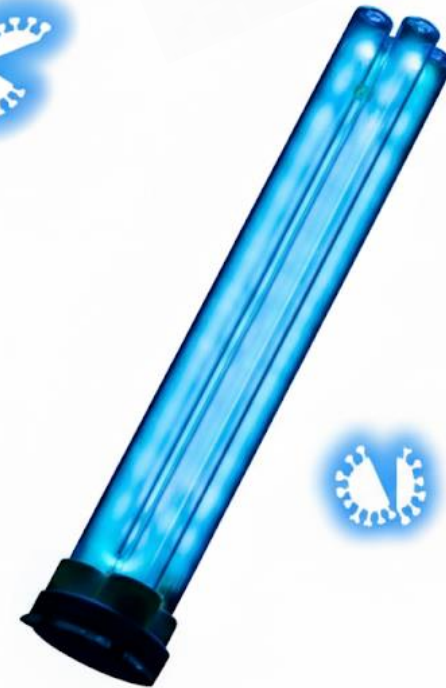
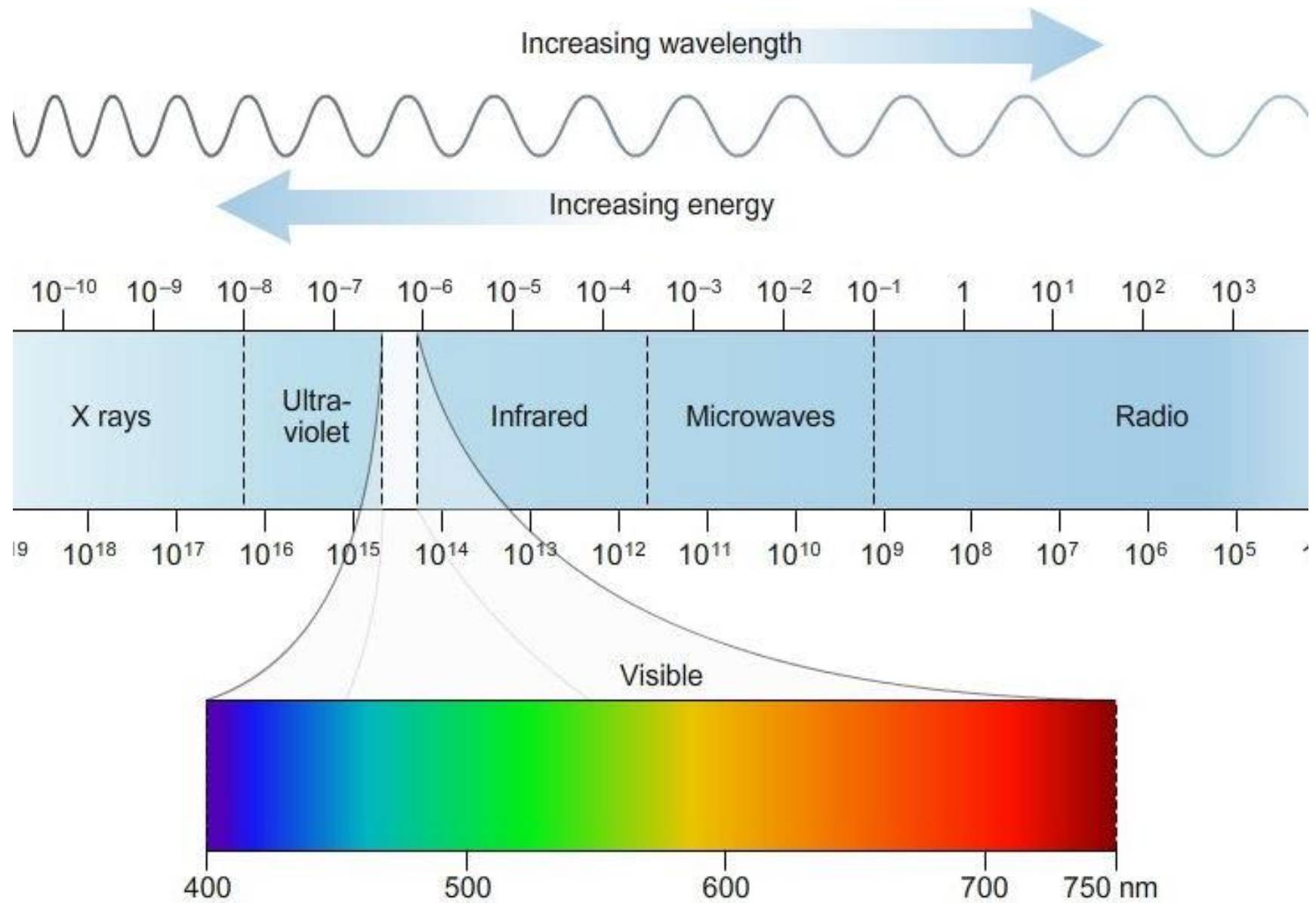


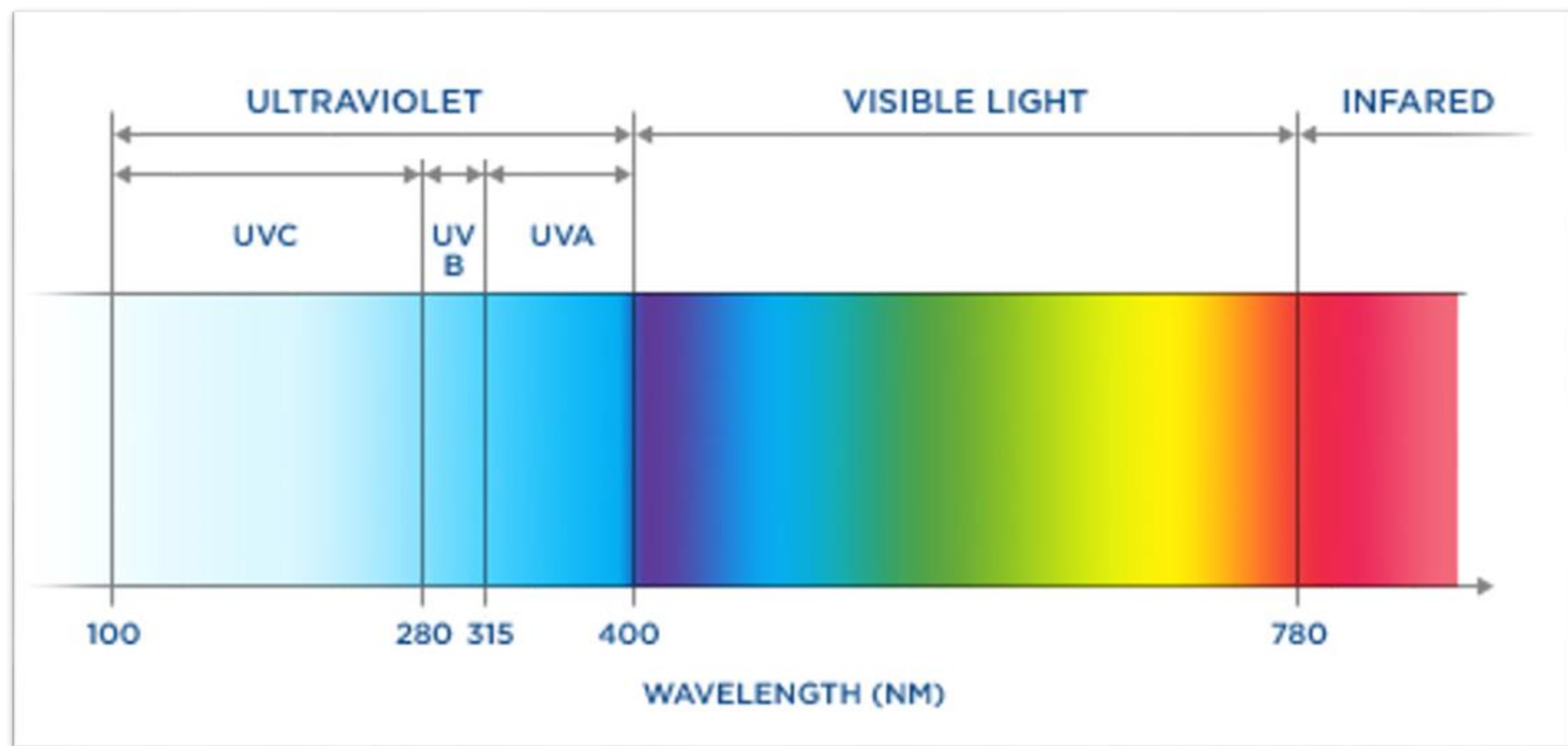
Combating infections with UV-C lamps

Focus on COVID-19

Alexia Behrend & Yélèna Höhler







CONTEXT

The clinical front:

- Crisis of Hospital-associated Infections (HAIs) and multidrug resistant organisms (MDROs).
- Insufficiency of manual cleaning: 5-30% of surfaces remain contaminated after standard cleaning.

Need for industrial level, "No-touch" sterilization method

The consumer front:

- Desire to inactivate SARS-CoV-2.
- Unregulated internet market flooded with high-intensity devices (eg- 278nm or 254nm lamps) intended for at home usage.

Constructors leveling fear of covid and lack of knowledge for marketing

HAZARDS IDENTIFICATIONS

BIOLOGICAL HAZARD FROM THE VIRUS

- The Covid virus can survive hours or even days, depending on the surface.
- Failing to disinfect properly leads to transmissions and outbreaks.

PHYSICAL HAZARD FROM UV-C

- **Skin:** Erythema (sunburn), apoptosis, and potential carcinogenesis.
- **Eyes:** Photokeratitis (welder's flash), corneal inflammation, and retinal damage.
- **Specific Evidence:** Consumer germicidal lamps (278 nm) can cause irreversible cell death in skin and eyes in as little as **30–70 seconds**.

USAGE CONTEXTS

THE CLINICAL FRONT

- **High bio-hazard environment.**
 - crisis of Hospital-Associated Infections (**HAIs**)
- UV-C for **terminal cleaning in unoccupied** rooms.
- **Procedural control** no human presence is permitted during operation due to radiation risks.

Standard methods in hospitals

- Continuous wave **~254 nm peak.**
- High-intensity pulses, broad spectrum (100–280 nm UV-C + UV-A/B + Visible).

THE CONSUMER FRONT

- Manufacturers play on **public fear** of COVID-19 to sell UV-C.
- Products do not necessarily respect legal radiation thresholds.
- Producers do not necessarily mention safety measures

Devices:

- UV LEDs: often **254nm- 278 nm.**

EXAMPLES



Wide Application



Pregnant women protection



Baby sleeping environment



The aging people immunity protection



Pet Supplies Sterilizer

PRODUCT

UV light for disinfection sold on the internet (30-60chf) :

- Advertised as **safe** and adapted for spaces up to **45m²** for 15min to **60min.**
- Features: **254 nmUV light at 38W**
- Little to **no prevention on safety measures.**

HAZARD DESCRIPTION:

- **1 m** away from source : over **1000 times higher** than the safe limit
- **5 m** away from source : **40 times higher** than the limit

EXAMPLES



UV Sterilamp PURPLEGLOW
Reaches limit in 5.3 seconds



Magic UV Light SanitizerTM
Reaches limit in 13.4 seconds



UVILIZER Flip
Reaches limit in 7.6 seconds

PRODUCT

UV light for disinfection within
seconds :

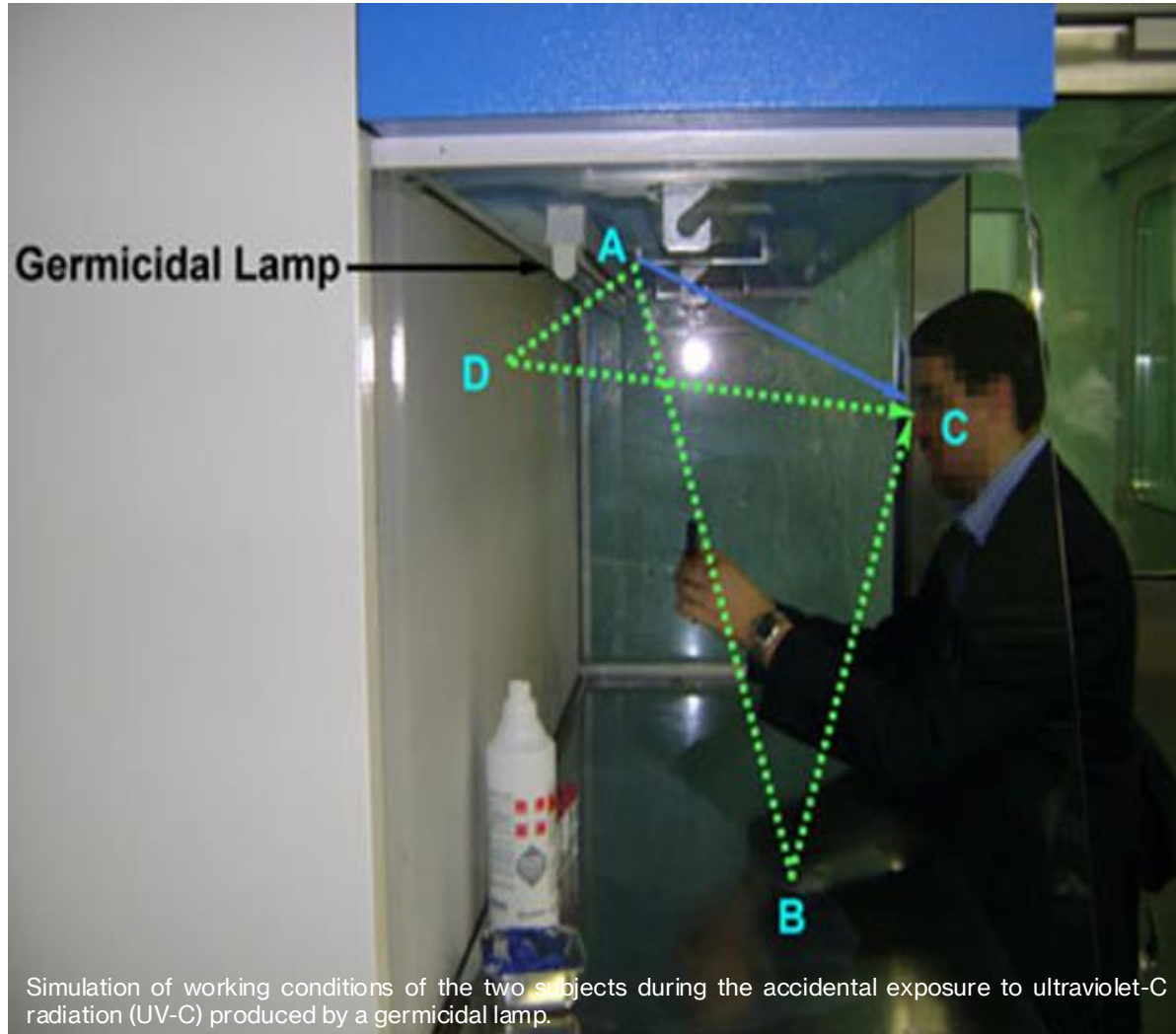
- Usually implies **3'000 times** the exposure limit for UV-C radiation

HAZARD DESCRIPTION:

- In just a few seconds these instruments cause injury to the skin and the eyes.

**The OFSP advises:
Against usage of household UV-C
products**

Extent & severity of reported harms



- **Documented accidents** : misuse of germicidal lamps → skin / eye injuries.
- **Example** : hospital-pharmacy staff over-exposed $>100\times$ safety limit → long-lasting symptoms for > 2 years.
- **Domestic use** : family of 3 experienced photokeratitis & skin burns after few seconds of unprotected lamp use.
- **Recent (2025) in-vivo study** : even “portable” UV-C lamps cause erythema (skin reddening/burn) and eye damage under conditions of misuse.

How likely is “standard” over-exposure?

- **People are present during irradiation**, or lamp emits into occupied space (reflected or direct).
- “Wand”-type / portable devices frequently **lack safety filters or interlocks**, and may emit radiation many times the recommended safe limit.
- Doses required for virus inactivation often **not validated** in consumer devices; surfaces may not receive sufficient UV → risk of **false sense of safety**.

Therefore risk is **high** if device is used improperly; **moderate to low** only if professionally installed, shielded, and used according to protocols.

Overall risk assessment

Risk-benefit ration evaluation

CLINICAL FRONT:

Benefit: Reduction of deadly Hospital-Associated Infections (HAIs)

Risk: High risk of radiation injury.

High Risk + High Necessity + High procedural safety control

=

Positive Risk-Benefit Ratio

CONSUMER FRONT:

Benefit: Disinfection but standard cleaning practices are often sufficient.

Risk: Rapid and severe biological damage (30–70s for irreversible cell death), no proper safety measures

High Risk + Low Necessity + Low safety awareness

=

Negative Risk-Benefit Ratio

Regulations

standards & recommended
good practice

Switzerland (OFSP / Product Safety)

- Follows European product-safety rules
- UV-C lamps must comply with **IEC 62471 + ISO 15858** to be sold.
- OFSP Fact Sheet (March 2021)
- No separate UV-C law, but applies strict market surveillance → unsafe lamps withdrawn.

International standards (apply worldwide for device safety)

- **IEC 62471**: photobiological safety classification for lamps.
- **ISO 15858**: safety requirements and exposure limits for UV-C disinfection devices.
- **ICNIRP**: publishes scientifically based exposure-limit guidelines (used as the basis for legal limits worldwide).

Exposure limits

Wavelength / Type of UV-C	Common exposure limit for unprotected skin/eye	Notes / remarks
254 nm (standard UV-C lamps)	≈ 6 mJ/cm²	ICNIRP / ISO 15858
222 nm (far-UVC – older limit)	≈ 23–25 mJ/cm	CIE / ICNIRP (pre-2022)
222 nm (far-UVC – ACGIH 2022 update)	~160 mJ/cm² (eye) / ~479 mJ/cm² (skin)	Reflects more recent safety data – still debated internationally

Practical guidelines

good-practice &
recommendations

- Only use **UV-C devices designed for disinfection** and **certified** to comply with safety standards.
- Use UV-C **only in unoccupied**
- If used in occupied spaces, ensure **upper-air, shielded installations** with correct mounting & measured irradiance.
- Provide **clear warning signs** at room entrances during operation, ensure **maintenance and lamp aging checks**.
- For domestic use, especially **avoid** handheld “UV-C wands” .
- Combine UV-C disinfection only with **other hygiene measures**, do not treat it as a “magic sterilizer”.



FAR UV-C (222nm)

A newer and safer solution ?

Safety:

Wavelengths <230 nm are strongly absorbed by proteins (peptide bonds).

- **Skin Safety:** Blocked by the *stratum corneum* (outer dead skin layer) does not reach stem cells in deeper layer.
- **Eye Safety:** Absorbed by the superficial tear layer/cornea does not reach the lens or retina.

Disinfection system:

- Unlike 254 nm (which only damages DNA), 222 nm damages the **genome**, denatures **spike proteins** (stopping cell binding), and oxidizes the **lipid envelope**.
- **Result:** Achieves 5-log inactivation of airborne coronaviruses at very low doses (<1 mJ/cm²).
- **Binding Blockade:** Even if the virus survives genetically, protein damage prevents it from entering host cells.

Far-UV

Downside in exploration

Newly Identified Hazard:

Indoor Air Quality (IAQ) hazard associated with 222 nm lamps:

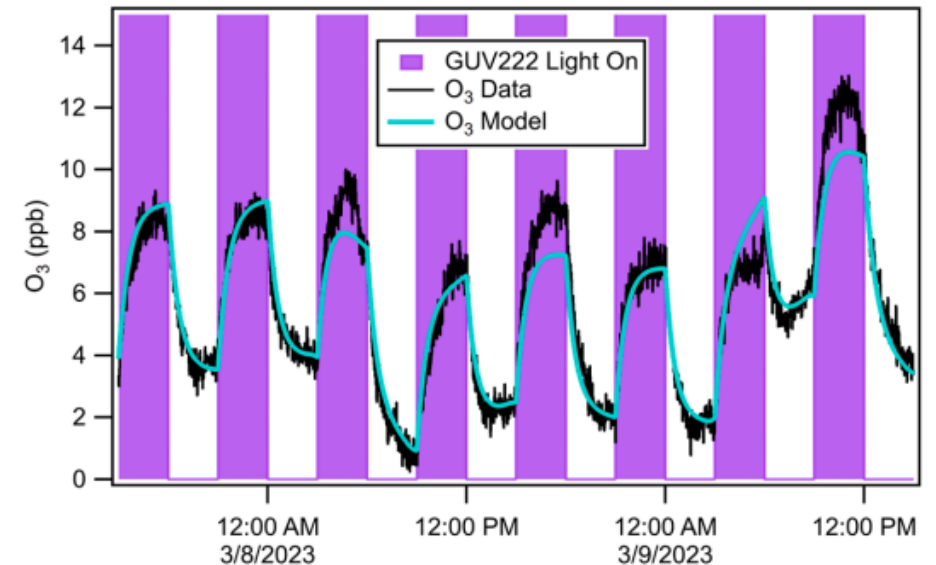
- Significant **Ozone** production.

Cause & Aggravating Factors:

- The wavelength (222 nm) is close to the 185 nm required to break down O_2 and form O_3
- **Unfiltered Lamps** (without spectral filters) and internal electrical discharge are key factors leading to high O_3 generation.
- **Health Implication:** Ozone is a **respiratory irritant and pollutant**. Long-term exposure, even at low levels, is linked to adverse respiratory and mortality risks.

Results:

- A rate of 22 ppb/h was observed for certain lamp modules in a 21m³ chamber. (8h limit is 50ppb)
- A real-world test in an office showed an increase of approximately 6.5 ppm during lamp operation.



Time series of O₃ in the office experiments, along with model results. (5)

CONCLUSION

- Real evidence linking misuse of UV-C lamps and serious eye and skin injuries.
- Consumer front:
 - The probability of harm increases when devices are used carelessly. Products are not compliant with safety standards. Use is strongly discouraged.
 - Other disinfection methods (cleaning, ventilation, chemicals) remain more reliable and safer.
- Clinical front:
 - Under strict professional conditions UV-C becomes a valid disinfection method, low to moderate risk.
 - In this context traditional disinfection is not enough.
 - Risk is managed and justified.
- Far UV-C:
 - Safer on the radiation point of view.
 - New hazard: respiratory and pollution.
 - Tolerable if proper ventilation systems are employed (professional vs at home usage)

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