Far-UVC for the inactivation of airborne pathogens

A brief review of the literature for Indoor Air Management of Airborne Pathogens: Lessons, Practices, and Innovations. August 18th, 2022.

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All of our far-UVC presentations, public engagement, research papers and publicity is available here:
http://www-star.st-and.ac.uk/~kw25/research/UVC/UVC.html

Disclosure

Ewan Eadie and Kenneth Wood have no conflicts of interest.

Collaborators' conflicts of interest can be found in our most recent publication https://www.nature.com/articles/s41598-022-08462-z

Take home message(s)

Far-UVC quickly inactivates a wide range of **airborne** and **surface pathogens** in the **laboratory**.

Upper-room UVC (254 nm) reduces transmission of airborne disease.

HYPOTHESIS: Far-UVC (in particular KrCl* lamps) will inactivate airborne pathogens in the real world.

Far-UVC, wavelength less than 230 nm, **do not penetrate** far into tissue.

Appropriately filtered KrCl* lamps **do not cause acute reactions** in skin until very high doses.

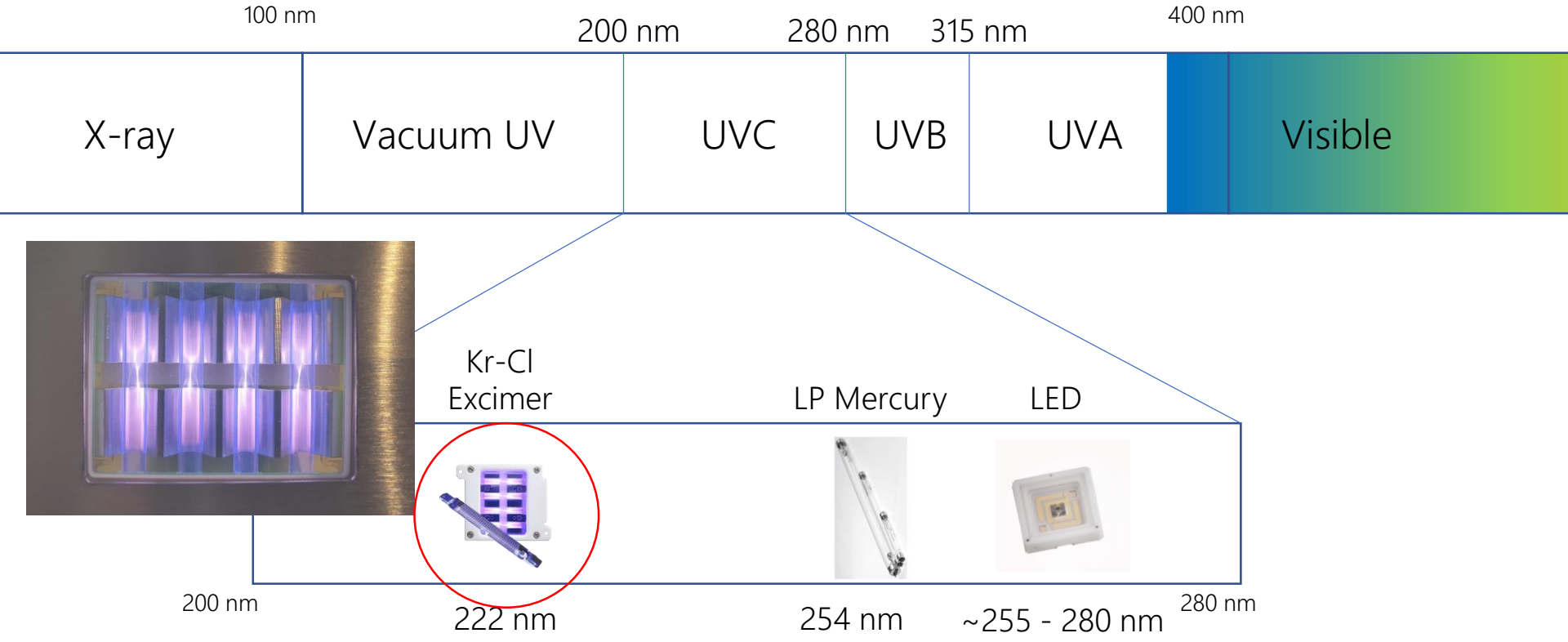
HYPOTHESIS: Far-UVC, when appropriately filtered, will not induce long-term adverse effects in the skin (i.e. skin cancer)

What is Far-UVC?

Useful References

https://dx.doi.org/10.3205/dgkh000378

https://doi.org/10.1080/10643389.2022.2084315



Guidelines on Limits of Exposure

ICNIRP	Exposure Limit	
222 nm only	23 $mJcm^{-2}$	
Highly filtered KrCl* lamp	23 $mJcm^{-2}$	
Unfiltered KrCl* lamp	18 $mJcm^{-2}$	
ACGIGH-2022	**S(λ)**	**S'(λ)**
222 nm only	161 $mJcm^{-2}$	479 $mJcm^{-2}$
Highly filtered KrCl* lamp	150 $mJcm^{-2}$	449 $mJcm^{-2}$
Unfiltered KrCl* lamp	43 $mJcm^{-2}$	99 $mJcm^{-2}$

ICNIRP Guidelines https://www.icnirp.org/cms/upload/publications/ICNIRPUV2004.pdf

ACGIH https://portal.acgih.org/s/store#/store/browse/detail/a154W00000DjYbgQAF

FACT

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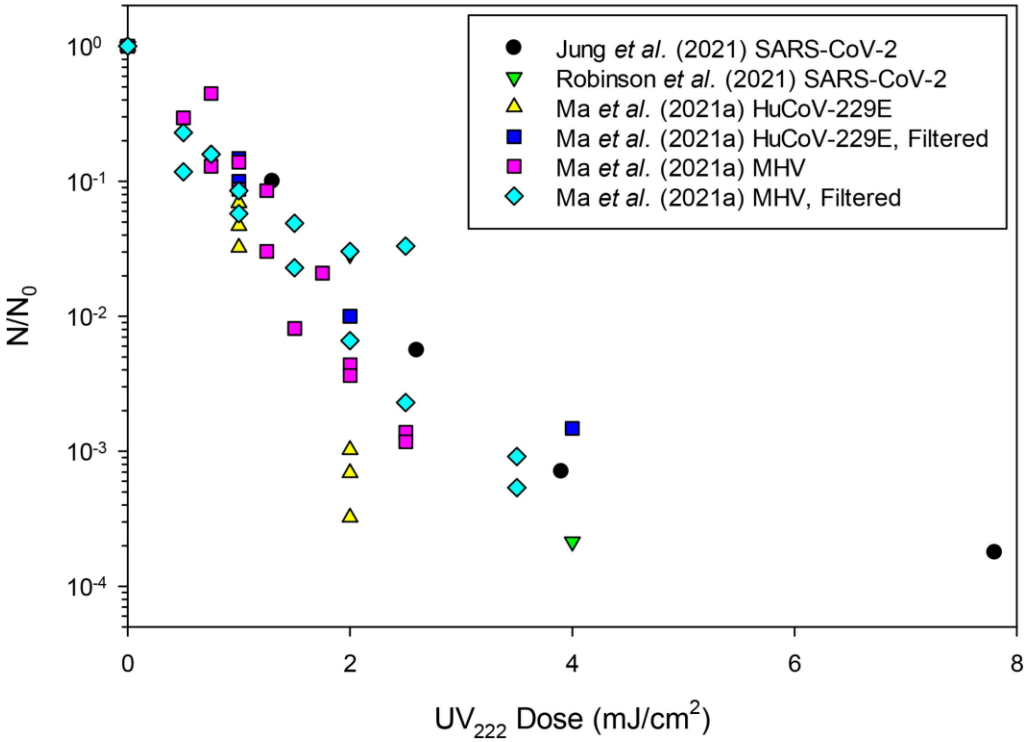

Image from: Blatchley III, E.R. *et al.* (2022) Far UV-C radiation: An emerging tool for pandemic control, Critical Reviews in Environmental Science and Technology https://doi.org/10.1080/10643389.2022.2084315

Other useful references for the inactivation of airborne pathogens with Far-UVC:

1. https://doi.org/10.1038/s41598-022-08462-z
2. https://doi.org/10.1038/s41598-021-99204-0
3. https://doi.org/10.1038/s41598-020-67211-2
4. https://doi.org/10.1038/s41598-018-21058-w

Upper-room UVC (254 nm) reduces transmission of airborne disease.

70% reduction in TB infections because of UV lights

https://doi.org/10.1371/journal.pmed.1000043

Upper-room UVGI provided **80% protection** from TB infection

https://doi.org/10.1164/rccm.201501-0060OC

Measles epidemic **infections 14.5% with UVGI**; 55.3% without

https://doi.org/10.1093/oxfordjournals.aje.a118789

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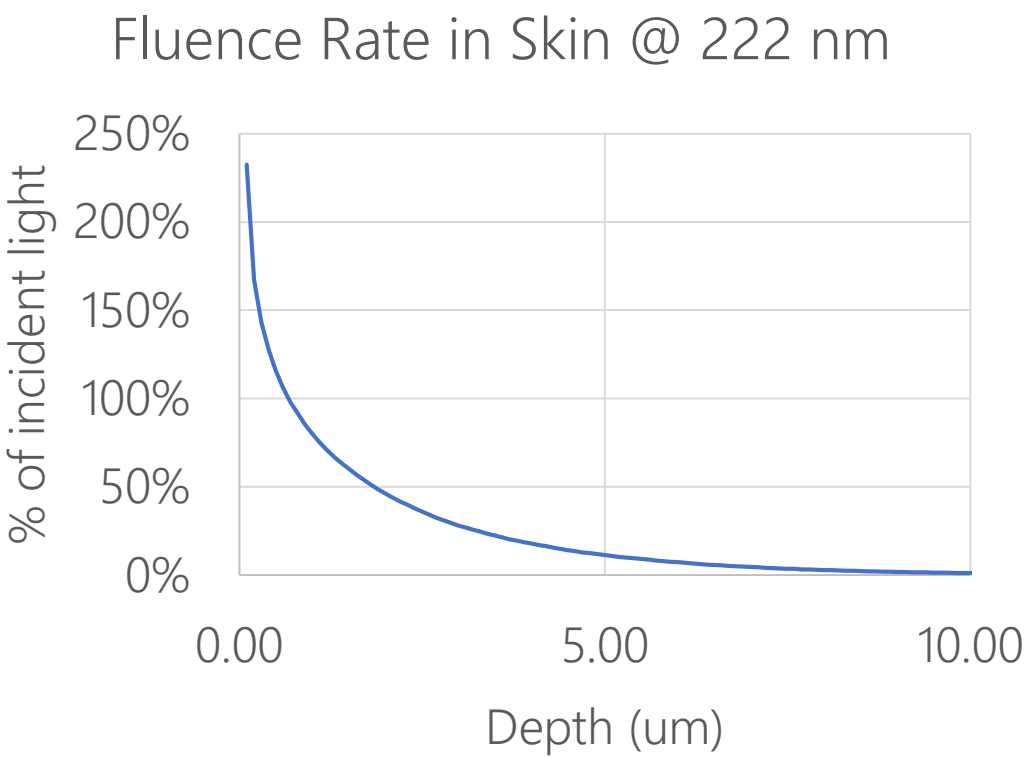
FACT

Far-UVC, wavelengths less than 230 nm, do not penetrate far into tissue



@ 222 nm **<0.1%** of incident light reaches the Epidermis (20 um)

Image from Finalyson, L. *et al.* Depth Penetration of Light into Skin as a Function of Wavelength from 200 to 1000 nm. Photochemistry and Photobiology. 2022;98(4):974-981. https://doi.org/10.1111/php.13550

Other useful references:

1. https://doi.org/10.1111/bjd.19816 (Skin)
2. https://doi.org/10.1111/php.13602 (Skin)
3. https://doi.org/10.1111/php.13383 (Skin)
4. https://doi.org/10.1111/php.13419 (Eye)
5. https://doi.org/10.1111/php.13620 (Surg. Site)

Appropriately filtered KrCl* lamps **do not cause acute reactions** in the skin until very high doses.

Unfiltered KrCl* lamp induces slight skin reddening @ 40 $mJcm^{-2}$

https://doi.org/10.1111/phpp.12156

No skin changes @ 1,500 $mJcm^{-2}$ with a **highly filtered** KrCl* lamp

https://doi.org/10.1111/php.13385

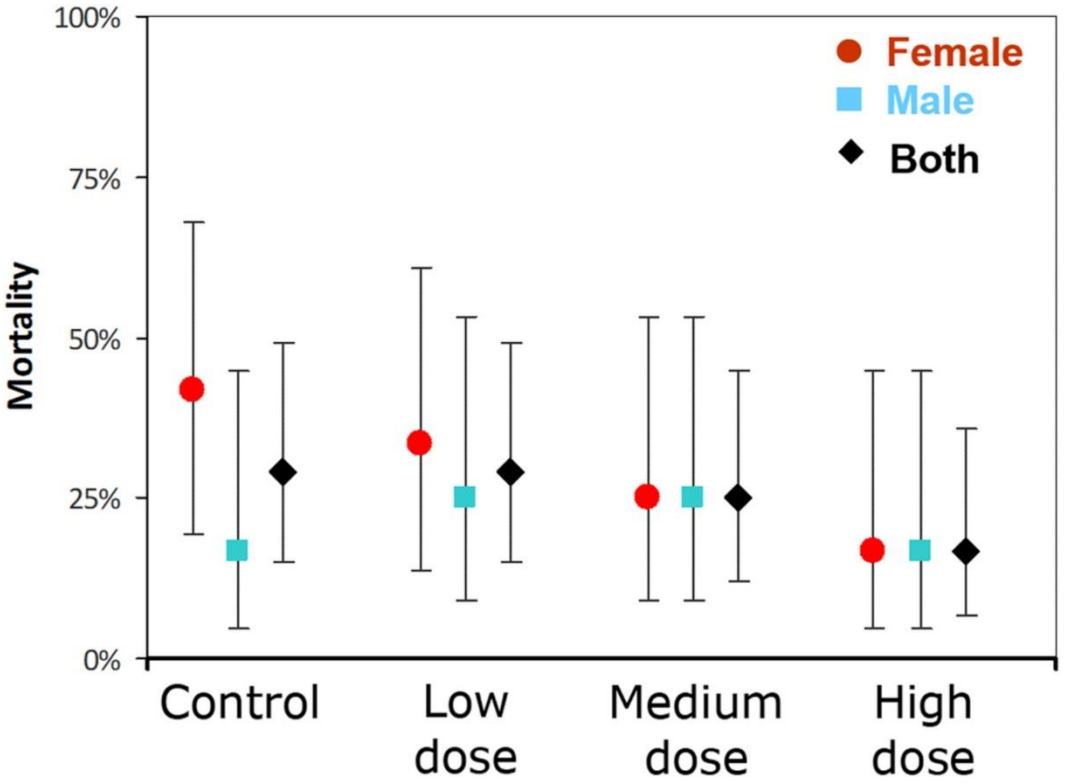
No skin reddening @ 500 $mJcm^{-2}$ with a **highly filtered** KrCl* lamp

https://doi.org/10.1371/journal.pone.0235948

HYPOTHESIS: Far-UVC, when appropriately filtered, will not induce long-term adverse effects in the skin (i.e. skin cancer)

Image from Welch, D *et al.* No Evidence of Induced Skin Cancer or Other Skin Abnormalities after Long-Term (66 week) Chronic Exposure to 222-nm Far-UVC Radiation. Photochemistry and Photobiology. 2022. https://doi.org/10.1111/php.13656

Another useful reference https://doi.org/10.1371/journal.pone.0235948



Research Priorities

1.Real-world efficacy studies

- Only one published study to date https://doi.org/10.1016/j.pdpdt.2021.102334

1.Interaction with the human eye

- One clinical study (yet to report) https://center6.umin.ac.jp/cgi-open-bin/ctr_e/ctr_view.cgi?recptno=R000048726
- Two (linked) studies in rats: https://doi.org/10.1111/php.13419 and https://doi.org/10.1080/10715762.2019.1603378

How best to deploy Far-UVC & awareness of limitations

- How much Far-UVC is needed in a space? Depends on how much inactivation is required.
- Is it just for air? Or also for surfaces?

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