REVIVING DECOMMISSIONED VENTILATORS

How a Circular Economy Approach Can Assist in Tackling the South African Shortage of Ventilators during Covid-19

By Katharina Gihring and Nickey Janse van Rensburg

Sub-Saharan Africa bears the highest disease burden in human and economic costs, but commands less than one percent of global health expenditure (Aikins et al., 2010). Strong health systems are fundamental to maintaining good health. Difficult geography, a severe shortage of trained medical personnel, poor infrastructure, a lack of critical care equipment and accompanying technical skills make it difficult to deliver the healthcare services people in Africa need to achieve good health. These weaknesses in the healthcare system have been compounded by the Covid-19 pandemic. Equitable and efficient healthcare provision requires properly balanced and managed resource inputs. There is a strong argument to be made for circular business models to optimise healthcare technology management strategies, to eliminate medical e-waste, and to establish a new, open niche market in Africa.

Healthcare technologies (physical resources such as fixed assets, equipment, consumables and personal protective equipment (PPE)) form the basis for the provision of all health interventions. The novel severe acute respiratory syndrome corona virus 2 (SARS-CoV-2) pandemic has overwhelmed some of the best healthcare systems in the world. While the global community races to slow down the spread of Covid-19, shortages of critical healthcare technologies have grabbed the headlines and are a sore point for world leaders

to answer to. Similarly, in Africa, the virus has spread to dozens of countries within weeks, with governments and health authorities across the continent struggling to limit widespread infections to protect the region's already fragile healthcare systems. South Africa's swift response has bought some time to prepare for peak infection and has been applauded by health authorities globally.

Patients who develop respiratory illness due to SARS-CoV-2 may need mechanical ventilation. As the world battles Covid-19, most countries are facing a shortage of life-saving ventilators, crucial in assisting the most critically ill patients with breathing. In South Africa, 3% of active cases need intensive care (Gerber, 2020), which is lower than the global average of 5% (WHO, 2020). The need for intensive care varies per country: while China reported 6.1% of all positive confirmed cases as critical, Italy reported 12% of cases in need of intensive care (Phua et al., 2020), buckling the healthcare system. The variation is caused by factors such as demographics, ICU admission criteria and management, and number of tests conducted (Cook et al., 2020).

Healthcare workers are faced with the challenge of an insufficient supply of ventilators and PPE while caring for the large influx of Covid-19 patients (Ranney et al., 2020). While wealthier countries can afford to considerably increase their intensive care beds – as done in Germany (OECD, 2020) – or mass-produce the required ventilators, African countries are faced with severe challenges to combat the spread of the virus without these resources (Baker, 2020). The response to Covid-19 – globally and in South Africa – has been to 'flatten the curve'. The goal is to not overwhelm the healthcare system to avoid unnecessary death. In South Africa there are an estimated 7,195 critical care beds available in private and public hospitals (Van den Heever, 2020).

Equitable and efficient healthcare provision during this pandemic boils down to the availability of healthcare technologies to treat critical care patients and PPE for healthcare workers, both of which are currently not in place in South Africa (Schütz, 2020). A combined 3,216 ventilators from the public and private sectors are available, which is half the estimated amount needed at peak infection, expected between July and September this year in South Africa (Du Toit & Kowan, 2020).

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A national Emergency Ventilator Project has been formed – led by the South African Radio Astronomy Observatory (SARAO) – to assist in managing the development, production and procurement of ventilators (SARAO, 2020). The design and business model of this initiative will play a crucial part in how products are used, maintained, reused, refurbished, and recycled in the future. Therefore, ways and tools to implement eco-design with End of Life in mind are needed to ensure the transition to a circular economy and to establish a niche market in Africa.

In all likelihood, the Covid-19 pandemic will not be the last of its kind. Policy interventions and future healthcare technology management strategies should never fall short again. A multidisciplinary, circular approach is needed to support the critical care technology development that is central to responding to the Covid-19 crisis. Responding to initial reports that between 40–70% of South Africans could get infected with Covid-19, depending on the national response to the crisis, the UJ-Process Energy and Environmental Technology Station (UJ-PEETS) is coordinating efforts to further develop open-source ventilators, to make rapid prototyping facilities available to enable PPE and component manufacturing, and to support repair and maintenance efforts to bring out-of-warranty equipment into service. This is in line with the mandate to support small and medium-sized enterprises (SMEs) within the green and circular economy, which is proposed as a new business case for healthcare technologies that are in critical shortage on the continent.

Eliminating Medical E-Waste Through a Circular Approach

A circular economy is an industrial system that is restorative or regenerative by intention and design (Korhonen et al., 2018). It is a new economic

paradigm which replaces the current linear economy, defined by take, make and dispose, resulting in globally interlinked environmental problems. It replaces the end-of-life concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals (which impair reuse and return to the biosphere), and aims for the elimination of waste through the superior design of materials, products, systems and business models (PACE & WEF, 2019; D'Amato et al., 2017). A circular economy is based on many different schools of thought (e.g. industrial ecology, cradle to cradle, blue economy), which look at resource usage through different lenses (Andersen, 2007; Braungart et al., 2007). A circular approach aims to keep products, materials and resources at their highest value for the longest duration, to eliminate waste (by, for instance, feeding products and resources back into the system), to redefine services, and to rely on renewable energy sources (Ellen MacArthur Foundation, 2013). This is proposed as a new paradigm to inform healthcare technology management strategies in Africa and the rest of the world.

Waste Electrical and Electronic Equipment (WEEE), or e-waste, is the fastest-growing domestic waste stream in the world, estimated at 44.7 Mt in 2016 and anticipated to tip the scales at 52.2 Mt in 2021 (Baldé et al., 2017). Insufficient infrastructure and waste management, as well as no legislative enforcement, lead to human health risks, environmental degradation, and the leakage of toxic and harmful substances into the environment. On the other hand, e-waste contains many valuable resources and can contribute to new decent and green jobs, unlocking an opportunity worth of over US $55 billion per year (PACE & WEF, 2019).

Within the paradigm of the circular economy and the waste hierarchy of integrated waste management, recycling is one of the last options, due to the down-cycling of valuable raw materials (Pires et al., 2019). In descending order of preferability, the top method is pollution prevention, followed by re-use, recycling, treatment and disposal, while a circular approach adds the refurbishment and remanufacturing step before recycling.

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Healthcare technology management has become an increasingly visible policy issue. The growing medical sector contributes to increased e-waste globally (WHO, 2019), while low to middle-income countries face the challenge of acquiring medical devices, which is currently illustrated by the desperately low number of ventilators across the African continent (Maclean & Marks, 2020). The good news is that decommissioned ventilators can be refurbished and reused. The refurbishment of medical devices can be defined as a process to prolong the lifetime of devices which have nearly reached their end-of-life stage (Kane et al., 2018; Thierry et al., 1995). Importantly for medical technologies, refurbished devices need to be licenced to safely and effectively operate after refurbishment.

Compliance, Data and Future Strategies

Ventilators fall under class C (moderate to high risk) of medical devices (Act No. 101 of 1965, Department of Health; SAHPRA, 2019), which means that more steps, such as decontamination, cleaning, and testing (WHO, 2019), are involved to reinstate the medical device to its old functionality. In order to refurbish a medical device, a manufacturing licence from the South African Health Products Regulatory Authority (SAHPRA), which falls under the Department of Health, needs to be obtained (The Medicines and Related Substances Amendment Act 14 of 2015, Republic of South Africa; Saidi & Douglas, 2018). All the refurbishment steps taken need to also comply with the manufacturer specification for the model. South Africa imports 90% of its medical devices (Deloitte & DTI, 2014), which makes it dependant on other countries' industries. To establish a circular economy, the business model for medical healthcare equipment must change and a compliant refurbishment network is needed. Such a network would not only have the advantage of prolonging the life of decommissioned medical equipment, but would also contribute

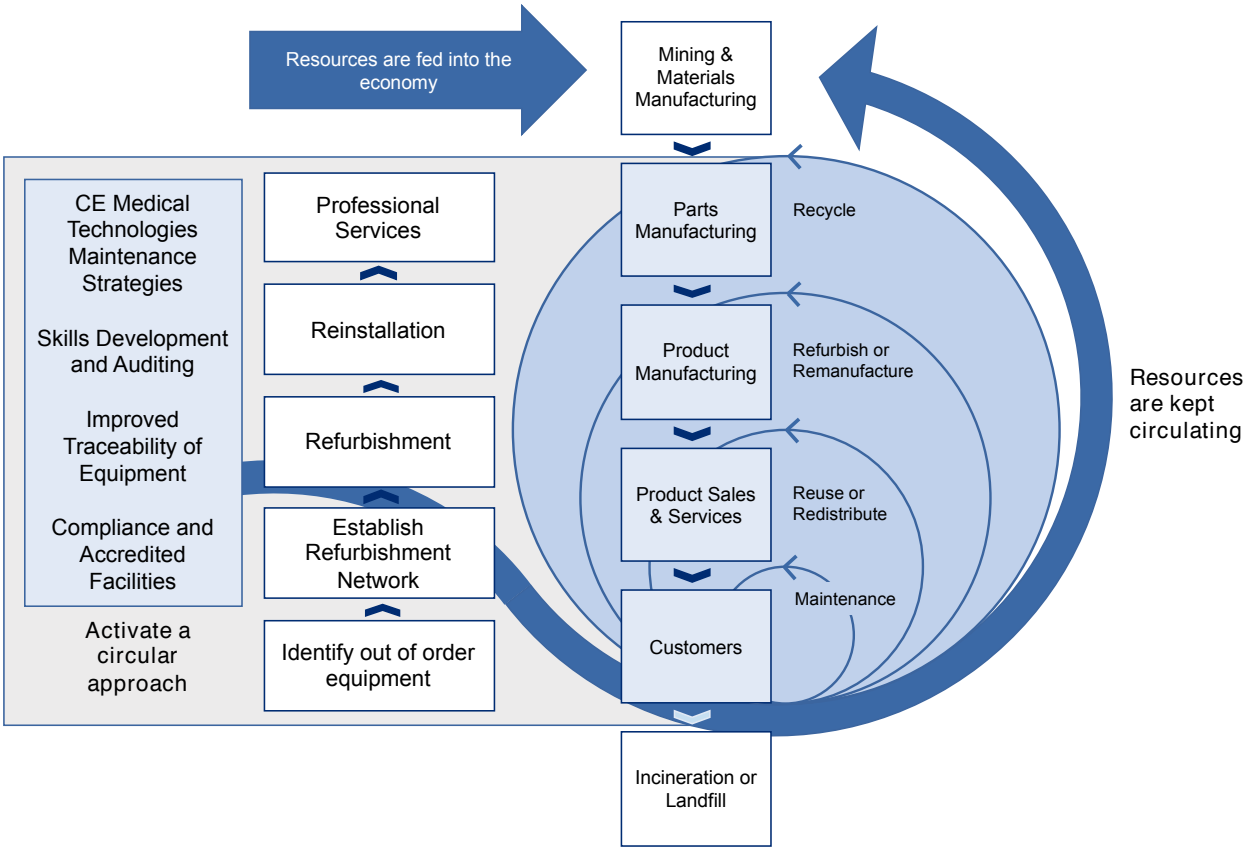

Figure 1 Activating a circular approach through refurbishment for ventilators (Adapted from the Ellen MacArthur Circular Economy Butterfly Model (2013) and Global Medical Imaging Industry (2016))

to safeguarding enough ventilators. Adding maintenance-related skills for refurbishment and repair within circular economy business models increases South Africa's professional technical service sector expertise. It also helps to close material loops by retaining functionality of critical medical technologies. At the same time, most current circular economy concepts concentrate on the products' end-of-life stage.

Data on the number of decommissioned ventilators, let alone on their location, is not readily available at a national level. Through a circular approach, a product is traceable through its entire life cycle, improving maintenance management and the eventual safe disposal of e-waste (see Figure 1). In order to refurbish medical equipment, the first step will be to identify decommissioned ventilators. Secondly, a refurbishment network needs to be created which allows for the technical feasibility and procurement of the right skillsets, such as medical engineers and technicians. It is critical that this network is established under the current national Emergency Ventilator Project, and that principles of circularity are incorporated in future product design. After refurbishment has taken place, equipment will need to be distributed. If circular business models are designed and informed by local policy, the decommissioning of medical e-waste can support a sustainable healthcare system in Africa. The proposed refurbishment network can unlock an economic niche, which allows for capacity building and job opportunities. These actions will further contribute

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to the creation of circular medical technology management strategies.

The redesign and improvement of product design and business models for medical technologies need to take place, to extend product lifetime and support refurbishment and recycling in a more efficient manner (Ertz & Patrick, 2020). Take-back schemes by manufacturers such as Siemens, Philips and GE (Kane et al., 2018) can also curb e-waste production from medical devices, while contributing to better accessibility for required medical devices, creating an open niche market in Africa.

UJ-PEETS is in the process of establishing a refurbishment network to respond to the current pandemic. This network will feed back into the broader e-waste project to unlock the economic and entrepreneurial potential within the sector for South Africa. For more information or to support these efforts, contact peets@uj.ac.za ■

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