

Guidance for Physicians

**On Assessment of Medical Fitness to Use Respirators
in Conditions of High Air Quality Health Index**

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1. INTRODUCTION

- 1.1 Starting from 30 December 2013, the Environmental Protection Department (EPD) replaced the reporting and forecasting the General and Roadside Air Pollution Indices, which were commenced in 1995 and 1998 respectively, by a health-based Air Quality Health Index (AQHI), for more timely and effective reporting of health risk due to air pollution in outdoor environment. Very high levels of air pollution might cause symptoms in persons with no underlying disease, but persons who have health problems may be affected at lower levels. The general public should reduce outdoor physical exertion and the time of their stay outdoors on high pollution days. Persons who are sick and unfit to work should take sick leave. Persons with cardiovascular or respiratory diseases or those who are on medications for such conditions, may need to consult their doctors if their symptoms worsen. For those outdoor physical exertion is unavoidable or those who need to work outdoor on days with high air pollution, they may indicate a wish to use respirators.
- 1.2 This Guidance Note is to assist physicians to assess the medical fitness of their patients or clients in using respirators.

2. THE AIR QUALITY HEALTH INDEX

- 2.1 The AQHI is a health-based and multiple-pollutant index, reflecting the risk to public health following exposure to certain air pollution levels. It provides timely information about the health risk due to air pollution to the public and to enhance their awareness. It also serves as an alert to the public before the onset of serious air pollution episodes and helps the general public, especially susceptible groups such as children and the elderly as well as those with heart or respiratory illnesses, to consider taking precautionary measures as necessary.
- 2.2 The AQHI estimates the additional short-term health risk caused by air pollution of respiratory and cardiovascular illnesses that lead to hospital admissions. It makes reference to the short-term World Health Organization (WHO) Air Quality Guidelines (AQGs) as anchor points to define the level where health risk is high due to short term exposure to air pollution. The AQHI is reported on a scale of 1 to 10 and 10+ and is grouped into five AQHI health risk categories. An AQHI level above 7 indicates a higher health risk for the high risk group and people with cardiovascular or respiratory illnesses may notice mild aggravation of their health conditions while some healthy individuals may also experience some discomfort. Details of calculation of the AQHI are set out in Appendix 1.

- 23 EPD updates and reports the General and Roadside AQHI hourly and provides AQHI forecast for the next 24 hours in two time blocks, i.e. a.m. and p.m. sessions. The AQHI information is reported by the media in newspapers, on the radio and on television. It is also available from the mobile application (namely GovHK Notifications and AQHI Apps), AQHI Hotline at 2827 8541 and at the EPD's AQHI website at www.aqhi.gov.hk. Please refer to the EPD's leaflet entitled "Air Quality Health Index" for further information.
- 24 The Roadside AQHI provides information on the increased health risk at locations very close to vehicle emission sources. It will, therefore, more often be higher than the General AQHI on a given day. For most people, the Roadside AQHI will be less relevant as they spend only a short period of time each day in busy roads or streets. The index is of more interest to those outdoor workers who need to spend several hours continuously each day in busy streets.
- 25 The detailed health advice in respect of different AQHI and health risk categories is at Appendix 2. The health advice varies with different susceptible groups.
- 26 Despite the rigorous control efforts to combat air pollution, there are still some periods each year when the air quality is poorer because of pollution from local or regional sources and meteorological events that adversely affect its dispersion. On days with calm and stable meteorological conditions (mostly in winter months and a few occasions in summer when tropical cyclones are approaching), the air pollutants may also be built up to unhealthy levels.

3. USE OF RESPIRATORS

- 3.1 To alleviate the possible adverse health effects on days with poor air quality, those who have existing respiratory or cardiovascular diseases should reduce or avoid outdoor physical exertion. Outdoor workers should take appropriate preventive measures to protect their health, such as reducing physical exertion and reducing the time of their stay outdoors, especially in areas with heavy traffic. Despite that, some workers or general public may indicate a wish to use respirators for additional protection. In this case, they must seek advice from physicians if they find difficulties or have doubt on their fitness to

use these devices. Physicians, inter alia, can help them by assessing and advising on their fitness to work outdoors and to wear respirators.

- 32 Due to the continual control efforts, serious air pollution incidents do not frequently occur. The proper use of light and disposable particulate respirators, such as N95 masks¹, should often be sufficient for providing protection on days with high particulate pollution for unavoidable prolonged outdoor activities. Nevertheless, the elderly, people with illness (such as chronic lung disease, heart disease or stroke), and pregnant women may already have reduced lung volumes or breathing issues, they should stop using a particulate respirator if they feel uncomfortable. They should consult their doctors as to check whether they can use the N95 mask. In general, light and disposable respirator that conforms to respiratory protection standard may not be of appropriate size to fit children. For other more sophisticated respirators, while effective in filtering both gaseous and particulate air pollutants, they increase the effort of breathing. Therefore, they should not be used by children, elderly, people with existing heart or respiratory illnesses, and pregnant women.
- 33 In general, respirators are only intended for use in situations involving relatively short duration of exposure when other preventive measures are not applicable or adequate. A user of the respirator should perform a seal check every time the respirator is worn. Procedures of performing the seal check are provided at Appendix 3 [1].

4. EFFECTS OF RESPIRATOR USE

- 4.1 Wearing a respirator results in increased resistance to breathing and prolongs the duration of both the inspiratory and expiratory phases of respiration. The pressure flow characteristics of respirators are such that the resistance to flow increases as the flow rate increase. High flow rates such as those demanded by heavy exertion may be difficult or impossible to achieve while wearing a respirator, even though breathing is less affected at rest or during mild exertion. Reductions in arterial blood oxygen tensions and elevations in arterial blood carbon dioxide levels have been observed in normal subjects exercising while wearing respirators.
- 4.2 Persons with airflow obstruction (such as those suffering from chronic obstructive airways disease (COAD)) have decreased expiratory flow rates and thus require more expiratory time in each breathing cycle to achieve the same tidal volume. As the respiratory rate

¹Please note that the N95 masks are NOT designed for PROLONGED use, especially outside work settings.

increases, the relative time for inspiration is decreased, requiring a higher inspiratory flow rate. Thus for people with airflow obstruction, the effect on maximal voluntary ventilation (MVV) of using a respirator may be much greater than for persons with normal respiratory function. Some people with moderate COAD may be asymptomatic during exertion but this is not an accurate reflection of gas exchange alteration [2].

- 43 The additional dead space associated with a respirator may cause carbon dioxide retention at high work rates, especially in persons with suppressed respiratory drive. Use of respirators in conditions of high heat and humidity may cause additional stress.
- 44 Some studies have shown elevated heart rates while using respirators and others have demonstrated significantly elevated systolic pressure and more moderately elevated diastolic pressure associated with respirator use, both at rest and during exercise [3].

5. MEDICAL ASSESSMENT

- 5.1 There are no simple or universal criteria in general which can be given in order to decide on fitness to use a respirator, especially under actual activity or working conditions. The examining physician must use his medical judgment based on the following:
 - The underlying pathology
 - The physiological effects of respirator use.
 - The nature of the activity or work (for workers)
- 5.2 The combination of these factors (and particularly the interaction of underlying pathology and altered physiology) will allow the examining physician to decide whether the client/patient can carry out the outdoor activities or perform the required duties and whether the use of a respirator will lead to an exacerbation of the underlying condition.
- 5.3 The main conditions which raise doubt about the ability of people to use respirators are respiratory and cardiovascular disease. It is the respiratory and cardiovascular systems which are primarily affected by high AQHI itself.

(i) Pulmonary function

- 5.4 A useful measure of pulmonary function is spirometry. The main causes of abnormal spirometry are obstructive and restrictive lung disorders. Those people or workers who

have both Forced Vital Capacity (FVC) and Forced Expiratory Volume in one second (FEV₁) meeting the predicted lower limit of normal value for a person of the same sex, age and height and a ratio of FEV₁/FVC meeting the predicted lower limit of normal value (Appendix 4) [4] will probably be able to tolerate the use of a respirator under moderate workloads.

- 55 Careful assessment of patients with asthma will be required. Factors to be taken into account include the severity and frequency of attacks and any triggering factors. Those with asthmatic attacks precipitated by non-specific factors or by exercise, cold air or stress are unlikely to be fit for respirator use.
- 56 Patients with past history of spontaneous pneumothorax may develop increased fluctuations in thoracic pressure while breathing with a respirator. The increase risk of barotrauma may be incompatible with the use of a respirator with relatively high resistance.

(ii) Cardiovascular Disorders

- 57 Those with cardiovascular disease must also be assessed carefully. A history of ischaemic heart disease, significant arrhythmia, severe hypertension or cerebrovascular accident may be incompatible with respirator use.

(iii) Allergic Skin Reactions

- 58 Allergic skin reactions may occur occasionally from wearing a respirator, and skin occlusion may cause irritation or exacerbation of pre-existing conditions such as *pseudofolliculitis barbae*. Facial discomfort from the pressure of the respirator may occur, particularly when the fit is unsatisfactory [5].

6. OTHERS

- 6.1 It must be emphasized that the above are guidelines only, and that each patient must be assessed on an individual basis.

References

- [1] *“Infection prevention and control of epidemic- and pandemic-prone acute respiratory diseases in health care”, WHO Interim Guidelines, 2007*
- [2] *Gee J B L, Burton G, Vassalo C, & Gregg J, “Effects of External Airway Obstruction on Work Capacity and Pulmonary Gas Exchange”, Am. Rev. Respir. Dis., 98, p.1003, 1968*
- [3] *Raven P B, Jackson A W, Page K, et al., “The Physiologic Responses of Mild Pulmonary Impaired Subjects while using a Demand Respirator during Rest and Work”, Am. Ind. Hyg. Assoc. J., 42, p.247, 1981*
- [4] *Ip MS, Ko FW, Lau AC, et al. “Updated spirometric reference values for adult Chinese in Hong Kong and implications on clinical utilization”, Chest. 2006;129:384-392.*
- [5] *“National Institute of Occupational Safety and Health Respirator Decision Logic”, U.S Government Printing Office, 1992*

CALCULATION OF AIR QUALITY HEALTH INDEX

The Air Quality Health Index (AQHI) is calculated by adding the increased hospital admission risks associated with the major air pollutants, viz., NO₂, O₃, PM₁₀ (or PM_{2.5} whichever the higher), and SO₂. The thresholds for issuing health advice is determined by the total increase in hospital admission risks for the four selected air pollutants being at concentrations at the respective short-term WHO AQGs. Accordingly, the thresholds for the high risk groups and the whole population are 11.29% and 12.91% respectively. Air pollution causing these health risk increases will be classified as “high” and “very high” in the proposed AQHI system.

2. The AQHI are reported on a scale of 1 to 10 and 10+ and are grouped into five health risk categories. The public, in addition to following the health advice to be issued for each of these health risk categories, may also make adjustments to their physical activities according to their own health conditions.

| Health Risk Category | AQHI | Added Health Risk (%) |
|-----------------------------|-------------|------------------------------|
| Low | 1 | 0 - 1.88 |
| | 2 | >1.88 - 3.76 |
| | 3 | >3.76 - 5.64 |
| Moderate | 4 | >5.64 - 7.52 |
| | 5 | >7.52 - 9.41 |
| | 6 | >9.41 - 11.29 |
| High | 7 | >11.29 - 12.91 |
| Very High | 8 | >12.91 – 15.07 |
| | 9 | >15.07 – 17.22 |
| | 10 | >17.22 – 19.37 |
| Serious | 10+ | >19.37 |

3. Similar to the EU^[1], to communicate the long-term health risks to the public, an annual index, which is derived from the ratio of the annual concentrations of the pollutants to their respective WHO annual AQGs, is available in the AQHI webpage.

^[1]<http://www.airqualitynow.eu/>

**Recommended Precautionary Actions under
Air Quality Health Index (AQHI)**

| Health Risk Category | AQHI | People who are sensitive to Air Pollution | | Outdoor Workers* | General Public |
|----------------------|------|---|--|---------------------------------|---------------------------------|
| | | People with existing heart or respiratory illnesses # | Children and the Elderly | | |
| Low | 1 | No response action is required. | No response action is required. | No response action is required. | No response action is required. |
| | 2 | | | | |
| | 3 | | | | |
| Moderate | 4 | No response action is normally required. Individuals who are experiencing symptoms are advised to consider reducing outdoor physical exertion. | No response action is required. | No response action is required. | No response action is required. |
| | 5 | | | | |
| | 6 | | | | |
| High | 7 | People with existing heart or respiratory illnesses are advised to reduce outdoor physical exertion, and to reduce the time of their | Children and the elderly are advised to reduce outdoor physical exertion, and to reduce the time of their stay outdoors, | No response action is required. | No response action is required. |

* The advice does not apply to outdoor workers who are sensitive to air pollution.

Such as coronary heart disease and other cardiovascular diseases, asthma and chronic obstructive airways diseases including chronic bronchitis and emphysema.

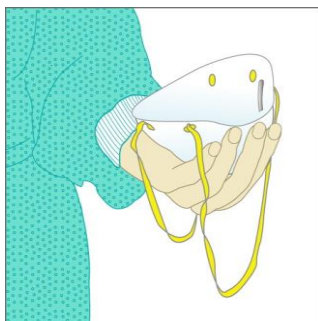
| | | | | | |
|-----------|-----|--|---|---|--|
| | | <p>stay outdoors, especially in areas with heavy traffic.</p> <p>They should also seek advice from a medical doctor before participating in sport activities and take more breaks during physical activities.</p> | <p>especially in areas with heavy traffic.</p> | | |
| Very High | 8 | <p>People with existing heart or respiratory illnesses are advised to reduce to the minimum outdoor physical exertion, and to reduce to the minimum the time of their stay outdoors, especially in areas with heavy traffic.</p> | <p>Children and the elderly are advised to reduce to the minimum outdoor physical exertion, and to reduce to the minimum the time of their stay outdoors, especially in areas with heavy traffic.</p> | <p>Employers of outdoor workers performing heavy manual work are advised to assess the risk of outdoor work, and take appropriate preventive measures to protect the health of their employees such as reducing outdoor physical exertion, and reducing the time of their stay outdoors, especially in areas with heavy traffic</p> | <p>The general public is advised to reduce outdoor physical exertion, and to reduce the time of their stay outdoors, especially in areas with heavy traffic.</p> |
| | 9 | | | | |
| | 10 | | | | |
| Serious | 10+ | <p>People with existing heart or respiratory illnesses are</p> | <p>Children and the elderly are advised to avoid</p> | <p>Employers of all outdoor workers are advised to</p> | <p>The general public is advised to reduce to the</p> |

| | | | | | |
|--|--|--|--|---|--|
| | | advised to avoid outdoor physical exertion, and to avoid staying outdoors, especially in areas with heavy traffic. | outdoor physical exertion, and to avoid staying outdoors, especially in areas with heavy traffic. | assess the risk of outdoor work, and take appropriate preventive measures to protect the health of their employees such as reducing outdoor physical exertion, and reducing the time of their stay outdoors, especially in areas with heavy traffic | minimum outdoor physical exertion, and to reduce to the minimum the time of their stay outdoors, especially in areas with heavy traffic. |
|--|--|--|--|---|--|

Note:

1. As the health effects on individuals may vary, you should seek advice from a medical doctor if you are in doubt or feel uncomfortable. If you are suffering with existing heart or respiratory illnesses (such as coronary heart disease and other cardiovascular diseases, asthma and chronic obstructive airways diseases including chronic bronchitis and emphysema), you should follow your doctor's advice on the amount of physical exercise and the management of your illness under different air quality health index bands. If you are a smoker, you should quit smoking now!
2. Outdoor workers need to be aware of the potential impact on their health at times when the AQHI reaches "Very High" or "Serious" health risk, and seek advice from a medical doctor if they are in doubt of their health condition or suffer from any chest or breathing discomfort. They should inform their employers of the medical advice so that suitable work arrangements can be worked out.
3. The amount of physical exercise that should be performed differs according to the individual's physical capacity, and should be tailored to one's own physical condition. Ask your doctor for advice.
4. Schools are advised to ensure their school children will avoid physical exertion when AQHI reaches 10+ with serious health risk.

Sequence of a particulate respirator seal check



1 Cup the respirator in your hand with the nosepiece at your fingertips allowing the headbands to hang freely below your hand



2 Position the respirator under your chin with the nosepiece up



3 Pull the top strap over your head resting it high at the back of your head. Pull the bottom strap over your head and position it around the neck below the ears



4 Place fingertips of both hands at the top of the metal nosepiece. Mould the nosepiece (USING TWO FINGERS OF EACH HAND) to the shape of your nose. Pinching the nosepiece using one hand may result in less effective respirator performance



5 Cover the front of the respirator with both hands, being careful not to disturb the position of respirator

5A Positive seal check

- Exhale sharply. A positive pressure inside the respirator = no leakage. If leakage, adjust position and/or tension straps. Retest the seal.
- Repeat the steps until respirator is sealed properly

5B Negative seal check

- Inhale deeply. If no leakage, negative pressure will make respirator cling to your face.
- Leakage will result in loss of negative pressure in the respirator due to air entering through gaps in the seal

**LOWER LIMIT OF NORMAL VALUE (LLN) FOR FORCED VITAL
CAPACITY (FVC) AND
FORCED EXPIRATORY VOLUME IN ONE SECOND (FEV₁) AND
PREDICTED RATIO OF FEV₁ / FVC**

The lower limit of normal value (LLN) for forced vital capacity (FVC) and forced expiratory volume in one second (FEV₁) and the ratio of FEV₁/FVC may be predicted by applying the following formulas.

MALE

Equation for Calculating Predicted FVC for Male:

$$FVC(\text{in litres}) = 0.05434H - 0.01395A - 5.52094$$

Equation for Calculating Predicted FEV₁ for Male:

$$FEV_1(\text{in litres}) = 0.03978H - 0.01766A - 3.46818$$

Equation for Calculating Predicted FEV₁/ FVC for Male:

$$FEV_1/FVC^{\#} = - 4.001 \times 10^{-5}H + 1.409 \times 10^{-5}A - 3.038 \times 10^{-7}A^2 + 0.00932$$

FEMALE

Equation for Calculating Predicted FVC for Female:

$$FVC(\text{in litres}) = 0.03894H - 0.00118A - 0.00012A^2 - 3.62948$$

Equation for Calculating Predicted FEV₁ for Female:

$$FEV_1(\text{in litres}) = 0.02825H - 0.00138A - 0.00017A^2 - 2.20792$$

Equation for Calculating Predicted FEV₁/ FVC for Female:

$$FEV_1/FVC^{\#} = - 4.900 \times 10^{-5} H - 1.062 \times 10^{-5} A - 2.046 \times 10^{-8} A^2 + 0.01119$$

Where,

A = Age of patient (applicable to patients ≥ 18 years old)

H = Height of patient in centimeter

Note:

the ratio is expressed by dividing by the square of height (i.e. H^2)