

# **Phasing Out The Use of Disposable Equipment at RadboudUMC**

**Anirudh Krishnan**



**Master Thesis for Environment & Society Studies  
Programme**

**Nijmegen School of Management - Radboud University  
July 2020**

# **Phasing Out The Use of Disposable Equipment at RadboudUMC**

**Author:**

Anirudh Krishnan (S1037157)

**Thesis Supervisors:**

Dr. Mark Wiering

Dr. Carlijn Hendriks

**Internship Organisation:**

RadboudUMC

**Internship Supervisor:**

Dr. Hugo Touw

**Radboud University**

**Nijmegen School of Management**

July 2020

Word Count: 20612

## Preface

Being a technology geek my whole life, I have always been interested in how gadgets work and what changes can be made in them for improvement. This took a turn when I started learning about sustainability and how unnecessary upgrades in technology are taking a toll on the planet. This made me eager to research equipment that has been causing an alarmingly high environmental impact, without getting much notice. RadboudUMC has given me the perfect opportunity to go ahead with this, and research about disposable medical equipment.

My sincere thanks and gratitude go out to all the employees and experts at RadboudUMC who have contributed to this research project and shared their knowledge and views with me. I specifically wish to thank Dr. Hugo Touw for supervising my internship at RadboudUMC and helping me with setting up telephonic interviews and helping me with queries I had at different stages.

Furthermore, I would like to thank Dr. Mark Wiering & Dr. Carlijn Henriks for supervising my thesis progress. Their invaluable feedback has helped me improve my work on many levels, and as a result, I was able to come out with a document that I am proud of.

Anirudh Krishnan  
Nijmegen, July 2020

## Abstract

Current patterns of environmental pollution and ecological instability threatens the existence of all living beings like. Human activities need to transform on the whole, and practices need to be made sustainable in order to ensure a long and healthy future for the planet. The healthcare industry, although a really important one has been leading to increased environmental pollution in the recent decades. Certain practices in healthcare are leading to incessant waste generation, which in many ways is proving to be harmful for the environment and life in general. The goal of this research project is to delve into the depths of the practices of using disposable equipment in the healthcare industry and formulate recommendations on how practices at RadboudUMC can be made more sustainable. A conceptual framework using the practice theory was developed, since the practice theory provides suitable breakdowns for sustainable practices and transformations using the concept of connections and disconnections of elements. The case of RadboudUMC was chosen as it is an academic hospital which enabled the gathering of information from different perspectives. Interviews were conducted to identify the changes in practices that took place to incorporate the change from traditional reusable equipment to modern disposable equipment. The interviewees were further asked about their preferences while using an alternative of an equipment, and what are the features they usually look out for while making a choice for a particular procedure. Furthermore, the sustainability consultant at RadboudUMC was contacted and interviewed for possible recommendations that can be made in different departments of the hospital and policy changes that can have a positive effect on the practices at RadboudUMC, transforming them into more sustainable practices. Finally, recommendations were formulated on how disposables can be ultimately phased out, for a more environmentally friendly medical center.

Key words: Practices, sustainability, transformation, elements, phasing out.

## Table of Contents

Chapter 1: Introduction	8
1.1 Problem context	9
1.2 Research aim and research questions	10
1.3 Scientific and societal relevance	11
1.3.1 Societal relevance	11
1.3.2 Scientific Relevance	12
Chapter 2: Theoretical Framework	13
2.1 Literature review - sustainability in healthcare	13
2.2 Practice theory	15
2.3 Life cycle assessment	17
2.4 Circular economy	19
2.5 Research aim and research questions	20
2.6 Conceptual framework	22
2.6.1 Historical perspective	22
2.6.2 Current scenario	23
2.6.3 Ideal scenario	24
Chapter 3: Methodology	27
3.1 Research philosophy: critical theory	27
3.2 Research approach	28
3.3 Research methodology: case study	30
3.4 Methods of data collection	31
3.4.1 Research methods in critical theory	31
3.4.2 Semi structured interviews	31
3.4.3 Literature reviews	33
3.4.4 Life cycle assessment	33
3.5 Reliability and validity of the research	33
3.5.1 Reliability	33
3.5.2 Validity	34
Chapter 4: Analysis of Practices	36
4.1 Historical perspective	36
4.1.1 Material	36
4.1.2 Competences	37
4.1.3 Meaning	38
4.1.4 Interaction of the elements	38
4.2 Current scenario	39
4.2.1 Material	39

4.2.2 Competences	39
4.2.3 Meaning	40
4.2.4 Interaction of the elements	40
4.3 Ideal scenario	42
4.3.1 Material	42
4.3.2 Competences	42
4.3.3 Meaning	43
Chapter 5: Results	45
5.1 Results: Sub question one	45
5.2 Results: sub question two	46
5.2.1 Discussion	47
5.3 Results: Sub Question Three	50
5.3.1 General policy change for intensivists	50
5.3.2 Purchase of new equipment	51
5.3.3 Purchasing policies	51
5.3.4 Training programmes for incoming medical professionals	51
5.3.5 Improving availability of reusables	51
5.3.6 Increasing awareness	52
Chapter 6: Discussion & Conclusion	54
6.1 Answering the main question	54
6.2 Reflections on practice theory	56
6.3 Strengths of this research project	56
6.4 Limitations of this project	57
6.5 Future research	58
References	59
Appendix A: List of Codes	64

## List of Figures

Figure 1.1 Variants of laryngoscopes	9
Figure 2.1 The three stages of practice formation (Shove et al, 2012)	16
Figure 2.2 The generic stages of a life cycle assessment (Curran, 2008)	17
Figure 2.3 Concept of circular economy (Ellen Macarthur Foundation, n.d)	19
Figure 2.4 Historical perspective of the practice of using laryngoscopes	22
Figure 2.5 Current scenario of the practice of using laryngoscopes	23
Figure 2.6 The ideal scenario of the practice of using laryngoscopes	24
Figure 2.7 Conceptual framework with phases of change	25
Figure 3.1 The empirical cycle (van Thiel, 2014)	29
Figure 3.2 List of interviewees	32
Figure 4.1 Weightage of elements in the practice	38
Figure 4.2 Practice formation in the current scenario	41
Figure 4.3 Weightage of elements in the ideal scenario	43
Figure 5.1 Raw materials used in laryngoscopes (Sherman et al., 2018)	46
Figure 5.2 Results of the life cycle assessment (Sherman et al, 2018)	47
Figure 5.3 Scope of the life cycle assessment (Sherman et al., 2018)	49
Figure 6.1 Comparison of the practices	55

## Chapter 1: Introduction

The use of disposable products and disposable equipment in the healthcare industry has been increasing drastically since the 1980s. In the present day, more than 85% of hospital medical equipment and supplies is single-use and disposable in nature, which poses an imminent threat to the environment and climate, in the form of increasing waste production and an array of other problems (Gilden, Scissors & Reuler, 1992). This also means that there are greater emissions, as these supplies need to be produced over and over again. No doubt, single use equipment has its advantages. They enable technically complicated surgeries and procedures to be performed, lower the risk of infection, are always on standby, the quality is constant and there are no reprocessing charges. But, all these advantages do not mean that their disadvantages can be neglected. A majority of these equipment are made of plastic and in bulk, meaning high emissions and accumulation of solid waste. Furthermore, disposable equipment usually gets deformed during usage and hence cannot undergo proper reprocessing and recycling procedures (van Drongelen & de Bruijn, 2008).

In certain situations, one of the variants is a more viable option than the other, but such situations are rare and choosing between disposable and reusable devices is a generally difficult decision. There are far more pros and cons to each variant than the ones described above. The most important decision to make while making a choice of devices is the identification of the level of infection control required. Medical devices are divided into three categories based on this criterion. The first category is the critical category. These items must be sterile before entering bodily tissues. These include equipment like catheters and surgical instruments. These devices are most likely to transmit life threatening infections when contaminated. The second category is the semi-critical category. These equipment can transmit various infections when not sanitized properly. At minimum, they must undergo a procedure of high level disinfection after every use. This category includes equipment like endoscopes and laryngoscopes. The third category comprises non-critical items, which are least likely to transmit diseases or infections. Equipment in this category comprises blood pressure cuffs, bedpans, stethoscopes etc, and are only limited to skin contact. The knowledge about transmitting infections through equipment came forward as early as 1978. The chief advantage of disposable equipment is preventing that. Moreover, reprocessing and sanitization of reusable equipment can expose healthcare workers and patients to toxic chemicals if procedures are not done in a safe manner. Most manufactures also do not provide adequate instructions on how to properly disinfect equipment. The information is either incomplete, inadequate, incorrect or impractical. Disposable devices also help in cutting down preparation and procedural times (Srejjic, 2016).

However, as mentioned before, disposables considerably increase the waste generation of healthcare facilities. This waste generation needs to reduce as it can have adverse effects if left unchecked. In today's time, investigation into the field of circular economy has focused on how products can be modified in order to fit in with the circular economy principles, and medical equipment should be no different (Bocken, De Pauw, Bakker & Van Der Grinten, 2016). Research has been performed on different products and which circular economy strategy suits them, the question arises between whether to retain the product's value by lengthening its life or

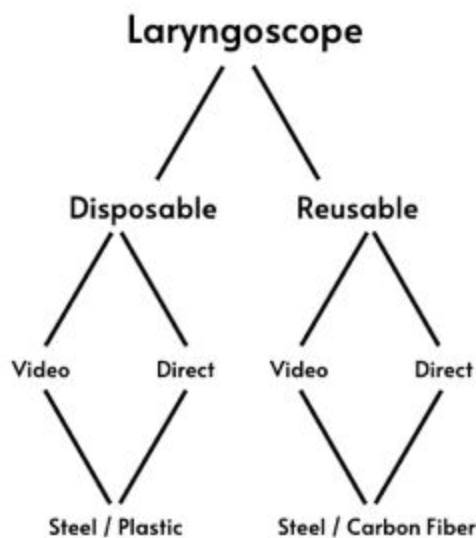


by recycling it (Bakker, Wang, Huisman & Hollander, 2014). Circularity and reusability can definitely help in slowing down the environmental impact caused by the use of disposable equipment, but disposable equipment is here to stay since most medical professionals are now used to them in their training. The general notion also persists that using disposables is easier and cheaper.

Based on the literature reviewed for the introduction, the following hypothesis was formulated: *'reusable medical equipment stands as a better alternative over disposable equipment due to less environmental impact'*.

### 1.1 Problem context

A disposable medical device that has gained prominence over the years is the disposable laryngoscope. A laryngoscope is a long, thin instrument with a light source and a video camera or a lens on the end, used to visualise the larynx (American Cancer Society, 2019). There are different variants of laryngoscopes, the two main types of laryngoscopes are - a laryngoscope with a reusable blade and handle, and a laryngoscope with a disposable blade and a handle, which is single use in nature.



*Figure 1.1 Variants of laryngoscopes*

Figure 1.1 highlights the main variants of laryngoscopes that are used in the medical industry. The most common and tested equipment is the direct reusable laryngoscope, which is rigid and comparable to the performance of disposable video laryngoscopes. Disposable laryngoscopes on the other hand, are prone to a variety of issues, which are explained in chapters ahead. Many institutions have been making the switch from the traditional reusable laryngoscope blades and handles to single-use, disposable video laryngoscope blades and

handles to meet infection prevention guidelines, since it offers to be an easier alternative (Sherman, Raibley & Eckelman, 2018). Medical professionals also prefer to use the disposable video laryngoscopes in critical cases, to maximise first-pass success rates, and in cases where direct laryngoscopy fails to achieve intubation (Rombey, Schieren & Pieper, 2018). Other reasons why the switch from reusable to disposable laryngoscopes include the training of medical practitioners. Dr. Hugo Touw (personal communication, 5th May 2020) mentions that medical trainees in the current days undergo training only for disposable video laryngoscopes, as it is easy to use. Hence, they never learn how to properly operate and manage the use of direct laryngoscopes. Purchasing policies also differ from institution to institution, and most of the institutions believe that using disposable equipment like laryngoscopes is cheaper than the reusable alternative. Another reason is that after every use of reusable laryngoscope blades, they need to be disinfected and this takes time, making the device unavailable during the disinfection process.

Even though the amount of raw materials going into the single-use blades and handles might be less, they cause a considerable increase in the amount of solid waste and also an increase in the life-cycle emissions. Healthcare pollution and environmental health is a new safety consideration, and there is an alarming trend in the increasing use of single-use disposable materials throughout the world in the healthcare industry. It has been found out that the single-use disposable laryngoscope handles have 25 times more greenhouse gas emissions, and single use disposable blades have 8 times more greenhouse gas emissions, when compared to reusable laryngoscope blades and handles treated with high level disinfection. Not only do the disposable blades and handles have higher emissions and environmental impact, instead, they also turn out to be the costlier alternative out of the two (Sherman et al, 2018). This data is presented in the life cycle assessment document by Sherman et al. (2018), which serves as a premise for this research project and the hypothesis, stating that disposable equipment like laryngoscopes are much more harmful for the environment than reusable equipment.

Although this project focuses on disposable and reusable laryngoscopes, there are several other devices like this that have seen the transition from reusable to disposable, and the analysis and the recommendations of this project can be applicable to all of these instruments, with the required modifications. The case of laryngoscopes is being taken as a mere baseline, as a representative of other disposable equipment.

## **1.2 Research aim and research questions**

The problem context serves as the building block for the development of the research aim and research questions. This project is being conducted at RadboudUMC, and the research aim was developed with regard to the situation at RadboudUMC. The following research aim was formulated -

*"To explore ways in which practices at RadboudUMC can be changed to reduce the use of disposable equipment"*

The main aspect that will be focused on in this research project are the elements of practices that are undertaken and the elements that changed to incorporate the transition from reusable laryngoscopes to disposable laryngoscopes, and what can be done to reshape them and gradually phase out the use of disposable equipment. Pertaining to the research aim, the main research question is as follows:

*“What changes can be brought about in the practice of using disposable equipment prevailing at RadboudUMC to change the practice and reduce the use of disposable equipment?”*

To answer the main research question, sub questions will be formulated after discussing the application of the chosen theories in the theoretical framework chapter.

### **1.3 Scientific and societal relevance**

#### **1.3.1 Societal relevance**

The societal relevance of this project relates directly to increased emissions, climate change and global warming. The life-cycle analysis done by Sherman et al (2018) on disposable and reusable laryngoscopes reveals that the life-cycle emissions caused by disposable laryngoscopes are substantially higher than the emissions caused by reusable laryngoscopes. This life cycle assessment document lays down several impact categories that have been studied. These include ozone depletion, global warming, acidification, eutrophication and ecotoxicity among others. Climate change and global warming have a direct impact on many aspects of daily life. Impacts have been seen in the fields of agriculture, water supply, transportation, energy, and many other aspects (Globalchange.gov, n.d). Bradford (2017) states that an increased concentration of carbon dioxide in the atmosphere leads to nutrient loss in plants, and also hinder food security in many regions of the world. Reduced food security levels have the potential to create imbalances in the global food market, famines, political unrest and civil unrest. Indigenous people and tribes all over the world that rely on agriculture as their primary activity would be the worst sufferers. Climate change also has a potential to disrupt other economic activities like tourism and transportation, and the insurance industry (United States Environmental Protection Agency, 2017). In the Netherlands, from the period of 1998-2004, there were increased sightings of pests, diseases and weed that usually did not occur. The effects on the transport sector in the Netherlands is also evident, as the transport system tends to have a worse performance under extreme weather events (Bresser et al, 2006). Overall, practices in the healthcare industry eventually affect daily lives of people all around the planet, and hence, it is essential that these services remain sustainable. The concept of circularity can be applicable in the healthcare industry to a large extent, since the industry mostly operates with disposable equipment. McArthur (n.d) proposes a technological cycle of the circular economy, where equipment is refurbished and recycled instead of being disposed of. This concept has been applied in many medical institutions with positive results. An example is seen in the Sacred

Heart Hospital in Wisconsin, which is elaborated in the literature review section. However, implementing circular economy measures in the healthcare industry can be challenging, as product designers need to keep up with safety regulations. It is a high risk field, where any potential reduction in quality or functionality can lead to a threat to the patients' lives. The goal for product designers, thus has been to develop products that can go through repeated life cycles while maintaining an extremely high level of functionality and quality (Kane, Bakker & Balkenende, 2018). Low value and cheap products thus need to be phased out to ensure better quality of healthcare and better environmental concern.

### 1.3.2 Scientific Relevance

No research has been conducted specifically pertaining to disposable laryngoscopes, apart from the few life-cycle assessments and life cycle costing assessment done by Sherman et al (2018) and McGain, Story, Lim & McAlister (2017). This particular research project aims to shed light on the practices, more importantly the three elements (material, knowledge and meaning) that lead to the formation of practices (Shove, Pantzar & Watson, 2012); and how these elements have shaped the practice of the use of disposable laryngoscopes, and what changes can be introduced into the elements to prompt a transformation that can enable a switch back to reusable laryngoscopes. Scientific research on disposable equipment in general on the other hand, is quite robust and up to date. Researchers have identified the increased environmental impact that the use of single use equipment has and how policies and measures need to be taken and made in order to curb the problem. Most of the research that is conducted with regard to disposable equipment merely mentions in passing the increased environmental impact, but research and information is required as to how the use of disposables can be reduced in healthcare. The recommendations can include the possible changes that hospitals and medical centers can make in their policies, the training that they give out to new doctors and medical professionals and the change in practices that can enable the transition back to reusables.

## **Chapter 2: Theoretical Framework**

### **2.1 Literature review - sustainability in healthcare**

In first world countries like the United States of America, the healthcare industry is one of the largest industries. Accounting for over 17% of the total GDP in the United States, the energy expenditure of this industry is over 73 billion kilowatt hours annually (CEA, 2009; DOE, 2012; Vogt and Nunes, 2014; WorldBank, 2014). This has also led to increased carbon emissions, majority of which can be attributed to excessive resource use (Chung and Meltzer, 2009). Healthcare structures and institutions were developed to cater to public health and safety, but in the recent years, they are creating a negative impact, environmentally and socially. This is mainly due to various unsustainable practices that persist in them (Buffoli, Capolongo, Bottero, Cavagliato, Speranza & Volpatti, 2013). Sustainability refers to the ability of a system to continue doing things in the same way over a long period of time. In recent years, a lot of medical facilities and societies in general have been going 'green' and becoming environmentally friendly (Health Research and Educational Trust, 2014). One practice that puts the idea of sustainability at risk is that of the use of disposable equipment in the healthcare industry.

The current literature pertaining to the topic of use of disposable equipment in the healthcare industry is also of the opinion that this phenomenon is on the increase, and is causing a problem. Drastic measures are needed to curb this problem, as it is leading to an increase in emissions and also causing problems with increased waste generation. Gilden et al. (1992) realised that the use of disposable products poses an imminent threat to the environment as it takes up a considerable amount of wasteland space. This has also led to an increase in landfill disposal fees, by a margin of 400%. Although this text is relatively older, it still highlights the importance of the study of this phenomenon, and the potential environmental impacts. The cradle-to-grave life cycle assessment that was conducted by Sherman et al. (2018) also yielded definite results that the use of disposable laryngoscopes exact an increased amount of emissions as compared to traditional reusable laryngoscopes.

There are several ways in which the healthcare industry can make operations more sustainable. Opportunities can be seen in various fields ranging from energy, water, waste management, supply chain and commissioning & recommissioning. This research project can be related to most of them, but the highest relativity can be drawn in the arena of waste management, since disposable items are being focused on. In the current day, more than 80% of the equipment and products in the healthcare industry ultimately become waste, and is categorized as general and unregulated waste. Waste management programmes and changes in the type of equipment used in medical centers can ultimately help in reducing the amount of waste generated, and can lead to saving on both handling costs and environmental pollution. An example can be seen at Sacred Heart Hospital in Wisconsin. In 2008, the hospital switched to reusable sharps containers. Sharps containers are used to store any devices that are used to puncture and lacerate the skin. Since the change has been made, they have been preventing more than 40,000 pounds of waste generation every year. Thus, this example portrays that even small changes can have a large impact (Health Research and Educational Trust, 2014).

Considering the area of environmental sustainability in healthcare, the World Health Organisation has come up with a policy mandate called Health 2020 (The Tallinn Charter),

which focuses on policy development in the area. This aims at providing an improved healthcare system in the European Union while minimising impacts on the environment, and even work upon improving it. One of the main aspects of this document stands at promoting sustainable procurement strategies, which in turn leads to overall lesser waste development. The WHO has identified five areas where healthcare institutions exert significant impact on the environment. These are waste generation, wastewater generation, greenhouse gas emissions, ecotoxicity and excessive use of resources. Two of the five areas defined by WHO are directly related to the scope of this project, since the life cycle assessment deeply delves into these factors. The WHO states that healthcare institutions are the highest contributors to waste generation, but most of it is general waste, that is, plastic items and other disposable equipment. It was also found that higher income countries tend to produce more waste, and have an increased use of disposable instruments and prepackaged materials. Going green and using less disposable items has benefits in different areas. Less waste generation and emissions will invariably lead to better health, financial benefits and betterment of the environment. However, there are several barriers that exist in the quest to go green. Lack of knowledge among health workers, inadequate training and general misinformation form individual level barriers. These barriers also relate to the practice theory element of competencies. Organizational barriers comprise policies, utilities and logistics. System barriers refer to the weak enforcement of described policies, inappropriate frameworks and regulations, and low incentives to make switches (WHO, 2016).

Furthermore, quantitative data and information regarding waste generation is required to develop suitable sustainable solutions, in order to maintain the standard of patient care and reduce environmental impacts (Berwick and Hackbarth, 2012). Another research area in which information is required is the use of disposables, which have recently been found to be costly, wasteful and unnecessary (Karlsson and Pigretti Ohman, 2005; Tudor et al., 2007; PGH, 2008; Swensen et al., 2011).

Adhering to all the points discussed above, the most common element in the discussion is that of sustainability. Sustainability as an idea can be implemented in healthcare by increasing awareness among medical professionals. It can also be instilled in people working in healthcare in the form of various sustainable practices like proper waste recycling, reduced waste generation and conscious use of disposable products. All these measures are representative of sustainable practices. Consequently, it is also required to understand why unsustainable practices persist in order to make change and transform them into sustainable practices. To study the evolution of practices and how they can be changed, the practice theory would serve as an excellent framework, because using the practice theory, focus can be put on different elements of the practice and connections between different elements can be studied efficiently. For this purpose, the practice theory by Shove et al (2012) seems to be the best fit.

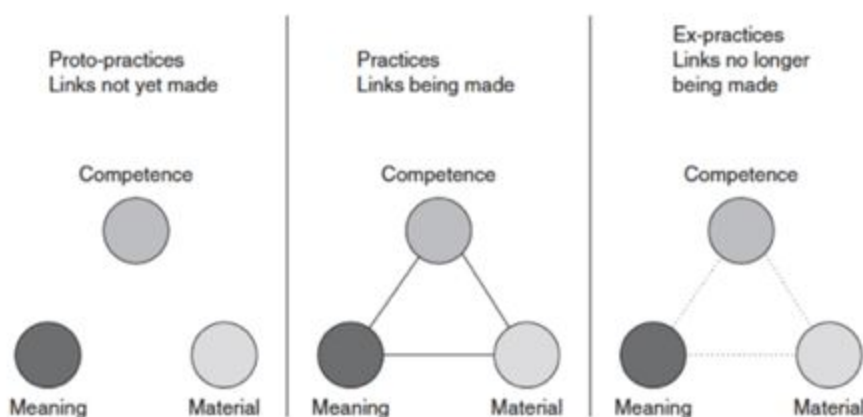
## **2.2 Practice theory**

The practice theory is an approach to look at societal transformations. Reckwitz (2002) defines practices as “routinized types of behavior” (p. 249). This means that practices exist as

long as they keep on being repeated. Societal transformation occurs when there is a change in underlying practices or these practices are stopped altogether. This transformation, however, does not happen instantly, but is a gradual change that occurs over a long period of time. This usually happens due to increased awareness or implementation of a new policy in response to a complex global phenomenon such as climate change (Warde, 2005, p.140). Warde (2005) also mentions that the understanding of the emergence, persistence and disappearance of practices is important. Reckwitz (2002) further argues that practices consist of interdependencies between different elements which include “forms of bodily activities, forms of mental activities, ‘things’ and their use, a background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge” (Reckwitz, 2002, p.249). Furthermore, Giddens (1984) states that practices and social structures that shape practices are recursively related, which means that human behavior is influenced by structures of rules and meanings, and these structures in turn are reformed due to human behavior.

Shove et al (2012) state that practices are formed up of three elements. These elements are materials, competences and meanings. Materials include things, technology and objects. Competences relate to the skills and techniques required to operate materials and other things. Meanings include the ideas and aspirations derived out of a particular practice. Shove et al (2012) also state that practices form, persist, shift and disappear when links and connections between these elements are made, changed or broken.

Figure 2.1 explains the stages of practice formation that pertains directly to making and breaking links between the elements. When the elements exist independently, no practices are formed. As the elements start interacting with each other, practice formation begins and it exists till the links between the elements persist. When new elements are introduced or existing elements are changed, new practices are formed.



*Figure 2.1 The three stages of practice formation (Shove et al, 2012)*

Reckwitz (2002), a strong proponent of the practice theory, mentions that practice theory is a type of cultural theory. This means that the theory highlights the ideas, beliefs and manifestations of a societal setting. He lays down different elements of practices, which include-body, mind, things, knowledge, discourse and structure. All these elements can be linked to the three elements that Shove et al. (2012) have used in their version of the theory. Body and things can be linked to the element of material; knowledge can be linked to the element of competencies; and mind, discourse and structures can be linked to the element of meaning. According to Reckwitz, things are resources that need to be used in a certain way to carry out a practice. Knowledge embraces ways of understanding and knowing how to engage in a particular practice. Thus, we can say that most theories of social practice tend to hover around the same structure, having similar elements.

However, simply changing one of the elements does not lead to a change in practices. There are several other variables that need to be adhered to, for this to happen. Changing or modifying an element serves as a starting point, which trickles down to other related practices and finally leads to transformation. Practices constantly are formed, reformed and deformed, but for it to happen, all three compatible elements must be present together (Shove et al, 2012).

The practice theory in particular would be of great help to assist reach the research aim, as the research aim pertains directly to the use of a particular medical equipment, and how the practice emerged over time. The importance of the elements can also be seen, as the goal of the research is mainly to change the practice, and according to Shove et al (2012), practices can be changed when links between elements are broken and new elements are introduced. One more reason why the practice theory would be useful in this research is that the elements are clearly defined in the research. The material element encompasses the disposable and the reusable laryngoscopes, the competence encompasses the training of the medical professionals to use the medical equipment, but the element of meaning seems to be unclear. It is interesting to note that when practices change, elements are left behind in several forms. Shove et al (2012) mention that materials, when left behind, have the tendency to become obsolete and phase out. Competences can lie dormant, which means that when a practice changes, the competency of the old practice is still instilled in practitioners. Meanings on the other hand, have the tendency to come and go. Rather than being dissolved, they are overlaid by new meanings. In this project, it will be interesting to note that when practices change, how the elements react and to what extent they are left behind. Shove et al. (2012) mention in their text that to change practices, policies need to be targeted towards bad unsustainable elements and not towards unsustainable practices. The practice theory will enable focus on the most unsustainable element of the practice of using disposable equipment so that suitable measures could be taken to change it.

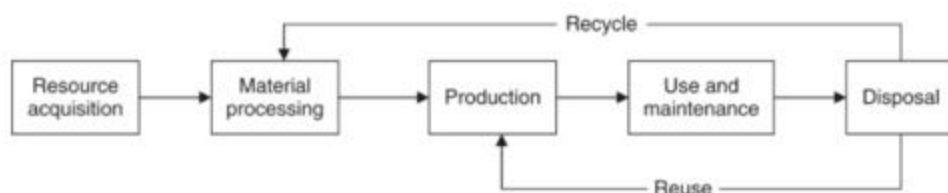
Connections and disconnections are of paramount importance in the practice theory. Shove et al (2012) mention that particular elements, when changed or modified, can lead to disconnections between the three elements and eventually, lead to a change in practices. In this project, the element of material is given the most importance, as the study is being conducted on disposable and reusable equipment, putting them under the material category. To argue why the



element of materials needs to be changed to bring about a change in practice, information relating to the environmental impact of disposable and reusable equipment is required. For this purpose, the life cycle assessment serves as a viable tool.

### 2.3 Life cycle assessment

Curran (2012) states that "life cycle assessment is an environmental accounting and management approach that considers all the aspects of resource use and environmental releases associated with an industrial system from cradle to grave" (p. 359). It is an environmental account and management approach which considers all aspects of resource use and environmental impacts associated with a system, function or a product. A life cycle assessment is a tool usually used for comparison, to help decision makers make a choice out of the many available alternatives (Curran, 2012). It systematically identifies and evaluates opportunities for minimising potential environmental consequences for resource usage.



*Figure 2.2 The generic stages of a life cycle assessment (Curran, 2008)*

Figure 2.2 shows the general steps that are taken into account for conducting a life cycle assessment. The arrows in the image indicate the use of transportation in the process of production, use and disposal. By taking into account the impacts in all stages of the production, use and disposal process, the life cycle assessment provides a comprehensive view of the environmental aspects and an accurate picture of the environmental trade-offs in product selection. It also enables decision makers to know how their choices influence each point in the life cycle of a particular product (Curran, 2012).

One thing that must be taken care of when using a life cycle assessment is the similarity of the products being compared. The basis of comparison should be equivalent use, that is both the products deliver an equivalent service. An example that Curran (2012) mentions is that of handwashing soap. If a bar of soap is compared to liquid hand washing soap, they must be compared on the basis of the number of handwashes they are rated for. Curran (2000) also mentions the four part approach that should be followed while conducting a life cycle assessment. Part one involves specifically stating the purpose of the assignment and identifying the scope of the assessment, part two involves quantifying the energy use, raw material input and environmental impacts associated with each stage of the life cycle of the product(s), part three pertains to the interpretation of results and part four involves formulation of

recommendations. Curran also lays down some constraints of the tool. A life cycle assessment is time consuming and costly. In many cases, the results of the assessment are not relevant to the actual decision making process that potential users make, since it is not that easy to interpret.

The life cycle assessment would be useful in this research project to compare the environmental impact caused by the disposable laryngoscope blades and handles, as compared to the reusable blades and handles. Both the alternatives provide the same service to medical professionals, that is imaging of the larynx. Since the life cycle assessment takes into account the impacts at all stages including transportation, it will be useful to see a comprehensive view of the state of affairs. This aspect will help in providing a 'why' argument to the cycle of change, and explain how the use of a particular variant of the equipment is much more harmful for the environment and why the change needs to occur as soon as possible. Once it is known which variant of the equipment is more harmful to the environment, the practice theory can be applied to focus on the most unsustainable element of the practice in order to take suitable measures to transform the practice into a more sustainable one. Different policies like purchasing policies and training policies would need to be implemented, so that decision makers can choose the most sustainable equipment to purchase and medical professionals can be well trained to efficiently use that variant of equipment. One pragmatic recommendation towards the problem can be a circular purchasing policy, which would mean that almost all devices and equipment that are purchased are recyclable and reusable, without any generation of waste. Thus, the circular economy theory can shed light on this front.

## **2.4 Circular economy**

Circular economy is a concept that can potentially be used as a solution to the aforementioned problem. This concept is based on 3 pillars- reducing waste and pollution, keeping products and materials in use, and regenerating natural systems.

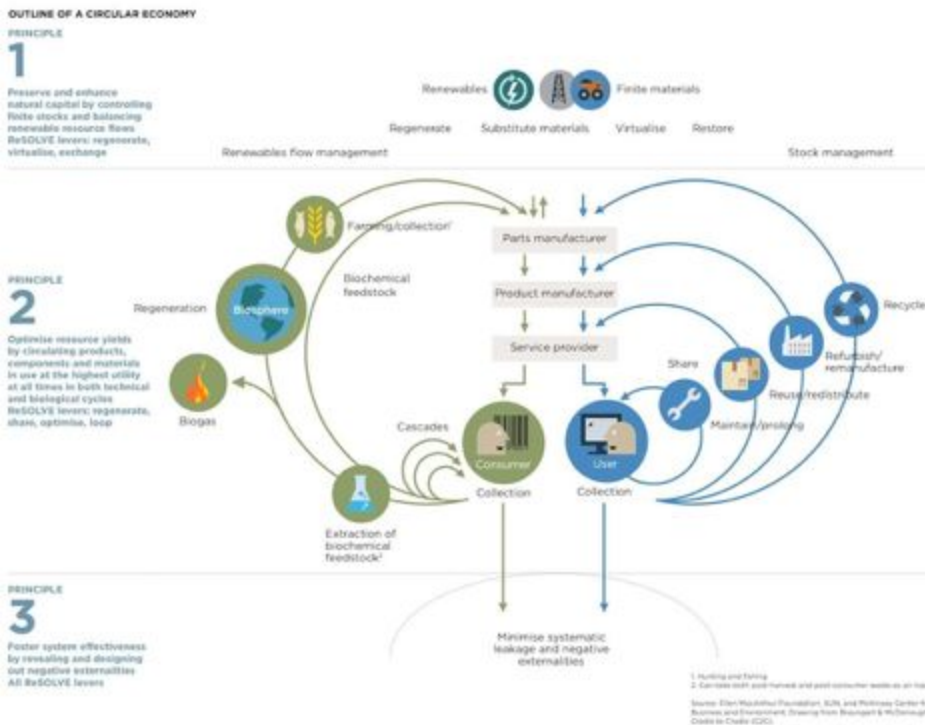


Figure 2.3 Concept of circular economy (Ellen Macarthur Foundation, n.d)

This concept distinguishes between technological and biological cycles. Biological cycles include the process of consumption, and the energy is fed back into the cycle through composting and anaerobic digestion. The technical cycle involves the restoration of products and promotes strategies like reuse, remanufacture, repair, and recycling (Ellenmacarthurfoundation.org, n.d). This should be the ultimate goal for all technical products.

The concept of circular economy has deep rooted origins in several different theories and ideas, and this idea has been floating around since the 1970s. One of the most important concepts is cradle to cradle. This concept was developed by a German chemist Michael Braungart along with an American architect Bill McDonough. It focuses on the elimination of the concept of waste, and strives to ensure betterment of product design which are reusable with life cycles that are safe for human health and the environment. The use of renewable energy is also heavily propagated with cradle to cradle. The second concept is performance economy, which pursues four main goals- product life extension, long life goods, reconditioning activities and waste prevention. It also heavily propagates the idea of selling services rather than goods. Biomimicry is another important building block of the circular economy. It focuses on nature as a model and tries to emulate forms, processes and strategies to help solve human problems. Nature is also used as a measure in order to judge the sustainability of new innovations. Industrial ecology studies the flow of material and energy through industrial systems. It strives to design a production process that is in accordance with local ecological constraints. Increasing

natural capital is another one of the building blocks. It focuses on increasing the productivity of natural resources and reinvestment in natural capital (Ellenmacarthurfoundation.org, n.d).

As mentioned before, a circular purchasing policy can be a potential solution to unsustainable practices that concern the use of technology and equipment, which is the case explored by this research project. The technological side of the concept will provide insights on how a particular material can be improved, what changes can be made in the material to make it more sustainable.

The three major theories used in this project might seem to be distant and unrelated, but there are certain connections that can be formed between them. As already mentioned, practice theory focuses mainly on the three elements - material, competence and meaning to explain formation and transformation of practices. The core aspect of this research project is a disposable equipment called laryngoscope, which comprises the element of material from the practice theory. The life cycle assessment provides valuable insight on the impact of this 'material' during various stages of its production, use and disposal. Hence, the material component of the practice theory is directly related to the life cycle assessment, and the insights gained from the assessment can help in the transformation of the practice by initiating a disconnect between the elements by introducing a new material. Another connection can be made between the circular economy and the practice theory. The technical side of circular economy can be directly linked to the material element, as it propagates the reuse and recycling of equipment instead of disposal. Reuse and recycling are both sustainable practices. This idea of sustainability and low emissions can be directly connected to the element of meaning of the practice theory.

## **2.5 Research aim and research questions**

Keeping the theoretical framework as a baseline and in order to better understand the environmental impacts of disposable laryngoscopes and the practices that led to the routine use of disposable laryngoscopes, the following research aim was formulated-

*"To explore ways in which practices at RadboudUMC can be changed to reduce the use of disposable equipment"*

The main aspect that will be focused on in this research project are the practices that are undertaken and the practices that changed to incorporate the transition from reusable laryngoscopes to disposable laryngoscopes, and what can be done to reshape them and gradually phase out the use of disposable equipment. Pertaining to the research aim, the tentative research question is as follows:

*"What changes can be brought about in the elements of the practice of using disposable equipment prevailing at RadboudUMC to change the practice and reduce the use of disposable equipment?"*

To further aid in answering the research questions, the following sub questions were formulated:

1. *How did the practice of the use of disposable equipment gain prominence over the practice of using reusable equipment? What are the dominant connections between the elements of the practice?*

This sub question primarily focuses on the historical perspective of the issue at hand, and how practices changed over the course of time to enable the routine use of disposable laryngoscopes and equipment. Once it is known how exactly the practice evolved, and what elements of the practice are the strongest, adequate steps can be taken to stop and change the practice. This research question also helps in knowing what elements are left behind and dissolved and in what forms.

2. *What are the potential environmental impacts of both variants of laryngoscopes?*

This sub question focuses on the aspect as to why this change from disposable to reusable laryngoscopes is important, and how the increased use of disposable laryngoscopes pose a threat to the environment. This sub question also highlights the problem of disposable equipment being more harmful to the environment, by taking laryngoscopes as a representative for all forms of disposable equipment that have a potential to cause heavy environmental impact. This sub question can also help in testing out the hypothesis, which needs to be verified.

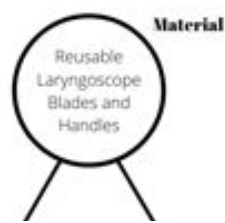
3. *What are the possible changes that can be made to the current practice of using disposable equipment to transform the practice into a more sustainable one?*

This sub question focuses on possible recommendations and policies which can help in cutting down on the use of disposable items in RadboudUMC and making suitable changes that lead to a sustainable transformation of the practice. The insights gained on the elements from sub question one and sub question two will be helpful in drafting suitable policies and recommendations to prompt a sustainable transformation.

## **2.6 Conceptual framework**

Taking the practice theory framework as the basis for this research project, three phases of the conceptual framework have been developed, which primarily focus on the choices made by medical professionals in terms of the use of laryngoscopes. The three phases are- historical perspective, present scenario and ideal scenario.

### **2.6.1 Historical perspective**



*Figure 2.4 Historical perspective of the practice of using laryngoscopes*

Initially, only reusable laryngoscopes were used in the medical industry. Medical professionals were trained adequately to use these kinds of equipment. The historical perspective will highlight the practices that existed in the early stages of healthcare, and also shed light on the elements that led to the formation of the practice.

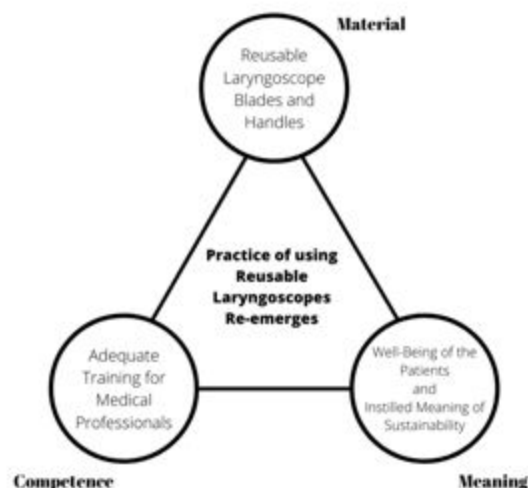
### 2.6.2 Current scenario



*Figure 2.5 Current scenario of the practice of using laryngoscopes*

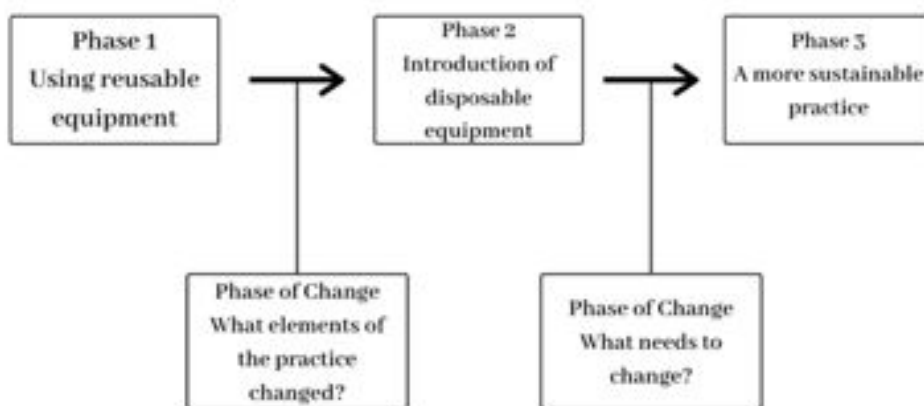
With the advent of disposable equipment like video laryngoscopes for emergency cases, the practices began to change and these equipment came to be used even in routine situations. The reusable laryngoscope was gradually phased out as medical professionals did not receive training on how to operate them, since the disposable video laryngoscopes were easier to use and were thought to be cheaper than their reusable alternative (Dr. H. Touw, personal communication, 5th May 2020). This scenario highlights the disconnections in the elements that took place to accommodate the shift in practice and move ahead to disposable equipment.

### 2.6.3 Ideal scenario



*Figure 2.6 The ideal scenario of the practice of using laryngoscopes*

The ideal scenario, when it comes to the use of laryngoscopes would be to go back to the basics, to the reusable laryngoscopes. For that to happen, the practice of using disposable laryngoscopes needs to be phased out, which, according to the practice theory, can be done by introducing a new element or changing a particular element (Shove et al, 2012). In this case, it would be the element of meaning, and a way to incorporate the idea of sustainability in medical professionals. Using these 3 phases of the practice, a conceptual framework has been developed.



*Figure 2.7 Conceptual framework with phases of change*

Figure 2.7 represents the conceptual framework of this research project, primarily focusing on practices and the phases of practice formation. The phases of change present two important transitional phases, in transformation can take place. The first phase of change occurred when medical professionals gradually shifted from reusable equipment to disposable



equipment. To find out why this change took place, elements of the practice will be studied over time, and insights will be gained on the change through expert interviews in the medical field. The second phase of change highlights transition towards the ideal, more sustainable situation. It reasons as to why the current situation is harmful for the environment, and why the change needs to occur. The reasoning for this will be done by the life cycle assessment for disposable and reusable laryngoscopes. This phase also signifies the elements of the practice that need to change.

The first phase of change focuses more on the historical perspective of the practice. Information will be collected in regards to the connection between the different elements, and which element changed the most and influenced the practice overall, in order to introduce the practice of using disposable equipment. The second phase of change, which is the change from disposable to reusable equipment is essentially a change from an unsustainable practice to a sustainable practice. Several barriers to changing of practices were mentioned in the literature review section. WHO (2016) also mentions that the same category of barriers can act as enablers to change. Individual enablers relate to proper knowledge of the use of material and an enhanced idea about environmental sustainability. Education and training forms an important part of individual enablers. This is also important as individual cooperation is required on all stages of the process in the quest to go green and sustainable. If all medical professionals decide not to use disposable equipment, then the shift will be easier. Organizational enablers are more like whole institutions taking strict measures to bring about a change. It can be as simple as hospitals vouching to reduce their single use disposable items or as complex as a change in the purchasing policy overall. System level enablers relate to financial and other incentives offered by the state in order to promote a certain kind of behaviour. This can play a major role in healthcare institutions making a switch to reusable, more sustainable alternatives of equipment.

Phases of change for practices however, are not simple. There are several other important variables to consider when practices change. Shove et al. (2012) mention that the three elements have different characteristics. Out of the three elements, the element of material is the only element that is tangible, meaning and competency are intangible. Thus, there are several factors that can influence changes in material, such as transportation, technological advancement etc. Meanings and competences of the other hand depend on existing concepts and can extent or erode with the change in elements. Shove et al. (2012) also mention that technological advancement in the form of material can also lead to collapse of skills and competences. In this study, it will be interesting to note whether the competence of using reusable and disposable medical equipment lies dormant or decays totally in the first and the second phases of change.

Continuation of practices is also a factor that needs to be considered when practices are being changed. Shove et al. (2012) mention that there are several reasons why practices are carried forward in their exact state. The repetition and continuation of practices occurs due to carriers that are influenced by social structures and networks. Practices are shared between people and often become second nature, meaning that people tend to engage in practices without thinking. This is the normal scenario, and in this project, the normal situation is the use

of disposable equipment, which has been passed on from person to person over a long period of time.

The phases of change or the transformation phases between practice involve changes in the established patterns of actions and structure. This can mean changes in legislation, infrastructure, rules and regulations of an institution etc. (Shove et al, 2012). Transitions can take place through governmental manipulations. People's choices can be influenced by shaping preferences and nudging individuals and groups towards more sustainable practices. According to Shove et al. (2012), this is a two step process in which persuasion towards change is needed and barriers to change need to be removed. The recommendations for the transformation phase will follow these steps for suitable measures, and also list out how the changes will occur and through what steps. There are four main things that need to be noted during this study for the transformation phase which are - drivers of change, role of infrastructure, technological developments and the most appropriate level of intervention.

## **Chapter 3: Methodology**

### **3.1 Research philosophy: critical theory**

All scientific research has roots that reinforce the search for knowledge, which is known as the philosophy of science (Ponterotto, 2005). This philosophy incorporates certain variables that shape the research. These variables are ontology, which refers to the question of the form of nature and reality, and what can be known about the real world and how it exists; epistemology, which refers to the relationship between the researcher and the things that can be known; and methodology, which refers to the steps that the researcher follows to find out about reality and what can be known about the reality (Guba & Lincoln, 1994). Each of these three variables encompass different research paradigms. A research paradigm can be defined as *“a set of interrelated assumptions about the social world which provides a philosophical and conceptual framework for the organized study of that world”* (Filstead, 1979, p.34).

Guba & Lincoln (1994) mention four major paradigms that exist in scientific research. These are positivism, post-positivism, critical theory and constructivism. Positivism focuses on naive realism, which means that an achievable reality is assumed to exist, and through research, one can obtain knowledge about the true state of affairs. It follows a sense of duality, in which the researcher and the object being researched are independent entities, and cannot influence each other. The methodology in positivism generally focuses on experimental methods and the research aim is pertaining more to the explanation of a said phenomenon. Postpositivism assumes the existence of reality, but it is only imperfectly apprehendable. It follows a modified

sense of dualism, in which again, the researcher and the object being researched are separate entities. The methodology remains experimental in postpositivity. Constructivism, on the other hand, argues that multiple realities exist, and most of them are mental and social constructs. These realities are alterable and not concrete. The researcher and the object are said to be interactively linked and findings are created as the research proceeds. The methodology of constructivism is said to be hermeneutical and dialectical, and information can only be obtained through good connections between the researcher and the interviewees. The different social constructions are then interpreted and compared using hermeneutical methods.

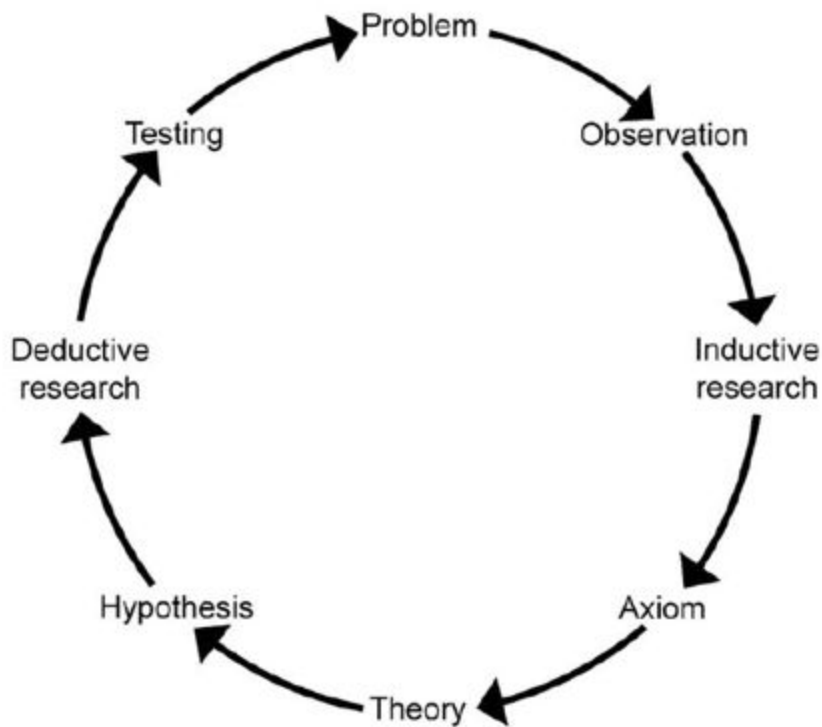
Taking the ontology, epistemology and methodology of this research project into account, this particular research project can be placed into the paradigm of critical theory, as the purpose of this research is to essentially *critique and transform* the existing social practices of using disposable laryngoscopes and disposable equipment.

The ontology for the critical theory paradigm, according to Guba & Lincoln (1994), is historical realism. This means that reality is shaped by social, political, cultural and gender values, shaped over time, and that this reality is apprehendable. Since this research project specifically studies the historical perspective and how a social practice came into existence, the ontology fits in perfectly with the critical theory paradigm. The value of sustainability and environmental impact is inherent in this research project, making the process of obtaining information value mediated, meaning that the researcher's values and beliefs are influencing the inquiry. Thus, the epistemology of this project also is in congruence to the critical theory. This research project would also focus on in-depth, semi-structured interviews, leading to a discussion about the emergence of the social practice in question, thus making the methodology dialectical, which also fits into the critical theory methodology (Guba & Lincoln, 1994). Critical theory's position with respect to practical issues are also fulfilled under this study. According to Guba & Lincoln (1994), the inquiry aim of critical theory is 'critique and transformation', which is highlighted by the research aim of this project. The nature of knowledge and information is deemed as structural and historical, which is corroborated by the nature of the interviews in which historical insights on the transformation of practices will be gained. Horkheimer (1982) provides three important criteria that characterizes the critical theory paradigm. These are - the research must be explanatory about what is wrong with the current social reality, it must identify the action that can change it and it must provide clear norms for criticism and transformation. Thus, the problem is not only to be explored, but steps on how to solve the problem also need to be addressed (Asghar, 2013). This research project fulfills Horkheimer's three criteria as it aims to identify and explore the unsustainable practice of using disposable equipment, strives to provide recommendations to curb the problem and denotes a clear set of functional norms. These norms revolve around the challenge of sustainability in healthcare and environmental protection. Furthermore, the element of historical aspect of the critical theory is also taken into account in this research project. This is done by studying the practices in three stages as mentioned before- the historical perspective, the current scenario and the ideal scenario. Critical theory is further applicable in synergy with the practice theory as the practice theory places strong focus on studying societal patterns of how practices are dispersed and

carried forward, and how people in society act as carriers. Practices are also sometimes seen as the 'normal' in society, which means that people engage in them without thought (Shove et al, 2012).

### 3.2 Research approach

According to van Thiel (2014), research approaches can be of two types- deductive and inductive. An empirical cycle was also laid down, which further provides an insightful division between inductive and deductive forms of research.



*Figure 3.1 The empirical cycle (van Thiel, 2014)*

The deductive approach specifies what theories will be applied in the research and how these theories are helpful in answering the research questions, and the operationalization of the theory. This is done at a preliminary stage, as a part of the research design. It usually results in the formation of hypotheses, which can be tested during the empirical stage. However, the existence of a hypothesis is not a requirement. The theoretical framework forms an important part of deductive research, but it is not merely the explanation of the theories. It implies the operationalisation of the theories and how the theories are used to answer the research question and sub questions (van Thiel, 2014).

The inductive approach on the other hand focuses on the development of the theoretical framework after the empirical research has been conducted, and the theoretical framework does not form a part of the research design. Observations are usually the starting point of the research, and the inductive approach usually follows an expectation that has been set for the research, and moves forward accordingly. There are set guidelines and in no instance does the research proceed in a random manner. The analytical process continues till sufficient data has been gathered and analysed, which in turn results in a theoretical framework (van Thiel, 2014). This research project falls under the category of the deductive approach, since the theoretical framework of practice theory and its operationalization is paramount to answer the research questions and achieve the set research aim.

### **3.3 Research methodology: case study**

A case study is a research strategy in which a case of the subject is analysed in an everyday setting. According to van Thiel (2014), a case can be anything ranging from a group, an organisation, a country, a city, a neighbourhood etc. Usually in case studies, qualitative data is gathered on a large scale. Case studies generally concentrate on a limited number of phenomena, but these phenomena are studied in great detail, rendering rich and descriptive explanations of the situations (Timney Bailey, 1992). A reason why case studies are popular among researchers is because of its applied nature. Since one case can act as a representative for the same kind of phenomena, there is no need to study additional cases. Case studies can also be used in research preparation (van Thiel, 2014).

The process of case selection has several steps. Initially, a decision has to be made by the researcher as to how many cases need to be studied. In case the researcher makes the decision to pick only one case, abstraction has to be taken into account really well and the generalisation should not distort details. In the case of multiple cases, the cases may all be similar or all of them could be different. If a deductive research approach is being followed, the theoretical framework can help in choosing the kind of cases. Another decision to be made apart from the selection of cases is the number of measurements. The researcher needs to outline how many times a particular phenomenon would be measured. He or she may choose to do the measurement once, or do it several times over a small time period (van Thiel, 2014). Choosing research methods is also an important decision to make. Most case studies include observations,

interviews, content analysis etc. Usually, a case study protocol is created where the decisions are written down, to make it easier for the researcher to follow up with things (Yin, 2008).

Like every other methodology, the case study has its disadvantages. The volume of data that needs to be collected and analyzed is difficult to organise and in most cases, the data is overwhelming. Some instances have also occurred where the researchers tend to shift the point of focus due to the intense depth of study. Publishing of case studies in the case of multiple cases is also challenging in some cases, as most journals have strict word limits (Heale & Twycross, 2018).

This research project essentially focuses on the practice of using disposable equipment, and in depth information about this practice is required. With the physical constraints in place due to the COVID-19 pandemic, it was decided that the case of RadboudUMC would be taken up to study this practice. The case study methodology proves to be useful in this project due to the constraints and also because pursuing a single case to study practices would offer a deep insight as to how the practice evolved in a particular institution that can be a representative of the general scenario of the healthcare industry in the Netherlands. The case study also provides the flexibility to use different research methods such as interviews, observations and literature reviews, which are helpful in obtaining information regarding practices.

### **3.4 Methods of data collection**

#### **3.4.1 Research methods in critical theory**

Over the years, critical theorists have used several different methods in their research. According to Asghar (2013), there are no concrete methodologies exclusive to the critical theory, as there are with other paradigms like constructivism and positivism. He further mentions that critical theorists are free to adopt any methods or methodologies that can help suggest a betterment in societal functions. Hussein, Eylaf & Naseef (2013) argue that critical theorists may use both qualitative and quantitative methods, but most critical theorists generally tend to lean towards qualitative methods. As mentioned before, the approaches tend to lean towards dialectical methods, giving importance to reflection. This reflection allows the researcher and the participants to think about what can be done to change the natural state of affairs.

#### **3.4.2 Semi structured interviews**

An interview is a conversation during which the researcher elicits information from the respondents by asking them questions. It is usually seen being used in the case study methodology. Interviews are really flexible tools of gathering information, because they allow for supplementary questions during the conversation. There are two main types of interviews- open interview and semi structured interview. Open interviews are also referred to as qualitative interviews, where the only fixed item is the initial question that the researcher begins with. The respondents answer to the question forms the starting point of the interview, as it leads to further questions. Sometimes, open interviews can be stressful for the researcher, as it is not

simply a normal conversation but also must help in the collection of data. This means that the interviewer has to perform several tasks at once, making it strenuous. Open interviews are essentially suitable for exploratory and inductive research. Semi structured interviews on the other hand uses a topic list or a manual as a guideline. It is usually used in deductive studies, as the theoretical framework and the research questions are used as context to list down the topics that will be covered in the interview (van Thiel, 2014).

To gain a deep insight into the development of the practice of disposable laryngoscopes and to find out the awareness about the environmental impact of the device, semi-structured interviews with medical professionals who use these devices and people in charge of purchasing policies were conducted. The list of interviewees along with their designations at the medical center can be found below.

<b>Name of Interviewee</b>	<b>Designation</b>	<b>Date of Interview</b>
Ms. Harriette <u>Laurisjen</u>	Policy advisor for sustainability	4 <sup>th</sup> May 2020
Dr. Hugo <u>Touw</u>	Consultant Intensive Care	5 <sup>th</sup> May 2020
Dr. Maarten van den Berg	Intensivist	13 <sup>th</sup> May 2020
Dr. Ashley de <u>Bie</u>	Intensivist	27 <sup>th</sup> May 2020
Dr. Dorien <u>Kiers</u>	Fellow – Intensive Care	28 <sup>th</sup> May 2020
Dr. Bernard <u>Fikkers</u>	Intensivist & Anaesthesiologist	12 <sup>th</sup> June 2020
Dr. Jeroen Schouten	Intensive care physician	19 <sup>th</sup> June 2020

*Figure 3.2 List of interviewees*

These interviews were highly useful in explaining the elements that form up the practice. Semi-structured interviews were helpful in this case to gain knowledge on why the traditional method of laryngoscopy is gradually being phased out. An interview guide for the semi-structured interviews was be prepared, which consisted information on basic themes and important questions to serve as a guideline, although the interviewee was be allowed to speak freely and spontaneously; and since it was a semi-structured interview, it allowed for questions that arise from the statements provided by the interviewees (Bryman & Bell, 2015).

Initially, before the onset of the COVID-19 pandemic, the plan was to focus the study on three different medical centers in the Netherlands, namely RadboudUMC, CWZ Nijmegen and Catharina Hospital in Eindhoven. Around 12 interviews from each medical center were planned. Due to the pandemic however, the focus has been shifted to RadboudUMC. A number of specialists in the field of sustainability, anaesthesiology and intensive care were interviewed. Some medical professionals who are in training were contacted and interviewed. This practice helped in keeping the pool of interviewees very diverse, and the problem could be viewed from perspectives of people working at different levels in the healthcare industry. The topics for the interview mostly revolved around the evolution of practices in the healthcare industry in the Netherlands, and what measures can be taken to phase out the use of disposable equipment and disposable laryngoscopes. An attempt was also made to gain the interviewees' awareness about the environmental impact caused by using disposable equipment. Interviews were conducted in English, and recorded with the permission of the interviewees for transcription. Respondent validation was taken into account, and these transcriptions were sent back to the interviewees for verification (Bryman & Bell., 2015).

The interviews were transcribed using MS-Word with timestamps. The transcribed data was then imported to Atlas Ti for analysis. Here, coding was applied systematically to analyse qualitative data. A list of codes and sub codes was created in Atlas Ti. These codes mostly pertain to the elements of practices, circularity, sustainability and environmental awareness. The list of codes can be found attached in the appendix of the document.

#### 3.4.3 Literature reviews

Literature reviews comprise secondary data, and forms a part of desk research (van Thiel, 2014). Different literary sources will be chosen and filtered, to make a selection of relevant documents on the use of disposable equipment in the healthcare industry. Literature reviews would mostly be used to gain arguments on the environmental impacts caused by the use of disposable equipment.

#### 3.4.4 Life cycle assessment

The life cycle assessment document would be an important contributor to the data that would be collected to answer sub question 2. The life cycle assessment conducted by Sherman et al (2018) would be used. The document focuses on the life cycle environmental impacts and life cycle costing for reusable and disposable laryngoscopes, based on the New Haven Hospital in Yale, United States of America. To check whether the results life cycle assessment stands true for the cases in the Netherlands, the document will be verified by a sustainability specialist at the RadboudUMC.

### **3.5 Reliability and validity of the research**

#### 3.5.1 Reliability



According to van Thiel (2014), the reliability of a research is a function of the accuracy and the consistency of the variables that are measured. The more accurate the measurement, the more systematic and representative the output would be. In this particular research, a high level of reliability would mean that the results can be used to make clear and functional recommendations.

Reliability is a product of accuracy and the consistency of the study. The more accurate and consistent the study of the variables, the more reliable the study. Accuracy refers to measuring the variable as precisely as possible, without any distortions. The variables should be captured and recorded as accurately as possible using different data collection methods. Consistency, however, is harder to achieve. It refers to the idea of repetition, meaning that the same research conducted again under similar circumstances will yield similar results (van Thiel, 2014). Consistency of this particular research project should be high, as the idea of sustainability and the phasing out the use of disposables in the healthcare industry would remain consistent. Consistency would also be high because the sample size and the number of interviews are of a high number. Replication would also be taken into account, and exact steps of the research process will be verified at every stage. When it comes to reliability in critical theory, Guba & Lincoln (1994) mention that knowledge grows through a process of historical revision. This means that knowledge that exists at one period of time may not be true for another period, and thus it needs to be updated with more insights from different parts of the society.

### 3.5.2 Validity

Validity has different forms: predictive validity, face validity, ecological validity, content validity, construct validity, statistical validity, or congruent validity (Cook & Campbell, 1979). These terms are variables of two main types of validity, which are internal validity and external validity (van Thiel, 2014). Internal validity refers to the question - 'has the researcher really measured the effect they intended to measure?' (van Thiel, 2014, p. 49). This relates to proper operationalization of theoretical concepts and the relationship between the variables. The internal validity of this project will be high, as the proposed variables will be measured as accurately as possible.

External validity, on the other hand, relates to the generalisability of the findings and the study. It mainly relates to the question - 'do research results also hold for other persons, institutions, moments in time or locations?' (van Thiel, 2014, p. 49). This research project will have a high external validity as the results will not differ too much from place to place, person to person, or institution to institution. Furthermore, adequate measures will be taken to ensure that no interferences are caused to disrupt the reliability and the validity of the study.

Reliability and validity for case studies take an interesting turn. Usually, cases are selected on the basis of theoretical grounds, but it can be tricky in inductive studies. Small numbers of units in the study can compromise the reliability and validity of the case study methodology. To counter this, Timney Bailey (1992) suggests triangulation, which involves

collecting data through different researchers, sources and methods. Other ways to counter the problem include distinguishing sub-units between different cases (Yin, 2008; King et al., 1994). These are all hard counters towards the problem.

Other ways to increase the reliability and validity of case studies include keeping a database (Yin, 2008) or keeping logs (Miles & Huberman, 1994). These steps are taken while the study is being done so that the whole process is documented, and the steps can be reviewed and verified after the study has been concluded. The researchers can also present their findings and views to peers in order to get second opinions, or ask independent experts for their expert opinions. This would help in validating the findings. Case studies in general have a rich and deep repository of data, and the body of information that is gathered is large and extends over a period of time. During this period of time, the researcher needs to maintain procedure and not give rise to the element of subjectivity and selectivity. At the same time, the researcher needs to be open to gather all kinds of information and absorb this information accurately and correctly.

Another aspect that affects the validity of case studies is when researchers try to arrive at the explanation and generalisation of the research subject. It is usually difficult to generalise findings because cases are mostly unique, and results apply particularly to the chosen case and the context in which the case has been studied (Flyvbjerg, 2006). The external validity of the case study is therefore limited to some extent. The internal validity of case studies however, is contrastingly very high as the amount of information collected is sufficient for this study.

## **Chapter 4: Analysis of Practices**

As mentioned earlier, the evolution and continuation of the practice of using disposable equipment will be analysed to formulate recommendations. For this purpose, the analysis of the practice has been grouped into three stages- historical perspective, current scenario and the future scenario or the ideal scenario. In each of the three stages, analysis will be done separately for materials, competences and meanings and there will be a separate section highlighting the connections and disconnections between the three elements and how the practice evolved or changed with these connections and disconnections. The context for this section is taken from the interviews conducted with the medical professionals at RadboudUMC.

### **4.1 Historical perspective**

The historical perspective highlights the stage when the use of disposable equipment had not yet been accepted and generalised in the healthcare industry. This was the period when medical practitioners were using reusable equipment and disposable equipment had not been introduced.

#### **4.1.1 Material**

Medical supplies like gloves, masks, trays, sharps, syringes, laryngoscopes, ureteroscopes, etc. form a part of the material component in the practice theory. Small medical supplies like disposable masks were introduced long ago in the healthcare industry. Disposable paper masks initially replaced reusable cotton masks, and this shift happened during the 1930s, and paper was gradually replaced by synthetic materials coming up to the 1960s. This substitution of reusable masks was the starting line of a broader transformation towards a trend of a total disposable system, which included syringes, trays, surgical instruments etc. (Strasser & Schlich, 2020). However, it was a long time after the 1960s when disposable equipment such as

laryngoscopes and ureteroscopes came into general use by medical practitioners. According to Dr. H. Touw (personal communication, 5th May 2020), disposable equipment became popular in the healthcare industry around 20 years ago, in the year 2000-2001. Before the advent of disposables, medical practitioners were using reusable equipment, without facing any difficulties. According to Dr. H. Touw & Dr. M. van den Berg (personal communication, 5th May 2020 & 13th May 2020), the reusable materials were preferred by doctors for a number of reasons. Since we are talking about just the materials in this section, advantages of the actual 'material' will be highlighted. It was mentioned during the interviews that reusable equipment and supplies in general are of a very high quality, and do not deteriorate with repeated use and sanitation processes (Sherman et al, 2018). Medical professionals also preferred to use reusables and traditional equipment since the disposable variants of many equipment hadn't entered the market yet and they did not have to choose between reusables and disposables (Dr. M. van den Berg, personal communication, 13th May 2020).

Since the equipment was all reusable, the environmental impact was minimal, before the advent of disposables. Companies that manufactured medical equipment were also satisfied with their products, and no new products were being introduced or created (Dr. H. Touw, personal communication, 5th May 2020). All these factors ensured that the material, which is reusable and traditional, stayed intact in the healthcare industry. With the information gathered during the interviews, it was clear that the material element changed due to external factors, and the change occurred because the practice was affected by outside elements, or due to other practices prevailing in the market.

#### 4.1.2 Competences

Competences are skills that are required to carry out a particular practice (Shove et al, 2012). Speaking in context to the healthcare industry, competences involve the training of medical professionals and the abilities of medical professionals to use particular pieces of equipment efficiently. Usually, medical professionals undergo on-the-job training, and attain mastery at several different medical equipment when they do the process again and again, and this usually takes place in the form of clinical practice (Dr. H. Touw, personal communication, 5th May 2020). This is what happened with reusable equipment. Since only one kind of device was available for practice, medical professionals did not have many equipment choices to make and were bound to one particular kind of equipment, for example, the direct laryngoscope (Dr. A. de Bie, personal communication, 27th May 2020). All laryngoscopy procedures took place with the direct laryngoscopes. Thus, medical professionals and intensivists who carried out these procedures were well versed with the use of the equipment (Dr. M. van den Berg, personal communication, 13th May 2020). This scenario holds true for other medical equipment as well, on-job-training leads to efficient results. Competences also depended on the medical center in which a medical professional was trained in. Since all medical centers were using reusable laryngoscopes, medical training was also done for the same, to make doctors more proficient in using the material (Dr. A. de Bie, personal communication, 27th May 2020).

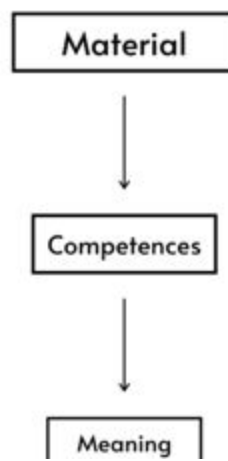
Competency wise, there arose no requirement for any new kind of equipment which would make processes easier as most medical professionals were trained adequately with the existing equipment. Introduction of any new equipment would mean that all medical professionals would have to undergo training again, in order to use the new equipment efficiently (Dr. M. van den Berg, personal communication, 13th May 2020). This would be a time consuming process and was deemed to be unnecessary, since the current system of using reusable and traditional equipment was working without any problems (Dr. D. Kiers, personal communication, 28th May 2020). The only reason that would prompt a change in the materials is when the cases are too complicated or when dealing with infections, or other external factors (Dr. M. van den Berg, personal communication, 13th May 2020). There are some difficulties that can arise while using direct laryngoscopy methods in some cases, since direct laryngoscopy only permits the user to view the images produced by the camera. In such cases, an alternative was required that could make the procedure easier and less complicated (Dr. H. Touw, personal communication, 5th May 2020).

#### 4.1.3 Meaning

Meanings are underlying ideas and aspirations pertaining to a particular practice. It can be the reason as to why people choose to follow a particular practice (Shove et al., 2012). Initially, with the practice of using reusable equipment and laryngoscopes, there was no underlying meaning or idea as the medical professionals were simply following the policy that existed. Since they did not have a choice of equipment to make, they had to make use of the reusable and traditional forms of equipment. The only meaning that can be attached to the practice in this scenario, the historical perspective is that of the welfare and well being of the patients (Dr. B. Fikkers, personal communication, 12th June 2020).

#### 4.1.4 Interaction of the elements

As Shove et al. (2012) mention, practices are composed of three elements and the interaction between the three elements, the connections between these three elements in the historical perspective will be highlighted in this section. The most prominent feature or element that gave rise to the practice was the element of material. As mentioned in the theoretical framework, material forms the most important part of this practice, and the analysis of the historical perspective and the interviews corroborate the statement. The material serves as a base and influences the other elements of the practice of using reusable equipment.



*Figure 4.1 Weightage of elements in the practice*

Figure 4.1 represents the weightage that each element has on the development of the practice. As mentioned above, the element of material is the most important, thus it receives the most weightage. Since the only equipment or material in availability at medical centers were reusable, medical professionals thus received training on how to operate the reusable material (Dr. A. de Bie, personal communication, 27th May 2020). The element of material, thus led to the development of the competency. These two elements were further linked due to the existence of the meaning of the practice, which was aimed at the welfare of the patients.

## **4.2 Current scenario**

The practice of using reusable equipment in the healthcare industry changed with the introduction of disposable equipment. This change is an ongoing process, but it has picked up pace around 20 years ago, when the first phase of disposable equipment came into the market and infection prevention guidelines became stronger (H. Laurisjen, personal communication, 4th May 2020). This section will highlight the disconnections that led to the change in the practice of reusable equipment and discuss the elements that make up the practice of using disposable equipment. As mentioned before, practices are also influenced by external factors. This section also aims to highlight the external factors that led to the phasing out of reusable equipment and changing of the practice.

### **4.2.1 Material**

The practice of using reusable equipment came to an end with the introduction of disposable equipment 20 years ago (Dr. H. Touw, personal communication, 5th May 2020). Thus, it can be said that the practice came to an end with the disconnection of the material element. By definition, disposable equipment are the kind of equipment that could be thrown away after a single use, and are generally made of inferior quality material like plastic, and are produced in bulk (Evans, 2016). The main reason why these materials gained prominence were the general notion of them being cheaper, and medical professionals can easily throw away a piece after use and get a new one for different procedures. Since these materials are always available, doctors don't have to wait to sanitize the reusable blades and handles (Dr. H. Touw, personal communication, 5th May 2020). Disposable material also help in adhering to infection prevention guidelines, since they are disposed off after every use. The process of supervision is also made easier with disposable video laryngoscopes. The image seen by the laryngoscope is projected on a screen, which makes giving out instructions more accurate (Dr. D. Kiers,

personal communication, 28th May 2020). However, there are several disadvantages to disposable equipment as well. Plastic equipment is prone to deformation in some cases during use since they are of inferior quality (Sherman et al, 2018). Many medical professionals are also aware about the potential environmental impact of using disposables, and hence, look down upon them (H. Laurisjen, personal communication, 4th May 2020).

#### 4.2.2 Competences

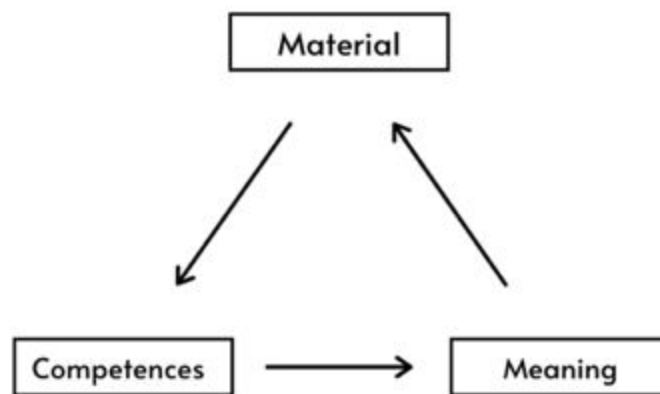
With a change in materials, a change in competences also took place. Disposable materials in general are really easy to use, since no sanitary precautions need to be adhered to before using them (H. Laurisjen, personal communication, 4th May 2020). When compared to some reusable equipment, some disposable equipment are also mechanically easier to use (Dr. H. Touw, personal communication, 5th May 2020). As mentioned before, the kind of equipment that a medical professional is trained for depends on the training facility (Dr. A. de Bie, personal communication, 27th May 2020). If the training facility only uses disposable equipment like laryngoscopes, then intensivists and anaesthesiologists are only trained to use the disposable kind. If the facility uses both the variants, then the practitioners are trained in both (Dr. M. van den Berg, personal communication, 13th May 2020). In the current days, most medical facilities prefer training anaesthesiologists and intensivists using disposable video laryngoscopes, because the video output from these kinds of laryngoscopes enable proper supervision, since the supervisors can also see what the trainee is seeing, and guide the trainees accordingly (Dr. D. Kiers, personal communication, 28th May 2020). Thus, currently, most trainees undergo training to use disposable laryngoscopes. To enable these new trainees to use reusable equipment, some additional training would be required and they may not be able to perform direct laryngoscopy straightaway (Dr. M. van den Berg, personal communication, 13th May 2020).

#### 4.2.3 Meaning

The most common and important meaning that can be attributed to the use of disposables in the healthcare industry is that of infection prevention (Dr. B. Fikkers, personal communication, 12th June 2020). Disposable laryngoscopes and other equipment are essentially very important in treating cases of communicable diseases. Currently, the COVID-19 crisis means that a lot of patients are facing trouble in their larynx. Thus, disposable video laryngoscopes are used in such cases to prevent further spread of infection, since proper information about the virus is not available yet, and thus, suitable sterilization mechanisms cannot be developed (Dr. M. van den Berg, personal communication, 13th May 2020). The use of disposable equipment in this case takes care of both the welfare of the patients and that of the medical professionals, while adhering to sanitation guidelines.

#### 4.2.4 Interaction of the elements

Unlike the historical perspective, in the current scenario, all three elements hold equal importance in practice formation and continuation.



*Figure 4.2 Practice formation in the current scenario*

Arguably, the practice evolved with the introduction of disposable equipment in the healthcare industry. This introduction prompted a change in training of medical professionals, who are now well versed with using disposable equipment. In anaesthesiology, most trainees nowadays are really comfortable in using disposable video laryngoscopes and not so much with reusable direct laryngoscopes (Dr. M. van den Berg, personal communication, 13 May 2020). The material and competence elements are followed by the meaning element, which is also equally important in the persistence of the practice. Most medical professionals are using disposable equipment in order to adhere to infection prevention guidelines (Dr. B. Fikkers, personal communication, 12th June 2020). Disposables make this factor really easy as no attention has to be paid to sanitize the material (Dr. H. Touw, personal communication, 5th May 2020). Thus, it can be said that the practice of using changed because of the introduction of a new material, and it is persisting because of the competences of the medical professionals using these materials and because of the attached meaning to it. This completes a whole cycle of elements, where each element is being influenced equally by the other two elements.



An external reason responsible for the shift from reusable to disposable is the manufacturers. Shove et al. (2012) mention that some practices are influenced by other related practices. In the case of this shift, an external practice that acted as an influencer was the changing in manufacturing and marketing techniques. Since most medical equipment manufacturing companies became profit oriented, selling reusable equipment was no longer good for margins. To avoid this, companies started investing in disposable technology so that they could keep selling products and keep their profit margins high (Dr. H. Touw, personal communication, 5th May 2020). This can be seen as one of the main reasons apart from infection prevention guidelines that led to the shift in the material and the practice overall.

However, this practice of using disposable equipment generates a lot of waste, most of which is non-recyclable (Sherman et al, 2018). Hence, a change in the practice of using disposable equipment should take place to make the healthcare industry more sustainable. As mentioned earlier, practices can change when a particular element is disconnected or changed (Shove et al, 2012). It would be hard to disconnect or change the element of material, since it has been deeply embedded in the practice. The element of meaning on the other hand, can be modified to a certain extent, and can be changed to involve sustainability and environmental concern. This would enable in bringing about a change in the other elements. This is discussed in the next section.

### **4.3 Ideal scenario**

The ideal scenario would represent a sustainable healthcare practice, which follows the guidelines of the circular economy and uses reusable equipment, without compromising the quality of healthcare provided, in order to cut down on greenhouse gas emissions and prevent excessive waste generation (McArthur, n.d). The characteristics of the elements that are required for this practice to be formed and continued are discussed in this section.

#### **4.3.1 Material**

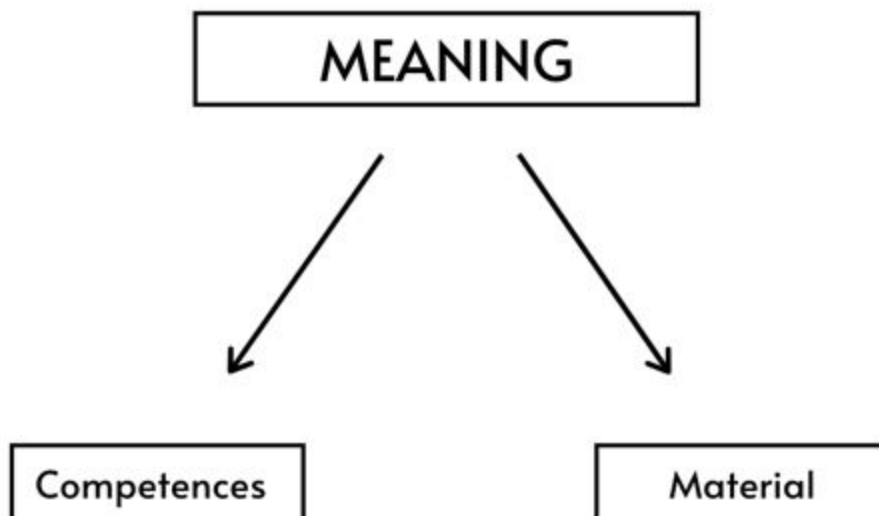
To create a sustainable practice in terms of usage of medical equipment, the element of material is the most important. Since the practice of using disposable material is deemed to be unsustainable in the hypothesis, this element of material is the one that needs to be changed. Reusable material pertains to less waste generation and emissions overall, and gets the job done as good as disposable material (H. Laurisjen, personal communication, 4th May 2020). In most cases, reusable materials work comparably well to disposable equipment (Dr. D. Kiers, personal communication, 28th May 2020). Exceptions can be made for really complicated or tricky situations where the job can only be done by disposable equipment made for the purpose and for cases which pertain to infectious diseases for which sterilization processes have not been perfected (Dr. H. Touw, personal communication, 5th May 2020). Reusable equipment have several advantages over disposable equipment as well. Most reusable equipment are of superior quality, and offer a high level of reliability (Dr. M. van den Berg, personal communication, 13 May 2020).

#### 4.3.2 Competences

As mentioned earlier, competences in the healthcare industry generally stem from clinical practice and training (Dr. M. van den Berg, personal communication, 13 May 2020). For the ideal scenario, medical professionals need to be capable of using reusable equipment in order to ensure that there is a synergy between the materials and the competences. Shove et al. (2012) have mentioned that competences from old practices sometimes lie dormant in people. Medical professionals who have been in the profession since a long time and have used reusable equipment before have a high chance of retaining the competency of using reusable equipment, but new medical trainees who have only been trained in using disposable equipment would need a few training sessions in order to better acquaint them to reusable material (Dr. M. van den Berg, personal communication, 13 May 2020).

#### 4.3.3 Meaning

The meaning element is the element that holds the most importance in the changing of this practice, since it is the element that can prompt a change in materials. In the current scenario, the meaning attached to the use of disposable equipment lies in strict following of sanitation guidelines and welfare of the patients and medical professionals (Dr. H. Touw, personal communication, 5th May 2020). Medical professionals, while treating patients have only one thing on their minds - well being of the patients. To change the practice of using disposable equipment into a more sustainable one, suitable measures can be taken to induce the idea of sustainability and environmental concern in the practice, since they seem to be missing (Dr. B. Fikkers, personal communication, 12th June 2020). This has to be done on different levels in order to make it impactful and lasting.



*Figure 4.3 Weightage of elements in the ideal scenario*

One of the ways to change the existing practice is to change the element of meaning (Shove et al, 2012). As mentioned earlier, if the notion of sustainability and environmental awareness can be instilled in medical professionals and other workers in the healthcare industry alike, there will be a disconnect in the current practice, prompted by a change in meaning. This new meaning of instilled sustainability will inevitably prompt a change in healthcare policies, as more and more personnel are made aware of the environmental impact of the excessive use of disposables. With this new meaning, one can expect a trickle-down effect to take place, which will influence the elements of material and competences (Dr. H. Touw, personal communication, 5th May 2020) .

The first of the two elements to change will be the element of material. With the enhanced information about environmental concerns and pollution, policymakers and other decision makers will be looking to shift to reusable material wherever possible. This can be either succeeded by or preceded by a change in the competences element. Going from a system which has all disposable equipment to a system with no disposable equipment would be a massive change. Doctors and medical professionals would need to be trained adequately to handle the change and use the new forms of equipment as efficiently as the older forms of equipment. If these changes happen and the elements are kept undisturbed, the ideal scenario can be achieved. It is however not easy to disconnect elements for a practice that has been going on for a long time, and will take efforts on many levels and a variety of changes to achieve the goal. The results section will further explore what measures can be taken at RadboudUMC to phase out the use of disposables.

## Chapter 5: Results

To answer the main research question accurately and completely, the answers to the sub questions will be analysed first, and the hypothesis needs to be verified. The context for sub questions one and three will majorly come from the interviews conducted, while the second sub question and the hypothesis will be answered using the life cycle assessment document by Sherman et al. (2018).

### 5.1 Results: Sub question one

The first question delves into two stages of the practice: the historical perspective and the current scenario. The first sub question reads '*how did the practice of the use of disposable equipment gain prominence? What elements of the practice were modified to bring about this change?*', this essentially puts focus on the disconnections of the elements from the historical perspective that allowed for a change in practice and led to the current scenario. As highlighted in the analysis of the practices section, there were several reasons due to which there was a disconnection between the elements and the practice changed. The most prominent reason that was highlighted by seven of the interviewees was the strengthening of infection prevention protocols. Medical centres and hospitals all over the world started paying much more attention on using sanitized materials and increased focus was channeled towards reducing the spread of infections through equipment. Thus, the element of meaning was the first element to be modified. To keep up with the demands for improved sanitation guidelines, new forms of equipment were developed - namely disposable versions of traditional equipment. This prompted a change in the material element of the practice. With changes in both the meaning and material aspect, the competences were also bound to change. This change was seen in the form of differential training for incoming medical practitioners. Trainees in anaesthesiology and intensive care in the present day are undergoing training to operate disposable video laryngoscopes for general procedures, and no training is provided to them to use the traditional direct reusable laryngoscope. This was the last element to change in order for the practice to change as a whole. Attention should be paid to the meaning aspect, as the only inherent meaning in the current scenario is welfare of the patients (Dr. B. Fikkers, personal

communication, 12th June 2020). In order for the practice to take a sustainable turn, the meaning of sustainability needs to be common in the healthcare industry.

Answering sub question 1, the element of the practice of using reusable medical equipment that changed first was the element of meaning, followed by the element of material and lastly the element of competences. Thus, it can be said that there was a trickle down effect that was observed in the elements, and a change in one element of the practice eventually brought about a change in other elements, and subsequently, the practice. The analysis of the practices thus correlates with the theoretical framework of practices, confirming that the study of how practices evolved is necessary to further bring about a change in a particular practice. With the analysis, it can be deduced that there is a change required in the meaning element of the practice, to move to more sustainable methods of healthcare. This can be done by following three steps of practice transition laid down by Shove et al (2012), which are explained further in this chapter.

## **5.2 Results: sub question two**

As mentioned earlier, the life cycle assessment performed by Sherman et al. (2018) will be used to answer this sub question. This document compares various categories of environmental impacts caused by the basic stainless steel reusable laryngoscopes and disposable plastic & steel laryngoscopes, representing the two basic materials that are used in the manufacture of the two alternatives - steel and plastic. The scope of this particular study was from cradle to grave, and included extraction of raw material and energy sources, manufacturing, packaging, transportation, cleaning and sanitation and finally, disposal. For the purpose of this study, device efficacy was presumed to be equivalent, meaning that they offer the same utility and efficiency to medical professionals. The materials that go into manufacturing were measured using a microgram scale for precise calculations. Reusable components were measured on the basis of one use and one cycle of cleaning, and then compared to the disposable alternative. This study was done particularly for the Yale New Haven Hospital in the United States of America, but can work as a suitable representative for the instrument in different hospitals and medical centers. The results can vary with places however, in terms of transportation distance, brands of laryngoscopes, usage policies and sanitation guidelines. The impact categories covered in the document include ozone depletion, global warming, smog, soil acidification, eutrophication, carcinogenic elements, ecotoxicity and fossil fuel depletion. The primary impact category consideration was that of global warming potential.

Laryngoscope Blades		Laryngoscope Handles	
<b>Multiuse Blade (Rusch Snaplight Fiber Optic)</b>		<b>Multiuse Handle (Rusch Green Spec Fiber Optic)</b>	
Chromium steel	70.2 g	Chromium steel	200 g
Fiber optic glass	4.2 g	Light emitting diode	6.2 g
Packaging film	1.6 g	Alkaline batteries	102.1 g
Kraft paper, bleached	1.7 g	Packaging film	1.7 g
Corrugated board box	16 g	Kraft paper	1.6 g
		Corrugated box board	16 g
<b>Single-Use Blade: Plastic (Heine XP Disposable)</b>		<b>Single-Use Handle: Plastic (Flexicare BritePro)</b>	
Polycarbonate	30.2 g	Synthetic rubber	7.2 g
Packaging film	1.6 g	Polyvinylchloride	28.1 g
Fiber optic glass	4.2 g	Lithium battery	6.1 g
Kraft paper	4.3 g	Polycarbonate	10.5 g
Corrugated board box	16 g	Light emitting diode	3.2 g
		Brass	1.3 g
		Kraft paper	1.7 g
		Packaging film	2.7 g
		Corrugated board box	16 g
<b>Single-Use Blade: Steel (BOMimed Fiber Optic Blade)</b>		<b>Single-Use Handle: Steel (BOMimed Fiber Optic Handle)</b>	
Chromium steel	66 g	Chromium steel	101 g
Packaging film	1.6 g	Alkaline battery	6.1 g
Fiber optic glass	3 g	Light emitting diode	3.2 g
Kraft paper	4.3 g	Brass	1.78 g
Corrugated board box	16 g	Kraft paper	1.7 g
		Packaging film	2.7 g
		Corrugated board box	16 g

Figure 5.1 Raw materials used in laryngoscopes (Sherman et al., 2018).

Figure 5.2 gives an overview on the different raw materials that are used in the manufacture of both kinds of laryngoscopes. Knowing what raw materials go into the two kinds of laryngoscopes is important in a life cycle assessment, as extraction of different raw materials through mining has a different impact on the environment. The disinfection of reusable laryngoscopes after every use has also been taken into account in the life cycle assessment. The reusable laryngoscope blades were assessed under high level disinfection and sterilization and the reusable handles were assessed under high level disinfection, sterilization and low level disinfection. Reusable blades cannot undergo low level disinfection as they enter the sterile tissue of the human body and low level disinfection is not adequate for the process. Other variables such as the use of batteries, disposal mechanisms, labour costs etc. are also included in the study. The results of the life cycle assessment are presented in the form of a table (figure 5.2) for each impact category in the original document, which will be summarised for the purpose of this study.

Impact Category	Blades				
	MU LLD	MU HLD	MU STZ	SUD-P	SUD-S
Ozone depletion (CFC-11-eq)	-	1.0	4.2	2.9	6.6
Global warming (CO <sub>2</sub> -eq)	-	1.0	3.9	6.6	7.5
Smog (O <sub>3</sub> -eq)	-	1.0	3.2	6.4	11.5
Acidification (SO <sub>2</sub> -eq)	-	1.0	3.6	4.9	9.9
Eutrophication (N-eq)	-	1.0	2.4	8.6	15.0
Carcinogenics (CTUh)	-	1.0	2.5	7.7	158.0
Noncarcinogenics (CTUh)	-	1.0	2.9	10.3	41.6
Respiratory effects (PM <sub>2.5</sub> -eq)	-	1.0	3.3	6.8	34.3
Ecotoxicity (CTUe)	-	1.0	2.6	13.5	95.2
Fossil fuel depletion (MJ Surplus)	-	1.0	3.7	5.4	4.2
Impact Category	Handles				
	MU LLD	MU HLD	MU STZ	SUD-P	SUD-S
Ozone depletion (CFC-11-eq)	32.2	1.0	3.2	16.4	19.1
Global warming (CO <sub>2</sub> -eq)	1.4	1.0	3.8	23.8	27.0
Smog (O <sub>3</sub> -eq)	1.8	1.0	3.2	41.6	49.7
Acidification (SO <sub>2</sub> -eq)	1.7	1.0	3.3	29.8	36.6
Eutrophication (N-eq)	2.6	1.0	2.3	60.5	69.0
Carcinogenics (CTUh)	3.3	1.0	2.4	44.8	253.3
Noncarcinogenics (CTUh)	2.2	1.0	2.6	135.8	180.8
Respiratory effects (PM <sub>2.5</sub> -eq)	2.3	1.0	3.1	42.4	80.7
Ecotoxicity (CTUe)	4.6	1.0	2.3	130.4	224.7
Fossil fuel depletion (MJ surplus)	1.0	1.2	4.5	18.8	18.4

*Figure 5.2 Results of the life cycle assessment (Sherman et al, 2018)*

According to the results of this life cycle assessment, single use disposable steel blades have 6.6 times the ozone depletion potential, 7.5 times the global warming potential, 11.5 times smog generation, 9.9 times the soil acidification potential, 15 times the eutrophication potential, a whopping 158 times carcinogenic generation, 95.2 times the ecotoxicity when compared to reusable laryngoscope blades treated with high level disinfection. Moving on to the handles, the single use disposable steel handles have 19.1 times the ozone depletion potential, 27 times the global warming potential, 49.7 times smog generation, 36.6 times the acidification potential, 69 times the eutrophication potential, 253.3 times the carcinogenic generation and 224.7 times the ecotoxicity as compared to reusable steel handles treated with high level disinfection.

### 5.2.1 Discussion

The results strongly suggest that the reusable laryngoscope alternatives have significantly lower global warming potential, ozone depletion potential, eutrophication potential, acidification potential and ecotoxicity potential when compared to the disposable laryngoscope blades and handles, confirming the hypothesis. This is mainly due to the materials and energy sources required to manufacture multiple disposable devices are much higher as compared to one reusable device. Steel handles and blades produce significantly more emissions due to the energy intensive activity of metal mining and refining (Sherman et al, 2018). When we look at reusable blades and handles, the impacts are always the lowest for the variants treated with high level disinfection. Sterilization has a higher amount of environmental impact because it includes high level disinfection in the process. The most surprising revelation in this study was probably the impact caused by low level disinfection procedures. Low level disinfection has a higher impact potential mostly because of the sanitation wipes that are used to carry out the procedure, and the use of chemicals that are used to make these wipes. Steel made disposable laryngoscope blades and handles are sometimes recycled, although it is more of a downcycle than a recycle as the steel and other minerals are made into carbon steel. In this study, the utility of the reusable and disposable blades were taken to be equivalent, however, it was found that the plastic disposable blades were sometimes prone to deformity, making the

procedure of laryngoscopy difficult in some cases. All these factors make the reusable laryngoscopes a better pick when environmental factors are considered.

However, there are certain differences that exist between the life cycle assessment conducted by Sherman et al. (2018) for the Yale New Haven Hospital and the current scenario at RadboudUMC. The differences arise basically in the brands of the laryngoscopes used, the number of uses a particular variant is rated for, refurbishment and sanitation guidelines and transportation and packaging. Brand: Different brands have different resource extraction and production mechanisms, which in turn have a considerable effect on the life cycle emissions by the product. This can make the study inconsistent when looking at different brands of laryngoscopes used at The Yale New Haven Hospital and RadboudUMC. Number of rated uses: Sherman et al. (2018) rated the reusable direct laryngoscopes for a total of 4000 uses. Again, this number depends from brand to brand and medical center to medical center, and it can be different for the Yale New Haven Hospital and RadboudUMC. Refurbishment: Refurbishment guidelines vary across medical centres and across countries. The life cycle assessment performed by Sherman et al. (2018) follows the protocols set by the Yale New Haven medical center, which calls for refurbishment of reusable direct laryngoscopes after every 40th use. This would also be different in the case of RadboudUMC, but the policy documents are not very clear on what the exact number is. It usually depends on the state of the equipment. Transportation and packaging: Transportation and packaging are two factors that can have a high variability. This depends on the brand, the location of the medical center and proximity to supply chains and ports. It is hard to come up with a consistent measure for the emissions caused by transporting a particular product, when all the stages of the life cycle are taken into account from the acquisition of raw material to the transportation of the product to the end user.

Other factors such as device specifications, battery requirements, unforeseen device malfunctions, improper use, overuse etc. can also lead to variable results. However, even with all these apparent differences, the life cycle assessment by Sherman et al. (2018) puts forward a compelling argument as to why reusable equipment is better than disposable equipment, when environmental protection and safety is concerned, while being at par with usability and effectiveness in most cases.



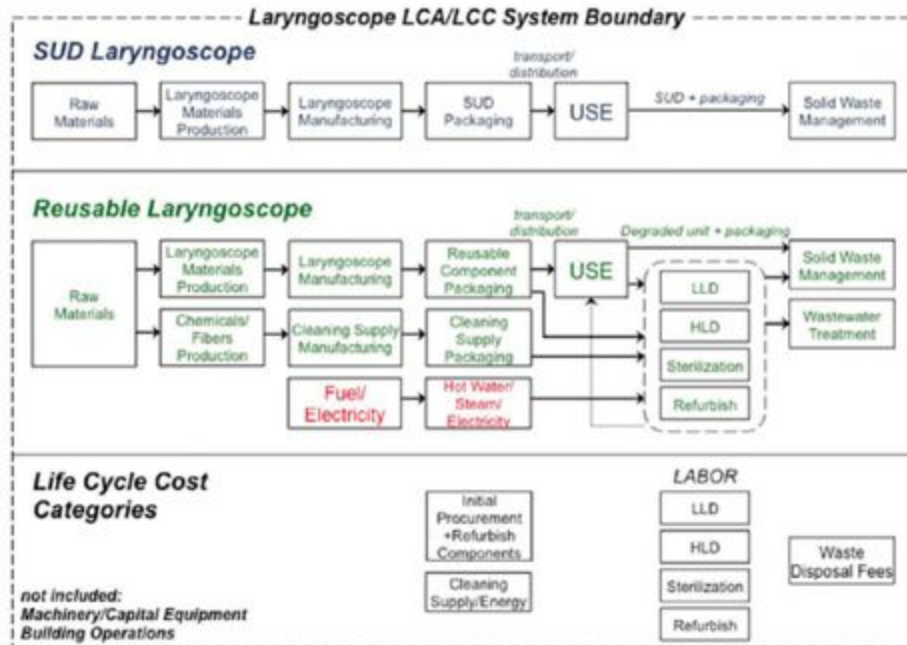


Figure 5.3 Scope of the life cycle assessment (Sherman et al., 2018). HLD indicates high level disinfection; LLD indicates low level disinfection; MU indicates multi-use; STZ indicates sterilization; SUD indicates single use disposable.

This particular life cycle assessment was chosen to answer this sub question for a number of reasons. The main reason is the scope of the life cycle assessment. Sherman et al (2018) have included a large number of variables that contribute to the environmental impact of the practice of using a particular variant of laryngoscopes. Figure 5.x represents the variables that were considered for this study. This life cycle assessment includes all variables like the energy required to gather raw materials, transportation costs of the raw materials and the final products, resources used during the production process, labour, packaging requirements and even resources used during sterilization procedures. This makes this document a reliable option since it covers all aspects that influence the environment during the production, use, disposal and transportation processes. Another reason why this document serves as a good representation for disposable equipment like laryngoscopes is the fact that it includes many variants of laryngoscopes, and also lays down information about the sanitation guidelines by defining how low level disinfection, high level disinfection and sterilization can have different environmental impacts and problems. This gives an overall holistic approach on the way things are and puts forward an accurate estimation of the drawbacks.

### 5.3 Results: Sub Question Three

When it comes to policies and measures that can be implemented at RadboudUMC for the reduction in the use of disposable equipment, several avenues can be explored. During the semi-structured in-depth interviews with medical professionals from the ICU and the sustainability department, the interviewees were asked for their opinions on viable policies and

practices that can be formulated at RadboudUMC in order to phase out the use of disposable equipment for routine procedures. All these are recommendations that can be possibly implemented in future, with the required modifications depending upon the department and the available resources. Some of the measures are policy oriented whereas others are awareness oriented. This section takes into account the three steps Shove et al (2012) have mentioned towards practice transition. The first step is the basis of action, which is dependent on societal values and norms. In this case, the societal values and norms need to be focused on the issue of sustainability, which influences the meaning of the practice. The second step is the process of change, which maps out the ways in which change occurs. This relates to the measures taken to change the elements of the existing practice. The third and final step is the policy position with regard to environmental action, which pertains to development of pro-environmental policies aimed at changing the unsustainable elements of a practice (Shove et al, 2012). Further, it is also mentioned that persuasion is of paramount importance if practices need to be made sustainable. Shove et al (2012) argue that people can be persuaded to take up sustainable practices with a change in attitude and behavior, and this can be done by providing people with choices. Removal of barriers that might hinder in the formation of sustainable practices is also required. The recommendations provided below will be followed by answering who the most influential drivers are, what the role of infrastructure in bringing about the change is, the role of technological development and the best levels of intervention.

#### 5.3.1 General policy change for intensivists

Internal medicine residents specialising in intensive care have to strictly follow the policies laid down by the department. For the purpose of visualising the larynx through the process of laryngoscopy, the department lays down strict guidelines and the residents have to use the disposable video laryngoscope due to its easy use and the ability to project the visuals on an external viewing source for supervision (Dr. D. Kiers, personal communication, 28th May 2020). This policy strongly portrays the meaning of 'welfare of patients' as laryngoscopy using disposable video laryngoscopes almost never fails. However, for routine use and general procedures that are not complicated, the department can potentially be flexible on the kind of laryngoscope that the trainees and residents choose, and urge them to use the direct reusable laryngoscopes for these cases. Even though a small step and a small change, it has the potential to prevent massive environmental harm and can also prove to be more affordable in the long run. Disposable video laryngoscopes can be kept as a backup for cases that are too complicated and where direct laryngoscopy fails. This recommendation influences the meaning and material element of practices.

#### 5.3.2 Purchase of new equipment

With the progress of technology, there are new and improved medical equipment that are entering the market on a daily basis. One such device is the reusable video laryngoscope (Dr. H. Touw, personal communication, 5th May 2020). This variant provides all the utility and the relatively easy use with an external image output source, while being reusable. Dr. D. Kiers & Dr. B. Fikkers (personal communication, 12th June 2020) mention that switching over to reusable

equipment would be easier if this variant was introduced at RadboudUMC, and if the variant fulfills the requirements of the disposable video laryngoscope. Similarly, there exist reusable variants of other equipment that provide the same utility, and can be considered to make RadboudUMC greener and more sustainable. This recommendation influences the material element of practices.

### 5.3.3 Purchasing policies

As discussed in the analysis of practices, medical practitioners have one concern: well being of patients. Thus, medical practitioners would not change their ways of operation while keeping in mind the environmental impact of the devices they use (Dr. B. Fikkers, personal communication, 12th June 2020). This is where the higher management of the medical center comes into the picture. A circular purchasing policy focusing on reduction in the purchase of disposable equipment can help in potentially reducing the use of disposable equipment overall. This would also complete the circular technological cycle as put forward by McArthur (n.d), which propagates reuse and recycling of all material. Moving from disposable to reusable video laryngoscopes can be one such change. For such a policy to be successful at RadboudUMC, all round effort is required on the parts of sustainability consultants, hospital management, decision makers and medical professionals.

### 5.3.4 Training programmes for incoming medical professionals

As mentioned in the analysis of the practice section, medical trainees currently in most places do not undergo training to use reusable direct laryngoscopes. Dr. M. van den Berg (personal communication, 13th May 2020) mentions that for the current trainees to be accustomed with using direct laryngoscopes, they would need extra training. This can be taken care of with a small training period for anyone who joins RadboudUMC as an intensivist or an anaesthesiologist. During this training period, they would take part in workshops which would enable them to be efficient with the use of reusable equipment. This can be done in many departments of the hospital and not just the intensive care unit. Dr. H. Touw & Dr. M. van den Berg (personal communication, 5th May 2020 & 13th May 2020) mention that this can prove to be a good step in order to make a green transition at the intensive care unit. This recommendation influences the competences aspect of practices.

### 5.3.5 Improving availability of reusables

Dr. B. Fikkers (personal communication, 12th June 2020) mentions that the availability of reusable equipment can sometimes be a problem due to excess demand or delays in sanitation procedures. Unavailability in such cases can lead to medical professionals picking disposable variants as they are always available. This problem can be solved by having pieces of reusable equipment on stand-by. One more solution for this problem can be in the form of having quicker sterilization and disinfection methods for reusables.

### 5.3.6 Increasing awareness

A reason why disposable equipment has gained prominence is because there is little awareness about their environmental impact. Dr. M. van den Berg (personal communication, 13th May 2020) mentions that one of the ways to help medical professionals transition to reusable equipment is to increase awareness about their safety and comparatively lesser environmental impact. This can again be done on a large scale, with information pamphlets and wherever possible, seminars. Dr. B. Fikkers (personal communication, 12th June 2020) mentions that a price tag programme was started some time ago at RadboudUMC. This programme focused on displaying prices of different equipment on them, so that medical practitioners could be aware of the costs of the equipment they are using. A similar practice can be adopted where the tags can provide information about the amount of emissions that the use of a particular equipment can cause. If tags like these are available, it will enable medical professionals to make greener, more sustainable choices. Such a practice can be implemented in all departments of the medical center, and is not just limited to the intensive care unit. Increasing awareness and information also fulfills the lack of meaning in the practice, and hence, there can be a notable change in the elements of the practice if there is a high level of awareness among medical professionals.

These recommendations have been formulated after careful consideration with professionals from different departments at RadboudUMC, and some of these recommendations came from the suggestions put forward by the professionals during the interview stage. To move forward with the implementation of these recommendations, Dr. H. Touw (personal communication, 13th May 2020) suggests a top down approach, in which the higher management is responsible for a big chunk of the work. This would pertain to formulation of policies, broadcasting information about these policies, and making sure that these policies are implemented. These kinds of policies are part of regulatory instruments, and regulations are best fulfilled in a top-down approach to assure quality and efficiency of services (Mukamen, Haeder & Wiemer, 2014). The answer to the sub question also lays down the foundation for the second phase of change, as mentioned in the conceptual framework.

Following the recommendations, it is important to highlight the roles of the four major factors that influence behavior change as put forward by House of Lords (2010) and how these factors apply in the case of RadboudUMC. The first factor is the most influential driver of behaviour change. Since a top down approach was suggested by Dr. H. Touw (personal communication, 13th May 2020), the most influential driver in this case would be the hospital management, since the management is capable of drafting and implementing suitable policies and strategies that can make practices more sustainable. The management can also persuade medical practitioners and healthcare workers to engage in sustainable behavior by providing them with incentives. The second factor is the role of infrastructure in changing existing behaviour. If proper infrastructure that enables sustainable behaviour exists, it will be easier to change practices. Infrastructure in the medical industry can be seen as proper equipment, adequate sanitation facilities, uninterrupted power supply etc. The third factor relates to technological development and advancements. Technological advancements in the healthcare industry relate to development of sustainable alternatives to disposable equipment that offer the

same amount of utility (Dr. J. Schouten, personal communication, 19th June 2020). Such advancements can lead to less waste generation and emissions. The next factor is the level of intervention most suited for behaviour change. A government level intervention for one institution is not favourable, and hence the level of intervention in this case should be of the institution itself, and can be done by the management.

## **Chapter 6: Discussion and Conclusion**

This section covers the discussion of the key findings that can be drawn from the interviews and the life cycle assessment results, and ultimately aims to answer the main research question with the insights gained by answering the sub questions. Additionally, the strengths and weaknesses of this research project are described with suggestions for future research avenues.

## 6.1 Answering the main question

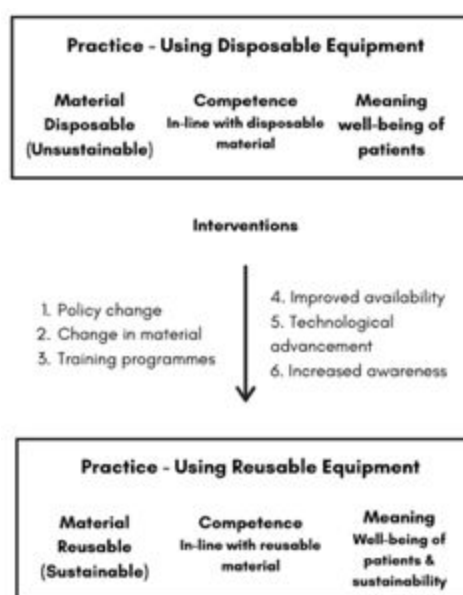
The answer to sub question two highlights that disposable laryngoscopes and disposable equipment in general have a much higher environmental impact than reusable equipment, and also confirms the hypothesis. This can be seen in the form of higher greenhouse gas emissions, global warming potential, ozone depletion potential, soil acidification potential, eutrophication potential and ecotoxicity among other impact categories. This provides enough evidence to conclude that the material element of the practice needs to change in order to transform the practice into a more sustainable one, while also corroborating the statement made by Shove et al (2012) which says that change should be brought to unsustainable elements and not unsustainable practices. The answer to sub question one highlights the missing element of meaning in the healthcare industry. Sub question three sheds light on how the practice can be changed with policy changes that influence all elements of the practice - material, competence and meaning, based on the practice theory by Shove et al. (2012). However, according to the analysis of the interviews and the practices, it was clear that the element of meaning was absent and needs to be influenced, along with material. This is done by increasing awareness and broadcasting information on a large scale so that a large number of people associated with the healthcare industry are aware about the potential environmental impact of using disposable equipment and how their profession can be greener if they consciously switch over to reusables for routine procedures.

With the insights gained from answering the three sub questions and the interviews, it is clear that changes need to be made in all three elements, but majorly they need to be done in material and meaning. Answering the main research question - the element of material can be changed by changing the material itself, that is going from disposable to reusable equipment and keeping the availability of reusable equipment high at all times. RadboudUMC can also choose to upgrade their materials to new, reusable versions. Changes in the meaning aspect are also equally important, as the meaning of sustainability needs to be instilled in medical professionals in order to transform the practice. A change in either the element of meaning or the element of material will consequently lead to a change in the element of competences, which would eventually lead to the transformation of the practice.

However, Dr. J. Schoten (personal communication, 19th June 2020) fears that in the intensive care unit specifically, going back to the use of direct reusable laryngoscopes is not a viable option as the meaning of safety is of utmost priority. Laying down rules on the use of reusable equipment can cause discomfort among medical professionals and it can turn out to be a bad move. However, he also feels that going back to an old stage of the practice is not the way forward, and more time and resources need to be invested into new technologies and equipment that offer the same level of utility that disposable equipment offer, while being environmentally friendly and/or reusable. Another point that was raised during the interviews was the reduction of practices that only provide a hint of safety, but are actually not very useful. This includes protective equipment coverage which are made of plastic, and are a business strategy by

companies to keep themselves relevant in the market. Such plastic coverings are highly unnecessary and do not help with safety at all (Dr. J. Schouten, personal communication, 19th June 2020).

Looking at the elements from the practice of using disposable equipment, in order to make it more sustainable, the disposable material is disconnected with the help of a change in the meaning. The old meaning is replaced by an added meaning of sustainability, which is done by availability and dispersion of information as explained in the recommendations above. This would enable the medical center to take adequate measures in reducing the barriers which exist when the shift from disposable to reusable equipment takes place.



*Figure 6.1 Comparison of the old, unsustainable practice with the new, sustainable practice*

Figure 6.1 gives an overview of the old, unsustainable practice and the new sustainable practice. The phase of change highlights the recommendations that can be undertaken to make this shift happen. A change in policy itself can lead to changes in all the three elements. Purchasing policies can be devised to change the kind of materials brought into the medical center, policies can be established to increase awareness about environmental pollution caused by disposable material, leading to a change in the meaning. Change in material pertains directly to the replacement of the old, unsustainable alternative with the new, sustainable alternative. Effective training programmes relate to enabling medical professionals having adequate skills to operate new and sustainable material, which directly lead to a change in the competency. Improved availability leads to disabling of any barriers that would exist in case of materials, whereas increased awareness ensures that all medical personnel know about the availability of sustainable alternatives for disposable equipment. Thus, by following these steps, the practice of using disposable equipment at RadboudUMC can be shifted to be more sustainably and greener,

thereby leading to a betterment of the environment and overall a higher quality of life in general, all while generating less waste and emissions.

## **6.2 Reflections on practice theory**

A major part of the analysis for this project comes from analyzing the elements of the practice of using equipment in three different phases, and how the elements changed over time to incorporate a transformation of the practice overall. The practice approach as put forward by Shove et al. (2012) was used for the framework of this project. In the context of this paper, the approach has proven to be useful since the existence of an unsustainable element in the form of disposable equipment was clear from the beginning. The framework was helpful in analyzing the role of individual element and how a single element contributed to a particular practice, which made it favorable to pinpoint exact problems in particular elements. However, when it comes to the practice approach put forward by Shove et al (2012), the literature does not provide enough guidance on the connection and disconnection of elements, and how the process takes place. It would have been helpful in having that knowledge and applying it in this project. Further, Jaeger-Erben and Rückert-John (2015) explain how the context of a social setting can influence practices. They put social settings as another variable that influences practices. This would have been an interesting avenue to consider while engaging in the practice approach, since it would provide a broader view on practices with more variables to be considered, possibly having different analysis and recommendations. It would also be interesting to note how this approach works for other medical centers, that are not academic in nature.

## **6.3 Strengths of this research project**

This research project has several strengths which will be highlighted in this section. Broadly, this research has led to a deeper understanding of why medical professionals at RadboudUMC choose to use disposable equipment, and their concerns while using reusable equipment. This understanding helped in two ways: to formulate the recommendations for the changes that can be made at RadboudUMC, and to suggest possible avenues for future research, which will be explored later in this section.

The interview pool of this project is another one of its strengths. Efforts were made to include medical professionals from different backgrounds and medical disciplines to gather views from varied perspectives. The interview pool was further diversified by including medical professionals from different experience levels and the amount of time they have been associated with medical practice. This enabled viewing the practice and the problem from different perspectives, and gaining knowledge on what different generations of medical professionals feel about the use of disposables and reusables.

## **6.4 Limitations of this project**

No research is without drawbacks and limitations, and this project is no different. The first limitation can be seen in the methods. Observation of practices and the phenomenon of



choice making by medical professionals would have been an ideal method to follow, but it could not be done due to the precautions in place for COVID-19. Observations would have given a new and different dimension to the results, as observations are usually candid and insights could be gained as to why medical professionals choose a particular alternative of equipment. This eventually led to an over reliance on interviews to determine the elements of the practice, which did not turn out to be favourable. The scale of the project can be seen as another drawback. Initially, the project was set to focus on three medical centers throughout The Netherlands, and recommendations were going to be drafted for the entire national policies. Due to logistical issues, the focus was only kept on RadboudUMC. This had further implications as working with a single case of RadboudUMC would not be a viable option of generalising policies for the whole of The Netherlands. Focus on more medical centers would have given a clearer perspective on the practice and more accurate recommendations could have been made if the pool of information was greater.

Another limitation that exists is a part of the interviews. Social desirability bias is an issue that could have played a major role in the responses gathered during the interviews. It refers to the tendency of respondents to report their answers in a way that would be more acceptable than the actual answer (Lavrakas, 2008). When questioned about the environmental impact of the increasing use of disposable equipment, most respondents answered that it was a problem, that they are highly aware of it and would be willing to make changes if it helps in reducing ecological pollution. The generalization that was made during the selection of the case can serve as another drawback. With the case of RadboudUMC, the empirical analyses and the interviews give a clear picture of academic medical centers, but not non-academic centers. Since the number of non-academic medical centers is more prevalent than academic medical centers, this generalization might distort results and recommendations would need to be altered for different cases.

Finally, another limitation comes in the form of the life cycle assessment data. With the differences in many aspects that are highlighted in the results section, the life cycle assessment is majorly favoured towards a different place and geography. Even though the assessment can be taken as a representative for counterparts in different locations, the variations can distort the data and eventually lead to inaccurate interpretations about status quo and consequently lead to unsuitable recommendations. This limitation is important to consider as the scope of the life cycle assessment was cradle to grave, and not every location will have an equal amount of impact when different variables are considered.

## **6.5 Future research**

Keeping the results and problems of this study in mind, the recommendations for future research can be suggested. Drawing more attention to environmental problems, robust research can be conducted on the environmental impact of several disposable equipment and their reusable alternatives. Such research will help in increasing awareness among medical professionals, as the current scientific knowledge about this subject is sparse. The lack of

knowledge also means that medical professionals and hospital management cannot make environmentally friendly choices when it comes to choosing equipment. Life cycle assessments can prove to be a pragmatic and useful tool for evaluation choices and drafting purchasing policies at medical centers. Another potential avenue to invest research time is the transformation of medical equipment. As discussed in the earlier sections, going back to traditional reusable equipment does not seem to be a viable option. In depth knowledge is required on how reusable equipment can be made as efficient and as user-friendly as disposable equipment. This can hugely be beneficial in terms of lesser environmental impact and more sustainable methods in healthcare.

With the onset of the COVID-19 pandemic, there was an unforeseen increase in the use of disposables because there was little to no knowledge about the virus and what sanitation procedures could be followed with regard to reusable equipment. Having robust knowledge about various communicable diseases and infections can help in devising proper sanitary guidelines and sanitation protocols that can help in cutting down on the use of plastic and disposable equipment.

Additionally, research can be conducted on waste management and recycling processes in healthcare. Medical equipment is generally accompanied by huge amounts of packaging and tutorial booklets, which are highly unnecessary (Dr. J. Schouten, personal communication, 19th June 2020). These are expenses and resources that can be cut down drastically, if attention is paid to more sustainable methods of packaging and handing out tutorial booklets for equipment.

## References

- American Cancer Society (2019). Laryngoscopy. Retrieved from <https://www.cancer.org/treatment/understanding-your-diagnosis/tests/endoscopy/laryngoscopy.html>
- Asghar, J. (2013). Critical Paradigm: A Preamble for Novice Researchers. *Life science*. 10. 3121-3127.

- Bakker, C., Wang, F., Huisman, J., & den Hollander, M. (2014). Products that go round: exploring product life extension through design. *Journal of Cleaner Production* 69, 10–16. <https://doi.org/10.1016/j.jclepro.2014.01.028>
- Berwick, D.M., Hackbarth, A.D. (2012). Eliminating waste in US health care. *Jama* 307 (14), 1513e1516.
- Blake, L. (2005). ACID RAIN AND SOIL ACIDIFICATION. In *Encyclopedia of Soils in the Environment* (pp. 1–11). Elsevier. <https://doi.org/10.1016/b0-12-348530-4/00083-7>
- Bocken, N.M.P., de Pauw, I., Bakker, C. & van der Grinten, B. (2016) Product design and business model strategies for a circular economy, *Journal of Industrial and Production Engineering*, 33:5, 308-320, DOI: 10.1080/21681015.2016.1172124
- Bolan, N. S., Curtin, D., & Adriano, D. C. (2005). ACIDITY. In *Encyclopedia of Soils in the Environment* (pp. 11–17). <https://doi.org/10.1016/b0-12-348530-4/00173-9>
- Bradford, A. (2017). Effects of global warming. Retrieved from <https://www.livescience.com/37057-global-warming-effects.html>
- Bresser, A.H.M. & Berk, M.M. & Born, G.J. & Bree, Leendert & Gaalen, Frank & Ligtvoet, Willem & van Minnen, Jelle & Witmer, M.C.H. & Amelung, Bas & L.Bolwildt, & Brinke, W. & Buiteveld, H. & Dillingh, Douwe & Dorland, R. & Huynen, Maud & Leemans, Rik & van, Strien, & Vermaat, Jan & Veraart, J.A.. (2006). The effects of climate change in the Netherlands.
- Bryman, A., & Bell, E. (2015). *Business research methods*. Oxford University Press, USA.
- Buffoli, Maddalena & Capolongo, Stefano & Bottero, Marta & Cavagliato, E & Speranza, S & Volpatti, L. (2013). Sustainable Healthcare: how to assess and improve healthcare structures' sustainability.. *Annali di igiene : medicina preventiva e di comunità*. 25. 411-8.
- CEA. (2009). The Economic Case for Health Care Reform. E. O. o. T. President and C. o. E. Advisers. Council of Economic Advisers, Washington, DC.
- Chung, J.W., Meltzer, D.O. (2009). Estimate of the carbon footprint of the US health care sector. *JAMA: J. Am. Med. Assoc.* 302 (18), 1970e1972.
- Cook, T.D., & Campbell, D.T. (1979). *Quasi-experimentation: Design and Analysis Issues for Field Settings*. Boston: Houghton Mifflin Company.

- Curran, M. (2000). Life cycle assessment: An international experience. *Environmental Progress -New York-*, 19, 65-71.
- Curran, M.A. (2012). Life Cycle Assessment Handbook. McGraw Hill.
- de Jonge, V. N., & Elliott, M. (2001). Eutrophication. In Encyclopedia of Ocean Sciences (pp. 306–323). Elsevier. <https://doi.org/10.1016/b978-012374473-9.00047-3>
- Demirel, Y. (2014). Thermoeconomics. In Nonequilibrium Thermodynamics (pp. 265–302). Elsevier. <https://doi.org/10.1016/b978-0-444-59557-7.00005-9>
- DOE. (2012). Energy Characteristics and Energy Consumed in Large Hospital Buildings in the US in 2007. CBECS 2007. K. Lewis, A. Swenson and J. Olsen. Department of Energy, Washington DC.
- Ellen MacArthur Foundation (n.d). What is a circular economy? Retrieved from <https://www.ellenmacarthurfoundation.org/circular-economy/concept>
- Evans, R. (2016). What are disposable devices? Retrieved from <https://www.medicaldesignandoutsourcing.com/what-are-disposable-devices/>
- F. McGain, D. Story, T. Lim, S. McAlister, Financial and environmental costs of reusable and single-use anaesthetic equipment, *BJA: British Journal of Anaesthesia*, Volume 118, Issue 6, June 2017, Pages 862–869, <https://doi.org/10.1093/bja/aex098>
- Filstead, W. J. (1981). Using Qualitative Methods in Evaluation Research: An Illustrative Bibliography. *Evaluation Review*, 5(2).
- Flyvbjerg, B. (2006). Five Misunderstandings About Case-Study Research. *Qualitative Inquiry*, 12(2), 219–45.
- Giddens, A. (1984). The Constitution of Society. Cambridge: Polity Press.
- Gilden, D & Scissors, Kenneth & Reuler, J. (1992). Disposable products in the hospital waste stream. *The Western journal of medicine*. 156. 269-72.
- Government of Western Australia (n.d). Ecotoxicity. Retrieved from <https://www.water.wa.gov.au/water-topics/waterways/assessing-waterway-health/ecotoxicity>
- Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 105-117). Thousand Oaks, CA: Sage.

Heale R, Twycross A. (2018) What is a case study? *Evidence-Based Nursing* ;21:7-8.

Health Research & Educational Trust. (2014). Environmental sustainability in hospitals: The value of efficiency. Chicago, IL: Health Research & Educational Trust. Accessed at [www.hpoe.org](http://www.hpoe.org)

Horkheimer, M., (1982). Critical Theory, New York: Seabury Press.

Hussain, M. A., Elyas, T. & Naseef, O. A. (2013). Research Paradigms: A slippery Slope for Fresh Researchers. *Life Science Journal*. 10/4: 2374-2381

Impacts on Society (n.d). Retrieved from <https://www.globalchange.gov/climate-change/impacts-society>

J. G. (2005). Qualitative research in counseling psychology: A primer on research paradigms and philosophy of science. *Journal of counseling psychology*, 52(2), 126.

Kane, G. M., Bakker, C. A., & Balkenende, A. R. (2018). Towards design strategies for circular medical products. *Resources, Conservation and Recycling*, 135, 38–47. <https://doi.org/10.1016/j.resconrec.2017.07.030>

Lavrakas, P. (2008). Encyclopedia of Survey Research Methods. <https://doi.org/10.4135/9781412963947>

Mukamel, D. B., Haeder, S. F., & Weimer, D. L. (2014). Top-Down and Bottom-Up Approaches to Health Care Quality: The Impacts of Regulation and Report Cards. *Annual Review of Public Health*, 35(1), 477–497. <https://doi.org/10.1146/annurev-publhealth-082313-115826>

National Geographic Society. “Global Warming.” *National Geographic Society*, 27 Mar. 2019, [www.nationalgeographic.org/encyclopedia/global-warming/](http://www.nationalgeographic.org/encyclopedia/global-warming/).

National Ocean Service (n.d) What is eutrophication? Retrieved from <https://oceanservice.noaa.gov/facts/eutrophication.html>

Karlsson, M., Pigretti €Ohman, D. (2005). Material consumption in the healthcare sector: strategies to reduce its impact on climate changedThe case of Region Scania in South Sweden. *J. Clean. Prod.* 13 (10e11), 1071e1081

PGH. (2008). Waste Management. Practice Greenhealth from: <http://www.practicegreenhealth.org/educate/operations/waste>.

- Ponterotto, J. G. (2005). Qualitative research in counseling psychology: A primer on research paradigms and philosophy of science. *Journal of counseling psychology*, 52(2), 126.
- Reckwitz, A. (2002). Toward a theory of social practices: a development in culturalist theorizing. *European Journal of Social Theory*, 5(2), 243–263.
- Rodriguez, J. M. (2007). Stratospheric Chemistry. In *Treatise on Geochemistry* (pp. 1–34). <https://doi.org/10.1016/b978-008043751-4/00252-2>
- Rombey T, Schieren M, Pieper D: Video versus direct laryngoscopy for inpatient emergency intubation in adults—a systematic review and meta-analysis of randomized controlled trials. *Dtsch Arztebl Int* 2018; 115: 437–44. DOI: 10.3238/arztebl.2018.0437
- Sherman, J.D, Lewis, A.R, Matthew, J.E (2014). Life Cycle Assessment and Costing Methods for Device Procurement: Comparing Reusable and Single-Use Disposable Laryngoscopes. *Anesthesia & Analgesia*. 127. 434-443.
- Tudor, T., Barr, S., Gilg, A. (2007). Linking intended behaviour and actions: a case study of healthcare waste management in the Cornwall NHS. *Resour. Conserv. Recycle*. 51 (1), 1e23.
- Shove, E., Pantzar, M. & Watson, M. (2012). *The Dynamics of Social Practice: Everyday Life and How It Changes*. London: SAGE Publications Ltd.
- Srejjic, E. (2016). Reusables, disposables, each play a role in preventing cross contamination. Retrieved from <https://www.infectioncontrolday.com/view/infection-preventionists-prepare-ride-second-wave-covid>
- Swensen, S.J., Kaplan, G.S., Meyer, G.S., Nelson, E.C., Hunt, G.C., Pryor, D.B., Weissberg, J.I., Daley, J., Yates, G.R., Chassin, M.R. (2011). Controlling healthcare costs by removing waste: what American doctors can do now. *BMJ Qual. Saf.* 20 (6), 534e537.
- United States Environmental Protection Agency. (2017). Climate impacts on society. Retrieved from [https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-society\\_.html](https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-society_.html)
- Van Drongelen, A & de Bruijn, A.C.P (2008). Reprocessing of medical devices. Retrieved from <https://www.rivm.nl/bibliotheek/rapporten/360020004.pdf>

- Van Thiel, S. (2014). *Research Methods in Public Administration and Public Management. An Introduction*. Routledge.
- Vogt, J., Nunes, K.R. (2014). Recycling behaviour in healthcare: waste handling at work. *Ergonomics* 57 (4), 525e535.
- Warde, A. (2005). Consumption and theories of practice. *Journal of Consumer Culture*, 5(2). 131–153.
- WorldBank. (2014). Health Expenditure, Total (% of GDP) e 2012. Data, from: <http://data.worldbank.org/indicator/SH.XPD.TOTL.ZS>.
- WHO Regional Office for Europe (2016). *Environmentally Sustainable Health Systems*. Report of a meeting in Bonn, Germany, 11–12 November 2015. Copenhagen: WHO Regional Office for Europe ([http://www.euro.who.int/\\_\\_data/assets/pdf\\_file/0016/301552/ESHS-Bonn-Mtg-Report-1112-Nov15.pdf](http://www.euro.who.int/__data/assets/pdf_file/0016/301552/ESHS-Bonn-Mtg-Report-1112-Nov15.pdf), accessed 22 May 2017).
- Yin, R.K. (2008, 4th edition). *Case Study Research: Design and Methods*. Thousand Oaks: Sage Publications Inc.