



# Treating SARS-Cov-2 & other Respiratory Diseases in Resource-Scarce Regions



In low- and medium-income countries (LMICs), the Covid-19 outbreak has put an additional strain on national healthcare systems that have scarce medical resources. Due to the weak medical infrastructure, respiratory diseases are one of the major causes of death in Africa. This POSTnote outlines the need of medical resources to become accessible in developing countries to offer treatments for respiratory diseases.

## Background

Respiratory diseases compromise the gas exchange in air-breathing organisms. Mild respiratory diseases such as common cold and influenza (also known as the flu) do not require special medical intervention. Severe life-threatening respiratory diseases include pneumonia, lung cancer, COPD (chronic obstructive pulmonary disease), pulmonary hypertension (PH), asthma and severe acute respiratory syndrome coronavirus: SARS-Cov-2, so called COVID-19. Asthma, COPD and pulmonary hypertension are classified as chronic respiratory diseases (CRDs)<sup>1</sup>: long-term diseases of the airways and the structures of the lung. Some CRDs are not curable but treatments can help relieve the symptoms and improve the well-being of the patient.

## Major respiratory diseases

COPD is a lung disease caused by an inflammation of the airways<sup>2</sup>. Asthma<sup>3</sup> is a disease in which airways narrow, swell and can produce excess mucus which obstructs the airways. Pneumonia is an infection on one or both lungs that causes inflammation of alveoli which makes the exchange between the gas and blood difficult<sup>4</sup>, leading to breathing difficulties. The origins can be bacterial, viral and fungal. SARS-Cov-2 is an airborne virus that spreads through small droplets<sup>5</sup> and can lead to pneumonia<sup>6</sup>. Pulmonary hypertension (PH) can damage the heart as the blood pressure in pulmonary arteries is high and limits the blood flow to the heart<sup>7</sup>. The diseases are characterised by their symptoms:

## Overview

- SARS-Cov-2, pneumonia, asthma, COPD and pulmonary hypertension are life-threatening respiratory diseases that are among the major causes of death LMICs, in particular so in Sub-Saharan Africa and in South Asia. Young children are among the most vulnerable.
- Oxygen therapies relieve symptoms and help patients recover from respiratory diseases.
- It is difficult to seek medical treatment in LMICs due to the shortage of healthcare resources (oxygen, health workers, ICU beds), lack of funding, political instability, expensive research and development of medical devices and insufficient awareness in the demographic.
- Innovative engineering can design and manufacture accessible, cost-effective and efficient technologies to provide treatment for respiratory diseases in resource-limited regions and contribute to saving lives.

### Box 1: Symptoms of major respiratory diseases:

- COPD: shortness of breath, cough, excess mucus<sup>8</sup>
- Asthma: wheezing, coughing, chest tightness, shortness of breath<sup>9</sup>
- Pneumonia: coughing, fever, shortness of breath, chest pain, tiredness, headaches<sup>4</sup>
- SARS-Cov-2: fever, muscle pain, cough, sore throat, shortness of breath<sup>5</sup>
- PH: shortness of breath, racing heartbeat, tiredness, chest pain, feeling faint<sup>22</sup>

## Death tolls predominant in LMICs, young children are among the most vulnerable

In 2019, COPD was the third leading cause of death world-wide, leading to 3.23 million deaths, 80% of which occurred in low- and middle-income countries (LMICs)<sup>10</sup>. In 2015, 329 million people were affected by COPD (almost 5% of the global population)<sup>11</sup>. The rapidly aging population in Africa can lead to an increase in COPD cases<sup>12</sup>. In 2019, asthma affected 262 million individuals out of which 461,000 died mostly in LMICs<sup>13</sup> and affected 14% of children in 2015<sup>22</sup>. In 2017, pneumonia led to 2.56 million fatalities, 800,000 of which were children under the age of 5<sup>14</sup>. It is the leading cause of death among children under the age of 5, accounting for 15% of all deaths in children under the age of 5 in 2017<sup>15</sup>. The mortality from pneumonia among children is highest in Sub-Saharan Africa and South Asia in countries such as India, Nigeria, Pakistan, the Democratic republic of Congo and Ethiopia<sup>16</sup>. As of June 2021,

5,200,000 positive SARS-Cov-2 cases<sup>17</sup> have been registered on the African continent, 137,000 of which lead to deaths<sup>18</sup>. Some countries of South-Asia have been particularly hit by the pandemic: as of June 2021, India has recorded 29.8 million cases, of which 385,000 lead to fatalities<sup>19</sup>. However, some developing countries have been criticised of under-reporting<sup>20</sup> the number of positive cases due to the limiting testing resources<sup>21</sup>.

#### Box 2: Causes of major respiratory diseases<sup>22</sup>:

- COPD: smoking, exposure to air pollution
- Asthma: genetic predisposition, exposure to air pollution and allergens
- Pneumonia: malnutrition, lack of immunisation, chronic health conditions, exposure to smoke
- SARS-Cov-2: transmission by contact of mucous membranes
- PH: blood clots, hypoxia, issues with smaller branches of pulmonary arteries<sup>7</sup>

## Medical attention helps patients recover from respiratory diseases

COPD patients can undergo oxygen therapy, consisting of exercise and pulmonary rehabilitation<sup>23</sup> and severe patients can be offered non-invasive ventilation that increases the pressure and oxygen content of the inhaled air<sup>24</sup>. There is no known cure for asthma but it can be treated to reduce the symptoms: avoiding allergens and using bronchodilators inhalers<sup>25</sup>. If the patient's breathing or oxygen levels in blood become worrying, ventilators can be used<sup>26</sup>. Effective treatment of pneumonia can be achieved by delivering supplemental oxygen<sup>22</sup>. For COVID-19 patients in severe condition, that require ICUs (intensive care units), oxygen therapy in the form of non-invasive and invasive ventilators<sup>27</sup> is employed. Pulmonary hypertension can be treated by oxygen therapy consisting of inhaling air with a higher oxygen content<sup>28</sup>.

## Limiting oxygen supply in LMICs

WHO estimates that 15% to 20% of SARS-Cov-2 patients need supplemental oxygen, where severe cases require 10L/min and critical cases about 30L/min<sup>29</sup>. This outbreak led to an increase in oxygen demand: more than 500,000 individuals are affected by the scarcity of oxygen and require 1.1 million oxygen cylinders per day<sup>30</sup>. India experienced a shortage of oxygen when the Covid-19 Delta variant emerged<sup>31</sup>. Another barrier leading to oxygen shortage is the price: hospitals in poor countries rely on oxygen to be delivered in vapour state in cylinders and not in tankers in liquid state or pipes like in western countries<sup>33</sup>. Most of the oxygen must be imported from other countries as very few LMICs manufacture medical oxygen<sup>32</sup>. This increases the overall cost: oxygen is approximately 5-times more expensive in LMICs than in Europe or North America<sup>33</sup>. Oxygen can leak out of the cylinders which decreases the oxygen concentration<sup>34</sup>. WHO developed oxygen concentrators<sup>35</sup>: machines that produce oxygen, but rely on a steady electrical power source, which is not predictable and reliable in LMICs<sup>36</sup>. In addition, the produced oxygen flow rate, 5L/min to 10L/min, may be insufficient for critically ill patients that need 15L/min<sup>37</sup>. Therefore, in countries where oxygen is a scarce supply, oxygen must be used efficiently and no oxygen must be wasted.

## Shortage of healthcare resources

The availability of hospital beds, physicians, ICU (intensive care unit) beds and medical equipment (ventilators or positive airway pressure devices) is low in LMICs. Uganda has got 0.1 ICUs per 100,000 inhabitants and Sri Lanka has got 1.6 ICUs per 100,000 inhabitants, whilst USA has got 20 ICUs per 100,000 inhabitants<sup>38</sup>. The lack of healthcare workers is also an issue<sup>39</sup>: Zimbabwe has got 1 physician per 10,000 inhabitants and Tanzania has got 1

physician per 30,000 inhabitants<sup>40</sup>. On the other hand, the United Kingdom has got 1 physician per 357 inhabitants<sup>41</sup>. The unequal demographic distribution of healthcare workers across sub-Saharan Africa creates additional complications: 25% of doctors and 40% of nurses are based in rural areas where 45% of the population resides<sup>42</sup>. This shortage puts the health services under pressure that cannot cope with the number of patients. To minimize downtime, healthcare workers must have rapid training and medical equipment must be reliable and easy to operate.

## Underfunded healthcare, monopoly, corruption and political instability

LMICs suffer from limited funding<sup>43</sup> – public healthcare systems are unable to afford oxygen supplies or medical equipment: 16% of the world population carries 23% of the global diseases burden, but African countries spend on average 10-times less on healthcare than the rest of the world<sup>44</sup>. During the pandemic, the two main oxygen suppliers in sub-Saharan Africa, The Linde Group and Air Liquide, have been accused of overcharging for oxygen and monopolizing the market by profit margins between 45% and 88%<sup>33</sup>. In some LMICs, the development of health sectors stagnates<sup>45</sup> as they are exposed to corruption<sup>46</sup> and political instability in African governments<sup>47</sup>. Close monitoring of the spending of the funds from external donors can avoid corruption and enable development of healthcare in LMICs.

## Uneconomical cost of developing breathing aids

Oxygen therapy is an effective treatment for respiratory diseases but requires oxygen and appropriate breathing aids: mechanical ventilators, non-invasive ventilators and oxygen concentrators. However, it is difficult for standalone manufacturers to create an economically viable business plan for developing medical devices<sup>48</sup>. Cost of developing medical devices is high due to the engineering research and development phase, as well as the need to comply with medical standards and regulations for every country. Yet, regulatory processes are not aligned across African countries and many regulatory agencies are under-resourced and overburdened<sup>49</sup>. The selling price of the end product would be too high, meaning that the product would not sell or it would have to be sold at a lower price, meaning the manufacturers will make a loss. Yet, partnering with non-profit organisations such as WHO, PATH or UNICEF, to obtain funding and medical approvals, may give manufacturers economic incentive for developing medical devices.

## Lack of awareness of respiratory diseases in the demographic

Severe respiratory diseases, such as lung cancer can be easily disregarded or mistaken for other diseases (flu) at first glance due to the light symptoms, allowing the disease to develop to a life-threatening state<sup>50</sup>. Educating people and spreading the awareness about the diseases and their symptoms can avoid unnecessary fatalities<sup>22</sup>. Moreover, providing education about the causes of major respiratory diseases, such as smoking, can avoid respiratory diseases occurring in the first place.

## Innovative, cost-effective technologies for treatment of respiratory diseases

Oxygen therapy is a medical treatment that is commonly used for patients affected by respiratory diseases. Technologies in medical devices play an important role in the recovery of such patients. Innovative engineering can be employed to design and manufacture inexpensive, medically approved, effective medical equipment devices to provide accessible treatment for patients affected by respiratory diseases in resource-scare countries and decrease the number of fatalities.

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Front page image: Mother with her child hospitalised for respiratory disease in South Africa, © Dr Rudzani Muloiwa.

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