

**ASTHMA AND ITS MEDICAL DEVICES**

**A THESIS SUBMITTED TO THE INSTITUTE  
OF GRADUATE STUDIES**

**OF  
NEAR EAST UNIVERSITY**

**By  
SABAREELA VICTORY MORO**

**In Partial Fulfillment of the Requirements for  
the Degree of Master of Science  
in  
Biomedical Engineering**

**NICOSIA 2021**

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**Sabareela Victory MORO: ASTHMA AND ITS MEDICAL DEVICES**

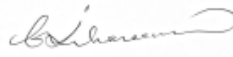
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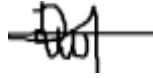
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## ABSTRACT

When the lungs are unable to inhale air properly, it becomes inflamed and swollen. The inflammation makes it difficult to breathe in air into the lungs and when air is not properly inhaled into the lungs, it could lead to death. There are different causes of asthma such as tobacco smoke, stress, dust, anxiety, pollen grains, genetics, pollen grains, obesity and low weight, occupational chemicals, old buildings/paintings. If these causes are not properly managed, it could lead to an asthma attack. An asthma attack occurs when there is a trigger or when any of the causes of asthma triggers the lungs hence making the airways become swollen and inflamed. The muscles around the airways decrease in size and make the airways produce extra mucus that causes the lungs or breathing tubes to be narrow. Symptoms of asthma include coughing, wheezing, tightness of chest and inability to breathe properly.

Asthma can be properly managed and treated with the right medical devices. These medical devices are called inhalers and designed specifically to give drugs or medication into the lungs through inhalation to allow the release of the lungs or expansion of the lungs in order to allow the flow of air properly. Inhalers are small portable devices used to administer drugs to asthma patients. The drugs are bronchodilators and anti-inflammatory and what they do is to release the lungs when the drug is inhaled to allow the flow of air.

Asthma is a respiratory disease that affects the lungs and makes it unable for an individual to breathe. One of the medical device used to allow the flow of air into the lungs is inhaler. The aim of this study is to know the different inhalers used for asthma and the technique used was a multi-criteria decision making called fuzzy PROMETHEE method. This method was used in analyzing the different inhalers according to important criteria such as efficiency, specificity and practicability and according to these criteria the inhalers were ranked or classified from the positive rank, which include Accuhaler, Soft Mist inhaler and Jet nebulizer and the least which is Ellipta dry powder inhaler.

*Key words;* Asthma, inhalers, inflammation, asthma medical devices, multi-criteria decision making; Fuzzy PROMETHEE.

## ÖZET

Akciğerler havayı düzgün bir şekilde soluyamadığında iltihaplanır ve şişer. İltihap, akciğerlere hava solumayı zorlaştırır ve akciğerlere hava düzgün bir şekilde solunmadığında ölüme yol açabilir. Astımın; tütün dumanı, stres, toz, kaygı, polen taneleri, genetik, polen taneleri, obezite ve düşük ağırlık, mesleki kimyasallar, eski binalar/resimler gibi farklı nedenleri vardır. Bu nedenler uygun şekilde yönetilmelidirler, aksi halde astım krizine yol açabilirler. Bir tetikleyici olduğunda veya astım nedenlerinden herhangi biri akciğerleri tetiklediğinde astım atağı meydana gelir ve bu durum hava yollarının şişmesine ve iltihaplanmasına neden olur. Hava yollarının etrafındaki kasların boyutu küçülür ve hava yollarının ekstra mukus üretmesine neden olur, bu da akciğerlerin veya solunum tüplerinin daralmasına neden olur. Astım belirtileri arasında öksürük, hırıltılı solunum, göğüste sıkışma ve düzgün nefes alamama sayılabilir.

Astım, doğru tıbbi cihazlarla düzgün bir şekilde yönetilebilir ve tedavi edilebilir. Bu tıbbi cihazlara inhaler denir ve havanın düzgün bir şekilde akmasını sağlamak için akciğerlerin serbest bırakılmasına veya akciğerlerin genişlemesine izin vermek için inhalasyon yoluyla akciğerlere ilaç vermek üzere özel olarak tasarlanmıştır. İnhalatörler, astım hastalarına ilaç vermek için kullanılan küçük taşınabilir cihazlardır. İlaçlar bronkodilatör ve anti-inflamatuardır ve yaptıkları şey, ilaç solunduğunda hava akışını sağlamak için akciğerleri serbest bırakmaktır.

Astım, akciğerleri etkileyen ve bireyin nefes almasını engelleyen bir solunum yolu hastalığıdır. Akciğerlere hava akışını sağlamak için kullanılan tıbbi cihazlardan biri inhalerdir. Bu çalışmanın amacı astım için kullanılan farklı inhalerleri değerlendirmek olup bunun için kullanılan teknik ise bulanık PROMETHEE yöntemi olarak adlandırılan çok kriterli bir karar verme yöntemidir. Bu yöntem, farklı inhalerlerin etkinlik, özgüllük ve uygulanabilirlik gibi önemli kriterlere göre analiz edilmesinde kullanıldı ve Bu kriterlere göre inhalerler, Accuhaler, Soft Mist inhaler ve Jet nebulizer ve son sırada Ellipta kuru toz inhaler olmak üzere pozitif üstünlüklerine göre sıralanmıştır.

*Anahtar kelimeler;* Astım, inhaler, inflamasyon, astım tıbbi cihazları, çok kriterli karar verme; Bulanık PROMETHEE.

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## LIST OF ABBREVIATIONS

**PROMETHEE:** Preference ranking organisation method for enrichment evaluations

## **CHAPTER 1**

### **1.1 INTRODUCTION**

Asthma is a respiratory disease that affects the lungs especially the small airways (bronchi and bronchioles). These airways have an inner lining called the mucosa and are surrounded by an area of smooth muscles. When the airways are tightened or restrict the flow of air, the airways become narrowed, inflamed and swollen which produces sticky mucus. The airways are chronically inflamed and hypersensitive to certain triggers/causes such as tobacco smoke, pollen dust, fragrances, exercises, cold weather, stress and even common cold (Huang et al., 2021). When a human lung is exposed to certain things or places that could trigger or cause asthma, the smooth rings of the muscle that circle the small airways contracts and become narrow causing inflammation, which makes the mucosa lining to become more swollen and secret mucus, that are sticky hence reducing the flow of air into the lungs. Under normal conditions, the body uses mucus to trap and remove foreign materials but during an asthma attack, the mucus blocks the airways making it harder to breathe (Kanami et al., 2020). The inflammation during an attack can make it difficult to exhale than inhale and this will require the body using more oxygen, hence reducing the oxygen delivery in the body and can lead to death (Zhiwang et al., 2019). Asthma is an inflammatory disease of the lungs, the lungs are affected where it is uneasy to breathe which leads to breathlessness, wheezing, tight feeling in the chest, continuous coughing. It makes it uneasy for the individual to breathe when he /she gets an asthma attack. If not properly managed and treated immediately could lead to complications/death (Charith et al., 2017).

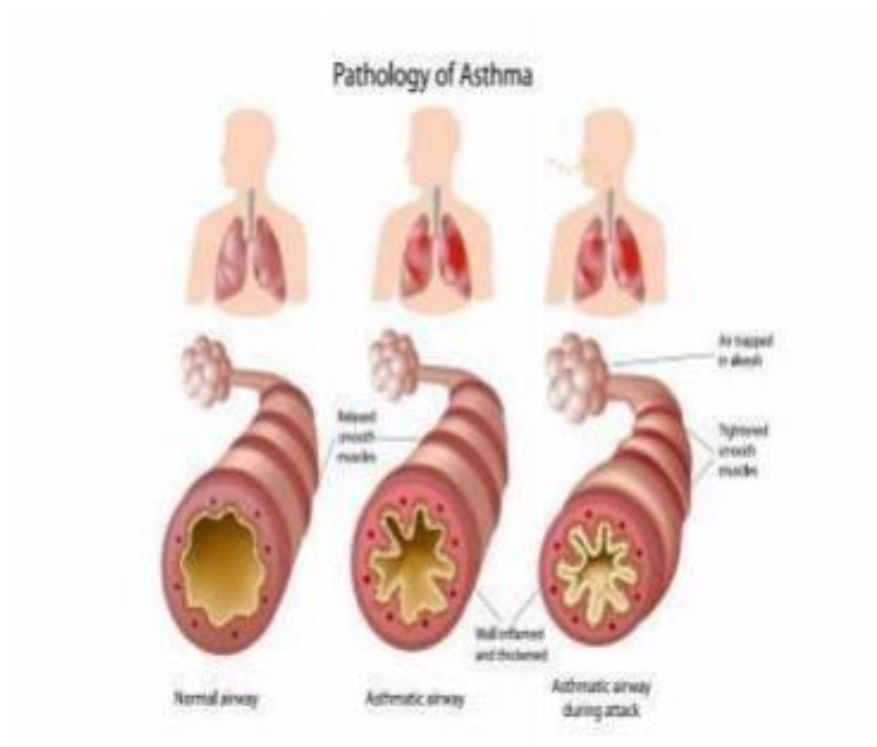


Fig 1.1 shows the pathology of asthma (Myamericannurse, 2015).

Asthma occurs mainly in children but if not overgrown can be seen in adults. Asthma is mostly associated with allergies; these allergies make the individual prone or react to substances in the environment. It can be seen as a chronic airway inflammation and structural remodelling which leads to irreversible lung function reduction in adulthood. Asthma has not been traced or known to what causes it but a combination of genetic and environmental factors has been seen to play a role (Na-Rae et al., 2019). It is very important for asthmatic patients to know what triggers their attack and how to prevent such from happening. They should be properly educated on what asthma is, what could trigger an asthma attack, places to avoid and how to prevent them. Asthmatic patients should be properly educated about asthma; how the devices can be used properly, else it can lead to lack of function of the lungs or death (Juliet et al., 2021). Asthma can be classified into two parts; Atopic (extrinsic): Asthma that is based on whether symptoms are caused by allergies and Non-atopic: Asthma that is not based on whether symptoms are caused by allergies. Medications of Asthma are of two types of quick relief medication: used to treat acute symptoms and long-term medication: used to prevent further asthma attacks (Carina et al., 2021).

The prevalence of asthma has been seen to be increasing over the years in the world and in different countries. The prevalence is usually more in the westernized or

developed countries than in the developing countries. This is because developed countries have more industries, which produce chemical emissions and gases. These gases and chemical emissions are very toxic to the environment which causes air pollution and in turn is very harmful to the body. As a country becomes more westernized or developed, the prevalence of asthma is highly determined to increase (Willisa et al., 2018).

In this study, we will be looking at asthma and its medical devices: the cell biology/etiology of asthma, population, causes, symptoms, prevention and treatment of asthma. Over 300 million people worldwide have been affected by asthma and it has been said that asthma cannot be overly cured but if properly managed by using drugs such as beta-2-agonists and steroids can lead to a healthy life. Asthma has affected a lot of people and sometimes it has actually led to the death of these individuals (Kim et al., 2011) Asthma can be diagnosed early by a medical practitioner, which should be checked regularly to avoid further complications. Proper education on asthma should be given to individuals on how to manage and prevent asthma because it has been seen from research that most people in countries die because of an asthma attack or trigger (Claudia et al., 2020).

## **1.2 POPULATION OF ASTHMA**

- The U.S National Health interview survey (NHIS) in 2017 shows that the current asthma .Prevalence among children is 8.4% which is higher than the 7.7% among adults. The prevalence was even higher among children in New York State with a prevalence of 8.7% in 2014 and increased to 10% with the highest burden in New York City in 2015. Approximately 400,000 people died from asthma worldwide in 2015 and the financial burden on patients with asthma in the U.S increased to 3636 dollars per person per year. From the 2018 NHIS, the incidences of respiratory allergies and skin allergies among children were 9.3% and 12.2% respectively (Xinlei et al., 2021).
- Asthma affects approximately 399 million people worldwide and generates a health spending service of approximately 1 billion pounds per annum in the UK alone (Peel et al., 2020).

- An Australian study of 346 participants found that children with severe asthma at age 7 years had 32 times higher risk of having chronic obstructive pulmonary disease (COPD) by age 50 compared with non-asthmatics. Another Australian cohort study of 5170 participants found out that children with asthma at age 7 years had double the risk of developing ‘chronic bronchitis’ (usual cough and phlegm) in middle age compared with non-asthmatics. A Japanese case control study of 700 participants concluded that childhood asthma was associated with three times higher risk of COPD between ages 50 to 75 (Asyha et al., 2021).
- Asthma is common in the United States and affects 25.9 million Asthma is common in the United States and affects 25.9 million people and asthma has been seen to be the primary cause of death for 383,000 individuals worldwide in 2015 (Lassmann et al., 2020).
- The prevalence of asthma is higher in Sweden and Finland than in neighbouring eastern countries including Estonia. There was a higher prevalence of asthma and allergic airway inflammation in adult general populations of Sweden and Finland compared to those of Estonia (Nwaru et al., 2020).
- A Population cohort study shows that the use of hormonal contraceptives in reproductive systems reduces the risk of asthma. Usually, asthma is higher in boys than girls after puberty becomes severe in women (Vanessa et al., 2020).
- Asthma affects approximately 300 million people worldwide, with negative consequences for individuals and society (Morales et al., 2021).
- In the United Kingdom, 62.6% of people were reported to have asthma (Takae et al., 2021).
- A survey from 2017 shows that approximately 2.7 billion persons worldwide had been affected by asthma. The commonness of severe asthma is estimated to be approximately 5%- 10% of the entire asthma population. Also, the prevalence of severe asthma was reported to be 3.6% of all asthma patients in the Netherlands and 8.1% in Danish adult (age 18- 44 years) patients. 10.6% of adult patients in Japan have severe asthma (asthma that requires high-dose inhaled corticosteroids [ICS] plus long-acting b2-agonists [LABAs]) with additional controllers to prevent the disease from becoming uncontrollable (Erika et al., 2021).
- Allergic diseases such as asthma and atopy are global public health concerns, affecting 25 million people in the United States alone (Stéphane et al., 2020).

- Asthma is the most prevalent chronic respiratory disease: According to World Health Organization (WHO), 235 million people worldwide, of all ethnic groups and ages are suffering from asthma (GBD, 2017; WHO, 2019) (Yunquan et al., 2020).
- More than 272 million patients are living with asthma and 43 million new asthma incidences globally in 2017, making asthma listed as the top leading respiratory causes of years of life lived with disability (YLD) (Juan et al., 2021).

### **1.3 CAUSES OF ASTHMA**

#### **A) Tobacco smoke/smoking**

When an individual is exposed to smoke, the airways are irritated causing it to be inflamed and swollen, when this happens it makes it difficult for the individual to breathe. Smoke, smoking and environmental tobacco smoke can be seen as a major cause of asthma. Environmental tobacco smoke (ETS) at home is still an important issue in homes because smoke can be found in our environment daily and we cannot totally avoid our environment and it is important we find a way to manage our environment properly. A study from Europe shows that environmental tobacco smoke was more common in the home (13%-40%) than in the workplace (3-32%). ETS exposure at home was less common in northern Europe as compared to central or southern Europe. This study shows that global smoking bans fail to reduce ETS exposure in homes and tobacco smoke is associated with asthma (Wanyu et al., 2020).

#### **B) Air Pollution**

Air pollution is a mixture of gases and solid particles in the air. These gases and solid particles come from industries and chemical industries which emitted to the environment are very poisonous. These Industries and chemical manufacturing industries produce hazardous substances that are toxic to the environment. When these substances are released to the environment, it pollutes the air and when the polluted air is inhaled it triggers the airways of asthmatic individuals to have an attack (Paul et al., 2020).



### **C) Occupational chemical**

Chemicals emitted from industries could be very hazardous to the human lungs. Also, chemical fumes, gases and dust are very toxic to the individual airway which could make it difficult for the individual to breathe (Hideki et al., 2021).

### **D) Dust**

There has been a relationship between Asian dust and mortality. Asian dust is an event of soil particles which emerge from the dry areas of Mongolia and China which are carried by strong winds and taken to an altitude of several meters then carried by westerly winds until it reaches the surface in the area of East Asia including Japan. In West Asia, dust storms have been seen to be originating from neighbouring deserts. Asian dust has led to mortality rate and also hospitalization and readmission of asthmatic patients in the hospital. Dust actually affects the respiratory organ which is the lungs, and this restricts the flow of air. Dust can be found all around us, in our homes, carpets, rugs, detergent, buildings and the environment. This high level of dust when inhaled can trigger an asthma attack causing an irritation in the airways (Lee et al., 2021; Oluwafemi et al., 2018).

### **E) Old buildings**

Old buildings could have a lot of dust and people who live in old buildings could be at risk of developing asthma. Old buildings could have home environment exposure that can influence respiratory health in children such as old buildings and stuffy homes (Chenyang et al., 2018).

### **F) Building materials/paints of buildings**

There are indoor materials and products that are used in homes or buildings that emit hazardous substances to the air and are very dangerous to the human respiratory organ. Air pollutants such as DEHP (di-ethyl-hexyl phthalate) and DBP which are emitted from flooring materials are toxic to the human body which can later lead to asthma. Also, there are paints which are used in our homes and this could emit chemicals which are hazardous to the human body (Perdita et al., 2020).

### **G) Obesity and low weight**

Fat produces inflammatory substances that can affect the lungs which can trigger an asthma attack. When a child or an individual has a low weight matrix, the organs such as the lungs may not be properly developed and these could lead to asthma attacks (He et al., 2020).

### **H) Genetics**

It has not properly been traced what causes asthma but it could be linked to genetics. The genes of an individual are hereditary and can be passed down from generation to generation (Rada et al., 2019).

### **I) Pollen Grains**

When rain droplets fall into airborne pollen, these pollen are then broken down into tiny particles. When the particles get into the lungs, they trigger a worse asthma response (McDowell et al., 2020).

### **J) Anxiety**

Physiological stress has been seen to be the cause of asthma through the influence of inflammation. Stress aggravates or worsen airway inflammatory response to irritants, allergies and infections hence increasing the frequency and seriousness of asthma symptoms. There are five personality traits/health behaviours: optimism, extraversion, conscientiousness, openness and neuroticism. Optimism is behaviours or people who are positive minded, extraversion is attached to behaviours that are outgoing, full of energy and social. Conscientiousness are behaviours that take things seriously, openness are behaviours that are open minded while neuroticism are behaviours linked to being anxious, tensed and withdrawn. A 2010 meta-analysis linked optimism, extraversion, conscientiousness and openness to being tolerant and receptive to stress while neuroticism and conscientiousness is linked to inability to cope with stress. These personality traits indicate the ways in which they handle stress and neuroticism which is a personal trait that has been seen to be consistently associated with asthma (Landeo-Gutierrez et al., 2020).

### **K) Stress**

People living in low areas or urban areas could lead to stress. When poverty and neighbourhood stress become a problem in an individual's life, it could affect their mental health which could lead to stress. When we stress about different things it could also contribute to asthma. Stress is a major contributor to asthma. When we stress and cannot breathe properly, it affects the lungs hence contributing to an asthma or development of asthma. Stress that leads to the development of asthma can be found mostly among adolescents, adolescents who live in low-urban areas or poor areas tend to stress about their standard of living and other life factors, hence leading to the development of asthma (Ahmed Zai, 2020).

## **1.4 SYMPTOMS OF ASTHMA**

### **A) Breathlessness**

Breathlessness is a symptom of asthma that is characterized by breathing discomfort. It disrupts the airflow making it uncomfortable for an individual to breathe (Shaodan et al., 2020).

### **B) Wheezing**

Environmental factors could contribute to the development of wheezing and asthma (Andreanne et al., 2020).

### **C) Tightness feeling in the chest**

When an individual finds it difficult to breathe because the airways are being inflamed, it could lead to tightness of the chest and pain (Castillo-Latorre et al., 2021).

## **D) Continuous coughing**

Inability to breathe or inhale air properly could lead to continuous coughing (Stéphane et al., 2020).

### **1.5 PREVENTION/MANAGEMENT OF ASTHMA**

Patients who know that they are prone to asthma triggers or attacks should avoid places that have a lot of smoke. Individuals should not live close to industries or chemical industries that emit smoke. Individuals should avoid smoking which is a major cause of asthma (Yuting et al., 2021).

Buildings should have better ventilation flow to avoid/prevent asthma (Dan et al., 2021). Texanol as a chemical should be reviewed carefully for toxicity and exposure assessment (Hien et al., 2021). Building materials/paints that are to be used should be properly examined and reviewed to avoid the emission of hazardous quantities of chemical contaminants that are toxic for the human lungs (Haines et al., 2020). Objects/structures such as carpets, rugs etc. which harbour dust in homes and buildings should be cleaned regularly to avoid asthma (Zainab et al., 2021). Environmental evaluation at home and in schools should also be done to prevent asthma. Children spend most of their time in school and homes and it is proper that these environments are properly kept clean to avoid the risk of asthma and its symptoms (Michelle et al., 2019). Individuals who are mostly anxious and stressed should also have regular mental check-ups and always talk to individuals to avoid triggers of asthma (Tianci et al., 2021). Individuals should avoid eating a lot of fatty foods, since fats contribute to the inflammatory diseases that cause asthma (Himes et al., 2019).

Another way to manage and prevent asthma is by using inhalers and mobile health applications. Individuals who usually have constant asthma attacks should always move around with their inhalers or mobile health applications could be attached to inhalers for better monitoring and management of asthma (Anna et al., 2020).

## CHAPTER 2

### LITERATURE REVIEW

According to the journal Quinton et al (2020) it is seen that in patients who have severe asthma, 2050% of the patients have uncontrolled asthma. Peer-reviewed literature reported the clinical, humanistic and economic overburden related with moderate or severe, uncontrolled asthma in the USA. It was established that patients with uncontrolled and severe asthma had a higher rise in prevalence of illness that are allergy related than those with mild to moderate or controlled asthma. The proportion of patients with GINA step 5 asthma who were readmitted within 90 days of discharge after an asthma-related ER visit/hospitalization was 58% and 25% for all -cause and asthma-related ER visits/hospitalizations. Total healthcare and asthma-related medical costs were 1. 4 and 1. 8 times higher for patients with severe, uncontrolled asthma than for those with non-severe, uncontrolled asthma, 3. 7 times higher for patients using SCS than for those not using SCS. Severe, uncontrolled asthma is associated with higher disease and treatment burden and higher all-cause and asthma-related costs than mild to moderate or controlled asthma. This research was conducted using targeted searches such as Medline, Embase and ScHARRHUD for English language articles reporting the clinical, humanistic or economic burden associated with moderate to severe asthma in the USA. Data reported here focus on severe, uncontrolled asthma (Cynthia et al., 2020).

An integrative review by Foronda et al (2020) on how family caregivers of children with asthma are faced with Psycho- logical and socio-economic burdens shows that asthma affects nearly one in every 12 children in the United States and carries a significant burden for patients and caregivers. A Caregiver is a person who gives care to people who need help taking care of themselves. They are responsible for obtaining and administering medications, coordinating and managing care, and assessing and intervening with appropriate intervention as life-threatening respiratory emergencies can occur. This journal talks about the psychological and socioeconomic burdens of caring for a child with a chronic condition such as asthma. These burdens have a negative effect on Caregiver's mental and physical health as well such as the

Psych-social burdens. The psych-social burdens include: decreased mental health, decreased quality of life, decreased sleep, educational deficit, family stress, health care communication challenges, cultural and health disparities. Caregivers suffer from anxiety, worry, fear, stress, distress, and depression because they were always afraid that something would happen to the child if they left their sight. One of the participants said 'I do not want him to drop dead somewhere'. The caregivers were always seen to be helpless, fearful, anxious and overwhelmed because they are trying to avoid any bad or worse situation from the asthma attack. Caregiving of patients with asthma has reduced the Caregivers mental health because they are always looking for ways to prevent any further life-threatening situation of the asthma attack or any worse situation of the asthma attack. Caregivers who were depressed also had children who were depressed. From this journal, 200 family caregivers were examined and it showed that anxiety levels of caregivers of children with asthma were higher than average. It was later concluded that caregiver anxiety and depression were risk factors for lower lung function in children. Caregiving of children with asthma has also reduced the quality of their lives. The higher the rate of asthma, the lower the quality of life of the care-giver. Caregivers of children with chronic illness such as asthma had a poor quality of sleep and more symptoms of insomnia. There was a challenge in communication between patients to communication providers. Most caregivers were not fluent in English, so when there was communication between both parties, the caregivers responded in Spanish which led to a language barrier. Family caregivers with less formal education have a higher risk of children being readmitted because they were not properly educated on how to manage and treat asthma. There were cultural and health differences between family caregivers of different ethnicity and race. These differences affected the quality of life among the caregivers. Latino caregivers were seen to have a worse quality of life than non-Latino caregivers did. It was also reported that Hispanic caregivers were seen to put their children on too much medication. Caregivers also faced Socio-economic burdens such as Poor access to care and work and financial challenges. Family caregivers of children with asthma were not able to have proper access to healthcare and this led to high risk of readmitting the child in the hospital. Family caregivers were not given proper healthcare information about asthma and this led to poor access to healthcare. Because caregivers are looking out for children with asthma, it affects their work and finances. They either had to miss their work, lose their income or the cost of visiting the doctor regularly was very high. 63% of Parents agreed that their job required them to change their care-giving plans and 44% of parents felt their jobs made it stressful for them to care for their children. 24% of parents also reported that stress from caregiving of children with asthma also affected their job

performance. Caregivers were also faced with a challenge in running their day-to-day activities because of the inflexible work hours. These inflexible hours do not allow them to switch between their personal time and caregiving time/plans. Caregivers faced financial problems especially employment and it was reported that caregivers who earned less than 10,000 dollars a year were likely to get the asthmatic children to be readmitted to the hospital regularly. Families with low income were faced with greater effort, more perceived effort and frequent visiting /admission in the hospital. According to this journal, the best way for the caregivers to properly improve in their care giving to children with asthma is to get a formal education on asthma and its symptoms, medications and devices used in asthma. Social support such as community health workers can provide community awareness and education to the caregivers to improve on the knowledge and information on the control and management of asthma. Also, it has been seen that the use of technology such as mobile health has helped in improving the lives of the caregivers of children with asthma. Better assessment of asthma and management can be done through the use of mobile applications; this helps the caregiver in reducing stress and anxiety by having access to good healthcare. The mobile application helps to enhance communication between the child with asthma and the caregiver and it improves in the management of asthma (Elif et al., 2019).

A systematic review by Isik et al (2019), talks about how proper information and education of asthma could prevent asthma attacks and hospitalization. According to the Centre for disease control (COD) it was reported that about 6.2 million children in the United States have asthma and 3.3 million children experienced worse situations of asthma symptoms based on 2016 National health interview survey (NHIS) data. According to this journal 3518 died of asthma related causes. Asthma when not properly managed, controlled or treated can lead to death. When asthma is not properly managed, children could experience severe asthma attacks which could lead to absence in school, constraints from school activities, emergency school visits and hospitalization. Children with asthma are at a high risk of special needs, emotional problems and lower academic accomplishment. As much as asthma affects children, it also affects the lives of the parents and guardians. The parents and guardians have to be absent from work. Stress and anxiety are also an issue to the parents and guardians because they are always worried that the children would have an asthma attack. Parents and guardians also have financial burdens because going to the hospital regularly or frequently requires some finances to be paid. This journal also focuses on some health asthma education which includes parents and caregivers. Its main focus is to develop asthma management strategies. School nurses can

execute educational programs on information about asthma. Nurses are a vital part in the clinical setting and it is important they have an understanding and education on asthma so that they can communicate it to the parents/guardians or caregivers of children with asthma. These nurses could listen to the parents and caregivers' experiences of their children with asthma, so that they can have a better understanding and give the parents better management strategies for their children. This will help the parents/guardians and caregivers to have a better and positive plan on how to care and manage children who have asthma. Asthma education programs should be implemented in primary schools so that they can have a knowledge of it and help to manage and care for themselves. This journal was to review the effectiveness of asthma management in primary schools. It provides how school nurses were able to educate parents on asthma in different school communities (Shilpa et al., 2018).

A literature review by Patel et al (2018) shows that the emergency department visits in the hospitals over 700,000 and this is due to the cause of acute asthma attack. Children are admitted regularly in the emergency department because of asthma attacks. Admission of patients in hospitals, especially in the emergency department is the most expensive in the healthcare industry. Over 4-10 billion dollars is spent annually for children with asthma. The emergency department providers are the ones responsible for admitting patients especially children with asthma and most times it is difficult for them to predict whether they need to be discharged or admitted. It is very difficult to know when to admit a patient which could be attributed to the asthma makeup. There are various asthmatic makeup and this could be very difficult in making hospitalization decision making. One of the ways to have a better way of making good decisions for asthma is by clinical guidelines. The clinical guidelines are based on the expertise and experiences of the clinicians and they agree that the decision to admit or discharge a patient is based on a variable clinical judgement due to lack of evidence based on disposition decision criteria. Unnecessary admission increases the burden of disease on children and families, wasted health resources and finances and also exposes these individuals to infections. Avoiding unnecessary admission could actually be a good clinical policy and help them to make good investigation and decision making of asthma. This review shows us how an accurate prediction model can help us improve efficiency and make good decision making for children with acute asthma attacks. As much as the prediction model was efficient, there were limitations of individual guesses to provide information and knowledge that will help the next generation in putting up a guideline for hospitalization and discharge (Usmani et al., 2021).



## **CHAPTER 3**

### **3.1 ASTHMA AND ITS MEDICAL DEVICES**

There are devices used in the management and treatment of asthma. The device used in treating asthma is called an inhaler. Inhalers are small devices that deliver medication such as bronchodilators and anti-inflammatory to the lungs. Bronchodilators open up the airways for more air to flow into the lungs while anti-inflammatory drugs reduce inflammation and swelling (Litt et al., 2020). There are different types of inhalers and each inhaler is used suitably for each patient. The aim of an inhaler is to deliver medications or drugs into the lungs that can open up the airways to allow flow of air. Asthmatic patients should be properly educated about asthma, how the devices can be used properly else it can lead to lack of function of the lungs or death.

Asthma cannot be totally cured but can be managed or controlled under good supervision and there are medical devices that can be used to achieve this purpose which include; Respimat soft mist inhaler, dry powder inhalers, metered dose inhaler and Nebulizer. One of the common problems among asthmatic patients is incorrect handling of inhaler devices and this could reduce the drug effectiveness, patients' not following instructions carefully which results in additional cost to buy new inhalers or drugs (Piyush et al., 2018). Although there are different types of inhalers, each has its disadvantages and advantages where they work effectively based on knowledge. Following instructions carefully about asthma medical devices is very essential for desired results to be attained and also to avoid any further complications. According to WHO (World Health Organization) herbal medicine can be used as drugs which are added to the inhalers for the treatment and management of asthma, it is being used because it is effective, less toxic and safe (Rakesh et al., 2021).

Asthma occurs in adults and children, it is important to know what triggers each individual, and handling asthmatic patients especially in children should be done carefully

because of their inability to handle an inhaler hence a valved holding chamber (VHC) with a facemask is used (Wesam et al., 2019).

Inhalers are classified into 4: Respimat soft mist inhaler, Dry Powder inhaler, soft mist inhaler and Nebulizers.

### 3.1.1 Respimat soft mist inhaler

This inhaler uses a mechanical energy to create an aerosol with low velocity spray and delivers a unit dose of drug in a single actuation. The inhalation done with this device is a slow deep breath and breathe in slowly. Soft mist inhaler is effective and safe in delivering bronchodilators to patients with asthma. The main aim of a Respimat soft mist inhaler is to relieve and prevent asthma. The medication/drug used alongside the soft mist inhaler is the tiotropium bromide Respimat. Dosage used could range from 2.5 and 5µg and could last from 12-48 weeks depending on the individual. It is usually administered for 12 weeks but if the individual is not responding then it is prolonged.

Soft mist inhaler is clinically efficient and safe, it is also commercially available and propellants are not necessary. The practicality is very high and its specificity is very high (90%). It delivers an aerosol with a high fine particle fraction at a slow velocity which improves overall drug deposition in the lungs with less undesirable or pharyngeal deposition (Wesam et al., 2019).

Table 3.1.1 Advantages and disadvantage of soft mist inhaler.

| Advantages                    | Disadvantages                                     |
|-------------------------------|---|
| It is efficient and safe      | Lack of proper inhaler technique                  |
| Commercially available        | One type of valve holding chamber is usually used |
| Propellants are not necessary |   |

Table 3.1.1 shows the advantages and disadvantages of soft mist inhaler.



Fig 3.1.1 Image of Respimat soft mist inhaler (Lungdiseaseneews, 2015).

### 3.1.2 Dry powder inhalers

This inhaler lets asthma patients breathe medicine into their lungs, which means they breathe in through their inhaler and the inhaler administers the drugs into the lungs. Generally, this type of inhaler delivers medication in powder form. Dry powder inhalers are breath-actuated devices in which inhalation is required to release the medication. Dry powder inhaler is not expensive, very handy and not harmful. They are easy to use and do not need coordination. The doses range from  $1.6\mu\text{g}$ - $8000000\mu\text{g}$  and could last for 3 months. It is clinically efficient and readily available. The drug used alongside this inhaler is N-acetylcysteine (Alpár et al., 2020).

There are three types of dry powder inhaler:

- 1) Turbuhaler: is a white cylinder with a coloured base. It is a 2-step process of unscrewing the device. The device is held gently and breathed out gently. It is used to deliver medicines in powder form. It delivers both the anti-inflammatory agent and the rapid-acting and long-lasting bronchodilator. As one inhales, air is drawn into the disk and delivers a dose to the airways, the drugs are separated into small particles before it goes into the airways. It has a dose counter window so you can see when it is nearly empty. Its doses are  $0.6\mu\text{g}$  to  $8000000\mu\text{g}$  and it can be used within 3 months. Efficiency is 60% and its aim is to prevent and control asthma symptoms (Alpár et al., 2020).



Fig 3.1.2. The image of turbuhaler dry powder inhaler (Healthywa, 2021).

2) Accuhaler: An accuhaler is a circular-shaped breath activated, dry powder inhaler (DPI). The drug is inhaled as fine particles without a propellant in the formulation. It is also a dry powder. Its doses are  $0.6\mu\text{g}$  to  $8000000\mu\text{g}$  and used within 3 months. Its efficiency is 90% and the main aim of an accuhaler is to prevent asthma (Velega et al., 2018).



Fig 3.1.3. Image of an accuhaler dry powder inhaler (Niformulary, 2021).

3) Ellipta: is a combination inhaled corticosteroid (ICS) and long-acting beta2-adrenergic agonists (LABA) used to treat airflow obstruction in patients with chronic obstructive pulmonary disease (COPD), including chronic bronchitis and/or emphysema. The doses are 0.6µg to 8000000µg and can be used for 3 months. Its efficiency is 40% (Robert et al., 2018).



Fig 3.1.4 Image of an Ellipta dry powder inhaler (Mims, 2014).

### 3.1.5 Metered dose inhaler

This inhaler is also known as pump inhalers. They are propellant based and self-administered via inhaler that the patient has to administer the inhaler so that the inhaler breathes medicine into your lungs. It delivers a specific amount of medication to the lungs in the form of aerosol spray. This inhaler does not depend on the patient's inhalation to release the drugs and they require coordination (inhaling and pressing at the same time). The same amount of dose is released every time. Masks are used alongside this inhaler for elderly patients and children who cannot hold the inhaler. It is not expensive and handy. The doses range from 1.5-50µg and could last for 14 days. It is clinically efficient and readily available. The drug used is a combination of drug crystals or glycopyrronium. It is 40% efficient and the main aim is to relieve asthma (Yasuhiro et al., 2021).

Table 3.1.5 shows the table between advantages and disadvantages of a metered dose inhaler.

| Advantages        | Disadvantages                                     |
|-------------------|---|
| Not Expensive     | Certain major drugs are not readily available     |
| Very handy        | Requires Propellant                               |
| Self-administered | Breath coordination requires short treatment time |

Table 3.1.5 This table explains the benefits of metered dose inhalers and the disadvantages of metered dose inhalers.



Fig 3.1.5 Image of a metered dose inhaler (Epill, 2021).

### **3.1.6 Nebulizer**

A nebulizer is a small machine that turns liquid medicine into a mist. It converts liquid medication to aerosol droplets which are best used for inhalation. The patient sits with the machine and breathes in through a connected mouthpiece. It is a conversion from mechanical to electrical energy. It is portable, durable and relatively inexpensive. The duration of medication could last from 2-6weeks. It is clinically efficient and readily available. Various antibiotics are used along-side the inhaler (Klein et al., 2021).

#### **Advantages of nebulizer**

1. Does not require medication
2. Delivers quickly and efficiently
3. Nebulizers are preferred for infants, children, elderly and critically ill patients during an asthma attack.

There are two types of nebulizers

1) Mesh nebulizer: These nebulizers are driven by a piezo-element and use ultrasonic frequencies to vibrate the mesh. The vibration of the mesh causes aerosol generation as the liquid passes through it (Jana et al., 2021).



Fig 3.16 shows the Image of mesh nebulizer (Indiamart, 2021).

2) Jet nebulizer: Based on Bernoulli principle by which compressed gas (air or oxygen) is passed through a narrow orifice, creating a low-pressure area at the adjacent liquid feed tube (Ochowiak et al., 2019).

### **3.2 ASTHMA AND ITS MEDICATION**

There are two types of medications which are quick relief medication and long-term medication. Quick relief medication is used to treat symptoms while the long-term medication is used to prevent further asthma attacks. The medications are divided into 4



categories namely: Reliever, Preventer, Symptom controller medication and combination medication.

### **3.2.1 RELIEVER**

The Reliever is used as a medication to alleviate or reduce asthma. Relievers are usually blue in color and the medication used for this is Airomir, Asmol, Bricanyl, Ventolin. The doses of this medication are usually 1.5-50 $\mu$ g which last for 14 days. One of the devices that has been used as a reliever is a metered dose inhaler. The metered dose inhaler can be used as a reliever (Ruth et al.,2020).

### **3.2.2 PREVENTER**

The work of the preventer is to stop/prevent an asthma attack from happening. The medications also used are the same as the reliever which are Airomir, Asmol, Bricanyl, Ventolin and the preventers are usually in autumn/desert colors. The drugs used are various types of antibiotics. These antibiotics are used to prevent inflammation in the lungs of an individual. The dose to take is 20mg for 2-6 weeks. It is clinically efficient and not so expensive. A mesh nebulizer and Accuhaler dry powder inhaler is usually used as a preventer (Sinha et al., 2020).

### **3.2.3 SYMPTOM CONTROLLER MEDICATION**

The symptom controller helps to control and manage the symptoms of asthma.it also uses antibiotics which helps to control the asthma symptoms. The medication used are Albuterol, Xopenex or Pulmicort (steroid) and the colour of a symptom controller medication is green. The dose taken is 20mg for 2-6 weeks. It is clinically efficient and a Jet nebulizer is used as a symptom controller medication (Bashati et al., 2008).

### **3.2.4 COMBINATION MEDICATION**

Combination medication prevents and controls asthma. It is a combination of prevention and control of asthma symptoms. The dose is usually 0.6 $\mu$ g to 8.0g for 3 months. It is commercially available and clinically efficient. The medication used for combination medication is Seretide (Flixotide and Serevent) and the drug used is N-acetylcysteine. The colour of the combination medication is purple, red and white. Turbuhaler dry powder inhaler is the asthma device used for combination medication (Bashati et al., 2008).

## CHAPTER 4

### 4.1 METHODOLOGY AND APPLICATION

This study was done for evaluation of the medical devices used to treat and reduce asthma attacks. In this study, we have applied the fuzzy PROMETHEE method, a multicriteria decision making method, for the analysis of the asthma treatment devices.

#### 4.1 Multi Criteria Decision Making

Multi Criteria Decision Making (MCDM) is a method to evaluate various available options, according to decision criteria and also to assign importance weightings to the criteria. Upon this, according to the assigned importance weightings, the best option can be determined and makes the alternatives a favorable (maximal advantage) or unfavorable (minimal concession) choice for a specific application (Ozsahin et al., 2020).

**4.1.1 Preference ranking Organization method for the enrichment evaluation (PROMETHEE)** PROMETHEE is a technique of the multi-criteria decision-making tool to analyze and rank available options based on the parameters of each option for researchers. Brans et al. (Brans, Vincke & Mareschal, 1986) develop it. The PROMETHEE technique is one of the easy to use and most effective methods both planning and application when it is compared to other Multi-Criteria Decision-Making methods (Sayan et al., 2020).

The reason of the PROMETHEE being most favorable technique of multi criteria decision methods are (Ulengin et al., 2001);

- PROMETHEE can be applied to real-life decision-making problems.
- PROMETHEE works on fuzzy logic and uncertainty.
- PROMETHEE can provide a control mechanism to researchers to check his or her fictitious and real data to observe their potential.



equal positive (leaving) and negative (entering) flows, is indifferent to  $(i, j)$  if  $(i, j) \in E$ .  
 $(i, j)$  is unique to  $(i, j)$  if  $\{ (i, j) \} \cap E = \emptyset$ .

6. Determine the net outranking flow for each alternative  $i$ :  $(i, j)$  (The net outranking flow = The positive outranking flow - the negative outranking flow) With usage PROMETHEE II, the complete pre order can be obtained by the net flow and determined by:  $i$  is preferred to  $j$  if  $(i, j) \in E$ ,  $i$  is indifferent to  $j$  if  $(i, j) \in I$ . As a result, the better alternative is the one having the higher  $(i, j)$  (the net outranking flow) value (Ozsahin et al., 2021).

### 4.1.3. Preference ranking organization method for enrichment evaluation

This data set contains the inhalers that have been evaluated. Based on importance and certain criteria it has been evaluated in the table below.

**Table 4.1.3: Parameter Values of Asthma inhalers**

|   | ☑        | ☑          | ☐        | ☑          | ☑             | ☑        | ☑          | ☑              | ☑           | ☑           | ☑              | ☑    |
|---|----------|------------|----------|------------|---------------|----------|------------|----------------|-------------|-------------|----------------|------|
| ● Bertrand  | Doses    | Efficiency | Function | Advantages | Disadvantages | Cost     | Limitation | Practicability | Side effect | Specificity | Treatment D... |      |
| Unit  | mg       |            |          |            |               |          |            |                |             |             | months         |      |
| Cluster/Group   | ◆        | ◆          | ◆        | ◆          | ◆             | ◆        | ◆          | ◆              | ◆           | ◆           | ◆              |      |
| ☰ Preferences   |          |            |          |            |               |          |            |                |             |             |                |      |
| Min/Max   | min      | max        | min      | max        | min           | min      | min        | max            | min         | max         | min            |      |
| Weight  | 0,50     | 0,92       | 1,00     | 0,75       | 0,75          | 0,50     | 0,50       | 0,25           | 0,92        | 0,75        | 0,50           |      |
| Preference Fn.  | Gaussian | Gaussian   | V-shape  | Gaussian   | Gaussian      | Gaussian | Gaussian   | Gaussian       | Gaussian    | Gaussian    | Gaussian       |      |
| Thresholds  | absolute | absolute   | absolute | absolute   | absolute      | absolute | absolute   | absolute       | absolute    | absolute    | absolute       |      |
| - Q: Indifference                                       | n/a      | n/a        | n/a      | n/a        | n/a           | n/a      | n/a        | n/a            | n/a         | n/a         | n/a            |      |
| - P: Preference   | n/a      | n/a        | 2,00     | n/a        | n/a           | n/a      | n/a        | n/a            | n/a         | n/a         | n/a            |      |
| - S: Gaussian   | 3,00     | 3,00       | n/a      | 3,00       | 3,00          | 3,00     | 3,00       | 3,00           | 3,00        | 3,00        | 3,00           |      |
| ☰ Statistics  |          |            |          |            |               |          |            |                |             |             |                |      |
| Minimum   | 0,08     | 40,00      | 7,00     | 0,25       | 0,08          | 0,25     | 0,08       | 0,08           | 0,08        | 50,00       | 0,50           |      |
| Maximum   | 0,92     | 90,00      | 9,00     | 0,75       | 0,92          | 0,75     | 0,25       | 0,92           | 0,92        | 90,00       | 3,00           |      |
| Average   | 0,66     | 58,57      | 8,17     | 0,57       | 0,62          | 0,32     | 0,15       | 0,57           | 0,43        | 68,43       | 2,00           |      |
| Standard Dev.   | 0,32     | 16,41      | 0,75     | 0,17       | 0,32          | 0,17     | 0,08       | 0,28           | 0,25        | 12,56       | 1,04           |      |
| ☰ Evaluations   |          |            |          |            |               |          |            |                |             |             |                |      |
| <input checked="" type="checkbox"/> Soft Mist Inhaler   | ☐        | 0,08       | 60,00    | 7,00       | 0,25          | 0,75     | 0,75       | 0,25           | 0,92        | 0,50        | 90,00          | 2,50 |
| <input checked="" type="checkbox"/> Metered Dose In...  | ☐        | 0,25       | 40,00    | 8,50       | 0,50          | 0,92     | 0,25       | 0,08           | 0,75        | 0,50        | 80,00          | 0,50 |
| <input checked="" type="checkbox"/> Turbuhaler Dry P... | ☐        | 0,92       | 60,00    | 8,00       | 0,75          | 0,50     | 0,25       | 0,08           | 0,08        | 0,50        | 59,00          | 3,00 |
| <input checked="" type="checkbox"/> Accuhaler Dry Po... | ☐        | 0,92       | 90,00    | 9,00       | 0,75          | 0,25     | 0,25       | 0,08           | 0,75        | 0,25        | 70,00          | 3,00 |
| <input checked="" type="checkbox"/> Ellipta Dry Powd... | ☐        | 0,92       | 40,00    | 7,50       | 0,75          | 0,08     | 0,25       | 0,08           | 0,50        | 0,92        | 50,00          | 3,00 |
| <input checked="" type="checkbox"/> Mesh Nebulizer      | ☐        | 0,75       | 50,00    | 9,00       | 0,50          | 0,92     | 0,25       | 0,25           | 0,75        | 0,25        | 60,00          | 1,00 |
| <input checked="" type="checkbox"/> Jet Nebulizer       | ☐        | 0,75       | 70,00    | n/a        | 0,50          | 0,92     | 0,25       | 0,25           | 0,25        | 0,08        | 70,00          | 1,00 |

Table 4.1.3 shows the dataset of the Seven inhalers which have been evaluated based on the criteria: doses, efficiency, function, advantages, disadvantages, cost, limitations, practicability, side effect, specificity and treatment duration (Sayan et al., 2020).

**Table 4.2: Linguistic scale of importance for patients**

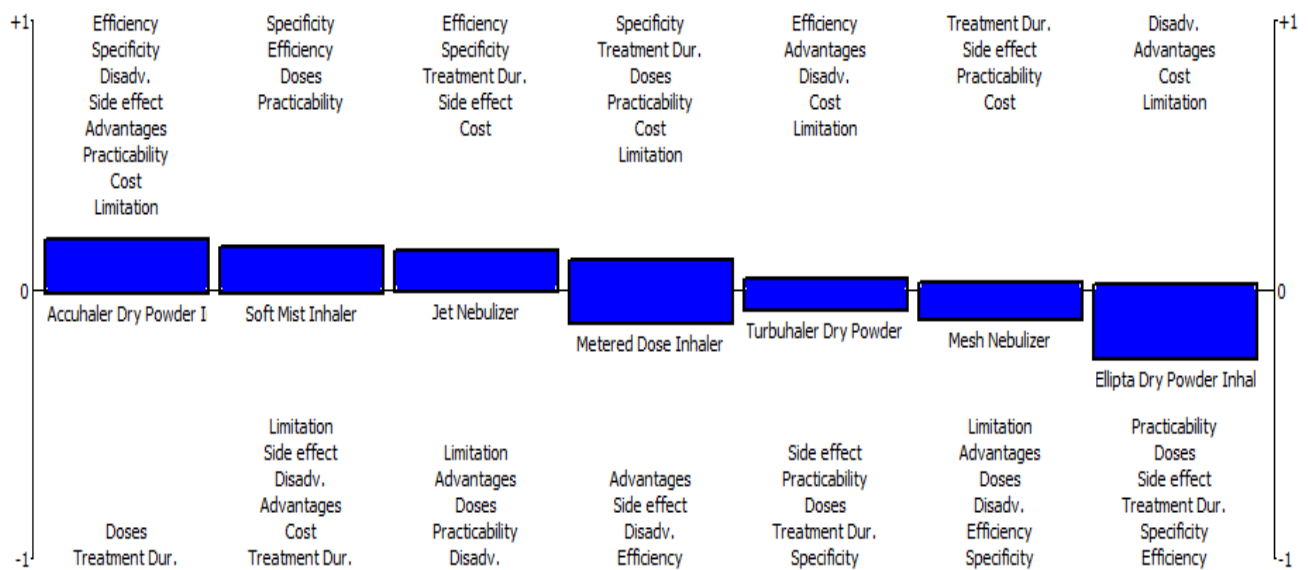
| Linguistic scale for patients | Triangular Fuzzy Scale | Importance ratings of criteria          |
|-------------------------------|------------------------|---|
| Very High (VH)                | (0.75, 1, 1)           | Efficiency, specificity, practicability |
| Important (H)                 | (0.50, 0.75, 1)        |   |

|            |                    |  |
|------------|--------------------|--|
| Medium (M) | (0.25, 0.50, 0.75) |  |
| Low (L)    | (0, 0.25, 0.50)    |  |
| Very Low   | (0, 0, 0.25)       |  |

Table 4.2 shows the linguistic scale of importance rating according to the criteria for patients (Mubarak et al., 2019).

**Fig 4.2.1: Ranking of the asthma medical devices according to its criteria**

FIG 4.2.1 Shows the positive and negative ranking of the inhalers based on their ranking (Ozsahin et al., 2017).



Accuhaler is seen to have a more positive rank followed by soft mist inhaler and jet nebulizer. Metered dose, turbuhaler and mesh nebulizer are both on the positive and negative rank while Ellipta dry powder inhaler is in the negative rank.

**Table 4.3 Complete Ranking of the positive and negative outranking flow values.**

| Inhalers                         | Positive outranking flow | Negative outranking flow | Net flow |
|----------------------------------|--------------------------|--------------------------|----------|
| Accuhaler                        | 0,2078                   | 0,0496                   | 0,1582   |
| Soft mist inhaler                | 0,1943                   | 0,0574                   | 0,1368   |
| Jet Nebulizer                    | 0,1912                   | 0,0664                   | 0,1248   |
| Metered dose inhaler             | 0,1151                   | 0,1426                   | -0,0274  |
| Turbuhaler<br>Dry powder inhaler | 0,0936                   | 0,1398                   | -0,0432  |
| Mesh Nebulizer                   | 0,0797                   | 0,1778                   | -0,0980  |
| Ellipta dry powder inhaler       | 0,0038                   | 0,2519                   | -0,2481  |

Table 4.3 shows the table of the positive, negative and net outranking flow values using the fuzzy PROMETHEE method. It shows the difference between the positive and negative rank. Some of the net outflow rankings are negative while some are positive (Uzun et al., 2020).

## CHAPTER 5

### RESULTS

The result of the analysis of asthma medical devices shows the action profile of each inhaler. The action profile shows the strength and weaknesses of each alternative. According to the analysis, Accuhaler is seen to have a positive ranking, followed by soft mist inhalers, Jet nebulizers, Metered dose inhaler, Turbuhaler dry inhaler, Mesh nebulizer and Ellipta dry powder inhalers (Mustapha et al., 2021).

Fig 5.1 Action profile of soft mist inhaler



Fig 5.1 shows the strength and weakness of soft mist inhalers. In the positive ranking, specificity is very high, followed by efficiency, doses and practicability. The advantages, disadvantages and cost are very low in the positive rank. There are no or minimal side effects. The treatment duration is in the negative ranking (Uzun et al., 2021).



Fig 5.2 Action profile of Metered dose inhaler

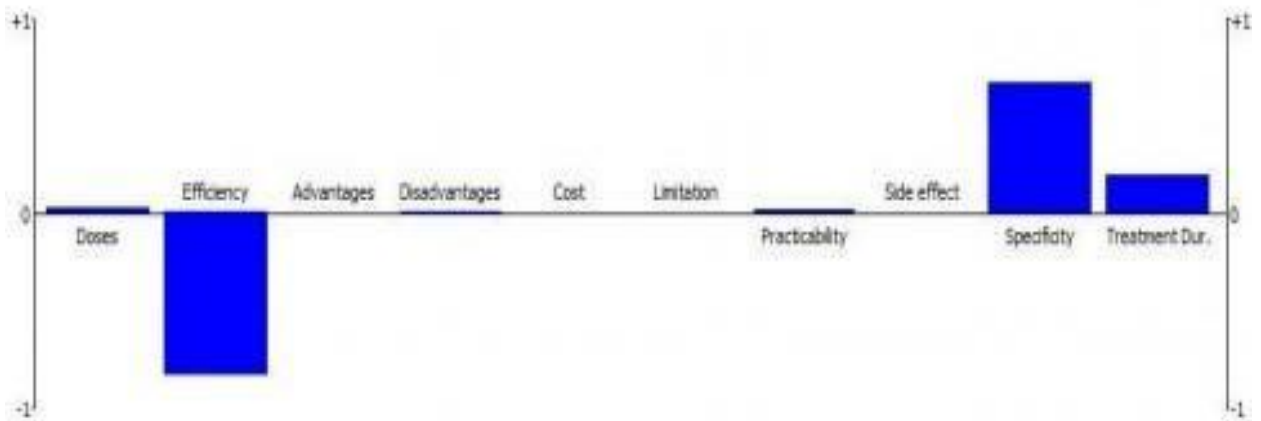


Fig 5.2 shows the strength and weakness of the metered dose inhaler. In the positive ranking, specificity is very high, followed by the duration of treatment, doses, practicability and disadvantages. The advantages, cost, limitation and side effects of using a metered dose inhaler are very low. The efficiency of this inhaler is seen in the negative ranking (Uzun et al., 2021)

Fig 5.3 Action profile of turbuhaler dry powder inhaler

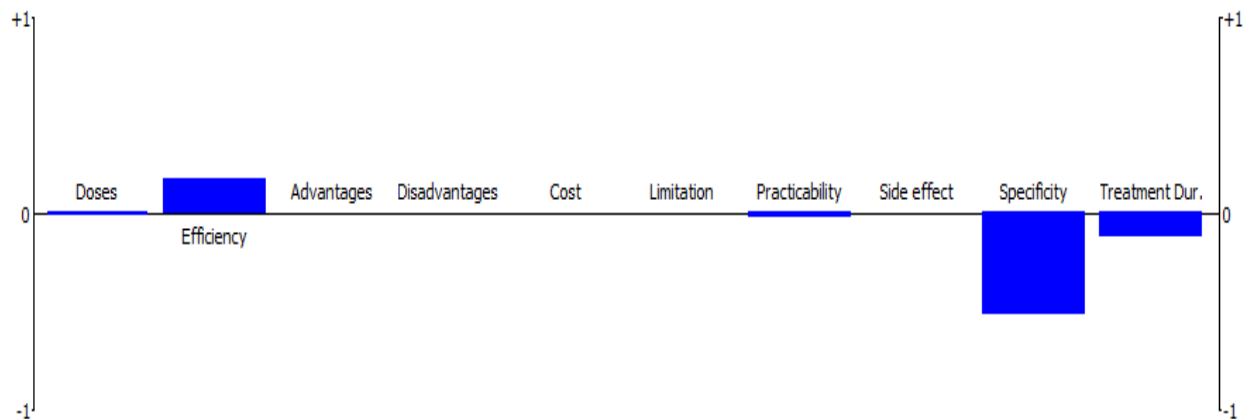


Fig 5.3 shows the strength and weakness of turbuhaler dry powder inhaler. Efficiency for the turbuhaler dry powder inhaler is very high in the positive rank followed by the doses of medication administered and how practical the inhaler is. Specificity and treatment of duration is very high in the negative rank (Mustapha et al., 2021).

Fig 5.4 Action profile of Accuhaler dry powder inhaler

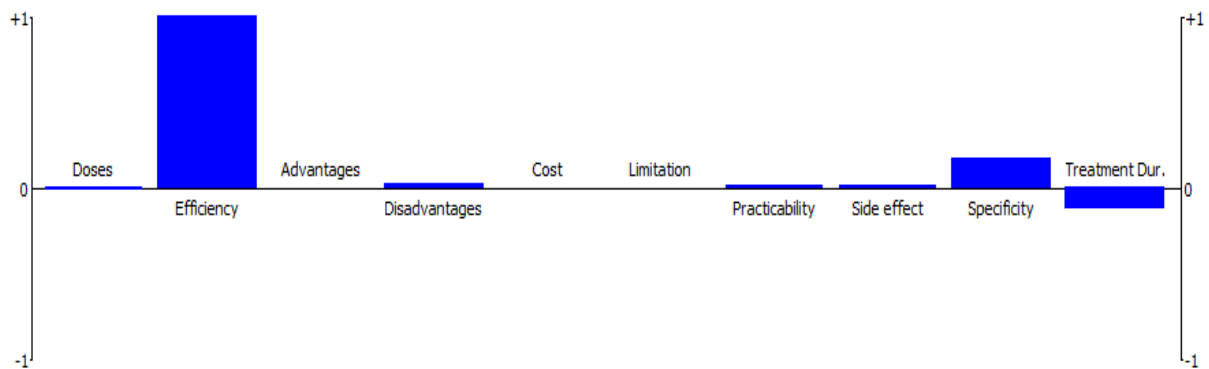


Fig 5.4 shows the strength and weakness of Accuhaler dry powder inhaler. Efficiency and specificity is high for an accuhaler dry powder inhaler, followed by disadvantages, practicability, side effects and doses. On the negative rank, the duration of treatment is very high (Mustapha et al., 2021).

Fig 5.5 Action profile of Ellipta dry powder inhaler



Fig 5.5 shows the strength and weakness of Ellipta dry powder inhaler. Disadvantages, doses and side effects are in the positive rank while on the negative rank its efficiency, specificity and treatment of duration (Ozsahin et al., 2021).

Fig 5.6 Action profile of Mesh nebulizer

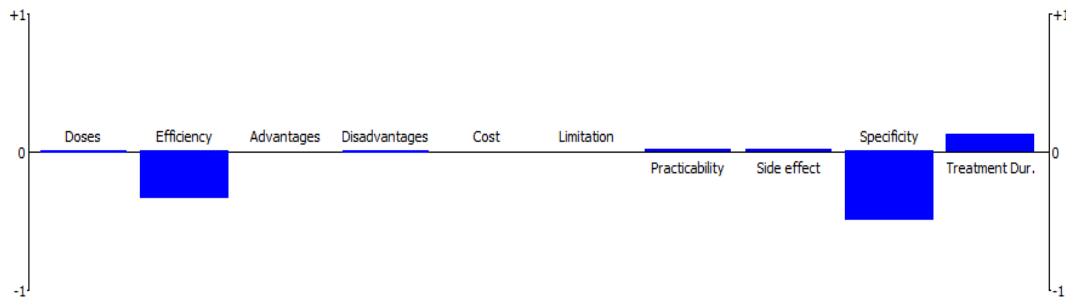


Fig 5.6 shows the strength and weakness of mesh nebulizer. Treatment of duration is very high in the positive rank. Doses, disadvantages, practicability and side effects which are also on the positive side are very minimal while the most important criteria such as efficiency, specificity are seen on the negative side (Uzun et al., 2021).

Fig 5.7 Action profile of Jet nebulizer

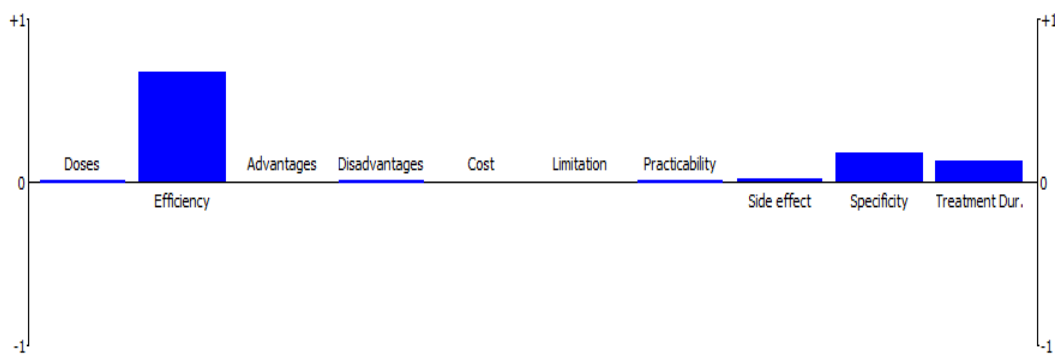


Fig 5.7 shows the action strength and weakness of Jet nebulizer. On the positive rank, the most important criteria such as efficiency, specificity and treatment duration are on the positive side alongside doses, disadvantages, practicability and side effects. Advantages, cost and limitations are very minimal (Ozsahin et al., 2017).

## **CHAPTER 6**

### **DISCUSSION**

The result of this study provides efficiency and practicability alongside other parameters or criteria on the type of inhalers to be used. This analysis was done to evaluate the inhalers that are efficient and practical. Although the inhalers may differ based on the patient's preference and usage, this analysis was prepared according to the present data, and results may change over time with developing devices.

## **CHAPTER 7**

### **CONCLUSION**

Asthma has been seen to be one of the respiratory diseases that bring about reduction of population in any nation. As little as asthma could look like, it has been a major cause of population death. There are so many causes of asthma and asthma attacks. Population percentage was carried out in different countries and it is seen how people died because of asthma.

Proper management and treatment of asthma is very important and vital for asthma patients especially for a nation to be productive. It is important for these patients to know the causes of asthma so that it could be avoided or managed properly. A major cause of asthma could be smoke. Smoke affects the lungs which block the airways from receiving sufficient air which is necessary for living/survival. Other causes of asthma include stress, anxiety, dust etc. When the lungs cannot inhale the sufficient air needed by the lungs, the lungs become inflamed and begin to swell and the only way/solution is to use drugs/medication that can reduce the swelling and inflammation to allow airflow.

One of the ways to properly manage and treat asthma is by using medical devices for asthma. The medical device used for asthma attacks is called an inhaler. Inhalers are small medical instruments that contain drugs and medication that are used to open the airways of an asthma patient or an individual during an asthma attack. In this review, we looked and compared different types of inhalers using the fuzzy method and we found out that it was efficient, less expensive and reliable. Inhalers come in different forms: from mist to dry powder and then to normal medication and drugs. Each asthma patient may have a suitable inhaler that is preferred for him/her. What works suitably for one patient may differ from the next patient. So therefore, it is essential for each asthma patient to know the inhaler that is best suitable for them. Some patients because of their age and physical strength, it is necessary to use an extension such as a spacer or spacer with a mask. There are four types of inhalers which are Respimat, soft mist, dry

powder and nebulizers. Each inhaler has different techniques on how they are used and it is best important to know what works for each individual.

Proper education and programs on asthma should be done by nurses, doctors or medical practitioners on what asthma is, causes, etiology, how to manage and treat an asthma patient and how to avoid asthma attacks. Asthma patients need to have proper education on how to handle the medical devices because inability to handle these devices properly could lead to death. Each inhaler works differently and it is important to know what works for them individually. Asthma causes stress to caregivers. Caregivers are people that take care of people that are physically ill or handicap. Asthmatic patients bring anxiety and stress to the caregivers because the caregivers are scared that if the asthma patients are left alone, an asthma attack may occur. Asthma attacks can occur in any minute; this is why an asthma patient should always walk around with his/her inhaler. The inhalers are portable, small and cheap and carrying it around would not be difficult.

The purpose of this study is to have a general knowledge on asthma and the medical devices used in the treatment and management of asthma. With using the Multi-criteria decision making technique, fuzzy PROMETHEE; we obtained the ranking results of the asthma device based on their most important parameters. Results showed that the first three best alternatives are: Accuhaler, Soft Mist inhaler and Jet nebulizer based on the given parameters and their importance levels.

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