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Review Article

Is 'FAR UVC' the Nearest Solution for Pandemic Containment?

Badrinarayan Mishra[1], Nidhi D Sinha[2], Miss Bidushi Mishra[3], Miss Gitisha Mishra[4]

[1]Professor, Community Medicine, Ruxmaniben Deepchand Gardi Medical College, Ujjain, Madhya Pradesh, India.
[2]Associate Professor, Department of Dentistry, Ruxmaniben Deepchand Gardi Medical College, Ujjain, Madhya Pradesh, India.
[3]1st, Year BDS, Peoples College of Dental Sciences and Research Center, Bhopal, Madhya Pradesh, India.
[4]Science Student, Carmel Convent Senior Secondary School, Ujjain, Madhya Pradesh, India.
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Corresponding Author:
Badrinarayan Mishra, Community Medicine, Ruxmaniben Deepchand Gardi Medical College, Ujjain, Madhya Pradesh, India.
E-mail Id:
badrinmishra@gmail.com
Orcid Id:
https://orcid.org/0000-0001-6956-0469
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A B S T R A C T

The devastating COVID-19 pandemic has brought many challenges for the scientific commune. Containment of infection becomes paramount when the agent is novel with little or no management options. The present one is one such and no one is sure how many more will surface in time to come. This emphasizes on exploring broad-based containment options as an important preparedness plan. Ultraviolet (UV) rays known for their germicidal effect are in the voyage as potent disinfectants for long. But their potential health hazards limit their uses to a controlled environment. Of them, Ultraviolet ray C (UVC) is the most potent broad-spectrum germicidal, that can neutralize all forms of Corona viruses with the reported accuracy of 99.9%. Recent researches have supported that a fraction of this Ultraviolet ray C (UVC) (FAR UVC) in the electromagnetic range of 207-222 nanometers demonstrates non-damaging properties for mammalian tissues while retaining the germicidal potency. This article reviews the available evidence and reports their important observations. The knowledge base so generated can guide researchers to test its credibility in diverse situations and come out with lasting solutions for future challenges.

Keywords: UVR, (UVC, FAR UVC, Pandemic Containment, Future Challenges

Background

In the changing world scenario, imagining pre COVID world norms looks a distant reality. Though the most optimistic may argue that the availability of a potent COVID-19 vaccine may provide a lasting solution and put life back on a normal track, the question remains 'is it the end of the problem in time to come'? This deep-rooted fear among scientists and policymakers has forced us to think differently.

The lasting lesion the present devastating COVID-19 pandemic has taught us is to stay prepared for future challenges. The way we presently conduct ourselves on all spheres of life has already opened up the Pandora box for future events of such propensity. This has led all concerned across all sects to go back to the basics of epidemiology: "to find potent preventive tools before a cure is in sight."[1-3]

With changing time, basics of epidemiology has undergone a substantial transformation. Now, to find a lasting solution to future crippling pandemics involves professionals across multiple sectors whose contributions can be path changers.

One such area of interest involves physicist in pandemic preparedness.[4-6]

Introduction

The mystery of the Universe is eternal and its energy reserve is unquestionable. It has everything in abundance that life needs to sustain. The emission of the Sun and other extraterrestrial Electromagnetic (EM) radiations have huge energy reserve that life on the planet earth requires. The exact amount with a safety tag is made available by effective filtrations by the earth's protective topology.[7,8]

We, in this empirical generation, started understanding the immense potentials of sunlight as late as 1800. Its Electromagnetic (EM) spectrum was first recognized beyond the visible bandwidth of light by German-born British astronomer Sir William Herschel who accidentally discovered infrared radiation while searching for its thermogenic properties. A year later in 1801 inspired by Herschel, German physicist Johann Wilhelm Ritter discovered the other end of the visible spectrum, the Ultraviolet (UV) rays.[9]

These UV rays fall between the lower range of the visible spectrum, i.e., violet and upper range of penetration EM spectrum, i.e., X-ray. Known for their short wavelength, 10 nm to 400 nm, and high frequency, i.e., 8×1014 to 3×1016 cycles per second, or Hertz (Hz), the spectrum consists of 3 bandwidth namely Ultraviolet A (UV A), Ultraviolet B (UV B) and Ultraviolet C (UV C). These trios have their own inherent scripts.[10,11]

While the Earth's atmosphere blocks the most harmful high-energy EM radiations which include the damaging x-rays, gamma rays and most of the ultraviolet rays along with the infrared radiation, it allows the important EM visible spectrum and most radio waves to reach its surface thus protecting and promoting life.[7,11]

Sources of UV Rays

UV rays have two sources, natural and manmade.

Natural Sources: Sunlight is the most common natural source for UV rays which has a range of 10 to 400 nm. At exosphere level, the earth receives close to 50% of infrared, 40% visible, and 10% UV rays. After travelling the five layers of our atmosphere what we receive at Earth's surface at the pick hours of the day are, infrared 53%, visible light 44%, and ultraviolet rays at 3%.[6] Out of this 3 %, UVA makes up to 90% to 95%, UVB 10% to 5% and UVC 0% on a normal day. Stratosphere, the second layer from the earth surface contains the ozone layer, the main filler for hazardous UV rays to which is credited for its' UV filtration potential.[12]

The protective ozone layer have little effect on UVA (320-400 nm). Most UVA radiation reaches the earth's surface and plays a significant role in tanning, skin ageing, ocular radiation damage, and suppression of immunity. But the same ozone is a killer for its cousin UVB (280-320 nm). Depletion of stratospheric ozone means more UVB exposure and increased prevalence of its health associates harmful, namely, sunburns, snow blindness, and depressed immunity along with varied skin problems of which the major ones are skin cancer and premature ageing.[13]

Oxygen gas in the upper atmosphere absorbs most of UVC (100-280 nm) and in the process generates ozone. The ozone layer so formed but to In contrast blocks most UVB along with the remaining UVC that escapes absorption by oxygen. Indeed, this virtuous cycle one of the bounties of the mystic nature![9,14]

FAR UV

In contrast to earth science, the astro-scientists use somewhat different nomenclature for UV rays. The corresponding names used by them with a twist in the wavebands that exhibits some overlaps are.

- Near Ultraviolet (NUV) Light (300-400nm)
- Middle Ultraviolet (MUV) Light (200-300nm)
- Far Ultraviolet (FUV) Light (100-200nm)
- Extreme Ultraviolet (EUV) Light (10-100nm)

While NUV, MUV and FUV are of greater concern for our day-to-day activities, EUV that can only travel through the vacuum is of aeronautic interest.[15]

Manmade Sources

Among the manmade sources, we have quite a handful of them. They are no way less hazardous to their natural counterpart.

- Tanning beds/ salons/ booths: They are commonly used as indoor substitutes to outdoor recreational activities. The modern-day ones mostly use UVA and some of them also use UVB to satisfy the hyped concept of tanning and vitamin D synthesis. There are lamps used to emit these radiations and the dose of exposure by these sources is many times in excess to that of the natural ones.
- Phototherapy: Used for treating skin diseases like psoriasis, also use artificial UV rays; either by UVB alone or by UVA with prior administration of skin sensitizer psoralen.
- Black-light lamps: These sources of UVA are used to view fluorescent material, to attract and kill bugs by bug-zapping insect traps, etc.
- Mercury-vapor lamps: Commonly used as light sources in large public areas as streets or gyms, these have actually 2 bulbs: an inner bulb that emits both visible light and UV rays and an outer bulb that filters out the UVRs. In case, the outer filtering bulb breaks, then the risk to UVR becomes univocal thereby exposing the public to its incumbent harm.

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- High-pressure xenon and xenon-mercury arc lamps, plasma torches, and welding arcs: they are used in UV "curing", disinfectants, as sunlight simulators to test solar panels and car headlights.[16,17]

UVC as Germicidal Agents: The search for germicidal agents has a long history that includes gases as fumigants, chemicals as disinfectants, and EM rays as broad-spectrum germicidal. The uses of manmade UVR as broad-spectrum germicidal are being recognized since early 20th century. Among the UVRs, UVC is widely advocated for its shorter waveband with less tissue penetration. Still, the entire range of UVC is not a safe option. Though its high end i.e. 254 nm waveband has proven efficacy as a broad-spectrum disinfectant/germicidal covering important Hospital Acquired Infecting (HAI) agents of the nature of Methicillin-Resistant Staphylococcus Aureus (MRSA), Vancomycin-Resistant Enterococci (VRE), and Clostridium difficile and their spores, Acinetobacter spp etc. Besides this, its quick and efficient germ neutralizing power for influenza viruses, SARS, smallpox, Mycobacterium tuberculosis bacteria including its resistant forms, differing strains of other viruses, bacteria and micro-organisms, both pathogenic or nonpathogenic over its competitors (gases and chemicals) is well documented. Their germ-killing power is attributed to its DNA and RNA base strand disrupting potential. Presently, it is used in tuberculosis wards and operation rooms. The UVC emitters used for this purpose are either the conventional UR-UVGI-MV (upper-room ultraviolet germicidal irradiation system with mercury vapour) or its newer substitute UR-UVGI-LED (light-emitting diode) sources. But the greatest concern about this is its hazardous effect on human/mammalian skin as a carcinogen and eye as cataractogen for which its human exposure is capped by several national and international groups to 8-hour/day at a Threshold Limit Value (TLV) of 6.0 mJ/cm2.[18-20]

FAR UVC and its Medical use

There is a subtle difference between the FAR UVC bandwidth used by astro-scientists (100-200 nm) and those used in medical disinfection for their germicidal effect (207-222 nm). This narrow wavelength usually generated by filtered excimer lamps are safe to mammalian/human skin and eyes, more efficient and rapid-acting in contrast to the conventional UVC sources and has an enhanced spectra, i.e., inactivates drug-resistant bacteria like Methicillin-Resistant Staphylococcus Aureus (MRSA), Vancomycin-Resistant Enterococci (VRE), and Clostridium difficile and their spores, Acinetobacter spp, all-important Hospital Acquired Infection (HAI) agents in absence of organic contaminants/ material along with other microorganisms including different airborne pathogens like corona group of viruses. These added advantages have drawn the attention of the scientific commune in resent time more so in the midst of present COVID-19 pandemic.[21,22]

Advantages of FAR UVC

- The supper fast killer, FAR UVC kills the dreaded C. difficile spores present as surface contaminants in seconds in contrast to hydrogen peroxide vapour which takes 45 minutes to do the job.
- The benefits of FAR UVC (207-222nm) as non-hazardous and potent germicidal agent lie in its strong absorbance into and high energy production on contact with biological materials.
- The high absorbance by surface biological tissues such as stratum corneum which is 5-20 µm thick and made up of proteinious tissues without nuclear material containing DNA are strong armors that absorbs the FAR UVC band. Similarly ocular surface epithelium takes the shine out of the FAR UVC's mammalian tissue penetrating properties thus, making them safe for use in areas of normal human activities.
- The broad spectrum germicidal power of FAR UVC 222nm, the strongest and safest of them all is attributed to the biological penetration and heat generation properties which the tiny microbes find very harsh and hostile. It affects their DNA and RNA molecules by denaturing them (killing the microbe) and inhibiting replication that to at a very minimal dose over a very short exposure time.
- Some examples of their claimed efficacy are substantiated as: FAR UVC 222nm light kills >95% of airborne aerosolized H1N1 influenza viruses at a very low dose of 2 mJ/cm2.
- The efficacy of far-UVC 222nm against airborne human corona viruses alpha HCoV-229E and beta HCoV-OC43 has also been proved. In a study involving the beta-HCoV-OC43, it was observed that continuous exposure of aerosolized droplets with similar sizes to those generated during normal course of sneezing and coughing to 2 mJ/cm2 which is below the present recommended dose of 3mJ/cm2/hour of UVC 222nm in occupied public locations can lead to 90% viral inactivation in 8 minutes, 95% within 11 minutes, 99% in 16 minutes and 99.9% within 25 minutes of exposure. Thus the bottom line is; FAR UVC is a strong and proven contender for uses in public places with human activities at a dose that is devoid of its exposure related health hazards.[23,24]
- The genomic and physical size of virusues plays a detrimental role to radiation response. As all corona viruses have comparable physical and genomic size FAR UVC can be the answer to the lethal weapon we are searching for the containment of the present COVID 19 pandemic and most future pandemic that may crop up in time to come.
- The current evidences if taken by their claims may

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make it feasible and safe to use the FAR UVC that can be generated by using inexpensive excimer lamps, that emit continuous low-dose in public places thereby, reducing the probability of person-to-person transmission of the novel corona virus and other seasonal viruses like influenza, MDR and XDR Tuberculosis and any unforeseen organism that may threaten human health in future.
- We can also design portable and fixed sterility devices using FAR UVC light emitting diode LEDs and incorporate them into Dental chair light units for ensuring killing of oral pathogens/ microorganisms including present COVID 19 ones thus providing dentist a safe oral cavity to carry out their procedures. The same concept can be used in ENT head light units to ensure work safety for ENT surgeons. For ophthalmologist the different examining light sources can be re-enforced with germicidal FAR UVC bulbs to ensure work safety. The portable units with FAR UVC 222nm bulbs will provide the much needed flexibility in ensuring disinfection in hospitals and other common places including use at common households. Their efficacy in high risk settings can further be enhanced in order to ensure complete inactivation by combining their use with other surface disinfectants i.e. hydrogen peroxide, glutaraldehyde, and microbial filters like VAPA which can kill/remove organic contaminants whose presence usually adversely affects the germicidal ability of UAR UVC light.[25,26]

Conclusion

Mass production of LEDs with this sweet-spot in UV emission, and their integration into everyday lighting is seen as a viable alternative in modern-day fast paced consumer centric world for pandemic control. The need for radical approaches like complete lockdown may not be an absolute necessity as the spread can be checked at its origin and the outbreak may not reach to a pandemic level.

A combination of no touch methods like FAR UVC along with chemical disinfectants like hydrogen peroxide, glutaraldehyde and insertion of different microbial filters like VAPA filters can be a lasting solution for controlling pathogens at high risk settings like hospitals and the non-touch devices for use in other low risk areas like market places, houses and transport sectors are going to be the new normal in future pandemic preparedness.

This approach too can be used for curtailing nagging public health issues like seasonal influenza, tuberculosis and its resistant forms, mumps-measles-rubella control, containment of chickenpox etc. which are responsible for hundreds of thousands of deaths and a tenfold increase in terms of their associated morbidity from which people around the globe suffered every year.

Conflicts of Interest: None

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