Assessment of a Novel Low-Cost Personal Respirator Evaluation Device

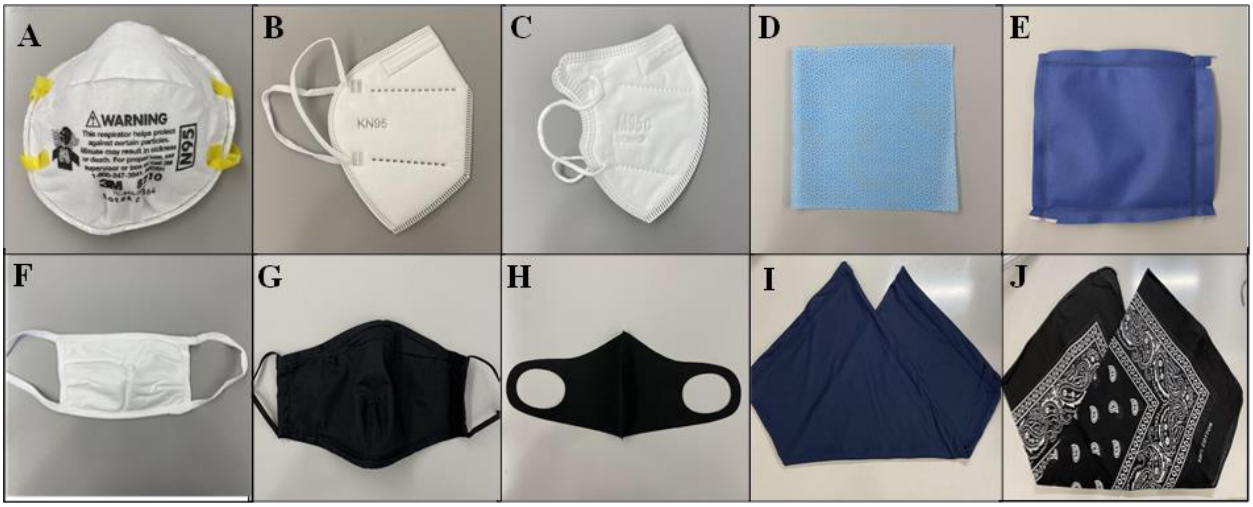
--

Quinton F. Burke M. Eng., Kevin Aroom M.S., P.E., and Martha O. Wang Ph.D.
Robert E. Fischell Institute for Biomedical Devices, University of Maryland, College Park

Supplemental Data

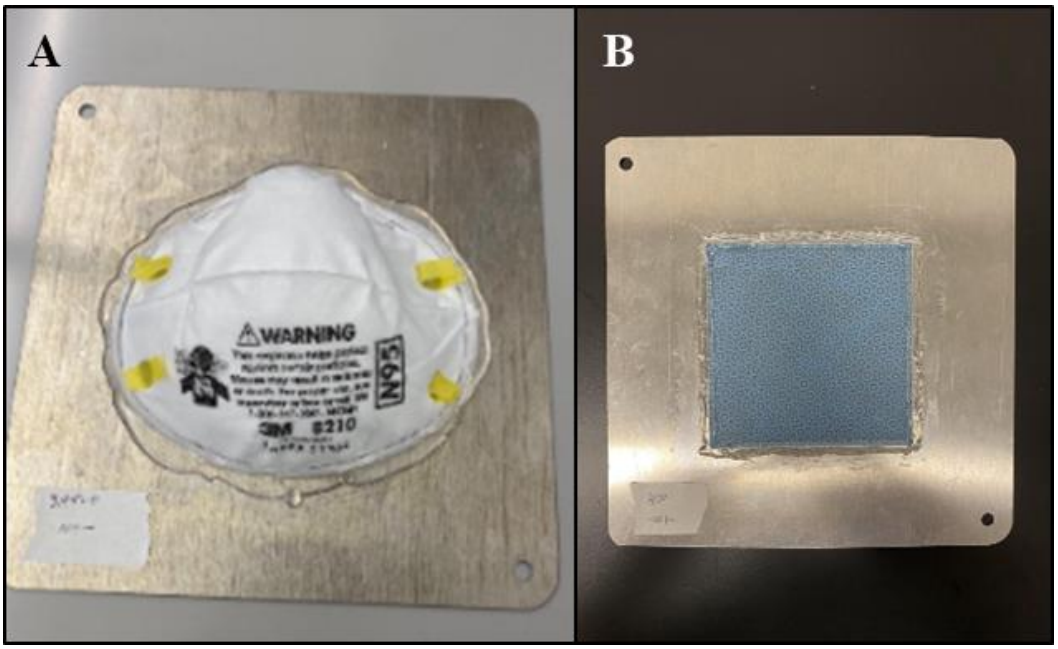
Supplemental Table I. Bill of materials for major components of the LREM in $U.S.

COMPONENT	UNIT COST	QUANTITY	TOTAL COST	SUPPLIER
Omega Flow Meter (FMA5542A)	$1,358.00	1	$1,358.00	Omega
TSI3076 Aerosol Generator	$3,375.00	1	$3,375.00	TSI Incorporated
Sensirion SPS30 Air Qualtiy Sensor	$45.84	2	$91.68	Digi-Key
Pressure Sensor (DLLR-L10D-E1BD-C-NAV7)	$68.06	1	$68.06	Digi-Key
Arduino Mega 2560	$43.13	1	$43.13	McMaster-Carr
Pressure Regulator (capable 35 psig)	$100.00	1	$100.00	n/a
Bacterial Viral Filter	$2.00	1	$2.00	n/a
Respirator Chamber				
Acrylic Tube (7" OD x 6-3/4" ID, L = 1')	$75.67	1	$75.67	McMaster-Carr
Acrylic Sheet (12" x 12" x 1/2")	$33.98	3	$101.94	McMaster-Carr
EPDM Foam Sheet (12" x 24" x 1/8")	$19.37	1	$19.37	McMaster-Carr
Mixing Chamber/Drying Apparatus				
Acrylic Tube (6" OD x 5-3/4" ID, L = 1')	$74.65	1	$74.65	McMaster-Carr
Wire Mesh (1' x 2')	$19.91	1	$19.91	McMaster-Carr
Silica Beads	$49.60	2	$99.20	Fisher-Scientific
TOTAL COST			**$5,428.61**	

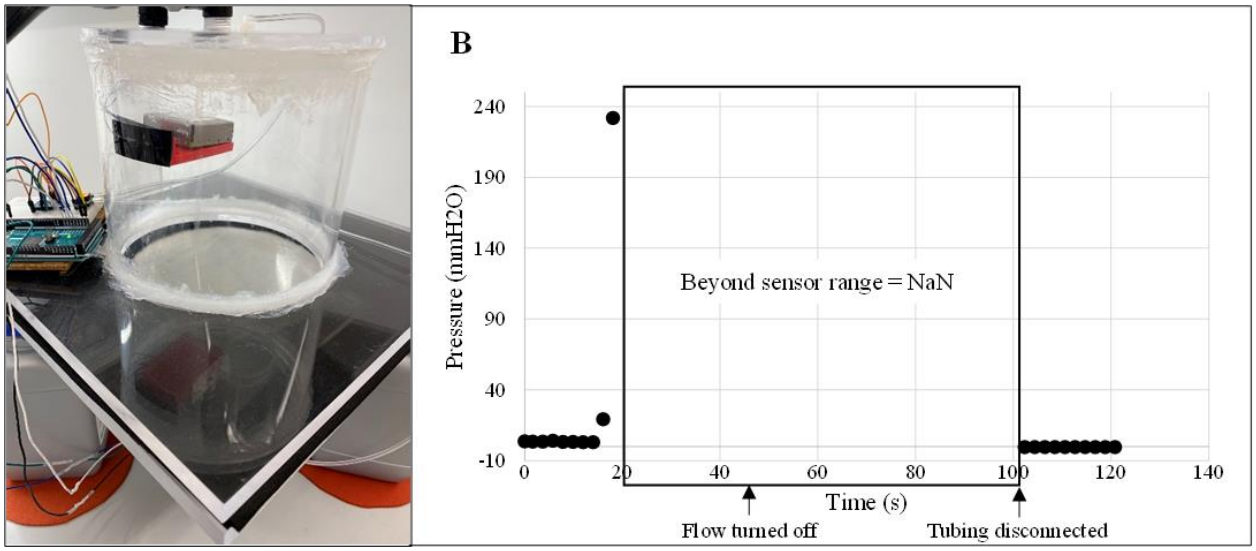


Supplemental Figure 1. The samples tested during this study. These were 3M 8210 N95 FFRs (a), Shanghai Tenry Pharmaceutical Co. Ltd KN95 respirators (b), Lutema M95c children's masks (c), Halyard H100 sterilization wraps (d), Medline heavyweight sterilization wraps (e), Hanes reusable cotton masks (f), VPAYI reusable cotton masks with PM2.5 filter inserts (g), Parquet polyester masks (h), neck gaiter material (i), and cloth bandanas (j).

Supplemental Figure 1. The ATI 100Xs used for this study.



Supplemental Figure 2. A 3M 8210 N95 FFR glued to an aluminum plate (a). An H100 fabric glued to a 100-centimeter squared aluminum plate (b).



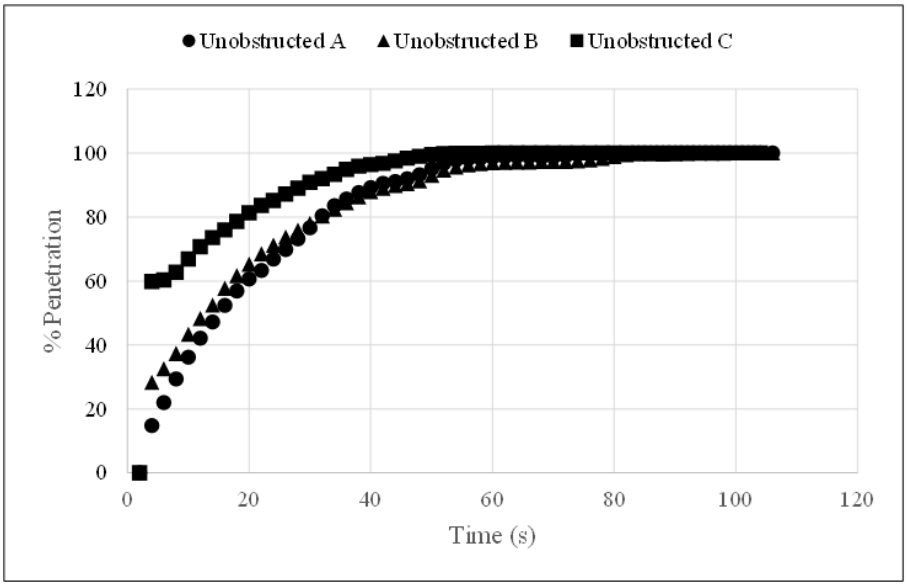
Supplemental Figure 1. Leakage testing setup for the LREM with an aluminum sheet blocking airflow within the chamber (a). During suction flow, pressure remained constant until the tubing was disconnected, indicating no leaks present (b).

Testing Day	Avg. Differential Pressure (mmH2O)
Test Day 1	-0.78
Test Day 2	-0.77
Test Day 3	-0.76
Test Day 4	-0.76
Test Day 5	-0.73

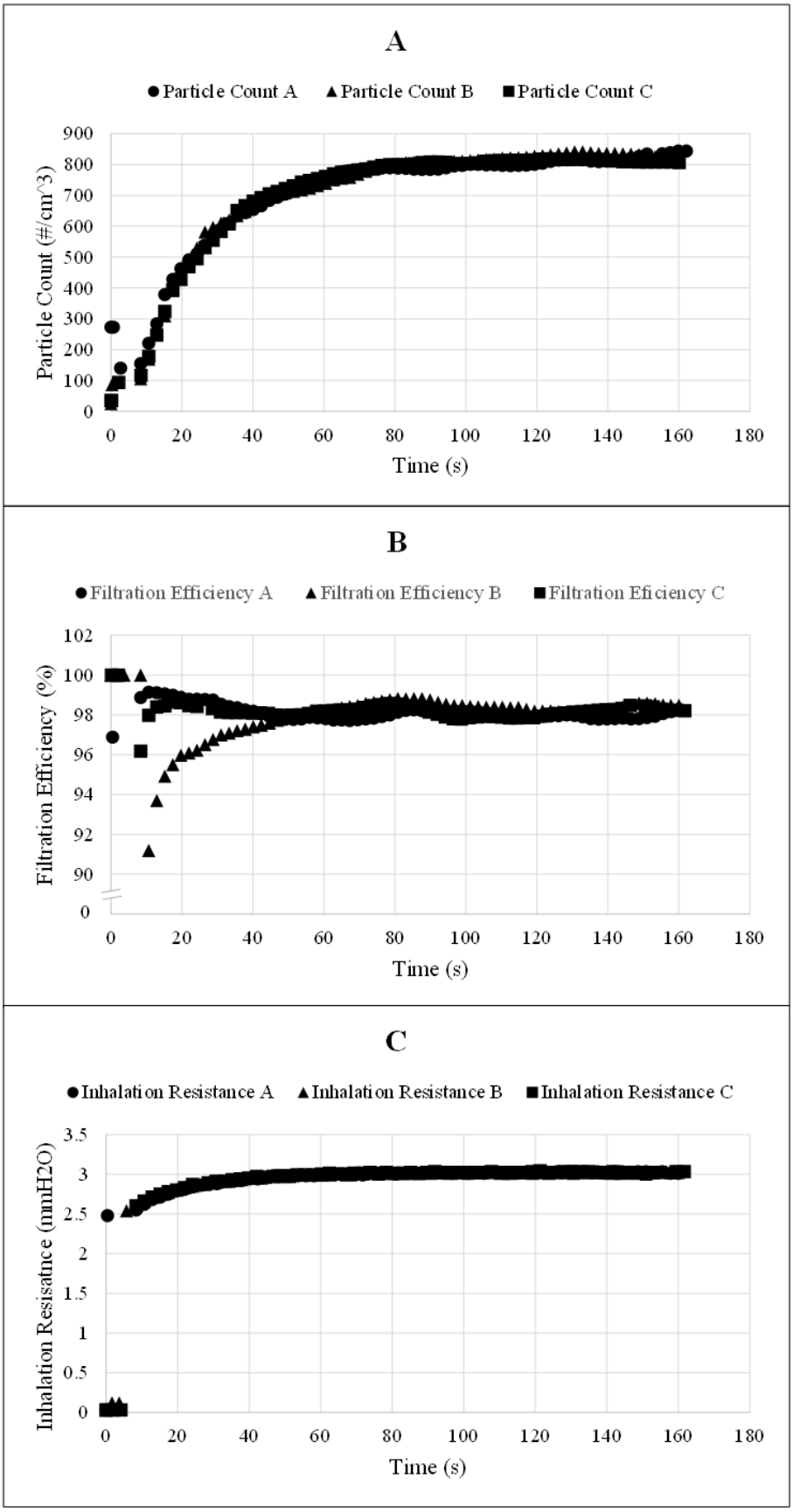
Supplemental Table II. Pressure baseline results for each test day. This step was done before testing on the LREM to set the baseline values on the Arduino sketch and calibrate the differential pressure sensor to zero.

Testing Day	Avg. % Difference Between Sensors
Test Day 1	1.45
Test Day 2	2.44
Test Day 3	2.62
Test Day 4	3.32
Test Day 5	1.67

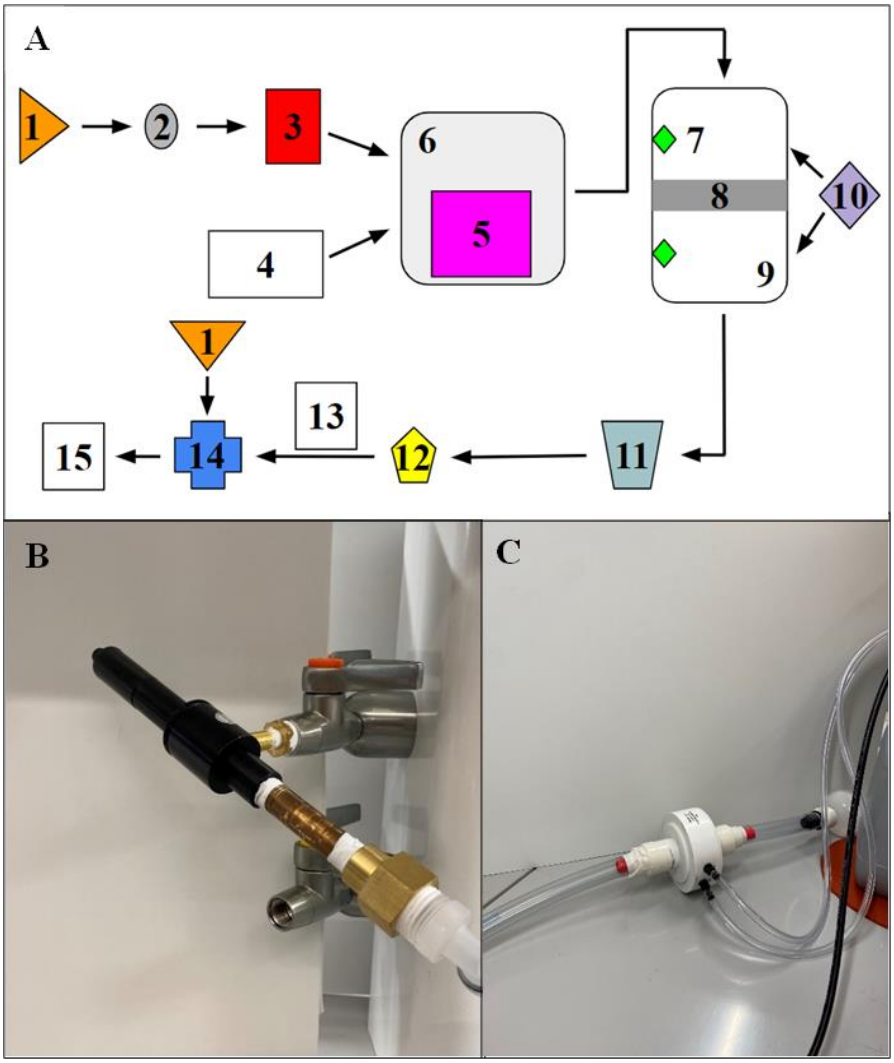
Supplemental Table III. Results of the PM sensors verification for each test day. This testing ensured that the two PM sensors were performing within the acceptable 5% of each other.



Supplemental Figure 2. Results of steady state testing on the ATI 100Xs. This testing was done at 10 lpm and found the time when the stationary point of percent penetration over time during unobstructed flow occurred. Over the three trials, this time was found to be at about 60 s.



Supplemental Figure 3. Results of steady state testing on the LREM. This testing was done at 30 lpm for three trials and found the time when the stationary point of particle count over time (a) was found as well as the stationary point of FE over time (b) and IR over time (c). Ultimately, steady state was determined to occur at 100 s.



Supplemental Figure 4. A schematic of the LREM design with the wall supply air source (1), pressure regulator (2), aerosol generator (3), ambient air (4), drying apparatus (5), mixing chamber (6), particulate matter (PM) sensors (7), mask/sample (8), respirator chamber (9), differential pressure sensor (10), pneumotachometer (11), bacterial viral filter (12), generated vacuum flow (13), venturi (14), and exhaust (15) (a). The actual venturi (b) and pneumotachometer (c).

Supplemental Table IV. Summary of average FE (%) and average IR (mmH2O) on both the ATI 100Xs and LREM with venturi vacuum pump setup.

	ATI 100Xs			LREM				
3M 8210 FFR (n=9 for ATI 100Xs, 10 for LREM)	*Average*	*Std.*	*Pass/Fail*	*Average*	*Std.*	*Pass/Fail*	*Statistically Significant?*	*% Difference*
FE (%)	99.778	0.075	**Pass**	99.068	0.256	**Pass**	Yes	0.71%
IR (mmH2O)	5.9	0.1	**Pass**	5.8	0.1	**Pass**	No	1.71%

Supplemental Material: Arduino sketches

DLLR Pressure Sensor Arduino Sketch from Github- jeremycole/AllSensors_DLHR

SPS30 PM Sensor Arduino Sketch from Github- paulvha/sps30

Combined Sensors Code Used for the LREM- qburke8/LREM