Is the use of masks, extended to the entire population, more harmful than useful?

A study on inhaled CO2 with the use of nose and mouth cover devices and a mini-review.

Authors: Bernhard Oberrauch * (Dr. architect and green building expert), Marco Adami (physicist), Ulrich Gutweniger (psychologist), Elisabetta Galli (MD), Veronika Dellasega (MD), Heike Müller (MD), Bernhard Thomaser (MD), Maria Paregger (MD), Roberto Cappelletti * (MD).
* correspondence to the authors: bernhard.oberrauch@archiworldpec.it ; roberto.cappelletti.03yu@tn.omceo.it

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Introduction. In Italy, from November 4, 2020, the obligation to wear a mask has been extended outdoors and, for students over 6 years old, to the entire period of stay at school. The symptoms complained of after prolonged use of masks, such as loss of concentration, headache, fatigue, difficulty in breathing, dizziness, could be caused, according to knowledge already known in physiology, by the high levels of carbon dioxide (CO2) (table 3). We therefore wanted to carry out some tests to detect the amount of CO_2 that is inhaled in the microenvironment of the mask, in the hypothesis that the excess of this gas can justify, at least in part, the frequently complained disorders.

A study on "Air quality with the use of nose and mouth covering devices" was recently published by the Province of Bolzano [1]. Since the conclusions of this study, as they were communicated to the general public ("masks are not harmful"), did not seem in line with what was reported by the same results of the Province, we also wanted to compare them with our data.

We therefore tried to understand how the mask works and the reason for the variations in results for the various types of devices. Finally, we carried out a research in the literature on other possible damages (increase in infections, psychological aspects, risk compensation, increased respiratory work, etc.) due to nose and mouth covering devices.

Method. We measured the re-inspired CO_2 in 24 healthy individuals of various ages (mean 48, range 5-88 years), with the different types of masks, exclusively in the sitting position. The portable carbon dioxide analyzer G100, Geotech (www.geotechuk.com), equipped with an internal 100 cm3 / min pump, an infrared sensor with a measuring range of 0-20 in volume (per cent) and an accuracy of 1%. The tube was placed under the nose and the pump was activated at the beginning of the inhalation and turned off at the end. The same for the measurements during the exhalation.

Results. the results of the inspiratory CO_2 measurements in sitting position are summarized here (for the purpose of comparison with the results of the province of Bolzano):

for the surgical mask: average CO_2 value **7,292** ppm (range 5000 - 13,000) versus 3,350 ppm (range 950 - 5320) from the study of the province of Bolzano.

For FFP2-N95 masks: average CO_2 value **11,000** ppm (range 7000 - 15,000) versus 3,850 ppm (range 1220 - 8080) from the study of the province of Bolzano.

For cloth masks / neck warmers: average CO_2 value **11,500** ppm (range 5000 - 24,000) versus 4590 ppm (range 1480 - 10,280) from the study of the province of Bolzano.

Without mask: average CO_2 value 3143 ppm (range 2000 - 5,000) versus 590 ppm (range 50 - 2250) of the study of the province of Bolzano.

The discrepancy between our results and those of the Bolzano Province study cannot be justified solely by the fact that the CO_2 values of the ambient air have been subtracted from the latter, nor by the presence of a different margin of error of the instruments of measurement. In fact, the measuring instrument used by the Province (Horiba_PG250) has an accuracy similar to that used by us (G100). Further studies are needed to better understand the causes of this discrepancy.

Our study confirms that masks with a large cavity (FFP2) are worse than tighter masks. The worse result with the cloth masks compared to the surgical masks is probably due to the lower permeability of the cloth masks. Talking or, worse, singing with the mask increases the amount of CO_2 in the inhalation + exhalation.

In tables no. 4, 5 and 6 (and related graphs) show the values of the measurements in the various subjects, in the different situations (only exhalation, only inhalation and mixed inhalation-exhalation), with the different types of masks.

Results of the mini-review. We have examined more than 40 studies on the usefulness of masks in preventing respiratory infections, finding no evidence of efficacy in extending their use to the entire population, outside healthcare facilities[2-47]. On the contrary, some studies highlight how, for example for cloth masks, moisture retention, reuse and poor filtration can even increase the risk of infection[39]. A study of thousands of individuals during pilgrimages to Mecca found more respiratory infections in the group that constantly wore masks[46]. Quite frequent appear dermatological forms such as "maskne" (mask acne). "Risk compensation" phenomena were also detected, caused by a false sense of security generated by the use of the mask[48]. Finally, it is necessary to note the increase in respiratory resistance and the consequent increase in the work of the respiratory muscles with the use of FFP2[36,49] masks. WHO currently recommends that people wear face masks only if they have respiratory symptoms or if they need to take care of someone with symptoms: individual states are left to possibly extend the indications.

Psychological effects. The mask is a symbol of danger which, by covering the face, prevents one from making the other known, and recognizing human expressions and emotions in the other. By thus limiting facial expressions, emotional contact is reduced with the consequence of making children - but this also affects adults - weak, anxious, insecure and even immunosuppressed since, the mental state represents a fundamental element to guarantee a good immune response.

From a psychological point of view, the health regulations provided by the Government that are imposed on healthy children are highly harmful and cause possible permanent mental disorders. Educating children to fear mutual closeness is highly detrimental to the development of their self-esteem. Furthermore, establishing a correlation between their behavior and the possible death of loved ones, which is difficult to demonstrate in practice, can profoundly damage their relationship with those around them.

Even in adults, the use of the mask suggests representations of disease, contagion, and death, and suggests that human proximity is a danger to life, causing psychological discomfort, and limiting the possibility of a real creative functioning of the brain. Psychologists are observing a drastic increase in anxiety disorders, social isolation, panic attacks, and cases of suicide[50].

Conclusions. For people wearing a mask, each measured CO_2 value (both in the present study and in that of the Province of Bolzano) is outside the acceptable values for indoor air quality in school buildings (table 2) [51] and it also exceeds the levels allowed in the workplace (5,000 ppm of CO_2). The symptoms complained by

patients after prolonged use of a mask are explained by the high levels of carbon dioxide[37] and these levels are incompatible with optimal blood oxygenation. From the analysis of the literature there is no clear evidence to extend the use of masks to the entire population. Only in particular risk situations, as can occur in work environments, with the presence of toxic dust, or in infectious disease wards, or in the case of a person suffering from a respiratory infection (in the presence of other people) or by whom takes care of such a patient, then in these specific cases it is necessary to use a mask. In these situations, it would be important that the workers, properly trained, could have adequate periods, interspersed with work, in which they can breathe without a mask. It is concluded that the use of the mask is harmful to health and it is recommended to use it only for short periods.

Limitations. the instrument used detects CO_2 only starting from 1,000 ppm. Therefore this did not allow accurate measurements of the amount of CO_2 in the ambient air, where the tests were carried out. The measurements of this study, unlike that of the province of Bolzano (which took place in the summer months, in a well-ventilated environment), were carried out in October in an outpatient clinic with partially open windows, a situation that better reproduces the condition that a child lives within his class at the desk.

School and masks. With the latest DPCM of 4/11/2020, the obligation to wear the mask at school continuously for children over 6 years, applies to the whole national territory, regardless of the risk of transmission, on which the WHO recommends to base decisions [52]. Imposing the mask on all schoolchildren for the entire period of stay at school, in the presumption of preventing an infection, does not appear justified at all. There are several reasons for not imposing the continued obligation of the mask on schoolchildren: [1] the Necessary Number of Treatments (NNT) to prevent an infection is quite high (the Norwegian Institute of Public Health has calculated that to prevent one infection per week , 200,000 individuals must use masks) [19]; [2] COVID has a benign course in children in the vast majority of cases; [3] the evidence of a school-level transmission of COVID has not appeared important so far (children transmit much less than adults) [53] and finally [4] the lack of scientific evidence on the advantages of using masks in the community [2 -47.54].

The mask certainly has a symbolic value, to better understand with a visible means that there is an invisible enemy[30].

However, although the symbolic value is important, it seems "unacceptable" to force our children to breathe intolerable amounts of CO^2 under the mask for the entire duration of their stay at school and often during physical education.

Diffusibility of CO2. The high levels of CO2 re-inhaled without a mask (table 1), contradict the false idea that CO2 is easily diffusible. CO_2 stagnation around the face takes some time to disperse because CO_2 is 1.5 times heavier than air. This also accounts for its easy accumulation of CO_2in closed environments. Therefore, the diffusibility of CO_2 inside the rooms should not be confused with the easy diffusibility of CO_2 through the alveolus membrane and the capillary wall.

Toxicity of carbon dioxide (CO2). Damage to health from CO_2 is mostly studied in adults (animals and humans), under experimental conditions, only in the short to medium term. The rise in CO2 is followed by acidosis of the blood and tissues; it is well known that water + CO2 form carbonic acid with consequent lowering of the pH. The kidney takes a few days, with the increase in urinary excretion of acids and the

reabsorption of bicarbonates, to compensate for acidosis and to bring the pH back to physiological values (7.36–7.44). However, if the increase in CO_2 is intermittent (as occurs with the use of masks), renal compensation does not occur and the acidosis is not fully compensated.[55] What this entails in the long term in the child is not known. It is known for sure that children have two to three times higher oxygen requirements than adults. Furthermore, the mask increases the respiratory dead space in an inversely proportional way to age: in an adult the mask increases the respiratory dead space by 53% (which in the adult is normally 150 ml with 500 - 640 ml of current respiratory volume at rest), in an 8-year-old the increase is 78%, in a one-year-old child 122%. Since the CO_2 concentration in dead spaces is 45,000 ppm, obviously this leads to a more marked increase in CO_2 inhalation in children.[56] The acidic blood environment induces several physiological alterations when doing exercises with the mask: 1) metabolic changes, 2) cardiorespiratory stress (increased pulse and pressure), 3) decreased renal function, 4) decreased immune response and 5) altered brain metabolism and mental health (decreased cerebral perfusion and inhibition of excitatory neurotransmitters) [27]. Chronic elevation of CO_2 in the body has also been linked to fetal malformations, damage to the reproductive system, lung and cardiovascular tissue inflammation and cancer.[55] Last but not least, neurological damage is possible.[55,57] Values of more than 5,000 ppm of CO_2, as it has been recorded in this study with the use of masks, appear incompatible with optimal school learning, as many children will experience the symptoms listed in table 3.

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	Independent study		Study of the Province of Bozen	
device	**average CO_2**	**range**	**average CO_2**	**range**
Surgical mask	**7,292** ppm	(5000 – 13,000)	**3,350** ppm	(950 – 5,320)
FFP2-KN95	**11,000** ppm	(7000 – 15,000)	**3,850** ppm	(1,220 – 8,080)
Cloth mask	**11,500** ppm	(5000 – 24,000)	**4590** ppm	(1,480 – 10,280)
No mask	**3,143** ppm	(2000 – 5,000)	**590** ppm	(50 – 2,250)

Table 1. Summary of results: CO_2 measurements with the various types of masks, in inhalation. Comparison with the Province of Bolzano.

Legenda: ppm = parts per million (1,000 parts per million correspond to 0.1 %). Normally the CO_2 concentration in ambient air is 0.04% (400 ppm), indoor 0.1% (1,000 ppm)

Guide values for indoor air CO_2 concentrations in school buildings (Ad hoc working group 2008 Umweltbundesamt Berlin)		
CO_2 (ppm)	**HYGIENIC EVALUATION**	**RECOMMENDATIONS**
< 1000	Hygienically insignificant	No further intervention
1000 - 2000	Hygienically relevant	Intensify ventilation (increase external flow volume or air changes
> 2000	Hygienically unacceptable	Check for ventilation possibilities and if necessary seek additional measures

Table 2. Guide values for indoor air CO_2 concentrations in school buildings.

CO_2 values	**symptoms**
from 0,5 % (5,000 ppm)	Drowsiness and loss of concentration, sense of exhaustion
from 2 % (20,000 ppm)	Headache, increased breathing and pulse rate
from 4 % (40,000 ppm)	Numbness, nausea, dizziness
from 8 % (80,000 ppm)	Convulsions, coma, death by cardiac arrest after 30-60 min (in adult)
oltre 30% (300,000 ppm)	Rapid loss of consciousness and death within minutes.

Table 3. Symptoms in relation to CO_2 concentrations

INHALATION

a

Surgical mask	CO_2 (ppm)	Breath rate (breaths/min)	Year of birth	Age (year)	(m/f)	Heigth (cm)	Weigth (kg)
average	**7,292**	13.22					
chp	6,000	7.7	1969	50	m	183	78
map	5,000	8.3	1954	65	f	160	56
mac	9,000	10.0	1942	78	m	180	92
paa	6,000	12.0	1940	80	f	165	55
bet	7,000	12.7	1970	50	m	175	66
frt	13,000	13.1	2007	13	f	165	50
roc	5,000	13.2	1957	63	m	187	99
gem	5,000	14.5	1932	88	f	165	54
nap	5,000	15.0	2007	13	f	174	51
nac	11,000	18.6	1985	35	f	170	65
lap	8,000	26.2	2013	7	m	123	21
mac	7,500	7.6	1942	78	m	180	92

b

Cloth mask	CO_2 (ppm)	Breath rate (breaths/min)	Year of birth	Age (year)	(m/f)	Heigth (cm)	Weigth (kg)
average	**11,500**	13.90					
vag	5,000	6.2	1970	50	f	173	64
cll	7,000	6.9	1964	56	f	160	63
beo	12,500	9.0	1967	53	m	180	72
job	10,000	9.6	1965	55	m	184	78
ank	24,000	9.9	1999	21	f	173	64
mak	11,000	11.5	2006	14	f	161	66
phk	9,000	12.5	2003	17	m	181	66
vew	8,500	16.4	1975	45	f	160	67
maa	14,500	20.4	1960	60	m	177	70
lip	18,000	25.0	2015	5	m	110	17
lep	7,000	25.6	2011	9	f	144	29

c

FFP2	CO_2 (ppm)	Breath rate (breaths/min)	Year of birth	Age (year)	(m/f)	Heigth (cm)	Weigth (kg)
average	**11,000**	11.87					
clc (no valve)	15,000	16.6	1973	48	f	165	81
het (with valve)	7,000	7.1	1967	53	f	175	71

d

no mask	CO_2 (ppm)	Breath rate (breaths/min)	Year of birth	Age (year)	(m/f)	Heigth (cm)	Weigth (kg)
average	**3,143**	11.11					
chp	3,000	7.7	1969	50	m	183	78
ank	5,000	8.2	1999	21	f	173	64
map	3,000	9.0	1954	65	f	160	56
phk	3,500	12.0	2003	17	m	181	66
mak	2,000	12.2	2006	14	f	161	66
nap	3,000	13.5	2007	13	f	174	51
vew	2,500	15.2	1975	45	f	160	67

Table 4. CO2 values during inhalation, by subject and average, with the various types of masks: a) surgical mask; b) cloth mask; c) FFP2; d) without mask.

a) inhalation and exhalation mixed

Cloth and surgical mask	CO_2 (ppm)	Breath rate (breaths/min)	Year of birth	Age (year)	(m/f)	Heigth (cm)	Weigth (kg)
average	**23,700**	12.79					
roc	18,000	11.5	1957	63	m	187	99
vag	20,000	7.0	1970	50	f	173	64
job	27,500	9.8	1965	55	m	184	78
beo	26,000	16.2	1967	53	m	180	72
maa	27,000	19.5	1960	60	m	177	70

b) while talking

Cloth and surgical mask	CO_2 (ppm)	Breath rate (breaths/min)	Year of birth	Age (year)	(m/f)	Heigth (cm)	Weigth (kg)
average	**35,500**	13,13					
nac	40,000	13,1	1985	35	f	170	65
maa	38,500		1960	60	m	177	70
vag	28,000		1970	50	f	173	64

c) while singing

Cloth and surgical mask	CO_2 (ppm)	Breath rate (breaths/min)	Year of birth	Age (year)	(m/f)	Heigth (cm)	Weigth (kg)
average	**30,625**						
roc	32,000		1957	63	m	187	99
beo	25,500		1967	53	m	180	72
job	32,000		1965	55	m	184	78
maa	33,000		1960	60	m	177	70

Table 5. CO2 values in the case of “mixed inhalation and exhalation”, a) with normal (calm) breathing, b) while speaking and c) while singing. We wanted to see what concentrations would result if there was no differentiation between inhalation and exhalation. These results were not considered in the evaluation.

EXHALATION

a

Surgical mask	CO_2 (ppm)	Breath rate (breaths/min)	Year of birth	Age (year)	(m/f)	Heigth (cm)	Weigth (kg)
average	**39,300**	14.53					
gem	30,000	15.8	1932	88	f	165	54
roc	31,000	11.5	1957	63	m	187	99
mac	35,000	10.4	1942	78	m	180	92
map	40,000	11.1	1954	65	f	160	56
paa	40,000	12.0	1940	80	f	165	55
frt	40,000	12.7	2007	13	f	165	50
lap	40,000	28.0	2013	7	m	123	21
bet	41,000	10.4	1970	50	m	175	66
nac	43,000	20.6	1985	35	f	170	65
nap	53,000	12.7	2007	13	f	174	51

b

Cloth mask	CO_2 (ppm)	Breath rate (breaths/min)	Year of birth	Age (year)	(m/f)	Heigth (cm)	Weigth (kg)
average	**43,889**	14.10					
maa	29,000	19.5	1960	60	m	177	70
beo	35,000	16.2	1967	53	m	180	72
lep	38,000	23.7	2011	9	f	144	29
lip	43,000	22.5	2015	5	m	110	17
vag	45,000	7.0	1970	50	f	173	64
job	48,000	9.8	1965	55	m	184	78
mak	48,000	11.1	2006	14	f	161	66
cll	49,000	5.4	1964	56	f	160	63
phk	60,000	11.8	2003	17	m	181	66

c

FFP2	CO_2 (ppm)	Breath rate (breaths/min)	Year of birth	Age (year)	(m/f)	Heigth (cm)	Weigth (kg)
average	**44,250**	12.79					
clc (with valve)	40,000	18.7	1973	48	f	165	81
het (no valve)	48,500	6.9	1967	53	f	175	71

d

no mask	CO_2 (ppm)	Breath rate (breaths/min)	Year of birth	Age (year)	(m/f)	Heigth (cm)	Weigth (kg)
average	**26,375**	17.23					
phk	12,000	9.6	2003	17	m	181	66
lap	28,500	38.7	2013	7	m	123	21
mak	32,500	7.9	2006	14	f	161	66
nap	32,500	12.7	2007	13	f	174	51

Table 6. CO2 values during exhalation, by subject and average, with the various types of masks: a) surgical mask; b) cloth mask; c) FFP2; d) without mask.

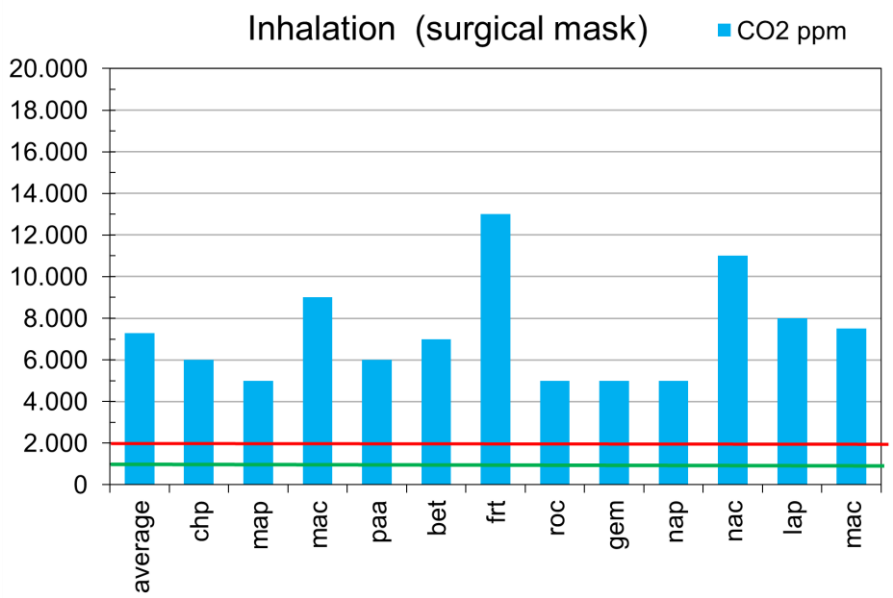

Figure 1a. CO_2 values during inhalation with surgical mask

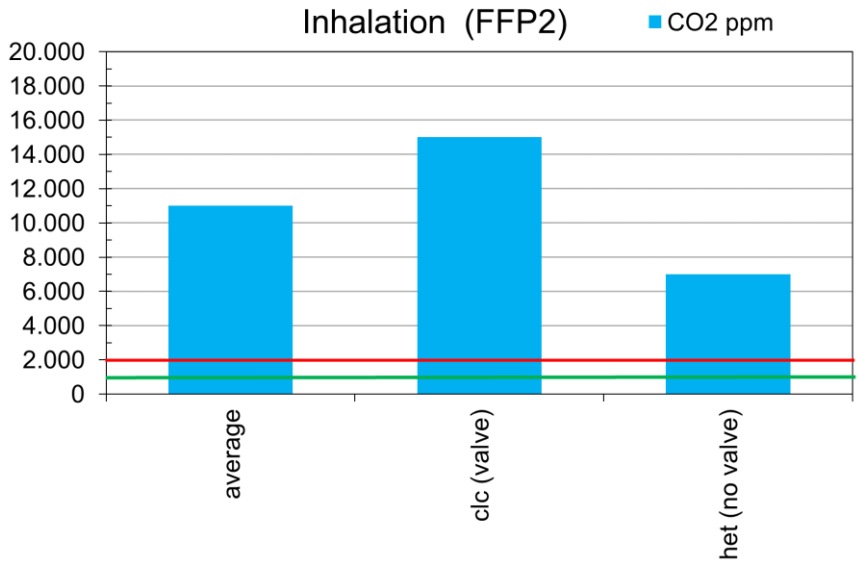

Figure 1b. CO_2 values during inhalation with FFP2 mask

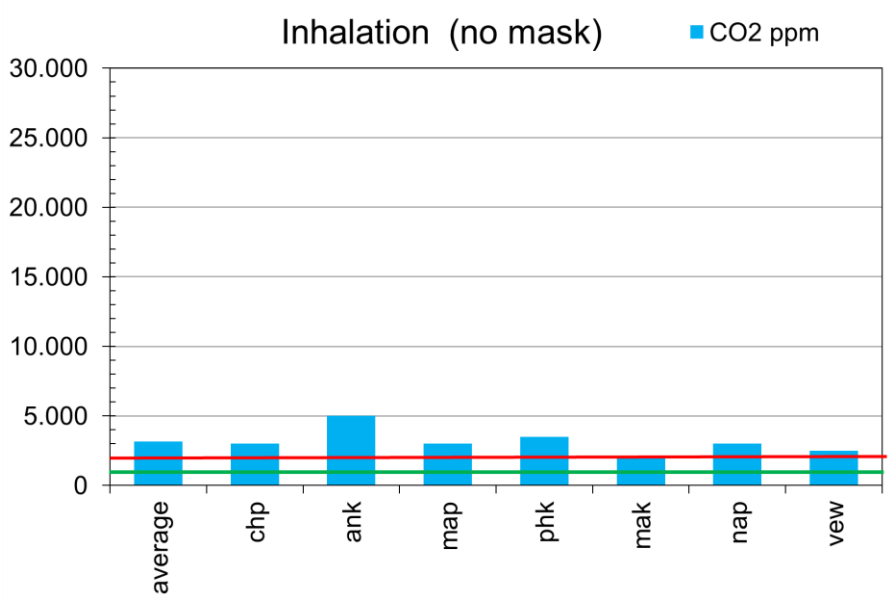

Figure 1c. CO_2 values during inhalation without masks

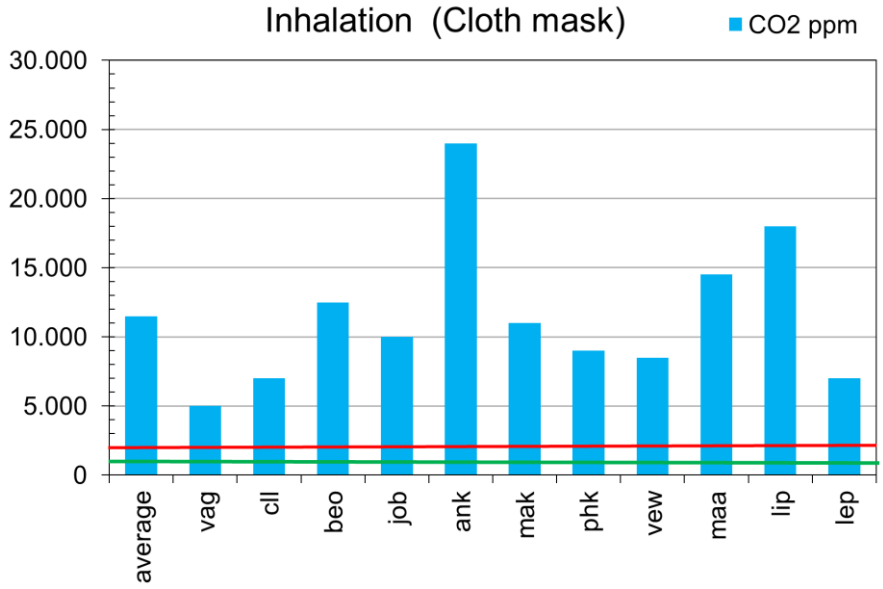

Figure 1d. CO_2 values during inhalation with cloth masks

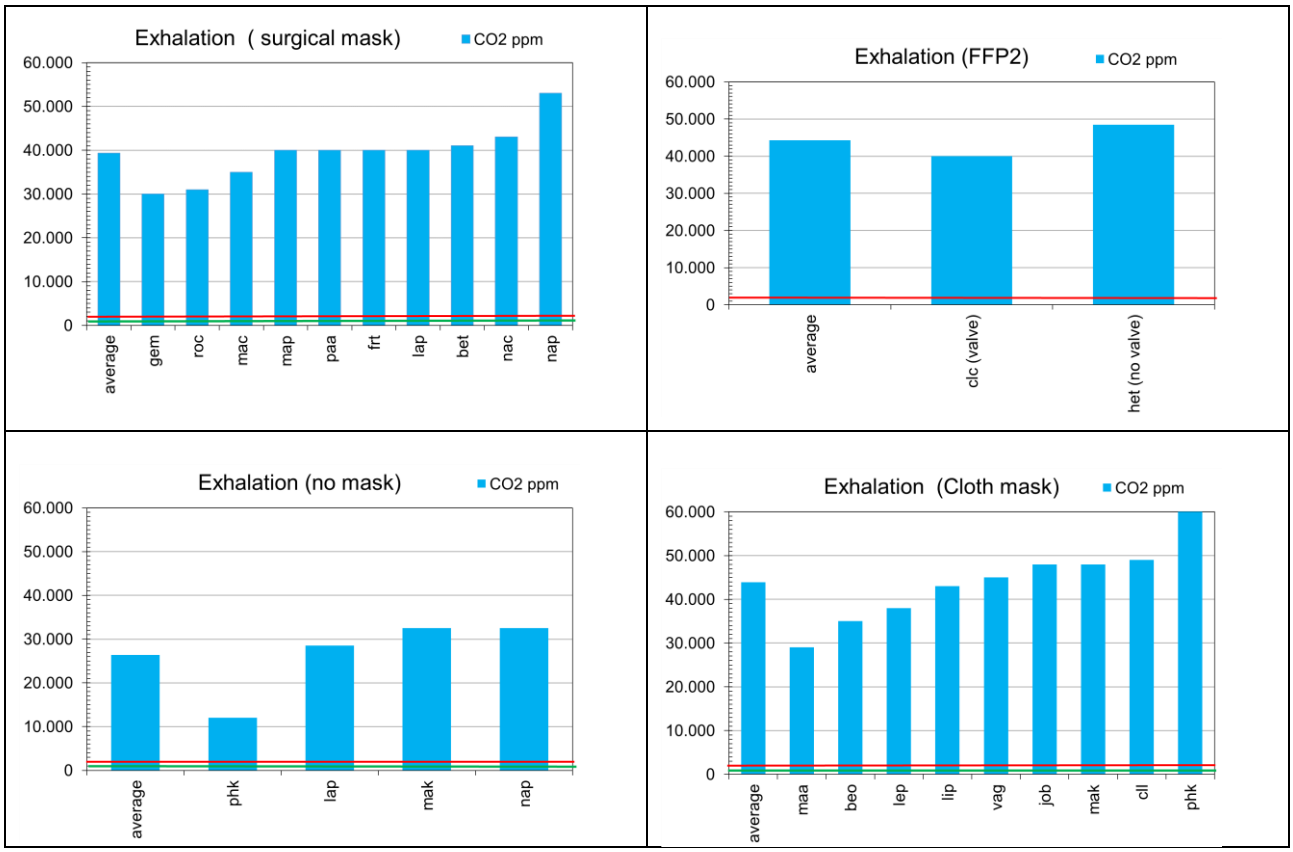

Figure 2. Summary graphs showing the CO_2 values during exhalation with the different types of masks