world are being done and hopefully in the coming months, improved efficacy and safety standards will be in place.

Air and surface disinfection using UVGI is currently being utilized and explored since SARS-CoV-2 has been shown to be transmitted via respiratory droplet and contact routes. Shortages of personal protective equipment (PPE) due to the sudden onset of the disease were also experienced at the early stages of the pandemic, leading to questions of use and re-use of PPEs using UVGI as one of the methods of disinfection.

The Photodermatology subspecialty core group of the Philippine Dermatological Society has come up with guidelines intended to provide advice for the selection, proper use and safety precautions of UVC devices in light of the current COVID-19 situation in the country. It is important to note that this document will merely serve as a guide, as there is as of the moment no internationally set standards for UVC lamps used for disinfection prior to being marketed and sold.

PART 1 – PRINCIPLES OF UVC FOR DISINFECTION

Shorter wavelength known as UVC in the spectrum of 200 to 280 nanometers are being used as germicidal UV (GUV). It is known to have peak germicidal effectiveness near 265 nm irradiation. This germicidal wavelength can be reproduced by using low-pressure germicidal lamps producing about 85% of their radiant in 253.7 nm energy which close to the peak of germicidal efficiency of 265 nm. UVGI is the use of germicidal UV in specific locations or areas.¹ UVGI can be used to disinfect air, water, and surfaces, although surface disinfection is limited by microshadows and absorptive protective layers.²

UVC photons photochemically interact with RNA and DNA in virus or bacteria to make them non-infectious.¹ The destructive effect of the UVC is dependent on 2 factors: the intensity of the UV irradiation to which the particle is exposed and the time of exposure.

Differences in the structural and cellular characteristics of the bacteria, viruses, fungal spores and mycobacteria consequently affect its susceptibility to UVC.³

UVGI has been shown to be an effective means of disinfection but it should be noted that UVGI should be used together with other more studied methods of disinfection and decontamination such as appropriate heating, use of HVAC systems and chemical decontamination of surfaces.⁴ It should also be kept in mind that UV in general can degrade polymer-containing materials such as plastic, vinyl, rubber, paints and silk. It can also be harmful to plants and animals.¹

Decontamination of Medical Treatment Facilities

Medical treatment facilities are using GUV in several ways such as:

1. Upper-room GUV fixtures with air mixing - Specially designed and installed UVC fixtures are placed on the upper area of the room. These could be either wall mounted, ceiling suspended, louvered/shielded, to irradiate only the air above 2.1 meters (7 feet), constantly disinfecting the upper air volume to control airborne pathogens in an occupied space.
2. Whole-room UVGI – Fixtures are suspended to direct UVC downward.
3. Mobile GUV units – These units are used to disinfect high-touch surfaces. Mobile GUV units such as UV robots are also being used in other countries to do the disinfection. These units have the advantage of moving around unoccupied rooms to disinfect surfaces in all directions which cannot be reached by fixed lamp installations.
4. GUV in heating, ventilation and air conditioning (HVAC) systems - Air would pass through an HVAC system, and UVGI would irradiate the entire cross section of the duct at high intensities.¹

Decontamination of Surfaces and Medical Apparatus

UVC irradiation for surface disinfection is affected by the fact that UVC cannot penetrate solid objects, soilage, dust and it cannot reach the recesses of shadowed areas hence can affect negatively the disinfection process. It can only disinfect areas that it can reach and the recommended exposures vary from 200 to 1,000 J/m² (20 to 100 mJ/cm²).¹

Disinfection of PPEs especially filtering face respirators (FFRs) using UVC has been studied and it has been found that UV dose range from 0.5–1.8 J/cm² was effective in disinfection with minimal effect on fit. This dose was tested on influenza A (H1N1), Avian influenza A virus (H5N1), low pathogenic Influenza A (H7N9), A/Anhui/1/2013, Influenza A (H7N9), A/Shanghai/1/2013, MERS-CoV, SARS-CoV, H1N1, Influenza A/PR/8/34, MS2 bacteriophage, producing a 99.9% antimicrobial kill.⁵ In another study conducted, 30 minutes irradiation of FFRs placed into a UV sterilizer cabinet with a 254 nm, 8W lamp, and 475 cm² internal area (17 mW/cm²) and let to stand under ambient conditions for 10 minutes per cycle did not damage the respirators within a reasonable number of treatment cycles and may be considered for disinfection, with doses smaller than 1000 J/cm².⁶ Some authors recommended the urgent need to raise awareness that at least 1 J/cm² is used to all surfaces for UVC decontamination methods to ensure that healthcare workers are not endangered.⁷

Very commonly seen now in the market is the availability of compact hand held UVC lamps being promoted for use in disinfecting small object like cellular phones and other small surface. Most of these emit 2-4 mW·cm² of 254-nm UVC disinfection. Optimal conditions of 40 to 65% relative humidity at 21 to 24 C in a short distance of 12.7 cm with direct beam exposure is best for its efficacy.⁸

PART 2 – GUIDANCE ON SELECTION OF UVC GERMICIDAL UNITS

There are a great number of UVC disinfecting devices currently being marketed and sold during this pandemic, but unfortunately there are limited accepted standards and testing if these devices are truly effective and safe. Hence, it is best to exercise due diligence in purchasing your UVC disinfecting units.⁹ Here are some tips on how to select your UVC Germicidal Units.

- Ask sellers to provide copies of scientific papers documenting effectivity of unit in disinfection and evidence of third-party testing (see resources below for examples of third-party testers). Look for user manuals and customer and technical service departments to contact. If these are not provided, you could be making a dubious purchase.^{10,11}
- Check if the device is registered with the US Environmental Protection Agency or other related agencies.
- Check if the device meets NIOSH (National Institute for Occupational Safety and Health), UL (Underwriters Laboratories), IEEE (Institute of Electrical and Electronics Engineers Standards Association) and related safety standards.
- Check if there are built-in UV safety sensors for automatic shut-off. If none and it is for manual operation, make sure that you have adequate PPEs while turning the unit On or Off.
- Avoid ozone generating/emitting devices.
 - Ozone emissions could be a safety hazard and ozone-producing devices are advised to be avoided, unless it is part of the treatment process and operators are fully trained to use and maintain these products safely.
 - If with ozone, is it compliant with NIOSH requirements? How is it mitigated?
- For UVC lamps used to disinfect medical devices, check if it complies with FDA requirements or related standards.¹⁰ See resources below.

For UV Wands used to disinfect surfaces (e.g. countertops, envelopes, papers, etc.)

- Look for technical specifications of device. It should give the UVC radiance at a fixed distance from the front of the device (e.g. 10mW/cm² at 2 cm).¹ It should tell you how close you should hold the device to the surface and how long you should hold it in place for it to be effective at disinfection.¹¹
 - UV dose should be at least **40mJ/cm²** to inactivate viruses from flat surfaces, so irradiance given should correspond with exposure time. (e.g. If the irradiance at the target surface is 10 mW/cm², the exposure time would have to be 4 seconds. Waving it over an object for 1 second will not provide reliable disinfection).^{1,10}

- For non-flat surfaces such as cloths or masks, the dose for inactivation may require as much as 1000-3000 mJ/cm². Studies regarding this are still in evolution.

ADDITIONAL RESOURCES:

- <https://uvsolutionsmag.com/buyersguide/> -- IUVA third party testing suppliers
- US FDA Regulations on Medical Devices --Document 21CFR 880.6600 available at <https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=880.6600>)

PART 3 – ADVERSE EFFECTS AND SAFETY PRECAUTIONS

Adverse Effects of UVC

- UV radiation (UVR), including UVC, is harmful to both skin and eyes with onset of symptoms within 4 to 24 hours. The user may not realize the danger right away as the effects are not immediately apparent.^{9,12}
- The effects on skin maybe acute and chronic. Acute effects appear within a few hours of exposure, typically that of erythema or sunburn like reaction. Long term adverse effects include photo aging and skin cancers.¹²
- UVR could also damage the eye. It is absorbed mostly in the outer layers of the eye – the cornea and conjunctiva causing photokeratitis and photoconjunctivitis. Subsequent overexposure to the UV is unlikely because of the pain involved. However, chronic and or repeated exposures may damage the retina and can lead to an increased risk of certain types of cataracts. ^{9, 12}
- Some UVC devices also produce ozone. Breathing ozone can result to certain health complaints such as chest pain and coughing secondary to irritation and inflammation of the air passages. Hence, people with respiratory problems such as bronchitis, emphysema and asthma may experience exacerbations when exposed to it. ^{9,13,14}
- UV in general can degrade polymer-containing materials such as plastic, vinyl, rubber, paints and silk. It can also be harmful to plants and animals.¹

Safety Precautions

- Like any disinfection system, UVC devices must be used properly to be safe.
- The American Conference of Governmental Industrial Hygienists (ACGIH) has established the threshold limit value (TLV) for germicidal lamp acute exposure at 6 mJ/cm². Exposure at this level for less than 8 hours will still allow detectable molecular damage to be fully repaired within 24 hours. For exposure longer than 8 hours, additional precaution is necessary. The threshold for chronic effects has proven to be impossible to calculate, hence, exposure should be minimized as much as possible.¹⁵
- All personnel who will operate a UVC machine for the purpose of disinfection should be trained in using the equipment safely. The manufacturer's manual of operations should be read and understood completely before trying to use the machine. If in doubt,

contact the manufacturer to clarify issues. Do not deviate from the operations instructions without first checking with the manufacturer if it is safe to do so.¹⁶

- When working with UVC germicidal devices, one should be familiar with the following;
 - Proper use of the UV light-producing equipment
 - Warning signs and labels
 - Proper use of protective equipment
 - Symptoms of UV exposure

Minimizing Exposure Risks

- DO NOT look at the UV light or expose your hands from the UV side AT ANY DISTANCE.
- Establishments having germicidal lamps must strictly control access to the area being irradiated. Consider posting a warning sign such as below;



- Operate only in a room without people, animals and plants.
- The operator should leave the room immediately after the machine has been turned on.
- Consider using a remote control device so that it may be operated by some personnel as far away from the device as much as possible.
- Consider a machine with time delay function, that gives enough time for the operator to leave the room before starting irradiation.
- A timer that will auto shut off the machine after a preset time may also be practical as this can ensure that adequate time for disinfection has been achieved with minimal monitoring on the part of the operator.
- A human sensor device may be an additional safety precaution as this automatically shuts off the machine once movement is detected.
- Make sure the UV lights are turned off before working / entering the irradiated area.
- Allow at least 30 minutes of ventilation after irradiation before entering the treated area to get rid of the smell of ozone.^{17,18}

- Restrict access to those personnel who are directly involved with the operation of the UV source. Do not loiter near the area of irradiation.
- Far UVC lamps may soon be readily available. This may be a safer option since it has reportedly lesser adverse effects.¹⁹

Personal Protective Equipment

- In cases, where the operator will need to work in an area while being irradiated by a UVC lamp. Proper PPEs should be donned. Note that PPEs may need to serve multiple purposes, such as protecting against chemical splashes and UVC in the process of disinfection.
 1. *Goggles / Face shield – goggles with UV protection should be used all the time when operating a UVC device. A face shield would even be better to protect the whole face as sunburn reactions may occur.*
 2. *Gloves - At a minimum, nitrile, latex, or tightly woven fabric gloves are recommended. The transmission of UV light through these materials is low compared to vinyl gloves. Gloves should protect personnel from UV light, as well as from the hazard of the activity being performed.*
 3. *Isolation gown- Operator should wear long sleeves and high neck gown made with tightly woven fabric because burns on wrist and neck may happen.*¹⁶

Maintenance of UVC Lamps

- Once a month, clean bulbs by wiping with a soft cloth followed by dampening with ethanol. Make sure machine is turned off, unplugged and bulbs are cool before cleaning.
- It is recommended that UV lamps be serviced every 6 months and irradiance be measured with a UV meter to ensure that the appropriate intensity of UV light is being emitted for germicidal activity. The amount of germicidal wavelength light emitted from these bulbs decreases with age, and bulb ratings may vary by manufacturer.¹²
- If lamps are broken, ventilate the area where the breakage occurred. Don appropriate PPEs before collecting broken bulbs and other debris without generating dust and mercury vapor. Place collected materials in a sealable container. After handling broken lamps, doff protective clothing and thoroughly wash hands before eating or using toilet facilities. Contact your hazardous waste collector for proper disposal. Never use a vacuum cleaner unless it has been designed specifically for mercury waste collection.¹²

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