A Retrospective Analysis of Appendicitis Symptoms in Saudi Arabia

Sara Bosbait[1], Rana Alrayes[1], Majd Aldahoos[1], Fatemah Almareq[1], Mohammed Gollapalli[2], Atta Rahman[3,*] and Aghiad Bakry[3]

[1]Department of Computer Information Systems, College of Computer Science and Information Technology, Imam Abdulrahman Bin Faisal University, P.O. Box 1982, Dammam 31441, Saudi Arabia
[2]Department of Information Technology & Engineering, Sydney Met, Sydney, NSW 2000, Australia
[3]Department of Computer Science, College of Computer Science and Information Technology, Imam Abdulrahman Bin Faisal University, P.O. Box 1982, Dammam 31441, Saudi Arabia
[*]Correspondence: aaurrahman@iau.eud.sa

Abstract
The appendix is a hollow organ near the end of the cecum that is often found in the right bottom quadrant of the abdomen. The occlusion of the appendiceal orifice is the cause of appendicitis. The underlying etiology of the obstruction may vary depending on the age group. The illness often manifests acutely, within 24 hours of start, but it can potentially manifest chronic if your appendix ruptures, bacteria will infect the peritoneum, the lining of your abdomen. Additionally, it might harm your internal organs. In Saudi Arabia, within the previous five years, there has been a ten-fold increase in the number of cases with acute appendicitis. Acute appendicitis is broadly categorized as acute simple appendicitis (SA), acute purulent appendicitis (PA), acute gangrenous or perforated appendicitis (GPA), and peri-appendiceal abscess. However, there is a lack of studies focusing on accurate diagnosis and treatment of GPA in adult patients. Therefore, in this study aims to utilize Data Analysis (DA) is being used to track three types of acute appendicitis using a Saudi Arabian hospital dataset to manage their progression. Therefore, we applied descriptive analysis techniques using R language, to tackle this universal epidemic. Notably, the dataset is in the 8- 60-year age group, with varying genders and symptoms days. The data includes 412 instances, and 30 attributes labeled using PathologyD, which facilitates categorization of data using Pathology diagnosis. The findings are quite effective and useful for the subsequent studies in Appendicitis detection and classification using data analytical approaches.

Keywords:
Social media; mental health; wellbeing; R programming language; data mining; data wrangling.

1. Introduction

Appendicitis is a common and potentially life-threatening medical condition that affects individuals of nearly all ages, often requiring surgical intervention [1]. Characterized by the inflammation of the appendix, a small, finger-like organ attached to the cecum in the lower right abdomen, appendicitis can present a wide spectrum of symptoms. Timely diagnosis and treatment are crucial to prevent complications, such as appendiceal rupture and peritonitis, which can lead to significant morbidity and mortality [2].

The symptoms of appendicitis typically include abdominal pain, nausea, vomiting, and fever. The pain usually begins around the navel and then migrates to the right lower quadrant of the abdomen. Other symptoms may include loss of appetite, constipation, and diarrhea [3][4].

Diagnosis of appendicitis is based on a combination of the patient's medical history, physical examination, and imaging studies. The most common imaging study used to diagnose appendicitis is abdominal ultrasound. However, abdominal computed tomography (CT) scan is more sensitive and specific for appendicitis, especially in cases where the diagnosis is unclear [5][6].

Treatment for appendicitis is surgery to remove the appendix. This surgery is called an appendectomy. Appendectomy can be performed laparoscopically, using a minimally invasive technique, or through a traditional open incision [7][8].

In the context of Saudi Arabia, a nation with a unique blend of cultural, environmental, and demographic factors, it is imperative to conduct a comprehensive retrospective analysis of appendicitis symptoms based on the locally collected data. Such an analysis holds immense value as it can shed light on the epidemiological trends and clinical manifestations specific to the Saudi population. This introduction sets the stage for the retrospective analysis of appendicitis symptoms data in Saudi Arabia, emphasizing the importance of such an effort in the context of the unique healthcare landscape and patient demographics within the country. The subsequent sections of this research will delve into the methodology, data collection, analysis, and findings, all of which will contribute to a deeper understanding of appendicitis in

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the Saudi population. In this study, we seek to explore the spectrum of symptoms and their variations in Saudi patients with appendicitis, aiding in early recognition and accurate diagnosis.

To ensure the accuracy and reliability of the analysis, statistical methods, including data mining techniques using R language, will be employed to identify significant associations and patterns. Furthermore, a comprehensive literature review will be conducted to establish a contextual framework and compare our findings with existing studies on appendicitis in other countries. The implications of this retrospective analysis are manifold. Firstly, it will contribute to the overall understanding of appendicitis epidemiology, enabling healthcare professionals to make informed decisions regarding prevention, diagnosis, and treatment. Ultimately, the findings from this analysis can inform public health policies, resource allocation, and future research directions related to appendicitis management in Saudi Arabia.
The paper is structured as follows. Section 2 contains literature reviews. Section 3 illustrates the materials and methods. Section 4, demonstrate the retrospective analysis. Finally, Section 5, for conclusion summary and future work.

2. Review of related literature

This literature review aims to provide a systematic and comprehensive analysis of current research on appendicitis. Through an extensive examination of relevant documents and scholarly journals, this review explores the identification, pain and symptoms, and various treatment options associated with appendicitis. This review will offer a complete overview of the current state of knowledge on appendicitis by combining data from numerous sources, by shedding light on major discoveries and outcomes in the field.

In Alotaibi, et al. [3], the purpose of this study was to evaluate the surgical results and hospital length of stay (LOS) for complex appendicitis (CA) against uncomplicated appendicitis (SA) in Saudi Arabia. A retrospective evaluation of appendectomy patients between 2016 and 2018 was carried out. 13.4% of the 449 individuals included in the study had complicated appendicitis. Increased age, pain duration, neutrophilia, elevated C-reactive protein, fecalith presence, and free fluid are all related with complicated appendicitis. The complex appendicitis group had a greater incidence of surgical site infection, wound infection, postoperative collection, and readmission within 30 days than the uncomplicated appendicitis group. Multivariate analysis revealed that increased hospitalization was associated with pain duration, operative time, and complicated appendicitis. Complicated appendicitis was found to have significantly more morbidity, a higher readmission rate, and a hospital stay that was six times longer than simple appendicitis. These findings highlight the burden of complicated appendicitis on hospital resources, as well as the importance of proper patient allocation and discharge planning in hospitals with limited beds.

AlJohani, et al. [4] conducted a comprehensive study to compare the sensitivity and specificity of computed tomography (CT) and ultrasonography (US) in diagnosing acute appendicitis. The study included 244 patients who underwent CT and US scans at Saudi Arabia's King Saud Hospital. CT scans had a sensitivity of 98% and a specificity of 16.7%, whereas the US had a specificity of 100% and a sensitivity of 29%. Most patients had no complications. In comparison to the United States, the study concluded that CT scans are the best modality for diagnosing acute appendicitis and its complications.

A study by Andersson, et al. [5] looked at the influence of the COVID-19 pandemic on the occurrences of complex and simple appendicitis. The researchers conducted a comprehensive literature search and meta-analysis of 63 papers from 25 countries, including a total of 100,059 patients. According to the data, there was an increase in the proportion of difficult appendicitis during the pandemic era, which can be linked to a drop in the prevalence of simple appendicitis. The authors propose that restricted access to healthcare during the pandemic may have led to a higher rate of spontaneously resolving uncomplicated appendicitis. The study emphasizes the importance of considering spontaneously resolving appendicitis when managing patients with suspected appendicitis during times of restricted healthcare access, such as the COVID-19 pandemic.

Ghomrawi, et al. [7] has investigated the use of a consumer-grade wearable gadget, Fitbit, for postoperative monitoring in children following appendectomy. The researchers collected data on daily physical activity, heart rate, and sleep from 162

children aged 3 to 17 years who had appendectomy. This data was used to build machine learning models to detect aberrant recovery occurrences in the two days preceding the incident. The models correctly identified 83% of aberrant recovery days in severe appendicitis and 70% in uncomplicated appendicitis. This supports the possible use of machine learning algorithms and consumer wearables as monitoring tools for the early diagnosis of surgical problems in children. The study highlights the importance of objective data in postoperative care and the potential of affordable consumer-grade wearables for remote monitoring in surgical patients [9].

Kadi, et al. [10] conducted a retrospective study at King Abdulaziz University Hospital in Jeddah, Saudi Arabia. The study aimed to examine the histopathological characteristics of cases with acute appendicitis. The study analyzed cases of acute appendicitis and investigated the histopathological findings. The study's findings and specific results are not provided in the document summary, but the study contributes to the understanding of acute appendicitis through histopathological examination. The publication provides the relevant details regarding the study's citation, including the authors, journal, publication date, and identifiers such as the PMID and PMCID numbers [11].

A recent and comprehensive study on classification of Appendicitis cases into various nonbinary cases considering their level of severity has been conducted by Gollapalli et al. [12]. In this study, the authors employed ensemble machine learning and explainable artificial intelligence (XAI) models. The study encompasses an effective dataset collected from King Fahd University of Hospital, Khobar, Saudi Arabia. Moreover, the study involved medical experts from the college of medicine to provide clinical compliance and expertise. This study employed four different experimentations using different machine learning algorithms, including K-nearest neighbors (KNN), decision trees (DT), bagging, and stacking.
The investigational outcomes demonstrated that the stacking model obtained the highest training accuracy, testing accuracy, precision, and F1-score, respectively 97.51%, 92.63%, 95.29%, and 92.04% in contrast to state-of-the-art studies in the literature.

Feature importance and XAI identified neutrophils, white blood cells count, total length of stay, post operative length of stay, and symptoms days as the primary features that substantially concerned the performance of the proposed model.

This literature review provides a comprehensive analysis of current research on appendicitis, covering various aspects such as symptoms, diagnosis, treatment options, post-operative care, and the impact of the COVID-19 pandemic [13-20].

Furthermore, the review investigates the potential use of machine learning algorithms and consumer wearables for post-operative monitoring, indicating their ability to detect abnormal recovery events. The impact of the COVID-19 pandemic on appendicitis is also investigated, with findings indicating an increase in the proportion of complicated cases due to a decrease in uncomplicated appendicitis during limited healthcare access.

Moreover, the review underscores the impact of complicated appendicitis on hospital resources and the need for appropriate patient allocation and discharge planning. In this regard, the accuracy of diagnostic sensory systems, such as computed tomography (CT) and ultrasonography (US) are also discussed. Moreover, CT scans are considered the preferred sensory system for diagnosing acute appendicitis and its complications.

Finally, a histopathological examination study contributes to understanding acute appendicitis through the analysis of histopathological findings. Overall, this literature review presents key insights and outcomes in the field of appendicitis, contributing to the current state of knowledge and informing clinical practice.

3. Materials and Methods

The research's goal is to conduct a retrospective study of appendicitis symptoms in Saudi Arabia. This section highlights the materials and methods employed in the current study.

3.1 Clinical data

The Saudi Appendicitis dataset was collected from King Fahad University Hospital (KFUH), Eastern Province, Khobar, Saudi Arabia [12]. It contains clinical raw data of 411 patient’s that was Admitted to the hospital and treated in the previous five years. Table 1 describes the definition of generic dataset features used in this analysis study. Table 2 describes the definition of symptoms of appendicitis.

Table 1: Features' description

Variables	Description
Sex	Male or Female.
Age	Length of human life.
Comorbidities	The simultaneous presence of two or more diseases or medical conditions in a patient.
Post operative LOS	Total days of admission before surgery (Length of stay) which is the clinical metric that measures the time elapsed between a patient's hospital admittance and discharge.
Total LOS	Total days of admission (Length of stay).
Pathology	The conditions and processes of a disease.
Symptoms Days	Total days of sense physical feature which is regarded as indicating a condition of disease.
Readmission	Admitted again to the hospital within 30 days of the previous discharge

Table 2: Symptoms' description

Variables	Description
Perforation	Piercing or a hole developed in an organ
Pus	Fluid induced by inflammation
Neutrophils	A type of White blood cells
Diarrhea	Loose stool
Nausea	Feeling of discomfort
CRP	C Reactive Protein is a protein made by the liver. The level of CRP increases when there's inflammation in the body.
WBC Count	White Blood Cells Count
RLQ Mass	Right Lumbar Quadrant of abdomen
RLQ tenderness	Pain or discomfort when an affected area is touched
RLQ rebound	More pain when pressure on the tender area is released.
Epigastric	Epigastric is the upper central region of the abdomen.
Periumbilical Pain	Periumbilical pain is a type of abdominal pain that is localized in the region around or behind your belly button.
Dysuria	The sensation of pain and/or burning during urination
Guarding	Voluntary guarding is a conscious contraction of the abdominal wall in anticipation of an exam that will cause pain.
Lack of appetite	Desire to eat is reduced.
Pain migration	Pain moving from side to side of the abdomen
Complicated	Appendicitis case complicated or not.

3.2 Statistical Analysis

When analyzing the dataset related to appendicitis statistically (as shown in Table 3), several variables provide valuable insights. Let's examine the information for each variable to gain a better understanding.

Symptom Days: The number of symptom days ranges from a minimum of one day to a maximum of seven days, for a total of six days. This indicates that patients had symptoms for varying lengths of time, with the longest observed period being 7 days. LOS (Total Length of Stay): The average total length of stay is 6.5, indicating that patients spent an average of 6.5 days in the hospital. The median total length of stay is 8, implying that half of the patients stayed less than 8 days, and the other half stayed longer. This variable provides an overview of the total time patients spent in the hospital, from admission to discharge. Length of Stay (LOS) after Surgery: The average length of stay for post-operative care is 5.34 days, implying that patients stayed in the hospital for 5.34 days on average after surgery. The median length of stay is two days, indicating that half of the patients had a shorter post-operative stay than the other half. The average length of the stay is 15 days, with a minimum of one day and a maximum of sixteen days. This variable focuses specifically on the length of hospitalization following appendectomy surgery. Age of the Patients: The dataset's minimum age is 1, indicating that the youngest patient included was one year old. The oldest patient in the dataset has a maximum age of 47. From the youngest to the oldest

patient, the age range is 46 years. The median age was 16, implying that half of the patients were 16 or younger, with the other half being older. Analyzing the age distribution provides insights into the age group affected by appendicitis and allows for comparisons across different age categories [13-20].

Table 2 (a): Numerical attributes statistical description

Feature	count	mean	std	median
Age	411	18	9.76	16
Weight	411	74.7	32.7	73
Post operative LOS	411	5.35	4.03	2
Total LOS	411	6.5	3.96	8
Symptoms Days	411	1.57	1.02	1
WBC Count	411	6	46.6	50
Neutrophils	411	77.20	42.4	78.1
CRP	411	6.54	6.56	4.5

Table 2 (b): Numerical attributes statistical description

Feature	min	max	range
Age	1	47	46
Weight	29.3	639	609
Post operative LOS	1	16	15
Total LOS	1	16	15
Symptoms Days	1	7	6
WBC Count	1	151	150
Neutrophils	0.8	895	894
CRP	0	33.5	33.5

Researchers and healthcare professionals can gain valuable insights into the duration of symptoms, and the impact of age on appendicitis cases by considering variables such as symptoms days, readmission rate, total and post-operative lengths of stay, and patients' age. These findings can help with further analysis and decision-making for appendicitis patients' diagnosis, treatment, and post-operative care. Finally, Table 4 describes a brief statistical description of the nominal features [21-30].

Table 4: Nominal attributes distribution.

Feature	Values
Sex	F (146), M (265)
Pathology	Complicated Acute Appendicitis (21), Mucinous Neoplasm (2), Neuroendocrine Tumor (2), Normal Appendix (2), Normal Appendix (384)
Readmission	Yes (12), No (399)
Diarrhea	Yes (31), No (380)
Nausea	Yes (201), No (210)
Vomiting	Yes (207), No (204)
Epigastric_Periumblical_Pain	Yes (178), No (233)
Generalized_Abdominal_Pain	Yes (104), No (307)
Pain_Migration	Yes (137), No (274)
Pain_Radiation	Yes (66), No (345)
Localized_RLQ_Pain	Yes (315), No (96)
Dysurea	Yes (36), No (375)
Lack_of_apetite	Yes (118), No (293)
RLQ_Tenderness	Yes (342), No (69)
RLQ_Rebound	Yes (280), No (131)
Guarding	Yes (70), No (341)
RLQ_Mass	Yes (35), No (376)
Perforation	Yes (54), No (357)
Pus	Yes (61), No (350)
Mass	Yes (13), No (398)
Complicated	Yes (87), No (324)

4. Retrospective Analysis

This section we explain and visualize the knowledge we gathered by analyzing the provided Appendicitis dataset.

4.1 Patients Epidemiology

As shown in Figure 1. The percentage of male patients (64.5%) is significantly higher than the percentage of Female patients (35.5%) in Eastern province in Saudi Arabia. Patient ages are between 8 years old and 77 years old with an average of 26 years old and patients' weights are between 26 kilograms to 142 kilograms with an average of 73 kilograms. The common range of samples is between (20-29) years old with (68-77) kilograms weight range.

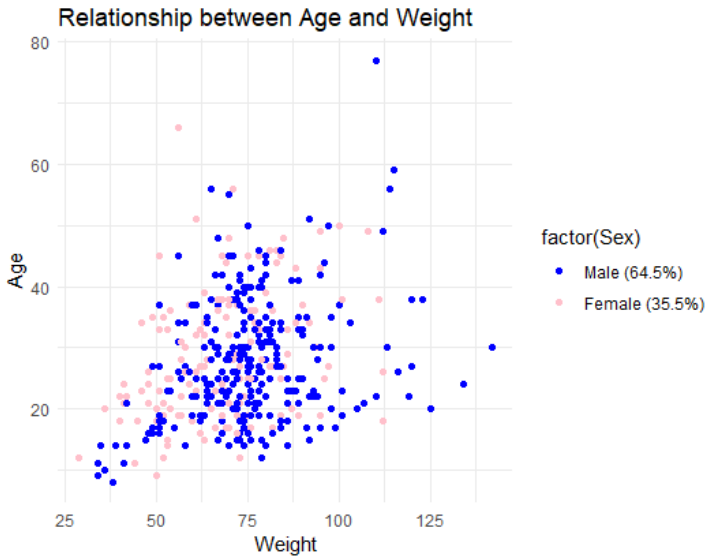

Figure1: Patients Epidemiology

4.2 Analysis of Complicated vs. Non-Complicated Cases

Based on the analysis, it is apparent that several factors contribute to potential causes of appendicitis. Such as age, weight, gender and number of days stay in the hospital etc.

According to Figure 2, the distribution of cases for complicated and non-complicated appendicitis with respect to age and the total number of days stay in the hospital. The distribution depicts the effects of these two factors in both male and female patients.

Similarly, in Figure 3, the impact of age and weight has been depicted over the complicated and non-complicated cases for both male and female.

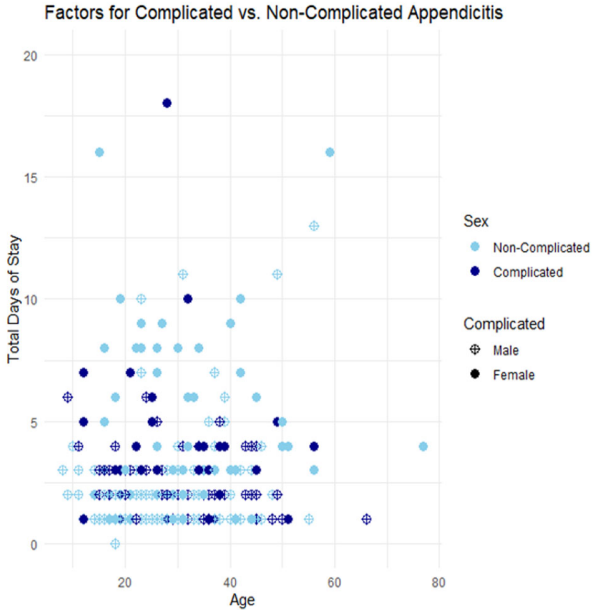

Figure 2: Complicated vs. non-complicated

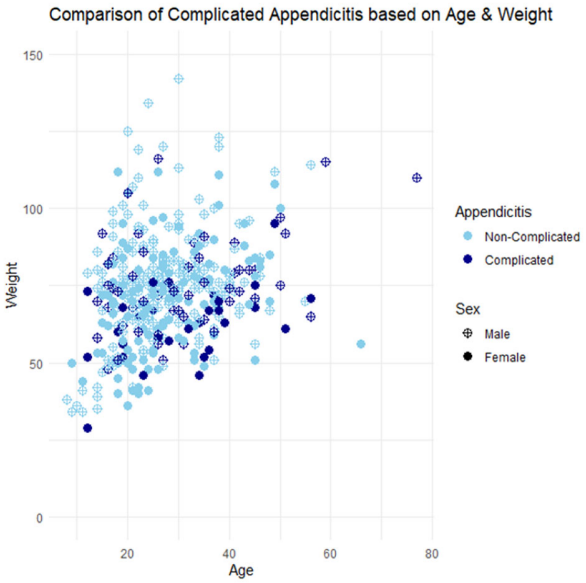

Figure 3: Complicated vs. non-complicated

Looking at the (Table 5) demonstrates the level of appendicitis in patients. Most cases are “simple acute appendicitis” (93.44%). It also shows the effect of the level of inflammation on choosing the type of surgery.

Where in "complicated acute appendicitis" open surgery is the most common (61.90%) and this indicates that these cases require more complex procedures.
While laparoscopic surgery is more common in cases of "simple appendicitis" at a rate of (80.73%).
Which indicates the effectiveness of this surgical intervention in these cases [31-40].

Table 5: Pathology and Surgical Procedures.

Pathology Type	Count	[illegible]	[illegible]
Mucinous Neoplasm	2	100.00000	0.00000
Neuro Endocrine Tumor	2	100.00000	0.00000
Simple Appendicitis	384	80.72917	19.27083
Normal Appendicitis	2	100.00000	0.00000
Complicated Acute Appendicitis	21	38.09524	61.90476

4.3 Appendicitis Symptoms

Figure 4 demonstrates what are the most common signs and symptoms of appendicitis. Whereas the major symptoms reported were vomiting and nausea, followed by pain, migration and lack of appetite. On the contrary, the least common signs to observe symptoms were diarrhea and dysuria based on the dataset under consideration.
It is essential to increase public awareness about the signs and symptoms of appendicitis, so the patients get an early warning and help in the timely management of the disease. For this reason, identifying the early common indicators can benefit to avoid any kind of complications [41-50].

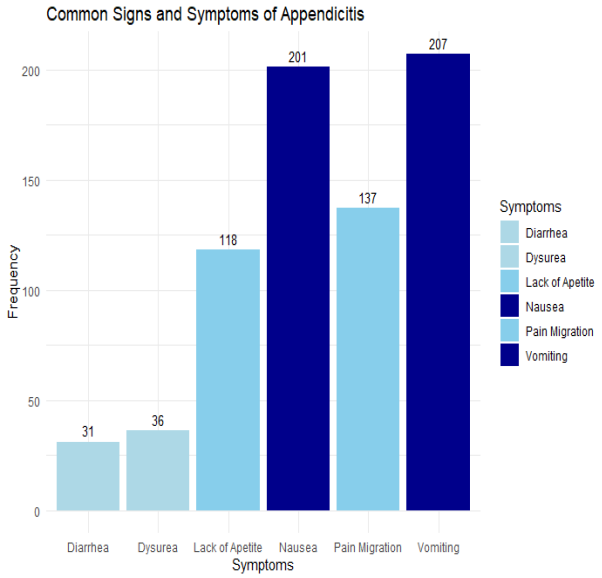

Figure 4: Symptoms frequency distribution

4.4 Risk Factors for Appendicitis

Figure 5 illustrates the risk factors that make someone prone to appendicitis, it has been established that white blood cells (WBC) count is the biggest risk in the graph. An indicator that monitors the immune system state is the WBC count. It is also important to note that in case of appendicitis, the count of WBCs reflects the intensity of the disease.

The higher WBC count shows that appendicitis is more serious. The following factor is patients' weight exhibited in the graph. Weight can also be a factor in the possibility of an appendix, although it is less important compared to the WBC count of the patient. This component should take into consideration the contribution of external factors like total health level and body fatness. An important component of the body's defense mechanism is neutrophil, which belongs to the group of white blood cells.

Hence, it is possible that the risk could be related to the level of neutrophils as well. Elevated neutrophil levels can be associated with more inflammation that manifests itself as a hallmark of appendicitis. Finally, the diagram indicates the degree of CRP.

CRP, which is produced by the liver in reaction to body irritation, is known as an inflammatory protein. Given that an elevated CRP level suggests inflammation, which is one of the risks associated with appendicitis, it can therefore be seen as a potential risk [51-60].

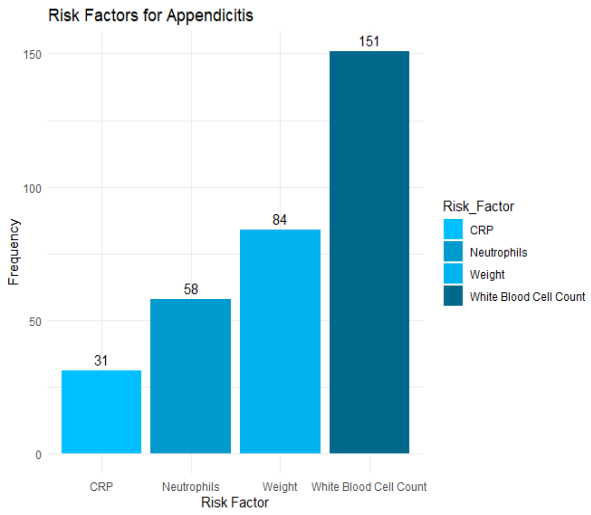

Figure 4: Risk Factors for Appendicitis

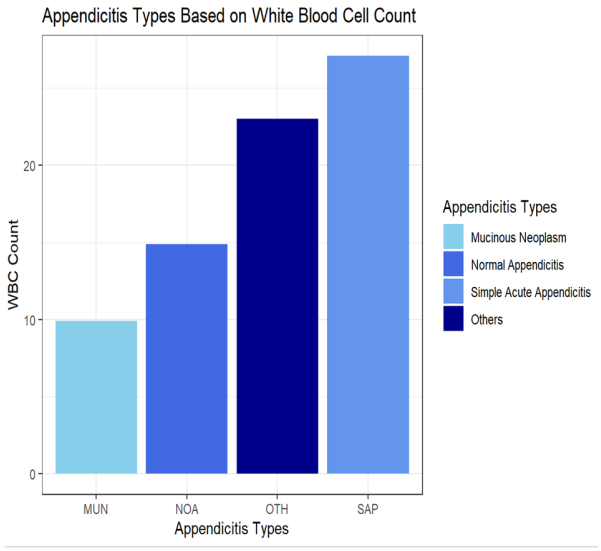

Figure 5: Appendicitis Types Based on WBC

4.5 Appendicitis Types

Understanding the various types of Appendicitis is essential for effective dealing with it and treatment. In this study, we analyzed the Appendicitis types based on white blood cells using a bar plot. Figure 5 displays four distinct types of Appendicitis. The analysis revealed that "MUN" had ten cases, followed by "NOA" had 15, while "OTH" had 24 cases. Interestingly, "SAP" exhibited the highest frequency among all Appendicitis Types, with 27 instances. This is depicted in Figure 5.

This emphasizes the significance of "SAP" and underscores the need for appropriate dealing with it and treatment strategies. These findings hold substantial implications for hospitals, as they offer valuable insights into Appendicitis types based on white blood cells, enabling them to optimize their operations and enhance the overall experience of the patient [61-70].

Overall, the white blood cell count is a potential indicator for several diseases, but particularly for the acute appendicitis case in collaboration with the other factors as described in the earlier sections.

On a nutshell the underlying study investigates the comprehensive dataset obtained from a major public sector hospital in the eastern region of Saudi Arabia using data wrangling approaches. The study aligns and motivated by the Saudi Arabia's vision 2030 for improved and quality healthcare services across the kingdom [71-80].

5. Conclusion and recommendations

In this study, we contribute to the health sector in Saudi Arabia by analyzing and visualizing real Saudi hospital dataset of appendicitis. After cleaning the provided data set and analyzing it using R language we managed to illustrate the patient's epidemiology in terms of age, weight and gender, discovering the most common signs and symptoms of appendicitis. Moreover, in this study we clarify Appendicitis Types, in addition, we demonstrate the comparison between complicated and non-complicated cases. Finally, we figured out the potential risk factors that make a person vulnerable to acute appendicitis. The results of the undergoing analysis can guide future research paths for the management of appendicitis in Saudi Arabia, as well as public health policy and resource allocation. As part of future work, we suggest researchers gather more Appendicitis data from multiple Saudi hospitals to accumulate and augment the data and confirm the results to get a clearer understanding of the disease in the country. In addition, we recommend researchers apply predictive and prescriptive analysis of the available dataset for greater useful contribution in the healthcare industry. Particularly by investigating deep learning, ensemble machine learning and transfer learning approaches for improved prediction accuracy.

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