

Assessing the Impact of Respirator Design and Demographics on the Performance of N95 Respirators

Xinyi Niu (PI), Jun Wang (Mentor)

Department of Environmental and Public Health Sciences, College of Medicine, University of Cincinnati

BACKGROUND

- N95 Facepiece Filtering Respirators (FFRs) approved by the National Institute for Occupational Safety and Health (NIOSH) are often used to protect wearers from exposure to hazardous airborne particles.
- Ill-fitted respirators may compromise the protection offered to wearers. The US Occupational Safety and Health Administration (OSHA) mandates that all employees wearing respirators be subject to OSHA's fit testing (OSHA 29 CFR. 1910.134) to ensure that the wearer is effectively protected.
- There are some specific design elements on the N95 FFRs, including nose-clip/shaped designs, respirator shape styles, etc., to ensure that respirators provide effective protection for the wearers.
- Sex/gender and race/ethnicity may affect respirator fit because of differences in facial structure variations, nose and cheekbone proportions, soft tissue characteristics, etc.



SIGNIFICANCE

- N95 FFRs are widely used to mitigate particle inhalation and offer significantly high level of protection in many occupational and non-occupational environments.
- Understanding the influence of potential factors on the performance of N95 FFRs is crucial; it is vital for advising workers and the general public on selecting the most suitable respirator style, thereby ensuring their effectiveness and safety.

SPECIFIC AIMS

- Quantitatively characterize how the **nose-clip shape** of a respirator affects the respirator performance by using both manikin-based and human subject-based evaluation approaches.
- Quantitatively characterize how the **respirator shape style** affects the performance of NIOSH-approved N95 FFRs through manikin-based and human subject-based study designs.
- Determine the impact of **subject characteristics** on the fitness of respirators.

Table 1. The N95 Respirators will be tested in this study.

Respirator model	Nose-clip	Respirators	Name	Model	Manufacture	Styles	Size
3M 8210	No nose-clip (Control)		3M™ particulate matter respirator	8210	3M (Saint Paul, MN)	Cup-shaped	Regular
	Conventional nose-clip		3M™ AURA™ health care particulate respirator and surgical mask	1870+	3M	3-Panel flat-fold	Regular
	M-shaped nose-clip		3M™ particulate respirator	9502+	3M	Vertical flat-fold	Regular
Moldex 2200	No nose-clip (Control)		3M™ VFlex particulate respirator	9105	3M	V-shaped pleats	Regular
	Conventional nose-clip		Kimberly-Clark N95 particulate filter respirator mask	46767	Kimberly-Clark (Irving, TX)	Duckbill	Regular
	M-shaped nose-clip		AOSafety pleats plus N95 particulate respirator	1050	AOSafety (Indianapolis, IN)	Large flexible pleats	"Small/Medium"; "Medium/Large"

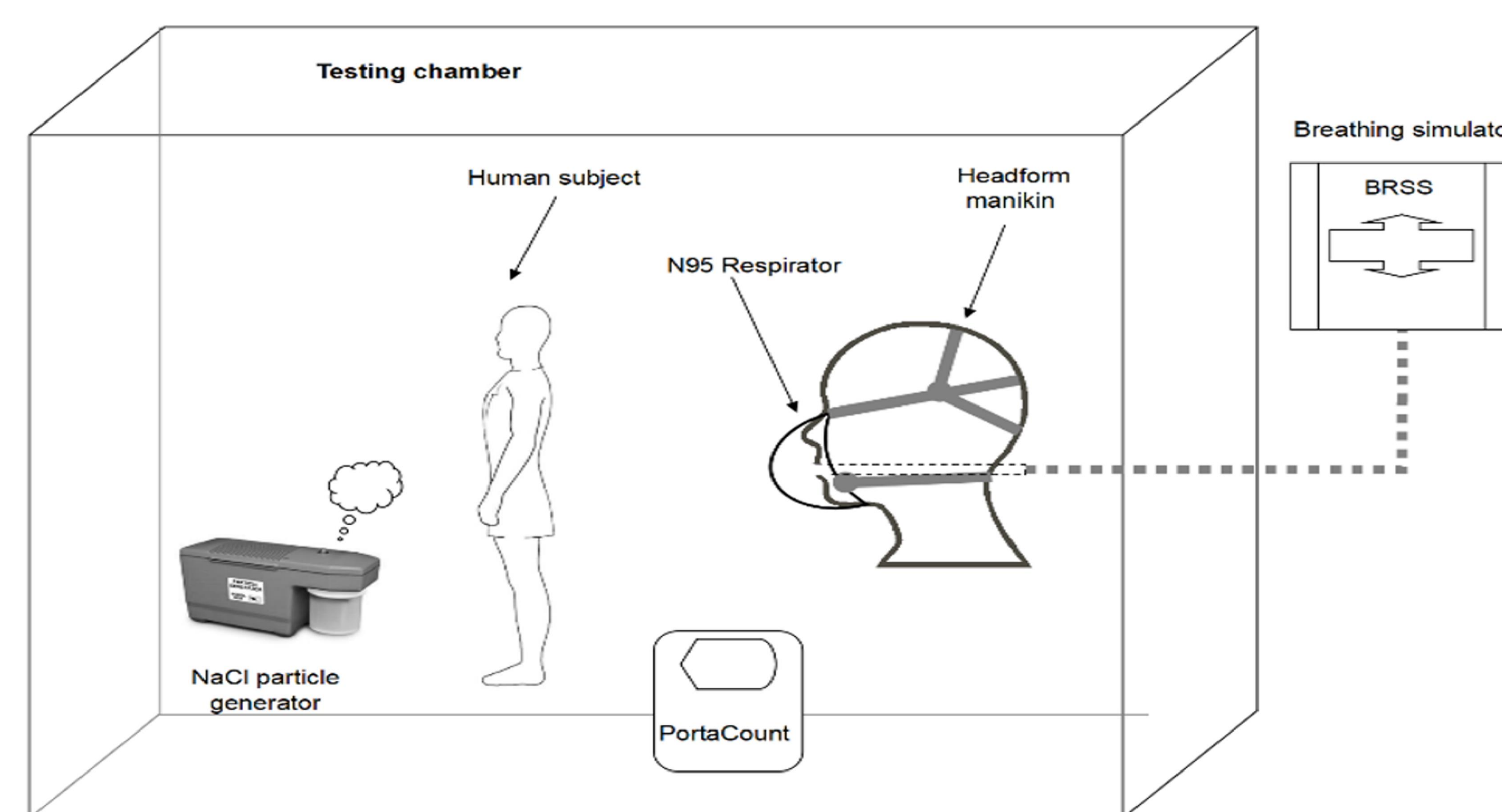


Figure 1. Experimental setup for respirator testing.

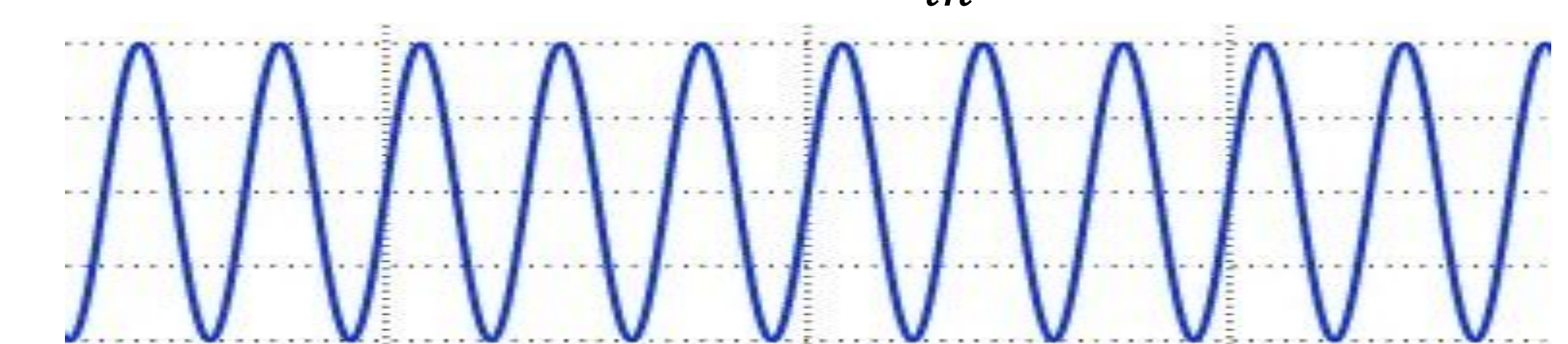
ACKNOWLEDGEMENTS

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RESEARCH DESIGN AND METHODS

- This study will be designed as a two-fold study: *Manikin-based testing* & *Human subject testing*. The testing will be conducted in a 24-m³ aerosol chamber. The experimental set up that will be used for testing the respirator performance is presented in Fig.1. N95 FFRs as shown in Table 1 will be tested.
- Manikin-based testing.** An advanced static headform will be connected to the breathing simulation system to simulate a sinusoidal breathing pattern of a human. Protection factor (PF) is an estimate of the performance of a respirator.

$$PF = \frac{C_{out}}{C_{in}}$$



- Human subject testing.** 20 human subjects will be recruited. The face width and length of subjects will be measured with spreading calipers. Subjects will randomly choose N95 to perform the quantitative fit testing (QNFT). Fit Factor (FF) will be used to evaluate the fit of N95 FFRs, and determined as

$$FF = \frac{C_{out}}{C_{in}}$$

DATA ANALYSIS

- The geometric mean (GM) and geometric standard deviation (GSD) of PF and FF values will be calculated. Comparisons will be performed among log-transformed PF-values and logged FF-values.
- Analysis of variance (ANOVA) will be performed to determine how the respirator designs (nose-shaped & respirator-shaped styles) impact the performance of N95 FFRs.
- Multiple regression analysis will be used to analyze the relationship between face dimensions influenced by gender/sex and race/ethnicity to the respirator fit.
- A p-value below 0.05 represents a significant difference.

EXPECTED RESULTS

- The FFR nose-clip design and shape styles will be significant factors in affecting the performance of respirator as quantified by the outcomes such as the PF and FF values.
- The facial dimension will impact the fit of FFR, and this relationship is influenced by the respirator design.