



Evaluation of a UV-C LED device for disinfection of medical instruments

Hannah Siwe

Laboratory of Liver Infectious Diseases, Faculty of Medicine and Health Sciences, Ghent University, Ghent, Belgium

Research and Development, ZAPARAY, Lokeren, Belgium

OVERVIEW

INTRODUCTION

- Ultraviolet radiation (UVR) and background
- UVR sources/UVR damage
- Hospital acquired infection (HAI) and infection prevention and control measures
- Reprocessing and challenges

OBJECTIVES

METHODS

- Instrument assessment
- Workflow UV testing

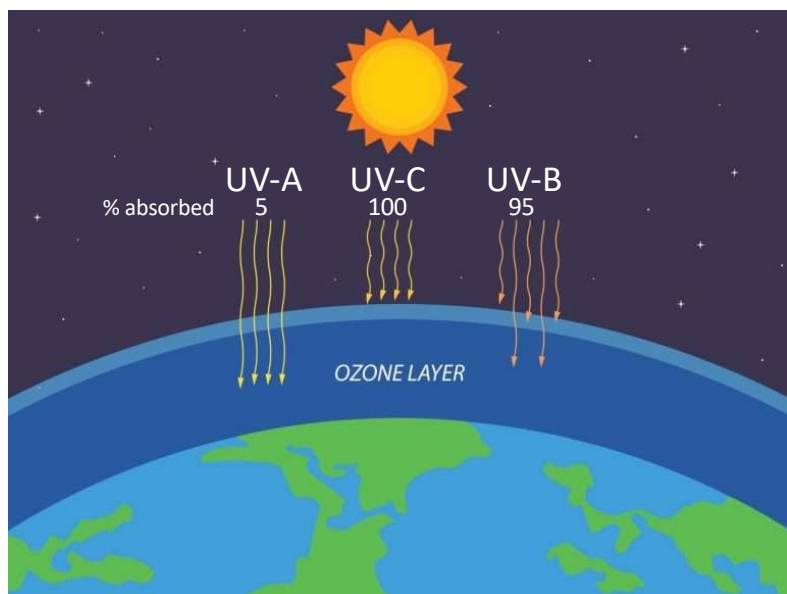
RESULTS

- Results on the standard surface (petri dish) and medical devices

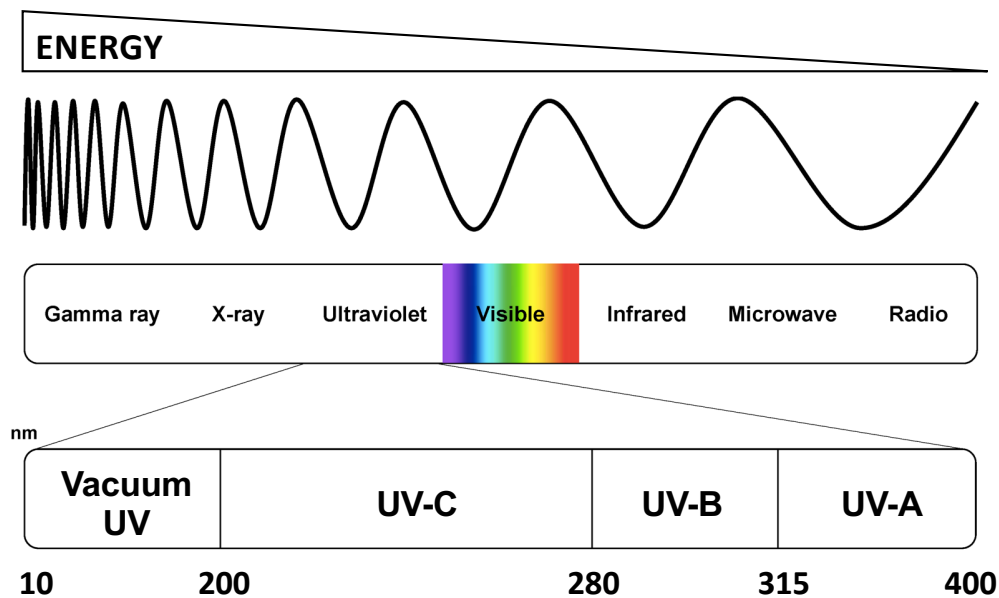
CONCLUSION

INTRODUCTION

ULTRAVIOLET RADIATION (UVR)



Source: adapted from Norcast weather



Source: adapted from Browne, K., Brought to Light: How Ultraviolet Disinfection Can Prevent the Nosocomial Transmission of COVID-19 and Other Infectious Diseases

BACKGROUND

INITIAL UV DISCOVERY

1801



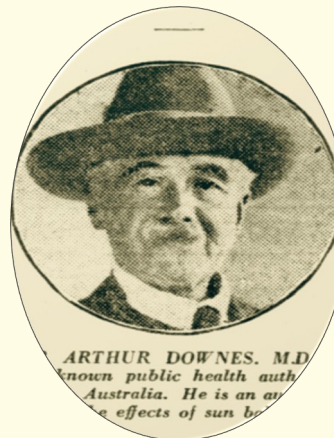
Johann Ritter

DISCOVERY OF MUTAGENIC PROPERTIES OF UV

1877



Thomas Blunt



Arthur Downes

USE OF UV FOR TREATMENT OF TB*

1895

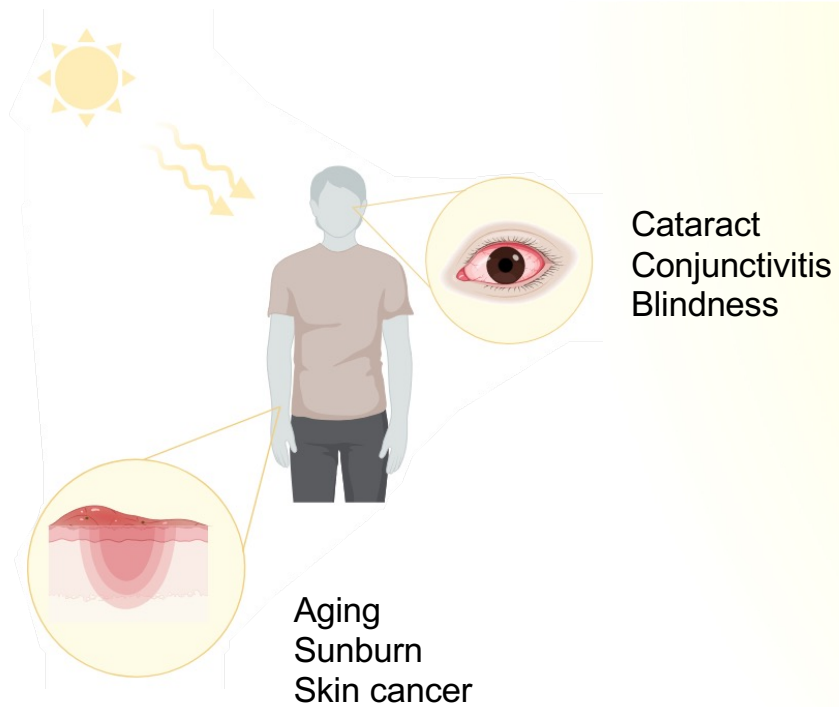


Niels Finsen

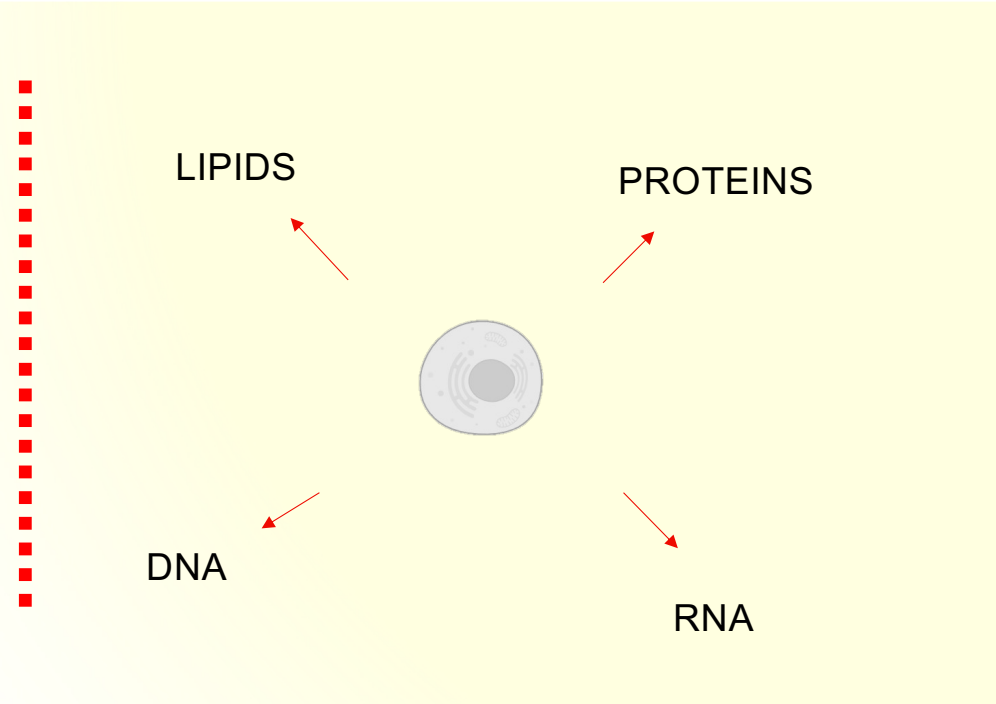
*tuberculosis 4

UVR DAMAGE

MACROSCOPIC LEVEL



CELULAR LEVEL



UVR SOURCES

TRADITIONAL UV MERCURY LAMPS



different sizes



mercury



broad spectrum

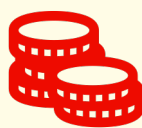


Heat generation

EXCIMER LAMPS



different sizes



cost



wavelength control



ozone

LIGHT EMITTING DIODES



compact



Relatively new
technology



wavelength control



limited output intensity

HOSPITAL ACQUIRED INFECTION (HAI) AND INFECTION PREVENTION AND CONTROL MEASURES

On any given day:



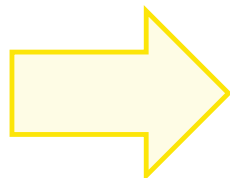
1 / 15

Hospital patients have at least one HAI



1 / 26

Long-term care facility residents have at least one HAI



Source: adapted from European Centre for Disease Prevention and Control (2016/2017)

REPROCESSING AND CHALLENGES

Reprocessing:



Definition by World Health Organization: All steps that are necessary to make a contaminated reusable medical device ready for its intended use. These steps may include cleaning, functional testing, packaging, labelling, **disinfection and sterilization**



CHALLENGES

ERROR PRONE MANUAL DISINFECTION

ENVIRONMENTAL BURDEN

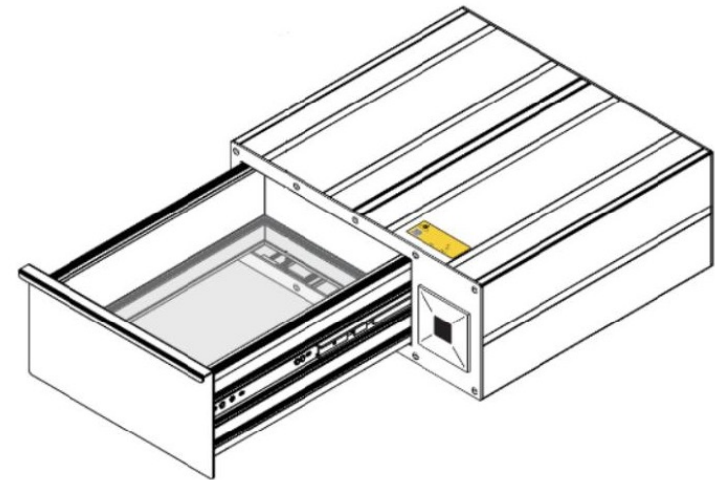
MICROBIAL RESISTANCE TOWARDS BIOCIDES

COMPLEX MEDICAL INSTRUMENTS

UVC DEVICE

Model: RAY-ONE model 0/102

- UV-C LED disinfection chamber with drawer
- Maximum size of disinfecting object:
200 mm x 300 mm x 70 mm (WxDxH)
- Average irradiance: 0.395 mW/cm²
- Wavelength: 272 ± 3 nm
- 5-minute disinfection cycle: 118.5 mJ/cm² **(UV dose)**



UV dose (mJ/cm²) = irradiance (mW/cm²) x exposure time (seconds)



OBJECTIVES

EVALUATE THE EFFICACY OF A UV-C LED DEVICE FOR
DISINFECTION OF **A STANDARD SURFACE**

(smooth, flat, regular, nonporous)

EVALUATE THE EFFECTIVENESS OF THE UV-C LED
DEVICE FOR DISINFECTION OF **MEDICAL INSTRUMENTS**

METHODS

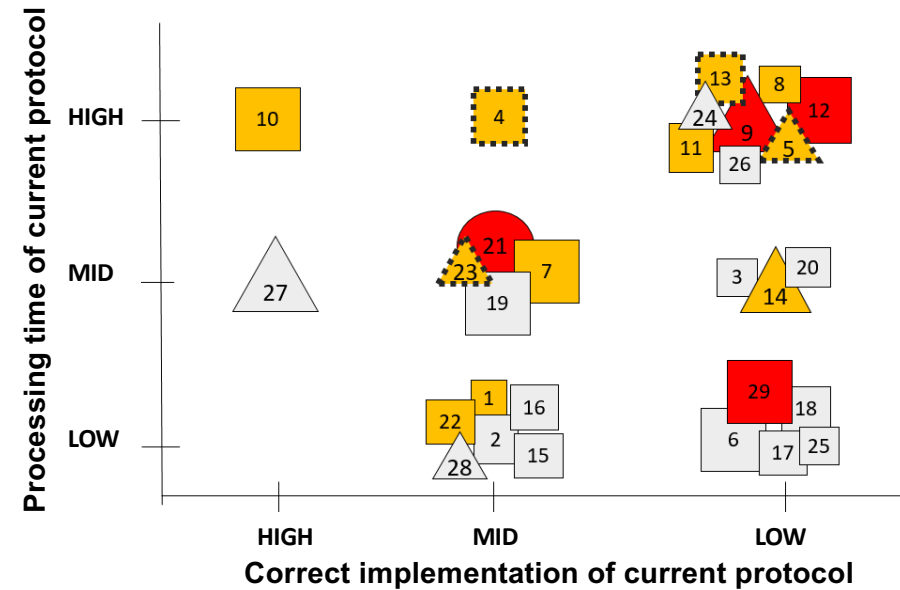
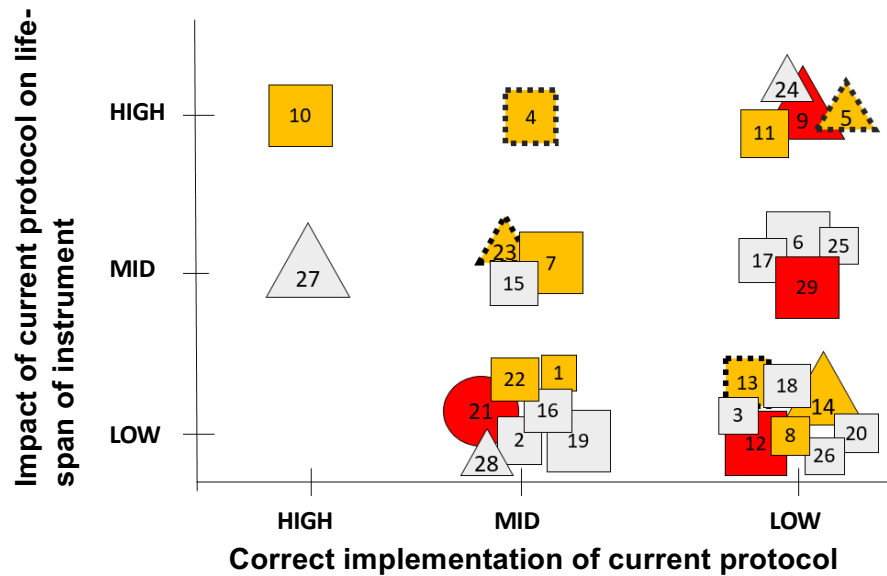
INSTRUMENT ASSESSMENT

- Surveys in **14 departments** at the Ghent University Hospital
 - Instruments scored high, mid or low against **6 parameters**:
 - Correct implementation of current protocol
 - Impact on lifespan of current protocol
 - Processing time of current protocol
 - Use frequency
 - Cost of instrument
 - HAI risk
- Protocol related
- Instrument related

INSTRUMENT SELECTION

- 29 identified instruments

	LOW	MID	HIGH
USE FREQ.	○	△	□
COST	○	○	○
RISK			



4: hand and angle piece
5: orthodontic plier
13: laryngoscope blade
23: Nasal sensor

Subjected to UVC testing

GENERAL WORKFLOW STANDARD SURFACE

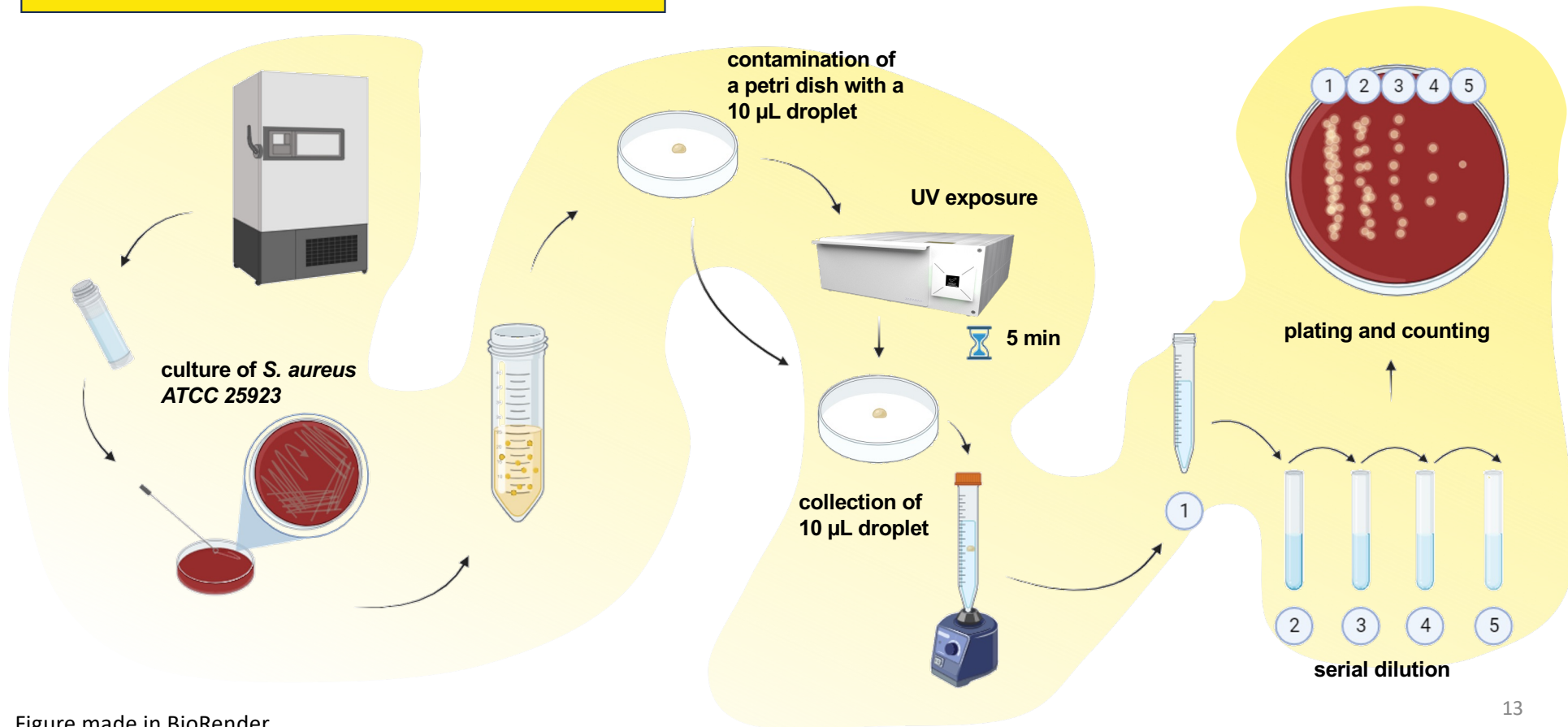


Figure made in BioRender

GENERAL WORKFLOW MEDICAL INSTRUMENT (1)

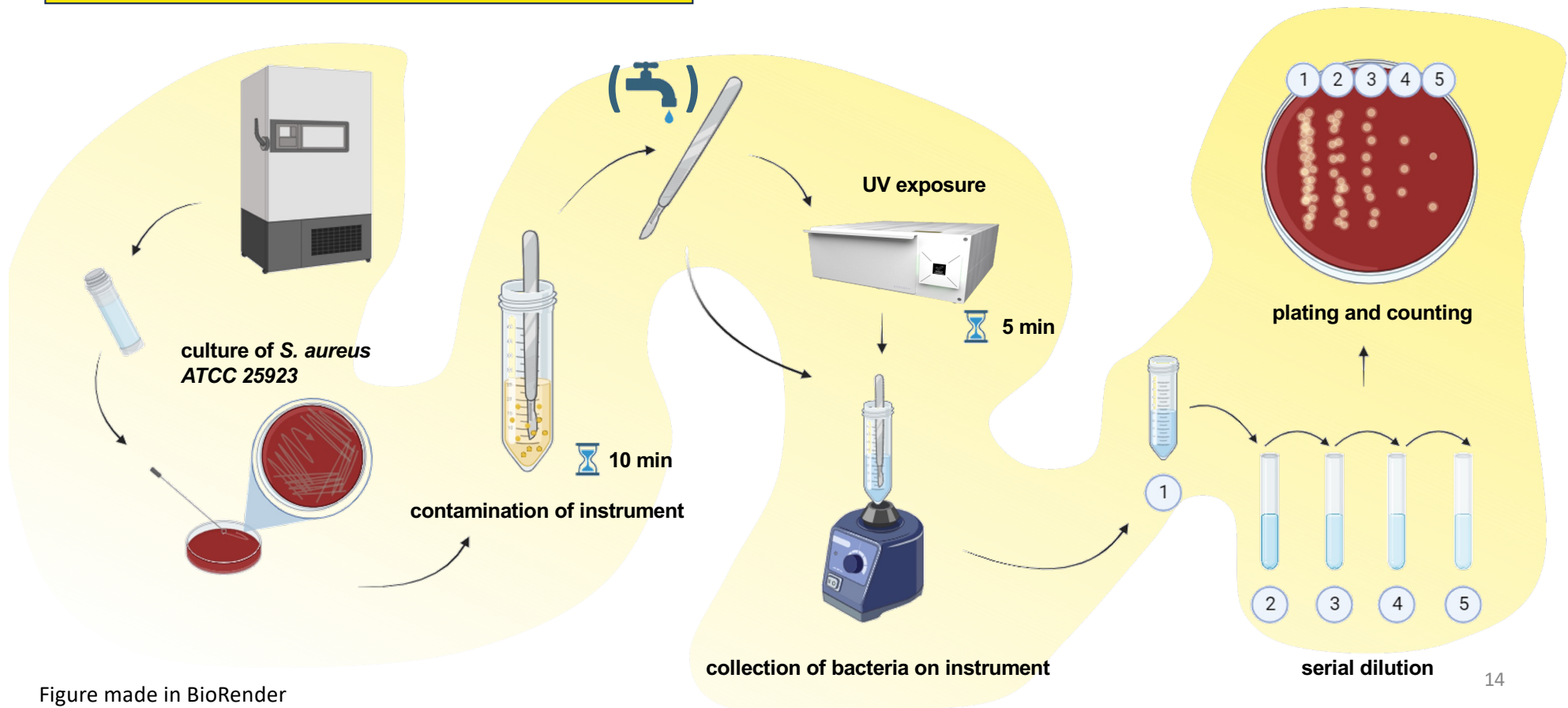


Figure made in BioRender

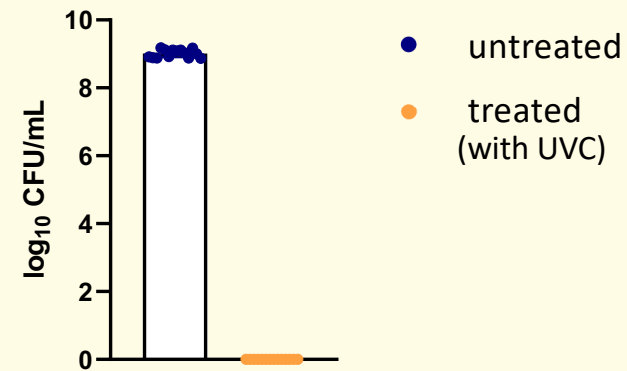
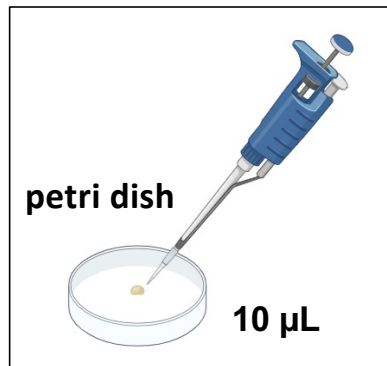
GENERAL WORKFLOW MEDICAL INSTRUMENTS (2)

- Contamination:
 - partial submersion
 - rubbing with swab (nasal sensor)
- Collection (in saline):
 - partial submersion
 - spraying
 - direct object imprint
 - swabbing
- Rinsing:
 - 3 second jet of water

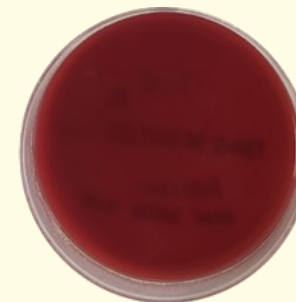


RESULTS

STANDARD SURFACE

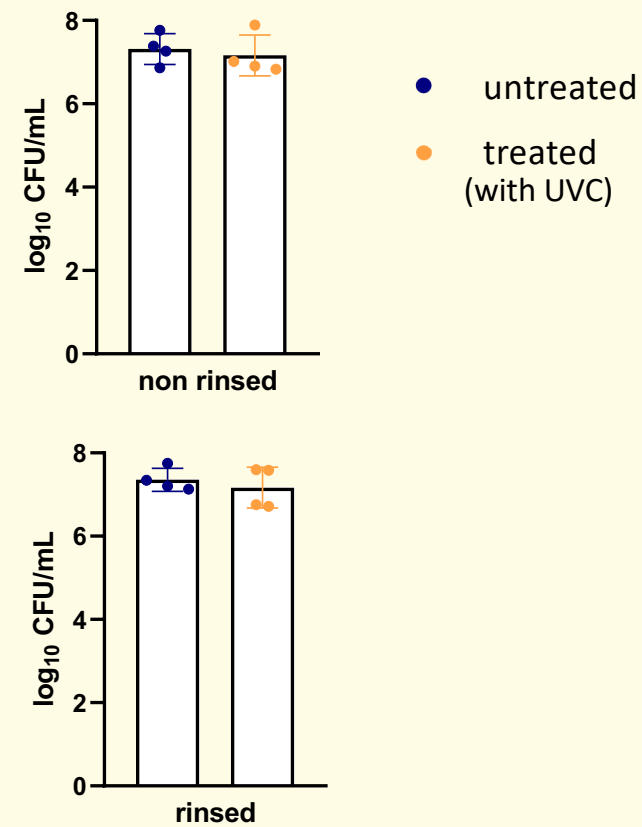


UNTREATED



TREATED

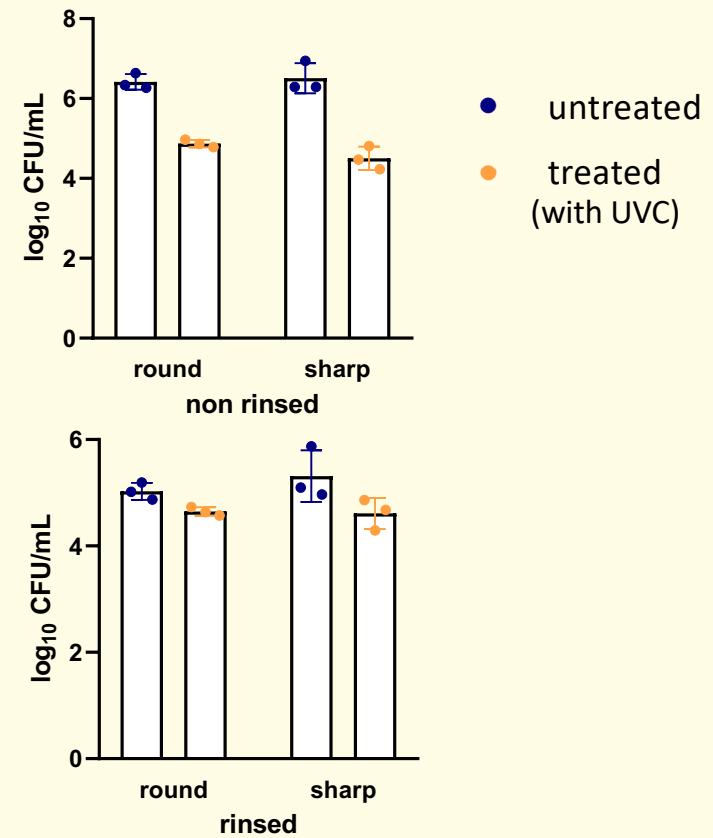
HAND AND ANGLE PIECE



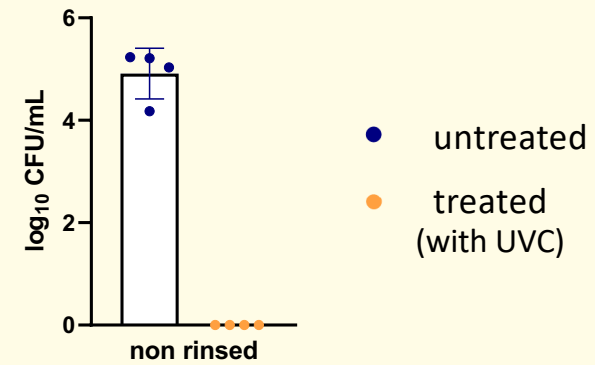
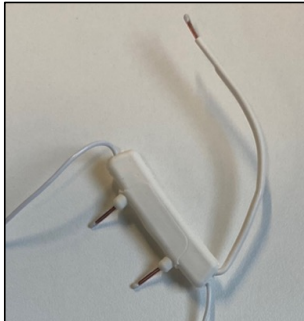
ORTHODONTIC PLIER

ROUND

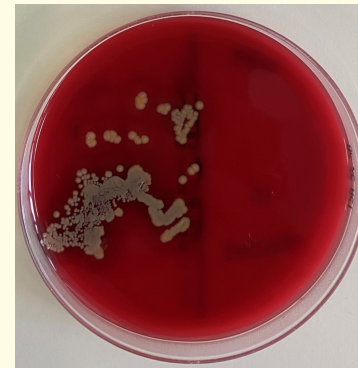
SHARP



NASAL SENSOR

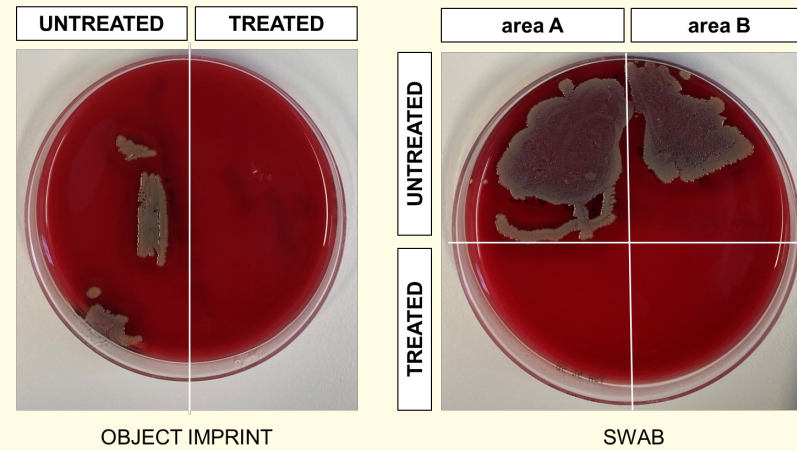
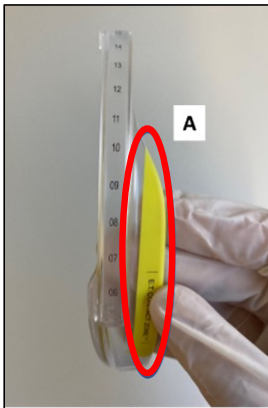
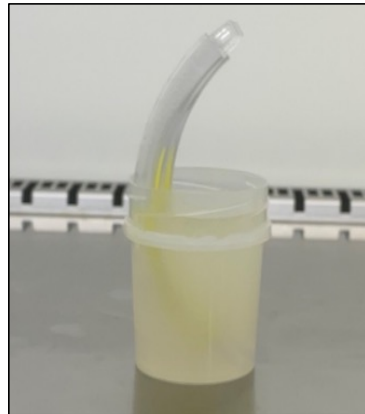
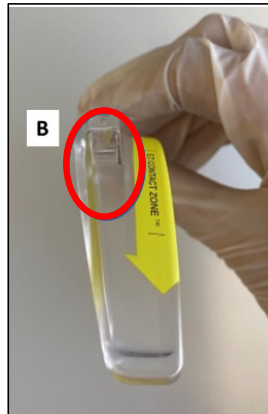


UNTREATED TREATED



OBJECT IMPRINT

LARYNGOSCOPE BLADE



OBTAINED LOG REDUCTIONS

STANDARD SURFACE

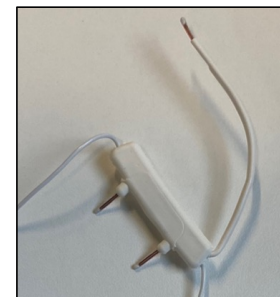


COMPLETE
REDUCTION
 $> 9 \log_{10} \text{CFU/mL}$

MEDICAL INSTRUMENT



NO REDUCTION
(HOLLOW CAVITIES)



COMPLETE REDUCTION
 $> 4.9 \log_{10} \text{CFU/mL}$



PARTIAL REDUCTION
 $\leq 2 \log_{10} \text{CFU/mL}$
(HINGE)



COMPLETE REDUCTION
 $> 6.8 \log_{10} \text{CFU/mL}$

CONCLUSION

- A **variety of medical instruments** were identified that **could benefit from an alternative** disinfection solution.
- We obtained complete inactivation of a **9 log₁₀ CFU/mL** droplet of *S. aureus* ATCC 25923 in a petri dish which demonstrates the **high disinfecting** ability of the UVC-LED device on a **standard surface (smooth, flat, regular, non porous)**.
- We obtained complete, partial or no reduction depending on the instrument showing that **shape influences the disinfection efficiency**.
- **Disinfection efficiency** on a **standard surface** is **not a direct indicator** for the **disinfection performance** of a **contaminated instrument** with irregularities such as cavities, notches, and crevices.
- **Shape** combined with the **desired level of disinfection** of the instrument (Spaulding), **should be considered when using a UVC** device as an alternative disinfection technology.

THANK YOU

Laboratory of Liver Infectious Diseases

Philip Meuleman

Laura Corneillie

Amse De Meyer

Freya Van Houtte

Lieven Verhoye

Silke Ternest

ZAPARAY

Duncan Verstraeten

Nabi Dastaran

Mieke Flour

Xavier Deklerck

Institute of Biomedical Engineering and Technology

Alain Kalmar

Laboratory Bacteriology Research

Piet Cools

Leen Van Simaey

Aliona Rosca

Eline Meyers

Nick Versmessen

Lisa Himschoot

Bodine Van Eenoooghe

Ghent University Hospital

Isabel Leroux-Roels

Annelies Aerssens

Krist Henrotin



Parameters and definitions

	Correct implementation of current protocol	Impact on lifespan of current protocol	Processing time of current protocol	Use frequency	Cost of instrument	HAI risk (patient + material classification)
High	always executed correctly	frequent damage or high wear and tear	very high TAT (Turn Around Time) due to transfer to central sterilisation department	more than 10x a day	more than 500 €	semi-critical material or other material in severely immunocompromised patients
Mid	occasionally wrong	risk of damages	multiple steps with induction period, but locally executed (e.g. Tristel or Clinell)	more than 1x per day	between 50 € and 500 €	semi-critical material
Low	almost never executed correctly	no or little impact on lifespan	rapid cleaning and disinfection (e.g. Clinell)	1x a day or less	less than 50 €	non-critical instruments

Instrument identification and assessment

Number	Instrument	Department	Correct implementation of current protocol	Impact of current protocol on lifespan of instrument	Processing time of current protocol	Use frequency	Cost of instrument	HAI risk (patient + material classification)
1	Tonometer tip	Ophthalmology	Mid	Low	Low	High	Low	Mid
2	Contact lenses/laser lenses	Ophthalmology	Mid	Low	Low	High	Mid	Low
3	Mask for exercise stress test	Pulmonary diseases	High	Low	Mid	High	Low	Low
4	Hand and angle pieces	Dentistry	Mid	High	High	High	Mid	Mid
5	Orthodontic Pliers	Dentistry	High	High	High	Mid	Mid	Mid
6	External echo probes (ultrasound probe)	Gynaecology	High	Mid	Low	High	High	Low
7	Vaginal echo probe (ultrasound probe)	Gynaecology	Mid	Mid	Mid	High	High	Mid
8	Speculum	Gynaecology	High	Low	High	High	Mid	Mid
9	Hysteroscope	Gynaecology	High	High	High	Mid	High	High
10	Rhino scope	Ear, Nose and throat	Low	High	High	High	High	Mid
11	Batteries used in operating room	Operating room	High	High	High	High	Mid	Mid
12	Flexible scopes	Operating room, Gastrointestinal surgery, pneumology	High	Low	High	High	High	High
13	Laryngoscope blades	Operating room	High	Low	High	High	Mid	Mid
14	Video laryngoscope blades	Operating room	High	Low	Mid	Mid	High	Mid
15	Computer keyboard	Low Vision	Mid	Mid	Low	High	Mid	Low
16	Trial frame glasses	Low Vision	Mid	Low	Low	High	Mid	Low
17	iPhone	Low Vision	High	Mid	Low	High	Mid	Low
18	Tablet	Low Vision	High	Low	Low	High	Mid	Low
19	Dermatoscope (classic or video)	Dermatology	Mid	Low	Mid	High	High	Low
20	Attachment for laser device	Dermatology	High	Low	Mid	High	Low	Low
21	Shower stretcher	Burn centre	Mid	Low	Mid	Low	High	High
22	Monitoring wiring ECG and EEG device	Operating room	Mid	Low	Low	High	Mid	Mid
23	Nasal sensor	Centre for neurophysiological monitoring	Mid	Mid	Mid	Mid	Mid	Mid
24	Respiratory Velcro strap with electronics inside	Centre for neurophysiological monitoring	High	High	High	Mid	Mid	Low
25	Rubber bands	Ergotherapy	High	Mid	Low	High	Low	Low
26	Velcro straps	Ergotherapy	High	Low	High	High	Low	Low
27	Virtual reality glasses	Ergotherapy	Low	Mid	Mid	Mid	High	Low
28	Thermoplastic material	Ergotherapy	Mid	Low	Low	Mid	Mid	Low
29	Echo probes (ultrasound probe)	Critical units (Intensive care, neonatal intensive care, haematology, paediatric oncology)	High	Mid	Low	High	High	High