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Simulated Workplace Protection Factor (SWPF) of Filtering Facepiece Respirators and Surgical Masks against Surgical Smoke

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Introduction

- Approximately 500,000 healthcare workers in the USA are exposed annually to surgical smoke produced by laser or electronic devices.
- Surgical smoke is generated during surgical procedures in an operating room (OR) while using laser or electrosurgical unit that thermally destroys the tissue.
- Adverse health effects of surgical smoke exposure include asthma, emphysema, eye irritation, headache, etc.
- Surgical smoke contains particles including blood fragments, bacteria, viruses and lung-damaging dust.
- Particles size in surgical smoke varies greatly depending on the energy method used. Submicrometer Particle has a major contribution to the total particle concentration. Most of them are ultrafine particles.

Introduction

- Occupational Safety and Health Administration (OSHA) has not published any laser/electrosurgery plume hazards related standard.

- The National Institute for Occupational Safety and Health (NIOSH) recommends combining general room ventilation with local exhaust ventilation (LEV) to control the airborne particles generated by the surgical devices.

- The Association for periOperative Registered Nurses (AORN) urges the use of personal protective equipment (PPE) and evacuation and filtration of smoke through an appropriate system.

Introduction

- Proper selection and use of respirators can reduce or prevent surgical smoke exposure. In the operating room, the surgical mask is a required PPE. However, the more efficient NIOSH certified N95 filtering facepiece respirators (FFRs) is not required.

- There are no specific recommendations or guidelines with respect to respiratory protection devices that should be used in operating rooms. Additionally, no study has been conducted on the performance of surgical masks and FFRs against surgical smoke.

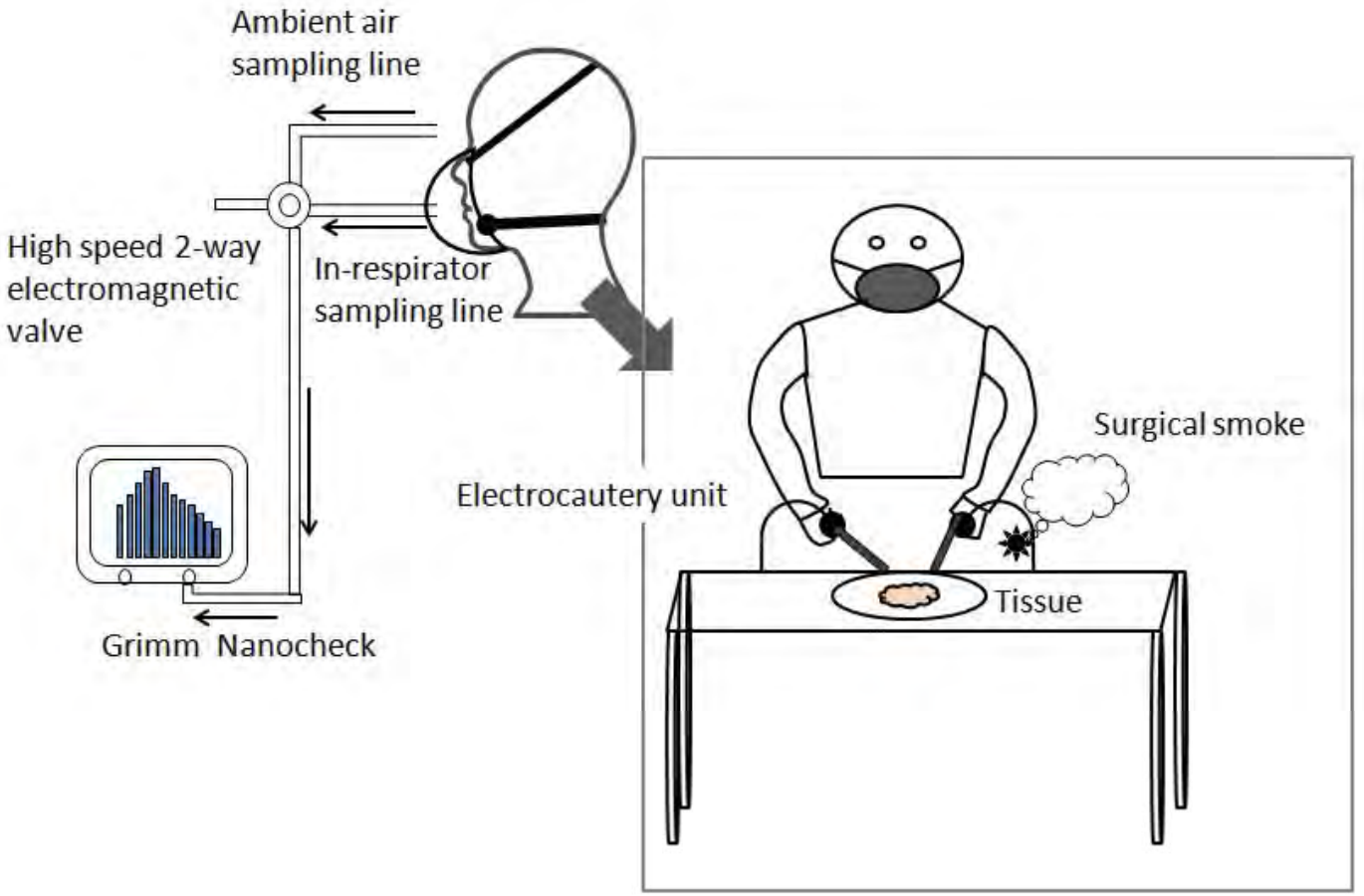
- Therefore, in this study, we will evaluate the protection offered by surgical masks and N95 FFRs against surgical smoke in a simulated workplace.

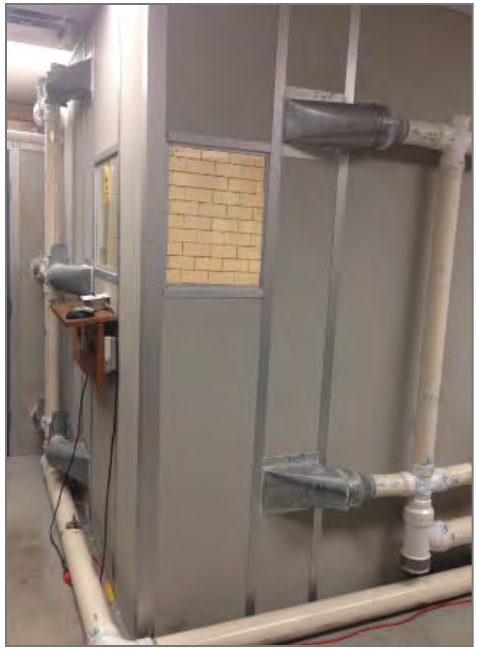
Objectives

- Determine the simulated workplace protection factors (SWPFs) of two surgical masks and two NIOSH-certified N95 FFRs currently marketed for use in ORs.

- Measure SWPFs on ten human subjects while they are exposed to surgical smoke generated by an electrocautery unit applied to an animal tissue in a room-size chamber.

Experimental Set-up





Exposure Chamber

Electrocautery Unit

Grimm NanoCheck

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Respiratory Protective Devices

- **Surgical Masks**

Surgical mask
3M 1800NL
(SM1)

Surgical mask
KC 14683
(SM2)

- **N95 FFRs**

N95 FFR 3M 1870
(N95 FFR1)

N95 FFR 3M 1860
(N95 FFR2)

SWPF Calculation

The Simulated Workplace Protection Factor (SWPF) is determined as the ratio of the particle concentration outside (C_{out}) and inside (C_{in}) of the respirator:

$$SWPF = C_{out} / C_{in}$$

Additionally, particle size specific SWPFs were determined using a Grimm Nanocheck particle spectrometer.

Results

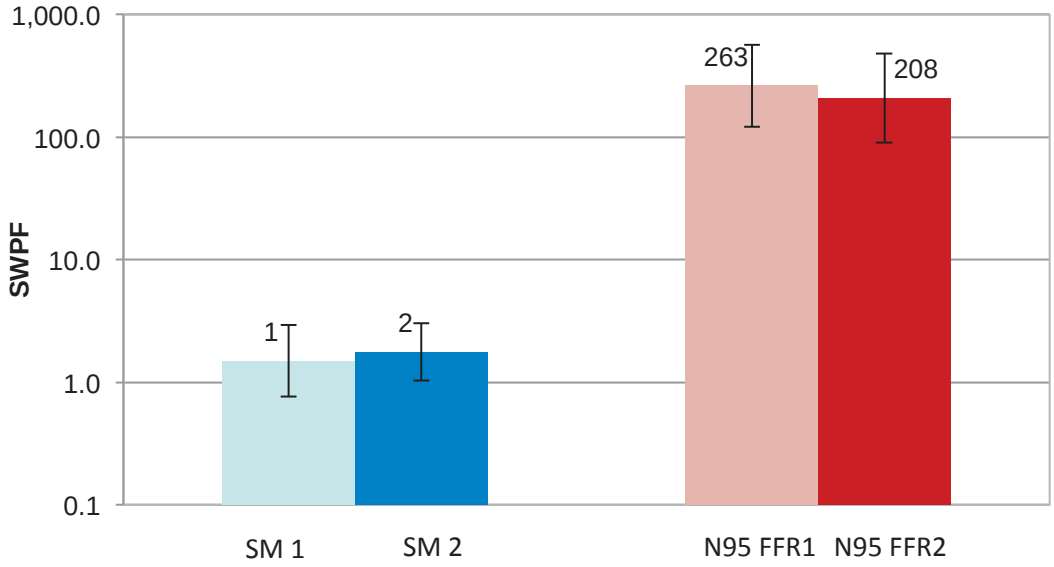

Figure 1. SWPF for commercially available SMs and N95 FFRs widely used in ORs

- Surgical masks offered essentially no protection to the healthcare workers.
- N95 FFRs offered measurable protection to the healthcare workers.

Table 1. P-values (paired t-test) for SWPF comparison between different respiratory protective devices

	Subject Number	Name of the Test	p-value
SM1 & SM2	10	Paired t-test	0.84
N95 FFR1 & N95 FFR2	10	Paired t-test	0.41
SMs & N95 FFRs	10	Paired t-test	0.0013 (**)

Note: $p < 0.01$(**)

- The difference between SWPF values obtained for two SMs was not significant ($p > 0.05$).
- The difference between SWPF values obtained for two N95 FFRs was not significant ($p > 0.05$).
- Compared to the N95 FFR, the SM had a much lower SWPF ($p < 0.05$).

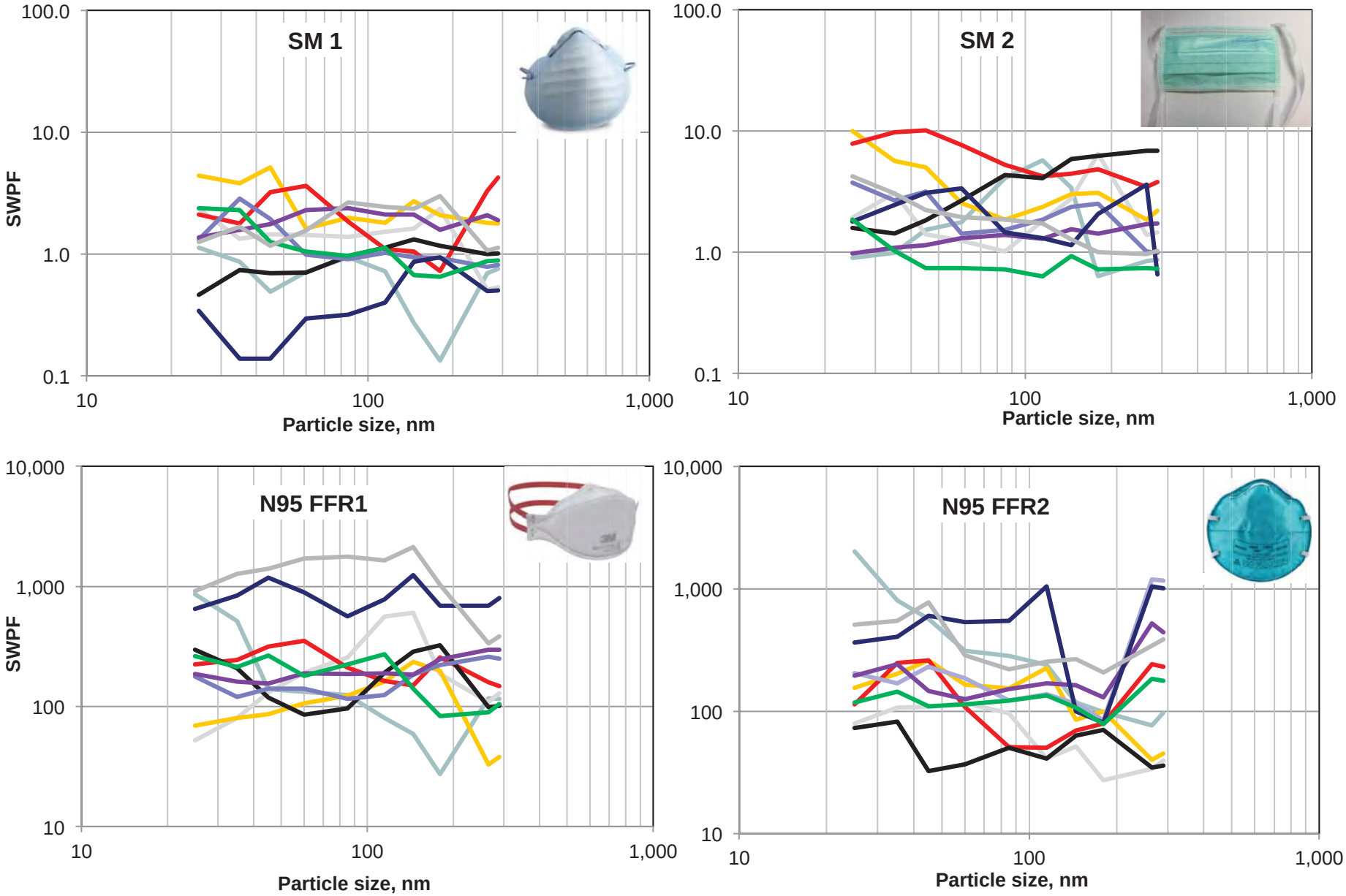

Figure 2. Size-selective SWPF values for SMs and N95 FFRs measured with ten subjects

Table 2. Effects of subject and particle size on the performance of respiratory protective devices (Two-way ANOVA)

RPDs compared	Factor	p-value
SM1	Subject	< 0.0001 (**)
	Size	0.822
SM2	Subject	< 0.0001 (**)
	Size	0.384
N95 FFR1	Subject	< 0.0001 (**)
	Size	0.170
N95 FFR2	Subject	< 0.0001 (**)
	Size	0.129

Note: $p < 0.01$(**)

Conclusions

- This study suggested that an SM could barely protect healthcare workers. More efficient N95 FFRs are recommended instead of SMs for the use in healthcare environment (including ORs) against surgical smoke.

- The performance of the respiratory protective device varies depending on the subject.

- Faceseal leakage is the main penetration passway for the particles to enter into the respirator. Healthcare workers should receive an appropriate training on how to wear respirators to reduce the faceseal leakage.

Thank You !

Questions?

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