Qualitative Knowledge of Filtering Facepiece Respirators for Filtration Performance Tests during the COVID-19 Pandemic

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ABSTRACT

Background: During the COVID-19 pandemic, the pressure on health centers to obtain certified N95 filtering facepiece respirators (N95 FFRs) and the pressure on the FFRs production sector led to a diversification of FFRs' supply chains, with the approval of several government authorities.

Objective: The main issue then becomes whether these purchased FFRs are as effective as the FFRs commonly used in the pre-COVID-19 period.

Methods: The most efficient way is to test these FFRs under normative conditions. The setup used here allows to measure the pressure drop Δp (mbar) and the filtration efficiency E (%) of FFRs with a constant 85 Liter per minute. However, it would be useful to find visible markers that could indicate a possible defect (intentional or not) or a possible counterfeit.

Results and conclusions: The performance measurements and visual inspections of 43 types of FFRs are compared and analyzed in this paper. 35% of the FFRs received in the laboratory have a minimum filtration efficiency greater than 95%, and 28% have a minimum efficiency less than 80%. The results show that marks on FFRs are not a clear and precise indicator of the efficiency of the FFR. However, a visual inspection and a preliminary fit test can identify some ineffective FFRs.

Keywords: COVID-19, filtering facepiece respirator, filtration performance, aerosol, visual inspection, respirator certification.

INTRODUCTION

The current COVID-19 pandemic has dramatically disrupted research into respiratory protection devices and transmission routes of a virus such as SARS-CoV-2. This pandemic has, to date, infected more than 16 million people worldwide (John Hopkins University) and more than 100,000 Canadians, killing almost 9,000 in the country. At the start of this critical period, health centers had difficulty resupplying themselves with NIOSH N95-certified filtering facepieces respirators (FFRs). Indeed, due to the COVID-19 pandemic, the exponential rise in the use of N95 FFRs in healthcare centers has resulted in a shortage of FFRs and medical masks (COED, 2020).

In Canada, Health Canada (Health Canada, 2020) then stated that FFRs approved under other certifications and equivalent to N95 FFRs, such as KN95 (Chinese certification) and FFP 2 (European Certification), can also be used by healthcare workers, if the manufacturer can provide evidence that they have been tested and meet these appropriate standards. A comparison of filtration performance measurements according to US, European and Chinese certifications seems to indicate that the FFP 2 and the KN95 are 'similar', on paper, with the N95 (Table I). Therefore, health centers then switched toward KN95 and FFP 2 filtering facepiece respirators. Although the standards are globally equivalent, under the current difficult circumstances, fraud and defective FFRs could also be part of the FFRs purchased. One can note that currently the Chinese certifications GB2626-2006 and GB2626-2019 are both applicable. This summer, it was decided that the implementation of GB2626-2019 alone will be postponed from July 1st 2020 to July 1st 2021.

Table I. Filtration Performance Information (Efficiency and Pressure Drop) for the United States, European and Chinese certifications

		Certifications			
	Standard:	**NIOSH - 42CFR84**	**EN 149-2001**	**GB2626-2006**	**GB2626-2019**
	FFR class:	**N95 (United States)**	**FFP2 (European)**	**KN95 (Chinese)**	**KN95 (Chinese)**
Pressure drop (inhalation): maximum limit and conditions		343 Pa at 85 Lpm	70 Pa at 30 Lpm, 240 Pa at 95 Lpm and 500 Pa after clogging	350 Pa at 85 Lpm	210 Pa at 85 Lpm
Filter efficiency: minimum limit and conditions		95% at 85 Lpm and tested with NaCl	94% at 95 Lpm and tested with NaCl and paraffin oil	95% at 85 Lpm and tested with NaCl	95% at 85 Lpm and tested with NaCl

During the very beginning of the COVID-19 pandemic, Concordia University's filtration laboratory was open during the lockdown to use its installation and expertise and to help decision-makers in Quebec (Canada) in the choice of available FFRs to provide health services. Although our laboratory is not able to perform certification tests, its expertise in the filtration performance of filtering facepieces and its installations are unique in Quebec. While the test conditions used in the laboratory are close to the standards, they differ in some points (Brochot et al, 2020b). The purpose of the tests carried out during this period were then to compare the filtration performance results of the samples received with those

obtained for a certified N95 FFR frequently used in our pre-COVID-19 research. The filtration performance, filtration efficiency and pressure drop measurements, were obtained at initial conditions (i. e. without loading tests) and without conditioning.

The laboratory tested more than 150 types of FFRs with the intention of comparing all the results. The FFRs included new imports, expired batches of FFRs, batches certified via different geographical areas, prototypes from Quebec industries, and FFRs treated for decontamination. Indeed, due to the shortage, several healthcare institutions have been looking into the retreatment of N95 FFRs via hydrogen peroxide vapor, UV or heat treatments for example. This study focuses specifically on the FFRs received which are neither prototypes nor treated FFRs.

This paper first presents the FFRs received, their visual inspection, and then their performance results. The data are analysed to attempt to determine what information might be used to acquire qualitative knowledge about FFRs prior to their use.

MATERIALS AND METHODS

Reception and testing process implemented in the laboratory

The evaluation of FFRs was coordinated by the National Institute of Public Health of Quebec (INSPQ). The INSPQ received requests for FFR evaluations from various health centers in Quebec. These evaluations were organized into two parts: the fit test evaluation and filtration performance measurements. The INSPQ then arranged for a minimum of five samples of FFRs to be sent to Concordia University's filtration laboratory to provide filtration performance measurements.

Upon receipt of the samples at the laboratory they are recorded, photographed and a visual inspection was performed. This visual inspection included the description of its design and composition as well as an integrity check. The samples and their container were photographed and used for identification. The samples were then tested by measuring the filtration efficiency and the pressure drop with the experimental test bench described later in this paper. A short test report included the results of three (3) different samples of the FFR tested, and the average filtration performance (filtration efficiency and pressure drop). Following completion of the testing, the samples were stored in the laboratory.

Filtering Facepieces received in the laboratory and used in this study

Only FFRs received with at least 3 samples and which are neither prototypes nor treated FFRs, are presented in this paper. From all of the FFRs received, 43 types of FFRs are used here.

Table II presents the characteristics of these 43 different FFRs. FFRs received at the laboratory were packaged either in boxes or in bags, with or without marks on it. FFR samples also may or may not have marks on them. These marks primarily may contain information about the manufacturer, the instructions and some provide certification information. It should be noted, however, that report of the classification does not necessarily imply a certified FFR. For example, the indication of ‘N95’ does not guarantee that the FFR has been N95 certified. According to its certification, it must, among other things, mention ‘NIOSH’ and the approval number associated with its certification. Likewise the ‘KN95’ mention does not guarantee that the FFR has been KN95 certified, it should mention ‘GB2626 2006’ or ‘GB2626 2019’. As well as the ‘FFP 2’ indication doesn’t guarantee that the FFR has been FFP 2 certified, it should mention ‘EN149+A1:2009’. 12 of 13 ‘N95’ FFRs present the ‘NIOSH N95’ indication, 5 of 7 ‘FFP 2’ FFRs present the mention ‘EN149+A1:2009’, 11 of 19 ‘KN95’ FFRs present ‘GB2626 2006’ and none of them mentioned the new Chinese standard ‘GB2626 2019’. Given the situation at the beginning of the COVID-19 crisis, although some FFR did not seem certified, the tests have been carried out to provide a

maximum of sufficient information for decision-makers. However, since the information on the boxes or bags couldn't be retrieved for all the samples, from here onwards FFRs are identified only with the information marked on the FFR.

Table II. Description of the FFRs on Receipt

FFR No.	Description on receipt	marks on the box/bag			marks on the FFR		
		N95	FFP2	KN95	N95	FFP2	KN95
1	Bags of 2 FFRs		‡			‡	√
2	Bags of 2 FFRs			†			
3	just the samples	not applicable			*		
4	Bags of 3 FFRs			†			†
5	Box of 20 FFRs	√			*		
6	Box of 20 FFRs	√			*		
7	Box of 20 FFRs	√			*		
8	Box of 10 FFRs	√	‡		√	√	
9	Box of 20 FFRs	√			*		
10	Bags of 5 FFRs			†		‡	
11	Bags of 2 FFRs			†			†
12	Bags of 4 FFRs						√
13	Bags of 2 FFRs		‡				
14	Bags of 6 FFRs		‡			‡	
15	Bags of 1 FFR			√			
16	Bags of 1 FFR			√			
17	just the samples	not applicable					
18	just the samples	not applicable					
19	Bags of 5 FFRs						†
20	just the samples	not applicable			*		
21	just the samples	not applicable			*		
22	Bags of 1 FFR	√			*		
23	Bags of 2 FFRs			√			†
24	Bags of 1 FFR						√
25	just the samples	not applicable				√	√
26	just the samples	not applicable					†
27	Bags of 5 FFRs			√			√
28	Bags of 5 FFRs		‡	√			√
29	Box of 10 FFRs		‡	√			√
30	just the samples	not applicable				‡	
31	just the samples	not applicable			*		
32	Bags of 1 FFR			†			†
33	Box of 50 FFRs		√	√			
34	Bags of 2 FFRs			†			†
35	just the samples	not applicable			*		
36	just the samples	not applicable			*		
37	Bags of 1 FFR				*		
38	just the samples	not applicable					
39	just the samples	not applicable					†
40	just the samples	not applicable					†
41	just the samples	not applicable				‡	†
42	just the samples	not applicable					√
43	just the samples	not applicable					†

*√: mentions only the classification, *: mentions NIOSH N95, ‡: mentions the CE standard, EN149+A1: 2009, †: mentions the Chinese standard GB2626, 2006*

In Table II, one can notice that 37% of the FFRs received are marked ‘KN95’, 28% are marked ‘N95’, 7% are marked ‘FFP 2’, 2% are marked both ‘FFP 2’ and ‘N95’, 7% are marked ‘FFP 2’ and ‘KN95’ and 19% of the FFRs received have no marks.

If we assume that these FFRs received by the laboratory are representative of those available by health centers in Quebec during the first period of the pandemic, one can notice that a third of the FFRs are marked ‘N95’. Almost half of the FFR are marked ‘KN95’, while only one tenth is marked ‘FFP 2’.

Experimental filtration performance setup

The experimental setup used for measuring the filtration performance of FFRs is presented in Figure 1. This setup was used in different pre-COVID-19 projects for the study of the filtration performance of FFRs according to different parameters, in order to get as close as possible to their actual conditions of use (particle diameter, respiratory simulation and its intensity, relative humidity, etc). These projects led to the publication of several papers (Bahloul et al, 2014, Mahdavi et al, 2014 and 2015, Brochot et al, 2015, 2020a and 2020b). This setup was then used to measure the pressure drop Δp (mbar) and the filtration efficiency E (%) of a filtering facepiece, with a 85 L/min constant flowrate and at the initial condition (i. e. without loading).

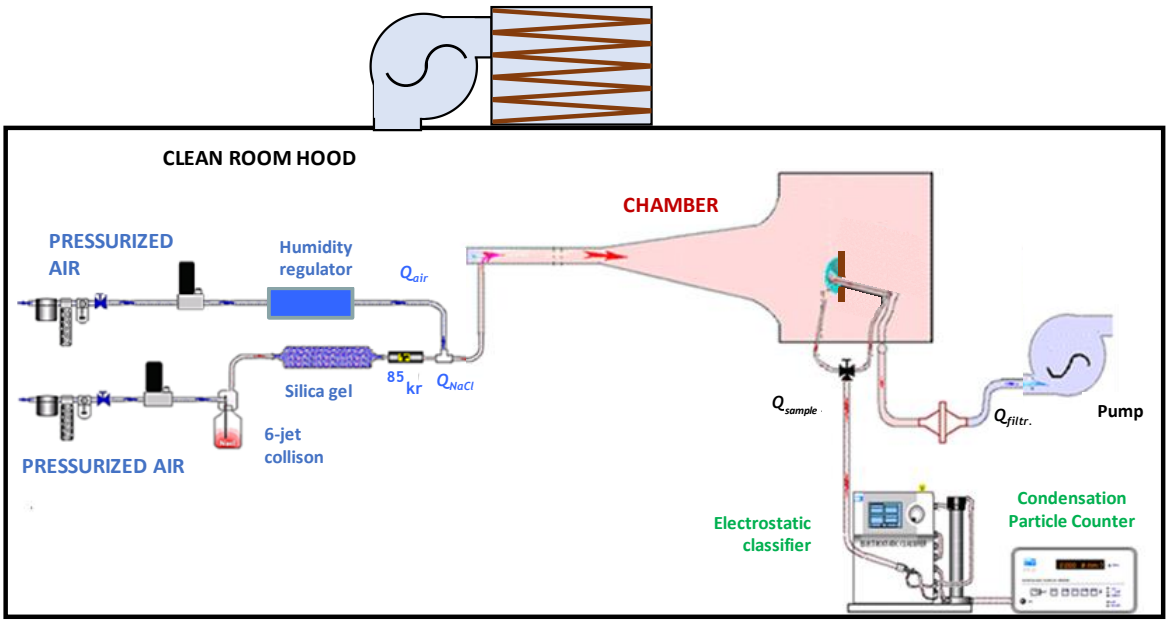

Figure 1. Experimental test bench used to measure the filtering facepiece respirator performance.

The chamber has been designed to provide a controlled environment with a homogeneous and constant flowrate upstream of the filtering facepiece. The aerosol generation is also constant over time, homogeneous and controlled over the entire test. The tested FFR is installed on a support plate and sealed with an adhesive tape.

The test aerosol consists of NaCl particles ranging from 20 nm to 600 nm, and centered at around 70 nm. This aerosol is generated using a 6-jet Collison nebulizer (CN2425 BGI Inc., Waltham, MA, USA) filled with an NaCl solution. The aerosol is then brought to a globally neutral charge (Boltzmann equilibrium) using an ^{85}Kr neutralization source (3054A, TSI Inc., Shoreview, MN, USA). The particles,

dried and diluted are then sent to the chamber. The relative humidity in the chamber is then measured to be less than 30%.

The constant flowrate is regulated at 85 L/min and two sample probes (of the same length) are used to collect the aerosol sample upstream and downstream of the FFR. These same two probes provide the FFR's pressure drop measurement.

The pressure drop is measured according to equation (1), using a FLUKE 922 differential pressure sensor (Fluke corp., Everett, WA, USA). This instrument has a measuring range of ± 40 mbar, with a reading accuracy of ± 1%, i.e. 0.4 mbar.

$$\Delta p = p_{upstream} - p_{downstream} \quad (1)$$

The FFR's filtration efficiency E is given as a function of the concentrations downstream and upstream of the FFR following equation (2).

$$E\,(\%) = (1 - P) \times 100 = \left(1 - \frac{C_{dowstream}}{C_{upstream}}\right) \times 100 \quad (2)$$

The aerosol concentration is measured using a Scanning Mobility Particle Sizer (SMPS) (TSI 3080, TSI 3081, TSI 3087, TSI 3775, TSI Inc., Shoreview, MN, USA). It measures the particle concentration of an aerosol as a function of the electric mobility diameter. After charging the aerosol according to a well-known distribution of electrical charges with an X-ray source, the particles pass through a differential mobility analyser (DMA) and under an electric field. The charged particles are deflected and a monodispersed and positively charged aerosol then enters into a condensation particle counter. The particle size is then increased by the condensation phenomenon and detected using a photodetector. The two sampling probes enable measurements of the concentrations (measured in number) upstream and downstream of the FFR.

Methodology for filtration performance measurement

For each type of FFR received in the laboratory, the same methodology has been used for its performance measurement and is presented below.

Each FFR was tested without conditioning. FFRs are well sealed on the support plate in order to eliminate leaks. After checking the NaCl solution level in the generator and setting the flowrate to 85 L/min (using a TSI 4043 flowmeter), the FFR is installed on the setup and the pressure drop is measured. During positioning, the higher pressure drop corresponds to the best FFR's position. It is therefore sought, and its stability is verified. Using the SMPS, the particle size distributions are then carried out with the sequence « upstream (3 scans), downstream (3 scans), then upstream (2 scans) ». The stability is verified by comparing the two upstream. The pressure drop is then checked again, as well as the flowrate. The FFR is then removed and another FFR is tested according to the same protocol. For each type of FFR, the results presented in this paper are the mean and the standard deviation of the three samples (N = 3). The whole performance measurement takes from 20 to 40 minutes for one sample. The choice of 3 samples is essentially motivated by the measuring time for a proper measurement of one sample and by the urgency of the situation. Indeed, during the beginning of the COVID-19, it was important to deliver information as quickly as possible to help decision-makers.

It should be noted that even if this setup is not used as the standard test, it is close to it, although differing in some aspects. The most important difference is that, unlike standard tests, the efficiency obtained in this test bench are measurements according to the particle diameter (expressed in electric mobility), and not a total mass measurement. It shows the difference in FFR efficiency depending on the particle size.

RESULTS AND DISCUSSION

Visual inspection of the Filtering Facepieces

Visual inspection is used to retrieve information on the samples, regarding their integrity but also their design and composition. Table III presents a brief description of the different FFRs presented in this paper.

Of the 43 types of FFRs presented, 77% of FFRs are flat fold FFRs. The remaining 23% of those received are molded, or ‘preformed’ FFRs. Following the same assumption as above, that the samples received are representative of FFRs available for the Quebec health centers during the first period of the pandemic, one can notice that the majority of available FFRs were 'flat fold' FFRs rather than 'molded' ones.

Also, 65% of the FFRs received include ear loops while 35% have head bands. Approximately two thirds of the available FFRs used ear loops.

Filtration performance results: filtration efficiencies and pressure drops

Following the methodology and with the test bench presented above, for each type of FFR received, the pressure drop and filtration efficiency are performed. As an example, the graphs of the results of two FFRs, FFR number 4 and FFR number 17 are shown in Figure 2 (filtration efficiencies) and in Figure 3 (pressure drops).

FFR 4 shows very good filtration efficiency, unlike FFR 17. The filtration efficiencies measured for FFR 4 are all greater than 95% while the minimum efficiency of FFR 17 is 55%. And even more, the average maximum efficiency of FFR 17 is 80%, much less than the average minimum efficiency of FFR 4. The most penetrating particle size (MPPS), i. e. the particle size at which the efficiency is minimal, is different for the two FFRs. While FFR 4 has MPPS less than 100 nm, FFR 17 has MPPS greater than 100 nm. Considering the literature data (Balazy et al., 2006; Huang et al, 2007; Brochot et al., 2019, 2020a and 2020b), these results suggest that FFR 4 may be composed of an 'electret' filter material while the FFR 17 may use mechanical means to filter the particles. Also, the FFR 4 and FFR 17 have comparable pressure drops to each other of 0.71 ± 0.00 mbar and 0.81 ± 0.19 mbar, respectively. It can therefore be noted that although the pressure drops are equivalent, the two FFRs have very different filtration efficiencies.

Table III. Description of the FFRs at Their Visual Inspection

FFR No.	flat fold	molded	adjustable nose clip	ear loops	head bands	sealed	stapled
1	X		X	X			X
2	X			X		X	
3		X	X		X	X	
4	X		X	X		X	
5		X	X		X		X
6		X	X		X	X	
7		X	X		X		X
8	X		X	X		X	
9		X			X	X	
10	X		X	X		X	
11	X		X	X		X	
12	X		X	X		X	
13	X		X	X		X	
14	X		X	X		X	
15	X		X		X	X	
16	X		X	X			X
17	X		X	X		X	
18	X		X	X		X	
19	X		X	X		X	
20		X	X		X	X	
21		X	X		X	X	
22	X		X		X		sewn
23	X		X	X		X	
24	X		X	X		X	
25	X		X	X		X	
26	X		X	X		X	
27	X		X	X		X	
28	X		X	X		X	
29	X		X	X		X	
30	X		X		X	X	
31		X	X		X	X	
32	X		X	X		X	
33	X		X	X		X	
34	X		X		X		X
35		X	X		X	X	
36		X	X		X	X	
37	X		X		X		X
38	X		X	X		X	X
39	X		X	X			X
40	X		X	X			X
41	X		X	X			X
42	X		X	X			X
43	X		X	X			X

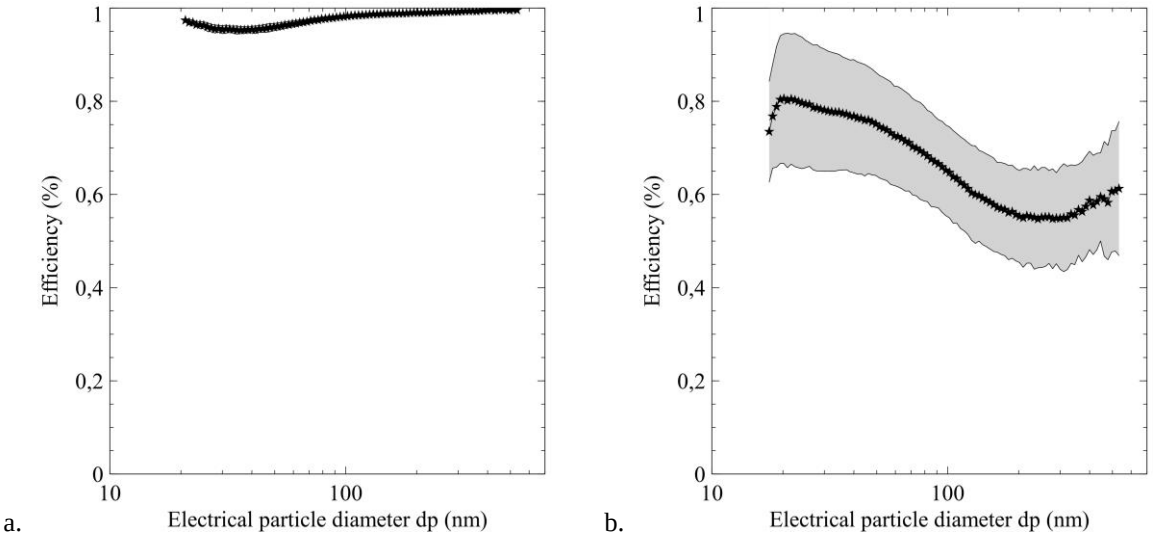

Figure 2. Mean filtration efficiency curves for: a. FFR 4 and b. FFR 17 (N = 3).

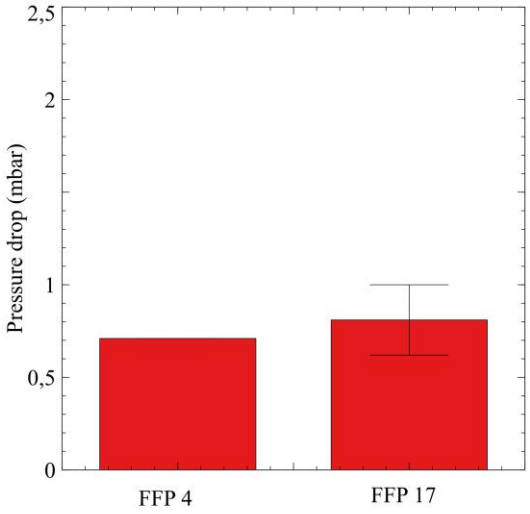

Figure 3. Mean pressure drops (with standard deviation) for FFR 4 and FFR 17 (N = 3).

Filtration performance results and comparison

Table IV and Figure 4 present a summary of the performances measured on the 43 types of FFRs tested in the laboratory during the beginning of the pandemic period.

Table IV and Figure 4 show that 35% of the FFRs received in the laboratory have a minimum filtration efficiency greater than 95%, or 44% have a minimum filtration efficiency greater than or equal to 95%. 60% of the FFRs have a minimum filtration efficiency greater than 90%, and 28% have a minimum filtration efficiency less than 80%.

Table IV. Performance Tests Results

FFR No.	Minimum efficiency measured (N = 3) in the 20-600 nm range (mean ± standard deviation)	MPPS range	Pressure drop (N = 3) (mean ± standard deviation)
1	95 ± 1 %	< 100 nm	0.96 ± 0.08 mbar
2	97 ± 1 %	< 100 nm	1.27 ± 0.08 mbar
3	96 ± 0 %	< 100 nm	0.89 ± 0.01 mbar
4	95 ± 1 %	< 100 nm	0.71 ± 0.00 mbar
5	97 ± 1 %	< 100 nm	1.22 ± 0.19 mbar
6	62 ± 1 %	> 100 nm	1.28 ± 0.24 mbar
7	96 ± 3 %	< 100 nm	0.97 ± 0.05 mbar
8	56 ± 10 %	> 100 nm	0.67 ± 0.21 mbar
9	96 ± 1 %	< 100 nm	0.84 ± 0.03 mbar
10	97 ± 0 %	< 100 nm	1.14 ± 0.07 mbar
11	80 ± 5 %	> 100 nm	0.75 ± 0.04 mbar
12	95 ± 1 %	< 100 nm	1.06 ± 0.29 mbar
13	89 ± 4 %	< 100 nm	0.44 ± 0.03 mbar
14	97 ± 0 %	< 100 nm	1.61 ± 0.05 mbar
15	95 ± 1 %	< 100 nm	1.05 ± 0.07 mbar
16	51 ± 6 %	> 100 nm	0.72 ± 0.25 mbar
17	55 ± 10 %	> 100 nm	0.81 ± 0.19 mbar
18	93 ± 3 %	< 100 nm	1.20 ± 0.15 mbar
19	96 ± 1 %	< 100 nm	1.39 ± 0.14 mbar
20	97 ± 1 %	< 100 nm	0.99 ± 0.10 mbar
21	85 ± 1 %	< 100 nm	0.66 ± 0.03 mbar
22	93 ± 1 %	< 100 nm	0.26 ± 0.03 mbar
23	41 ± 5 %	> 100 nm	0.80 ± 0.04 mbar
24	86 ± 3 %	< 100 nm	0.53 ± 0.07 mbar
25	87 ± 3 %	< 100 nm	0.72 ± 0.09 mbar
26	80 ± 4 %	> 100 nm	0.91 ± 0.04 mbar
27	96 ± 1 %	< 100 nm	1.03 ± 0.03 mbar
28	78 ± 3 %	> 100 nm	0.69 ± 0.04 mbar
29	74 ± 1 %	≈ 100 nm	0.56 ± 0.05 mbar
30	96 ± 1 %	< 100 nm	0.54 ± 0.03 mbar
31	97 ± 1 %	> 100 nm	1.03 ± 0.01 mbar
32	41 ± 2 %	≈ 100 nm	1.00 ± 0.11 mbar
33	89 ± 1 %	< 100 nm	0.88 ± 0.05 mbar
34	94 ± 1 %	< 100 nm	0.92 ± 0.04 mbar
35	96 ± 0 %	< 100 nm	0.94 ± 0.04 mbar
36	97 ± 0 %	< 100 nm	0.95 ± 0.02 mbar
37	94 ± 1 %	< 100 nm	0.71 ± 0.05 mbar
38	92 ± 4 %	> 100 nm	0.92 ± 0.25 mbar
39	94 ± 1 %	< 100 nm	1.04 ± 0.20 mbar
40	94 ± 2 %	< 100 nm	0.94 ± 0.02 mbar
41	98 ± 2 %	< 100 nm	1.71 ± 0.15 mbar
42	79 ± 32 %	> 100 nm	1.35 ± 0.57 mbar
43	59 ± 25 %	> 100 nm	0.55 ± 0.09 mbar

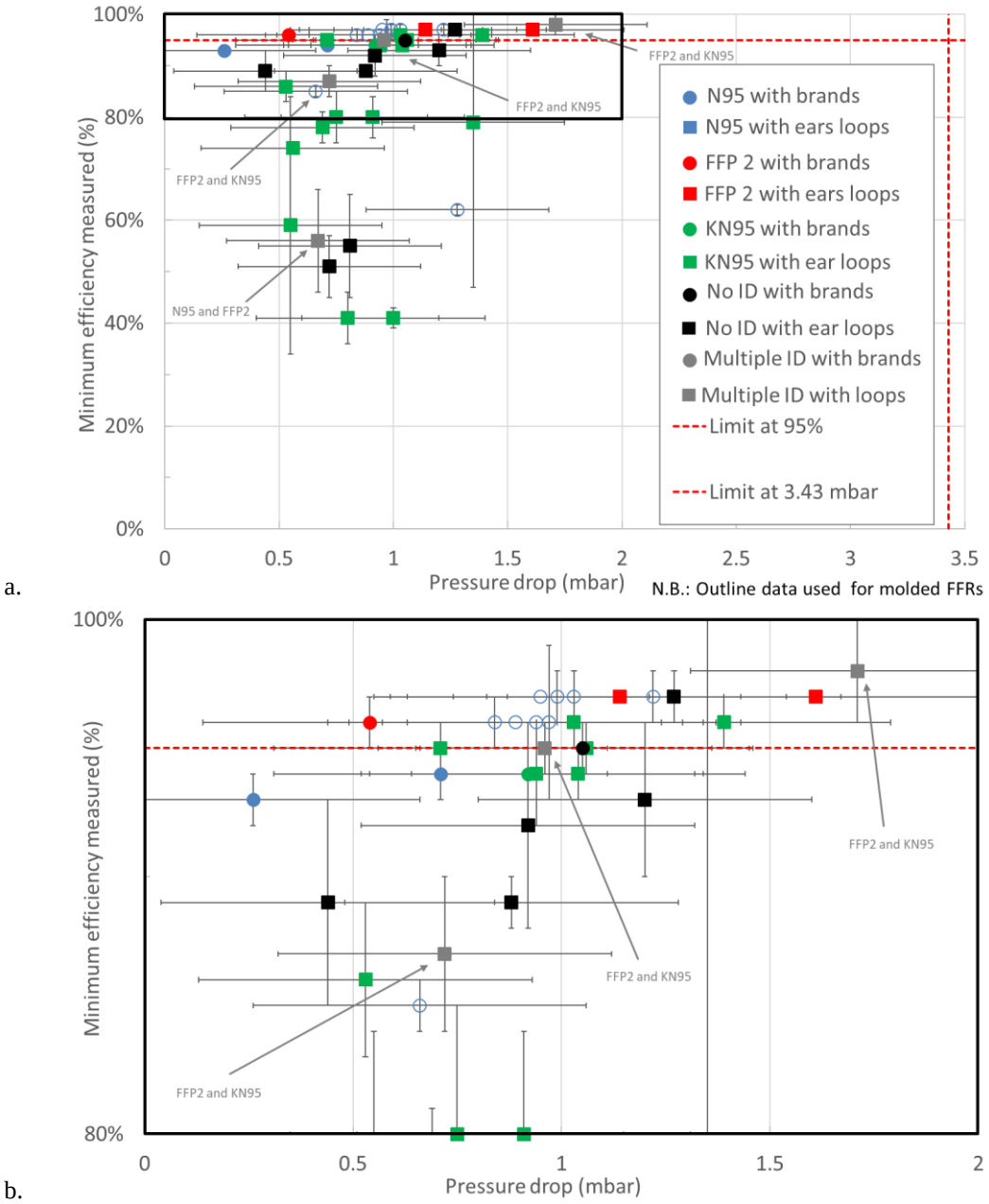

Figure 4. Minimum efficiencies (with standard deviation) according to pressure drop (± 0.4 mbar) a. for the 43 types of FFRs tested, and b. zoom at minimum efficiency values higher than 80%.

For this paper, and to facilitate discussion, FFRs that have minimum efficiencies greater than or equal to 95% are termed ‘good FFRs', and those with minimum efficiencies less than 80% are termed 'poor quality FFRs'. It can also be noted that only 6 results present minimum efficiency standard deviations greater than 5%. These results have a minimum efficiency value of less than or equal to 80%. For this type of FFR, depending on the sample used, the wearer's protection will not be the same, and therefore its protection cannot be precisely known.

In the population of ‘good FFRs’ (minimum efficiency ≥ 95%), it is observed that 42% of them are marked 'N95' (i.e. with standard citation), 26% are marked 'FFP 2', 32% are marked 'KN95' and 11% have no marks following these certifications. Considering the proportions from the 43 FFRs received, one can observe that the N95-labeled FFRs generally perform better than KN95-labeled FFRs. However, it should be noted that due to the wide dispersion of the filtration efficiency results, this difference is not statistically significant. Also, the fact that there are no markings on the FFR does not necessarily mean that the FFR is not good. Still in the category of ‘good FFRs’, 95% of those tested have an MPPS below 100 nm. On the contrary, in the case of the ‘poor quality FFRs’ (minimum efficiency < 80%), 100% of these FFRs show an MPPS more than or equal to 100 nm. From the literature (Kanaoka et al, 1987; Huang et al, 2007; Kim et al, 2007; Lore et al, 2010), it can be deduced that the majority of ‘good FFRs’ consist of an ‘electret’ medium.

In the population of ‘good FFRs’, 58% are ‘flat fold’ FFRs and 42% are ‘preformed’ FFRs. Considering the proportions of the 43 FFRs, one can observe that the received molded FFRs are better than the flat folded FFRs. Also, 47% of FFRs are made up of ear loops and 53% are with head bands. Considering the proportions from the 43 FFRs, one can observe that FFRs with head bands are more likely to perform better than FFRs with ear loops. Also, one should note that, according to the CDC (CDC, 2020a), FFRs made up of ear loops ’have difficulty achieving good fit’. This is also one of the criteria cited by the CDC to identify possible counterfeits of FFRs: they consider that an FFR that has ear loops instead of head bands may be counterfeit (CDC, 2020b).

It should be noted that 43 types of FFRs were analysed in this article, which represents a large amount of data to perform and process. Regardless, 43 different sample types do not provide a comprehensive view of the huge array of FFRs that came to the market during this period. However, these results demonstrate that the manufacturers’ proclamations should be put into perspective with the actual filtration performance of FFRs.

CONCLUSION

During the pandemic period, the use of FFRs has exploded around the world, making the production, availability, and acquisition of FFRs difficult. Health Canada's opening up to certified FFRs from other parts of the world has helped to limit pressure on this sector. However, the results of different samples obtained by some laboratories, including our laboratory, showed that some of these FFRs did not meet the requirements. The CDC and Health Canada, among others, once alerted to defects and counterfeits masks found on various masks, then recalled the goods after testing for non-compliance (Government of Canada, 2020; CDC, 2020b; HSE, 2020; Ippolito et al, 2020).

This paper reports the outcomes of experimental work which investigated the filtration performance of 43 different filtering facepieces respirators received during the beginning of the pandemic period. The question raised in this paper is whether, through visual inspection, it is possible to derive simple but useful information to understand the filtration performance of FFRs.

First, one can see that the majority of FFRs come from the Asian region. The results show that marks on the FFRs, regardless of the written certification, are not conclusive with regards to their efficiencies. It can also be seen that it is impossible, with simple visual inspection, to determine which samples are effective, counterfeit, or which samples contain manufacturing defects, intentional or not. First, a visual inspection makes it possible to verify that the markings on the FFRs correspond to the certifications’ requirements. Also, it appears that a visual inspection could help us know if the fit test could be negative. Indeed, according to the CDC, FFRs with ‘ear loops’ have difficulty achieving a good fit ’and may be counterfeit’. It therefore seems important in the evaluation of an FFR to first carry out a fit test study, then to test the filtration performance of the FFR.

However, it is important to note that the results presented here are the FFR filtration performance, and do not reflect its performance during actual use. Installation of the FFR and leaks during use are not taken into account in these tests. To use FFR correctly, wearers must have usage information, follow training sessions and pass a fit test.

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