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Topic:

Machine learning and deep learning-based prediction of uterine tumors and some treatments in the Ouargla region

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Dedication

Praise be to Allah for His guidance and grace.

I dedicate this work to my dear parents, Ahmed and Aïcha the light and support of my life.

To my beloved siblings: Moaz, Abdelhaq, Bouthayna, Aqeela, Oumayma, and Abderraouf you have been my strength and support at every step.

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chaima

Dedication

To those whose giving knows no bounds,

To my mother Karima, the source of tenderness and my support in life,

And to my father ELCheikh, who endured hardships and toiled for my sake,

This success is yours before it is mine. Without your prayers, patience, and sacrifices, I would not have reached where I am today.

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And I cannot forget my friend and thesis partner, Chaima Dabbabi

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MAROUA

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General Introduction

The global burden of tumors, particularly uterine tumors, continues to rise, negatively affecting the physical, psychological, and economic well-being of affected women, while also placing a heavy strain on healthcare systems. These challenges are especially pronounced in low- and middle-income countries, where healthcare systems often lack sufficient resources and proper equipment. This leads to delays in diagnosis, limited access to appropriate treatment, and ultimately, poorer health outcomes.

In contrast, countries with advanced healthcare systems achieve higher recovery rates due to the implementation of effective early detection strategies, the availability of accurate diagnostic tools, and the provision of advanced treatment options tailored to each individual case[1].

Uterine tumors are among the most common gynecological tumors and range from benign tumors, such as fibroids which are generally not life-threatening to malignant tumors, such as endometrial carcinoma and uterine sarcoma, which pose a serious health risk due to their aggressive nature and potential to spread in advanced stages[2].

With the rapid advancement of artificial intelligence and machine learning technologies, modern diagnostic tools have emerged that improve the accuracy of medical assessments. These tools analyze radiological images and clinical data intelligently, helping physicians make evidence-based treatment decisions more quickly and precisely, thereby increasing the chances of recovery and improving the quality of care provided to patients.

Chapter I: provides a general overview of uterine tumors, their types, symptoms, diagnostic methods, and treatments, along with their classification based on severity.

Chapter II:explains the concept of machine learning and its types, and presents the main algorithms used in classifying and predicting tumors through artificial intelligence.

Chapter III: presents an applied statistical and analytical study of uterine tumor cases recorded at the Cancer Control Center in Ouargla, along with a comparison of the performance of the applied machine learning models.

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Chapter I:

General Overview of Uterine Tumors

I.1. Introduction:

Uterine tumors occur when the cells of the uterus undergo genetic changes that cause them to grow and divide abnormally. In some cases, these tumors remain confined within the uterus, while in others; they may spread to surrounding tissues or travel to other parts of the body through the blood or lymphatic system a process known as metastasis. These metastases can lead to serious complications and are often the main cause of the patient's condition worsening.

Early diagnosis is crucial, as it allows for control of the tumor before it spreads, which increases the chances of effective treatment and recovery. Uterine tumors are classified into two main types: **benign tumors**, which are generally non-threatening, and **malignant tumors**, which require careful monitoring and treatment. In this chapter, we will explore the different types of uterine tumors, how they are diagnosed, and the most important treatment methods currently used [1].

I.2. Definition of tumors:

Neoplasms (from Greek neo, “new,” and plasma, “formation”), are abnormal growths of cells arising from malfunctions in the regulatory mechanisms that oversee the cells’ growth and development. However, only some types of tumors threaten health and life. With few exceptions, that distinction underlies their division into two major categories: malignant or benign. [1]

I.3.Types of tumor:

I.3.1. Benign Tumors:

Benign tumors are non-cancerous and do not spread to other parts of the body. However, they can still cause serious symptoms and complications if they grow near important vital organs. [2].

There are many types of it, including:

- **Adenomas** – Start in epithelial tissues (like glands).
- **Chondromas** – Develop in cartilage.
- **Fibromas** – Found in tendons and ligaments.
- **Hamartomas** – Common benign lung tumors.

- **Hemangiomas** – Grow from blood vessels.
- **Lymphangiomas** – Often in children, affect the lymphatic system.
- **Meningiomas** – Arise in the brain/spinal cord lining.
- **Skin Tumors** – Include skin tags, keratoses, and angiomas. [3]

I.3.2. Malignant Tumors (Cancer) :

The name of cancer comes from the Greek physician Hippocrates, known as the father of medicine, in relation to the cross-sectional shape of a malignant tumor, in which the stretched blood vessels appear in a way that resembles the legs of a crab. Cancer, also called a malignant tumor, is a disease characterized by the abnormal proliferation of cells and the formation of a mass called a tumor. This proliferation results from DNA mutations in normal cells, which then invade nearby tissues and spread to distant parts of the body.

Abnormal cells carry molecules on their surface called tumor antigens, which stimulate the growth of new blood vessels that feed the cancerous cells.

British scientists discovered that the earliest known case was the skeleton of a young man who lived 3,000 years ago during Ancient Egypt. This discovery was made through X-ray imaging and electron microscopy, which provided a clear image of cancer spread in the bones of the clavicle, shoulder, upper arms, vertebrae, ribs, pelvis, and thighs. Scientists hypothesized that inhalation of wood smoke, genetic factors, or infectious diseases may have been the cause.

a) Earliest Cases in the World

The oldest documented case in the world comes from Ancient Egypt in 1500 BC, where eight cases of breast tumors were recorded. These were treated with cauterization, a technique referred to as *"foci"*, which aimed to destroy the affected tissue, though this method was not effective in curing the disease [4].

b) Types of Cancer:

There are more than 200 different types of cancer, including the following types The most common and prevalent types of cancer in the world in 2022 [5]:

- **Breast cancer** – The most common, especially in women.٪ 12.4

- **Lung cancer** – One of the deadliest, often linked to smoking.11.6%
- **Colorectal cancer** – Related to diet and lifestyle.% 9.6
- **Prostate cancer** – Common in men % 7.3
- **Stomach cancer** – More common in parts of Asia.% 4.9

I.4. Differences between Malignant and Benign Tumors:

It is essential to distinguish between benign and malignant tumors, as this difference has a direct impact on diagnosis, treatment, and the patient's overall prognosis. Benign tumors are generally less dangerous, while malignant tumors pose a greater threat due to their ability to spread and affect vital tissues and organs. The following Table (I.1) highlights the key differences between these two types of tumors in terms of their nature and behavior [6].

Table I.1: the difference between bening and malignant tumors in terms of their nature and behavior.

Feature	Benign Tumors	Malignant Tumors
Nature	Non-cancerous	Cancerous
Invasion of tissues	Do not invade surrounding tissues	May invade surrounding tissues
Growth rate	Most grow slowly	Most grow quickly
Shape	Smooth	Irregular

I.4.1.Potential Transformation of Benign Tumors into Malignant Tumors:

Benign tumors are usually non-cancerous and pose little health risk. However, some benign tumors may transform into malignant ones over time due to factors such as genetic mutations, chronic inflammation, or prolonged exposure to carcinogens [7].

Examples of benign tumors that may become malignant:

- **Colonic polyp's** ⟶ may develop into **colorectal cancer**.
- **Moles (nevi)** ⟶ certain atypical types may progress to **melanoma (skin cancer)**.
- **Uterine fibroids (leiomyoma's)** ⟶ in rare cases may transform into **leiomyosarcoma**.

Uterine tumors are among the common health issues affecting women. They vary between benign and malignant types, differing in their nature, symptoms, and treatment approaches. These tumors can affect fertility and a woman's overall health. In this research, we will explore them in detail.

I.5.Uterine Tumors:

I.5.1. Uterus Anatomy:

The uterus is the organ of gestation in women. It is a hollow smooth muscle with a cavity lined by a mucous membrane that undergoes cyclical changes throughout the reproductive life, an unpaired median organ located in the pelvic cavity, above the vagina, in front of the rectum, behind and above the bladder, and below the intestinal loops and the pelvic colon (see figure I.1) [8].

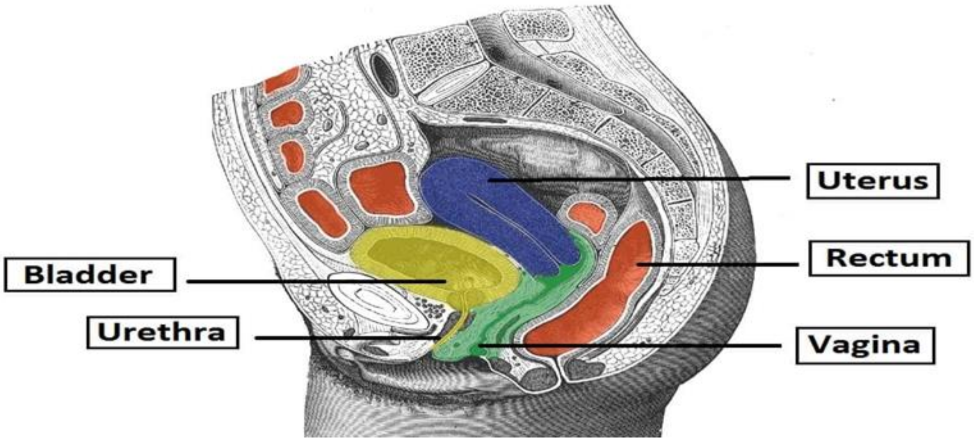

Figure I.1: An illustrative image showing the location of uterus in the pelvis [9].

The components of the uterus include (as shown in figure I.2):

- **Fallopian Tube**: A pair of tubes connecting the ovaries to the uterus. These tubes serve as the primary pathway for egg transport and the site of fertilization.
- **Fimbriae**: Finger-like projections at the end of fallopian tubes. They sweep over the ovary to capture released eggs during ovulation.
- **Ovary**: The female gonad responsible for egg production and hormone synthesis. Each woman typically has two ovaries that produce eggs alternately.

- **Ovarian Ligament**: Fibrous tissue that connects and anchors the ovary to the uterus. It provides structural support and maintains proper positioning.
- **Myometrium**: The thick, muscular wall of the uterus. It contracts during labor and menstruation.
- **Cervix**: The lower portion of the uterus connecting to the vagina. It produces cervical mucus and dilates during childbirth.
- **Endometrium**: The inner lining of the uterus. It thickens monthly to prepare for potential pregnancy and sheds during menstruation.
- **Vagina**: The muscular canal connecting the external genitalia to the cervix. It serves as the birth canal and menstrual flow passage.
- **Ostium Uteri**: The opening of the cervix into the vagina. It allows passage of menstrual flow and dilates during childbirth.
- **Cavity of Uterus**: The hollow space within the uterus. It provides the environment for fetal development during pregnancy.
- **Fundus of Uterus**: The uppermost rounded portion of the uterus. It expands significantly during pregnancy to accommodate fetal growth.
- **Uterine Tube**: Another term for the fallopian tube, essential for egg transport and fertilization.
- **Infundibulum**: The funnel-shaped opening of the fallopian tube near the ovary. It catches eggs released during ovulation.
- **Ovarian Stroma**: The supporting tissue framework within the ovary. It contains blood vessels and hormone-producing cells.
- **Follicles**: Fluid-filled sacs containing developing eggs. They also produce hormones essential for the menstrual cycle.
- **Corpus Luteum**: A temporary endocrine structure formed after ovulation. It produces progesterone to support potential pregnancy.
- **Ovarian Membrane**: The outer covering of the ovary. It protects the internal ovarian structures.

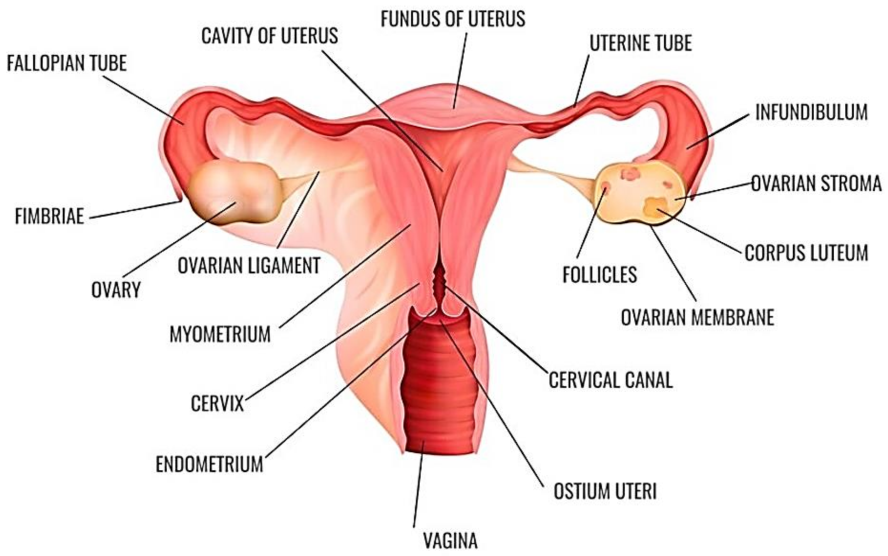

Figure I.2: Anatomy the uterus [10].

I.5.2.Types of Benign Tumors in the Uterus:

Understanding the types of benign tumors in the uterus is essential for both diagnosis and treatment. Each type has distinct characteristics that affect both clinical management and the patient's health.

I.5.2.1.Fibroids: Fibroids are muscular tumors that grow in the wall of the uterus (womb). Another medical term for fibroids is leiomyoma or just "myoma".Fibroids can grow as a single tumor, or there can be many of them in the uterus. They can be as small as an apple seed or as big as a grapefruit.

There are different types of **uterine fibroids** (as shown in figure I.3) depending on their location and how they are attached. Specific types of uterine fibroids include:

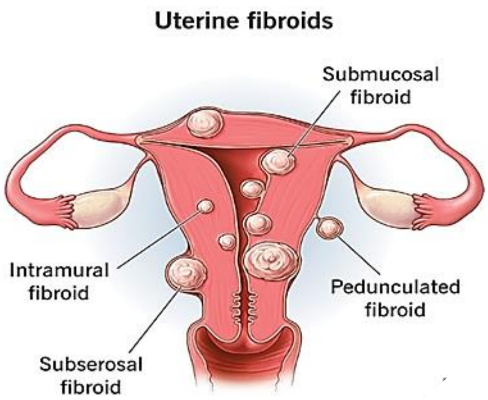

Figure I.3: Types of uterine fibroids [12]

- **Intramural fibroids:** The most common type; grow within the muscular wall of the uterus.
- **Submucosal fibroids:** Grow beneath the inner lining of the uterus and may affect fertility.
- **Subserosal fibroids:** Develop on the outer surface of the uterus and can extend into the pelvic area.
- **Pedunculated fibroids:** A rare type attached to the uterus by a stalk, often mushroom-like in appearance.[11]

I.5.2.2.Uterine polyps:

Polyps are fingerlike growths that attach to the wall of the uterus, either at the level on the endometrium (lining of the inside of the uterus) or the cervix. They can be as small as a sesame seed or as large as large as a golf ball. There may be just one or multiple polyps as shown in figure I.4 [13].

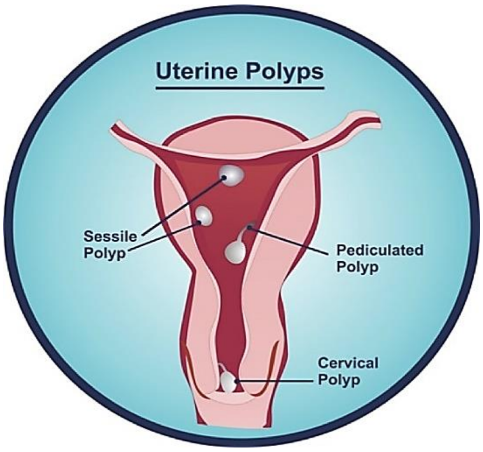

Figure I.4: Location of uterine polyps

I.5.2.3.Cystadenoma:

Cystadenomas are benign epithelial tumors that usually form cystic structures. The term "cyst adenoma», itself is broken down into "cyst" (a fluid-filled sac) and "adenoma" (a benign tumor that originates from glandular tissue). Bladder adenomas are classified according to their epithelial lining into serous and mucinous types. Serous bladder tumors, which are most commonly found in the ovaries, are lined with fluid- producing serous cells while mucinous bladder tumors produce a mucus-like fluid [14].

I.5.2.4.Mature Teratoma:

Ovarian dermoid cyst and mature cystic teratoma are terms often used interchangeably، as they represent the most common types of ovarian tumors. These tumors are typically slow growing and contain tissue derived from multiple germ cell layers. However, there is a key histological difference between the two: The dermoid cyst is composed only of ectodermal elements, such as hair and nails. In contrast, the mature cystic teratoma contains not only ectodermal components, but also tissues from the mesoderm and endoderm, including bones and internal organs like the intestines and lungs [15].

I.6.Symptoms of Benign Uterine Tumors:

Most women with benign uterine tumors do not experience any symptoms. When symptoms do appear, they depend on the tumor’s location, size, and number. The most common signs include

- Heavy menstrual bleeding.
- Pain during menstrual periods
- A feeling of pressure and pain in the pelvic area
- Frequent or difficult urination.
- Pain during sexual intercourse.
- Add to the disorders of the menstrual cycle and hormonal symptoms[16].

I.7.Diagnosis of of Benign Uterine Tumors:

Benign Uterine Tumors are usually detected during a routine pelvic exam in most cases, due to irregular changes in the shape of the uterus, which may indicate their presence. Amony them; we find:

- **Ultrasound imaging:** This test used to capture images of the uterus to confirm the presence of fibroids.
- **Laboratory tests:** In cases of irregular bleeding, blood tests may be needed to determine possible causes.
- **Magnetic Resonance Imaging (MRI):** This test provides detailed information about the size and location of the fibroids. It can also help identify different types and assists in selecting the most appropriate treatment options [17].

There are many factors that may play a role in the likelihood of developing it, these include:

- Obesity: obese women are more likely to suffer from it.
- The absence of children.
- Early onset of menstruation and late age of dates.
- Family history of the presence of fibroids.

I.8. Treatment of Benign Uterine Tumors:

The treatment of tumors varies according to their size, number and location, some of them may not need treatment if they are small and do not cause any symptoms, while those that cause symptoms such as anemia and pain need treatment. Treatment options include:

- **Medicines:**
  - **Gonadotropin-releasing hormone (GnRH):** works to shrink the size of the tumor before surgery.
  - **Birth control:** helps to relieve her symptoms, and a range of birth control options are available such as oral contraceptive pills, rings, and IUDs.
- **Surgery:**

  There are some surgical options that preserve the uterus and allow pregnancy in the future, while others may lead to damage and removal of the uterus, so the desire to get pregnant is an important factor in drawing up a treatment plan. Types of procedures include:

  - **Hysteroscopy:** the doctor inserts a speculum through the vagina and cervix into the uterus to cut and remove tumors.
  - **Hysterectomy:** the only way to cure it definitively is to completely remove the uterus.
  - Treatment of ovarian tumors can be performed either through **laparoscopy** or open abdominal surgery (**laparotomy)**. However, studies have shown that laparoscopy is often the preferred method, as it is associated with less postoperative pain, shorter hospital stays, and lower costs compared to laparotomy [18].

Treatment of ovarian tumors:

The procedure can be done by laparoscopy, or (laparotomy). It has been shown that laparoscopy is often preferred because it is associated with less pain, a shorter hospital stay, and a lower cost compared to laparotomy[19].

I.9.Malignant Tumors of the Uterus:

Malignant tumors of the uterus are among the most common types of gynecological cancers and often affect women after menopause. Symptoms and treatment options can vary depending on the stage of the disease and the type of tumor. Among these types, we find:

I.9.1.Uterine Sarcomas:

Uterine sarcoma originates directly from the stromal or muscular cells within the uterus and has no biological or developmental connection to other uterine tumors. It is an aggressive type of cancer and includes several subtypes. Leiomyosarcoma (LMS) is the most common histological subtype, followed by endometrial stromal sarcoma (ESS) and undifferentiated uterine sarcoma. ESS is further classified into low-grade and high-grade forms based on differences in histopathology and clinical outcomes [20].

I.9.2.Squamous cell carcinoma:

It is the most common type of cervical cancer, originating from squamous cells, which are thin, flat cells. It usually begins in the transformation zone. Squamous cells have grades of differentiation, which are an important factor in determining the aggressiveness of the tumor, as well as its growth rate and potential to spread. They are classified into three main grades [21].

Table I-2: Grades of squamous cell cervical cancer differentiation their morphological characteristics and clinical behavior

Differentiation grade	Characteristics Morphological	Growth rate and aggressiveness
Well-differentiated	Closely resemble normal cells	Grow slowly Less aggressive
Moderately differentiated	Partially resemble normal cells	Moderate growth Moderate aggressiveness
Poorly differentiated	Do not resemble normal cells	Grow rapidly More aggressive

The Table (I-2) the cellular differentiation grades in squamous cell cervical cancer illustrating the relationship between the microscopic appearances of the cell (morphological characteristics) the tumor growth rate and its level of aggressiveness.

I.9.3.Adenocarcinoma:

Adenocarcinoma is one of the most common types of cancer in the endometrium. This type originates from the glandular cells that line the inside of the uterus. It is classified into different subtypes based on the glandular tissue and the appearance of the cells under the microscope.

- **Endometrioid Adenocarcinoma :**

The most common type, slow-growing, and generally associated with a favorable prognosis when detected early.

- **Serous Carcinoma :**

An aggressive type, often diagnosed at an advanced stage, and linked to a poorer prognosis.

- **Clear Cell Carcinoma :**

A rare subtype characterized by clear cells under the microscope, with a higher risk of recurrence.

- **Mucinous Adenocarcinoma :**

Less common, contains mucus-producing glands, which may affect the tumor's behavior and treatment approach. [22]

I.10. Symptoms of Malignant Tumors of the Uterus:

- Abnormal vaginal bleeding during the menstrual period or between periods, considered one of the most common and earliest signs.
- Bleeding after menopause.
- Unusual foul-smelling vaginal discharge, especially in women over the age of 40.
- Pain in the lower abdomen, pelvic area, or lower back.
- Irregular menstrual cycles or unusually prolonged periods.
- Sudden, unexplained weight loss and loss of appetite.

- Changes in urinary habits, such as pain or burning during urination, difficulty urinating, or increased frequency.
- Persistent fatigue, extreme exhaustion, or bone pain [23].

I.11. Diagnosis of Malignant Tumors of the Uterus:

The doctor initially discusses the symptoms the patient is experiencing, then proceeds with an examination using one of the following methods:

- **CA-125 test**: a test that uses blood to measure the level of CA-125, a tumor marker that is often found in larger amounts than normal in the blood of people with ovarian cancer [24].

- **Pap smear:** Used to detect abnormal changes in the cervical cells and is an effective tool for the early detection of cervical cancer.
- **Human Papillomavirus (HPV) test:** Used to identify infection with the virus associated with cervical cancer.
- **Ultrasound:** Used to detect the thickness of the endometrial lining or the presence of masses in the uterus.
- **Biopsy:** A tissue sample is taken from the cervix, endometrium, or uterus and examined under a microscope to confirm the presence of cancer cells. It is considered a definitive diagnostic step.
- **Hysteroscopy:** If endometrial cancer is suspected, a hysteroscope can be used to visualize the inside of the uterus and collect tissue samples.
- **Magnetic Resonance Imaging (MRI) or Computed Tomography (CT) scan:** Used to evaluate the extent of cancer spread and accurately determine the stage of the disease

I.12. Risk Factors for Malignant Tumors of the Uterus:

A risk factor is anything that increases the likelihood of developing a disease such as cancer. These factors vary depending on the type of cancer.

I.12.1.Risk factors for ovarian cancer:

A risk factor is anything that increases your likelihood of getting a disease such as cancer. These factors differ depending on the type of cancer. In the case of ovarian cancer:

- **Obesity:** women who are obese are more likely to get ovarian cancer, but it is not necessarily aggressive
- **Age:** Aging is most common in women from 50 to 75 years.
- **Family history:** Having a family member with ovarian cancer, breast cancer, endometrial cancer, colon, or rectal cancer increases the risk by 10 to 15%.
- **Childbearing:** Not having children or facing a problem in pregnancy.

If one or more of these factors is true for you, it does not mean you will get ovarian cancer. However, you should speak with your doctor about your risk [25].

I.12.2.Risk Factors for Cervical Cancer:

One of the most prominent risk factor that may increase the likelihood of developing Cervical Cancer:

- **Human Papillomavirus (HPV):** Cervical cancer is caused by sexually acquired infection with certain types of HPV.
- **Smoking:** Women who smoke are twice as likely to develop cervical cancer compared to non-smokers.
- **Family History of Cervical Cancer:** Having a mother or sister with cervical cancer increases the risk.
- **Long-term Use of Oral Contraceptives:** Prolonged use of birth control pills may increase the risk [26].

I.12.3.Risk factors for endometrial cancer and uterine sarcoma:

Many are related to the balance between estrogen and progesterone, including:

- **not being pregnant:** increased exposure to estrogen.
- **family history:** genetic mutations such as Lynch syndrome (hereditary nonpolyposis colorectal cancer).
- **age:** most cases occur in women over the age of 50.
- **early menstruation:** starting periods before age 12.

I.13.Treatments for Malignant Uterine Tumors:

Treatment varies depending on each case and is determined through collaboration between the patient and the cancer care team: a medical oncologist, a surgical oncologist, and a radiation oncologist, to develop the appropriate treatment plan for her. It depends on several factors, including .This depends on several factors, including:

- The type and location of the tumor
- The stage of cancer spread [27].

I.13.1.Treatment of Ovarian Cancer:

Among the main treatments are:

- **Surgery:** to remove as much of the cancerous tumor as possible, and it often includes the removal of the ovaries, uterus, and fallopian tubes [28].
- **Chemotherapy:** the use of special drugs to shrink or eliminate the cancer, it may be pills you take or given through a vein or both.
- **Targeted therapy:** these drugs are used to prevent the growth and spread of cancer cells.
- **Radiation therapy:** used only in rare palliative cases [29]

I.13.2.Treatment of Cervical Cancer:

- **Surgery:** It is used to treat small cancers and may include:
  - Removal of the cancer only.
  - Removal of the cervix (cervical excision).
  - Radical hysterectomy (removal of the cervix, uterus, part of the vagina, and nearby lymph nodes) [30].
- **Radiation Therapy:**

  It works by destroying cancer cells using ionizing radiation.It can be given at different stages of the disease before, during, or after surgery.It may be used alone or combined with chemotherapy,a combination known as chemoradiation (radio-chemotherapy) [31]..

  The implementation of the chosen treatment approach requires a team of qualified experts.This team includes specialists in radiation oncology, medical physics, and radiation therapy technology.Their collaboration ensures the effective use of radiation to destroy the tumor while minimizing damage to healthy cells as much as possible [32].

The number of treatment sessions varies from person to person, depending on the cancer’s size, type, stage, and location [33].

- **Chemotherapy:**
  Chemotherapy uses powerful drugs to kill cancer cells ,Low doses are often givealongside radiation therapy.It can also be used before surgery to shrink the size of cancer cells
- **Hmmunotherapy**:
  This is a type of treatment that uses medications to help the immune system destroy cancer cells [34].

I.13.3.Treatment of Endometrial Cancer:

- **Surgery:**
  Endometrial cancer is usually treated first with surgery to remove the cancer. It may include removal of the uterus, fallopian tubes, and ovaries.
- **Radiation therapy:**
  In some cases, it is recommended before surgery to shrink the tumor and make it easier to remove.
- **Chemotherapy:**

  used after surgery to reduce the risk of cancer returning or to limit its spread.

- **Hormone therapy**:

Taking medications to lower hormone levels in the body, usually in advanced stages [35].

I.13.4.Treatment of uterine sarcoma:

- **Surgery:**
  It is considered the main treatment in the early stages. It involves the removal of the uterus with its appendages and, in some cases, the lymph nodes [36].
- **Radiation therapy:**
  After surgery (adjuvant radiation) it may help lower the chance of the cancer coming back in the pelvis. It might be done for cancers that are high grade or when cancer cells are found in the lymph nodes [37].
- **Chemotherapy treatment:**

It is performed after surgery to prevent the cancer from returning or in case of inability to perform surgery and may not work with certain types of uterine sarcoma [38].

- **Hormone therapy:**

It is used to treat low-grade uterine sarcoma, and is rarely used with other types [39].

I.14.Classification and stages:

Although CT scans can determine the spread of the disease, an accurate histological diagnosis and staging of the patient are determined surgically, Operative findings determine the precise histologic diagnosis, stage, and therefore the prognosis, of the patient [40].

Sometimes, if surgery is not possible right away, the cancer will be given a clinical stage instead. This is based on the results of a physical exam, biopsy, and imaging tests done before surgery [41].

I.14.1.Classification and stage of ovarian cancer:

The system described below is the most recent AJCC system. It is the staging system for ovarian cancer, fallopian tube cancer, and primary peritoneal cancer as shown in Table (I.3):

Table I.3: Classification and stage of ovarian cancer [42].

AJCC Stage	Stage grouping	FIGO Stage	Stage description
I	T1 N0 M0	I	The cancer is only in the ovary (or ovaries) or fallopian tube(s) (T1). It has not spread to nearby lymph nodes (N0) or to distant sites (M0).
IA	T1a N0 M0	IA	The cancer is in one ovary, and the tumor is confined to the inside of the ovary; or the cancer is in one fallopian tube, and is only inside the fallopian tube. There is no cancer on the outer surfaces of the ovary or fallopian tube. No cancer cells are found in the fluid (ascites) or washings from the abdomen and pelvis (T1a). It has not spread to nearby lymph nodes (N0) or to distant sites (M0).
IB	T1b N0 M0	IB	The cancer is in both ovaries or fallopian tubes but not on their outer surfaces. No cancer cells are found in the fluid (ascites) or washings from the abdomen and pelvis (T1b). It has not spread to nearby lymph nodes (N0) or to distant sites (M0).

IC	T1c N0 M0	IC	The cancer is in one or both ovaries or fallopian tubes and any of the following are present: • The tissue (capsule) surrounding the tumor broke during surgery, which could allow cancer cells to leak into the abdomen and pelvis (called **surgical spill**). This is stage **IC1**. • Cancer is on the outer surface of at least one of the ovaries or fallopian tubes **or** the capsule (tissue surrounding the tumor) has ruptured (burst) before surgery (which could allow cancer cells to spill into the abdomen and pelvis). This is stage **IC2**. • Cancer cells are found in the fluid (ascites) or washings from the abdomen and pelvis. This is stage **IC3**. It has not spread to nearby lymph nodes (N0) or to distant sites (M0).
II	T2 N0 M0	II	The cancer is in one or both ovaries or fallopian tubes and has spread to other organs (such as the uterus, bladder, the sigmoid colon, or the rectum) within the pelvis **or** there is primary peritoneal cancer (T2). It has not spread to nearby lymph nodes (N0) or to distant sites (M0).
IIA	T2a N0 M0	IIA	The cancer has spread to or has invaded (grown into) the uterus or the fallopian tubes, or the ovaries. (T2a). It has not spread to nearby lymph nodes (N0) or to distant sites (M0).
IIB	T2b N0 M0	IIB	The cancer is on the outer surface of or has grown into other nearby pelvic organs such as the bladder, the sigmoid colon, or the rectum (T2b). It has not spread to nearby lymph nodes (N0) or to distant sites (M0).
IIIA1	T1 or T2 N1 M0	IIIA1	The cancer is in one or both ovaries or fallopian tubes, **or** there is primary peritoneal cancer (T1) and it may have spread or grown into nearby organs in the pelvis (T2). It has spread to the retroperitoneal (pelvic and/or para-aortic) lymph nodes only. It has not spread to distant sites (M0).
IIIA2	T3a N0 or N1 M0	IIIA2	The cancer is in one or both ovaries or fallopian tubes, **or** there is primary peritoneal cancer and it has spread or grown into organs outside the pelvis. During surgery, no cancer is visible in the abdomen (outside of the pelvis) to the naked eye, but tiny deposits of cancer are found in the lining of the abdomen when it is examined in the lab (T3a). The cancer might or might not have spread to retroperitoneal lymph nodes (N0 or N1), but it has not spread to distant sites (M0).
IIIB	T3b N0 or N1 M0	IIIB	There is cancer in one or both ovaries or fallopian tubes, **or** there is primary peritoneal cancer and it has spread or grown into organs outside the pelvis. The deposits of cancer are large enough for the surgeon to see, but are no bigger than 2 cm (about 3/4 inch) across. (T3b). It may or may not have spread to the retroperitoneal lymph nodes

			(N0 or N1), but it has not spread to the inside of the liver or spleen or to distant sites (M0).
IIIC	T3c N0 or N1 M0	IIIC	The cancer is in one or both ovaries or fallopian tubes, **or** there is primary peritoneal cancer and it has spread or grown into organs outside the pelvis. The deposits of cancer are larger than 2 cm (about 3/4 inch) across and may be on the outside (the capsule) of the liver or spleen (T3c). It may or may not have spread to the retroperitoneal lymph nodes (N0 or N1), but it has not spread to the inside of the liver or spleen or to distant sites (M0).
IVA	Any T Any N M1a	IVA	Cancer cells are found in the fluid around the lungs (called a malignant pleural effusion) with no other areas of cancer spread such as the liver, spleen, intestine, or lymph nodes outside the abdomen (M1a).
IVB	Any T Any N M1b	IVB	The cancer has spread to the inside of the spleen or liver, to lymph nodes other than the retroperitoneal lymph nodes, and/or to other organs or tissues outside the peritoneal cavity such as the lungs and bones (M1b).

I.14.2.Classification and stage of Cervical Cancer:

The staging of cervical cancer is based on the FIGO system, which considers the extent of the primary tumor (T category). The following Table (I.4) outlines the different tumor categories along with their corresponding FIGO stages and the criteria used to define each stage. This classification is essential for evaluating the progression of the disease and guiding treatment decisions.

Table I.4: Classification and Staging of Cervical Cancer According to Tumor Category (T) and FIGO Criteria [43].

T CATEGORY	FIGO STAGE	T CRITERIA
TX		Primary tumor cannot be assessed
T0		No evidence of primary tumor .
T1	I	Carcinoma is strictly confined to the cervix (extension to the corpus should be disregarded)
T1a	IA	Invasive carcinoma that can be diagnosed only by microscopy with maximum depth of

		invasion ≤5 mm
T1a1	IA1	Measured stromal invasion ≤3 mm in depth
T1a2	IA2	Measured stromal invasion >3 mm and ≤5 mm in depth
T1b	IB	Invasive carcinoma with measured deepest invasion >5 mm (greater than stage IA); lesion limited to the cervix uteri with size measured by maximum tumor diameter; note: the involvement of vascular/lymphatic spaces should not change the staging, and the lateral extent of the lesion is no longer considered
T1b1	IB1	Invasive carcinoma >5 mm depth of stromal invasion and ≤2 cm in greatest dimension.
T1b2	IB2	Invasive carcinoma >2 cm and ≤4 cm in greatest dimension
T1b3	IB3	Invasive carcinoma >4 cm in greatest dimension
T2	II	Carcinoma invades beyond the uterus but has not extended onto the lower one-third of the vagina or to the pelvic wall
T2a	IIA	Involvement limited to the upper two-thirds of the vagina without parametrial invasion
T2a1	IIA1	Invasive carcinoma ≤4 cm in greatest dimension
T2a2	IIA2	Invasive carcinoma >4 cm in greatest dimension

T2b	IIB	With parametrial invasion but not up to the pelvic wall
T3	III	opto2023Carcinoma involves the lower one-third of the vagina and/or extends to the pelvic wall and/or causes hydronephrosis or nonfunctioning kidney; note: the pelvic wall is defined as the muscle, fascia, neurovascular structures, and skeletal portions of the bony pelvis; cases with no cancer-free space between the tumor and pelvic wall by rectal examination are FIGO stage III
T3a	IIIA	Carcinoma involves the lower one-third of the vagina, with no extension to the pelvic wall
T3b	IIIB	Extension to the pelvic wall and/or hydronephrosis or nonfunctioning kidney (unless known to be due to another cause)
T4	IVA	Carcinoma has involved (biopsy-proven) the mucosa of the bladder or rectum or has spread to adjacent organs (bullous edema, as such, does not permit a case to be assigned to stage IVA)

I.14.3.Classification and stage of endometrial cancer:

The two systems used for staging endometrial cancer are the FIGO (International Federation of Gynecology and Obstetrics) system and the American Joint Committee on Cancer TNM staging system. The following Table (I-5).

Table I.5: Classification and stage of endometrial cancer [44].

Stage	Stage grouping	FIGO Stage	Stage description*
I	T1 N0 M0	I	The tumor is growing inside the uterus and/or is limited to the uterus and ovary for non-aggressive types. The cancer has not spread to nearby lymph nodes (N0) or to distant parts of the body (M0).
IA	T1a N0 M0	IA	The tumor is limited to the endometrium (inner lining of the uterus) [IA1]. **Or** The tumor is a non-aggressive histologic type with growth less than halfway through the underlying muscle layer of the uterus (the myometrium) with no or focal lymphovascular space involvement (LVSI) [IA2]. ** **Or** The tumor is a non-aggressive histologic type limited to the uterus and ovary [IA3]. The cancer has not spread to nearby lymph nodes (N0) or to distant parts of the body (M0).
IB	T1b N0 M0	IB	Non-aggressive histologic types with growth more than halfway through the myometrium, but not beyond the body of the uterus with no or focal LVSI [IB] . The cancer has not spread to nearby lymph nodes (N0) or to distant parts of the body (M0).
IC		IC	Aggressive histologic types limited to the endometrium.

II	T2 N0 M0	II	The cancer has spread from the body of the uterus and is growing into the supporting connective tissue of the cervix (called the **cervical stroma**). **Or** There is substantial LVSI. **Or** The cancer is an aggressive histologic type with any invasion into the myometrium. The cancer has not spread to nearby lymph nodes (N0) or to distant parts of the body (M0).
IIA		IIA	Non-aggressive histologic type with invasion of the cervical stroma
IIB		IIB	Non-aggressive histologic type with substantial LVSI
IIC	T2 N0 M0	IIC	Aggressive histologic type with any myometrial invasion
III	T3 N0 M0	III	The cancer has spread outside the uterus, but has not spread to the inner lining of the rectum or urinary bladder (T3).
IIIA	T3a N0 M0	IIIA	The tumor has spread to the ovary or fallopian tube (and criteria for stage IA3 is not met) [IIIA1] The tumor has spread to the outer surface of the uterus (called the **serosa**) [IIIA2]. The cancer has not spread to nearby lymph nodes (N0) or to distant parts of the body (M0).
IIIB	T3b	IIIB	The cancer has spread to the vagina or to

	N0 M0		the tissues around the uterus (the parametrium). [IIIB1] The cancer has spread to the pelvic peritoneum (The peritoneum is a sheet of smooth tissue that lines the abdomen and pelvis).[IIIB2] It has not spread to nearby lymph nodes (N0) or to distant parts of the body (M0).
IIIC1	T1-T3 N1, N1mi or N1a M0	IIIC1	The cancer has spread to pelvic lymph nodes (N1, N1mi, or N1a), but not to lymph nodes around the aorta or distant parts of the body (M0). IIIC1i Micrometastasis+ IIIC1ii Macrometastasis^
IIIC2	T1-T3 N2, N2mi or N2a M0	IIIC2	The cancer has spread to lymph nodes around the aorta (para-aortic lymph nodes) (N2, N2mi, or N2a), but not to distant parts of the body (M0). IIIC2i The cancer has spread but is very small. It is a micrometastasis. IIIC2ii The cancer has spread but is very small. It is a macrometastasis.
IVA	T4 Any N M0		The cancer has spread to the inner lining of the rectum or urinary bladder (called the **mucosa**) (T4). It may or may not have spread to nearby lymph nodes (Any N), but has not spread to distant parts of the body (M0).
IVB	Any T Any N M1	IVB	The cancer has spread to the abdominal peritoneum. The cancer can be any size (Any T) and it might or might not have spread to other lymph nodes (Any N).

IVC		IVC	The cancer has spread to distant parts of the body such as lungs, liver, brain or bone or has spread to lymph nodes outside of the abdomen or lymph nodes above the kidneys.

I.14.4.Classification and stage of uterine sarcoma:

After a woman is diagnosed with uterine sarcoma, doctors will try to figure out if it has spread, and if so, how far. This process is called staging. The stage of a cancer describes the amount of cancer spread in the body and helps determine how best to treat it (Table I.6). Doctors also use a cancer's stage when talking about survival statistics**.**

Table I.6: Classification TNM and stage of uterine sarcoma [44].

Stage	Stage grouping	FIGO Stage	Stage description*
I	T1 N0 M0	I	The cancer is growing in the uterus, but has not started growing outside the uterus. It has not spread to nearby lymph nodes (N0) or to distant sites (M0).
IA	T1a N0 M0	IA	The cancer is only in the uterus and is no larger than 5 cm across (about 2 inches) (T1a). It has not spread to nearby lymph nodes (N0) or to distant sites (M0).
IB	T1b N0 M0	IB	The cancer is only in the uterus and is larger than 5 cm across (about 2 inches). (T1b). It has not spread to nearby lymph nodes (N0) or to distant sites (M0).
II	T2 N0 M0	II	The cancer is growing outside the uterus but is not growing outside of the pelvis (T2). It has not spread to nearby lymph nodes (N0) or to distant sites (M0).

IIIA	T3a N0 M0	IIIA	The cancer is growing into tissues of the abdomen in one place only (T3a). It has not spread to nearby lymph nodes (N0) or to distant sites (M0).
IIIB	T3b N0 M0	IIIB	The cancer is growing into tissues of the abdomen in 2 or more places (T3b). It has not spread to nearby lymph nodes (N0) or to distant sites (M0).
IIIC	T1-T3 N1 M0	IIIC	The cancer is growing in the body of the uterus and it might have spread into tissues of the abdomen, but is not growing into the bladder or rectum (T1 to T3). The cancer has spread to nearby lymph nodes (N1), but not to distant sites (M0).
IVA	T4 Any N M0	IVA	The cancer has spread to the rectum or urinary bladder (T4). It might or might not have spread to nearby lymph nodes (Any N) but has not spread to distant sites (M0).
IVB	Any T Any N M1	IVB	The cancer has spread to distant sites such as the lungs, bones, or liver (M1). The cancer in the uterus can be any size and may or may not have grown into tissues in the pelvis and/or abdomen (including the bladder or rectum) (any T) and it might or might not have spread to nearby lymph nodes (Any N).

I.15.Conclusion:

Uterine tumors represent one of the major health challenges affecting women, due to their significant physical and psychological impact. These tumors arise from abnormal cell division within the uterus, leading to the formation of masses that may be benign or malignant. Early detection of such histological changes is a critical factor in improving treatment outcomes and increasing survival rates.

With the rapid advancement in biotechnology and information sciences, artificial intelligence (AI) has emerged as a promising tool for the early prediction of uterine tumors by accurately analyzing medical data and clinical indicators. Recent studies have demonstrated that integrating AI technologies into diagnostic processes supports medical decision-making, enhances early intervention, and contributes to achieving more effective therapeutic results.

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Chapter II :

Machine Learning

II.1. Introduction:

Artificial Intelligence (AI) is one of the most significant technological innovations that has brought a radical transformation across various sectors, especially in the medical field. It has greatly contributed to improving the quality of healthcare by enhancing diagnostic accuracy, accelerating medical processes, and providing intelligent solutions to support clinical decision-making.

AI helps analyze vast amounts of medical data quickly and efficiently, enabling doctors to predict diseases at early stages, tailor precise treatment plans for each patient, and advance technologies such as surgical robots, intelligent image interpretation systems, and electronic medical record management tools. With the continuous advancement of machine learning and deep learning technologies, AI is expected to play an increasingly vital role in the future of medicine by improving health outcomes and making advanced care more accessible around the world.

In the therapeutic context, artificial intelligence technologies are increasingly being integrated into medical imaging tools and radiotherapy devices, where advanced algorithms are used to adjust radiation doses and enhance targeting precision .The significance of these technologies is growing in light of the rising number of cancer cases worldwide, making the integration of AI into radiotherapy a critical necessity [1].

This chapter will begin by explaining the concept of machine learning, followed by a comprehensive overview of the key principles and techniques used in this field.

II.2. Definition of Machine Learning:

Machine learning (ML) is a fast-evolving scientific field that effectively copes with big data explosion and forms a core infrastructure for artificial intelligence and data science. ML bridges the research fields of computer science and statistics and builds computational algorithms and statistical model-based theories from those fields of studies. These algorithms and models are utilized by automated systems and computer applications to perform specific tasks, with the desire of high prediction performance and generalization capabilities. Sometimes, ML is also referred to as a predictive analytics or statistical learning. The general workflow of a ML system is that it receives inputs (aka, training sets), trains predictive models, performs specific prediction tasks, and eventually generates outputs. Then, the ML system evaluates the performance of predictive models and optimizes the model parameters in order to obtain better prediction [2].

II.3.Types of Machine Learning:

Machine learning is generally a training system to learn from past experiences and improve performance over time. Machine learning helps to predict massive amounts of data. It helps to deliver fast and accurate results to get profitable opportunities. There are several types of machine learning, each with special characteristics and applications. Some of the main types of machine learning algorithms are as follows and summarized in Figure II.1 [3]:

-. Supervised Machine Learning

-. Unsupervised Machine Learning

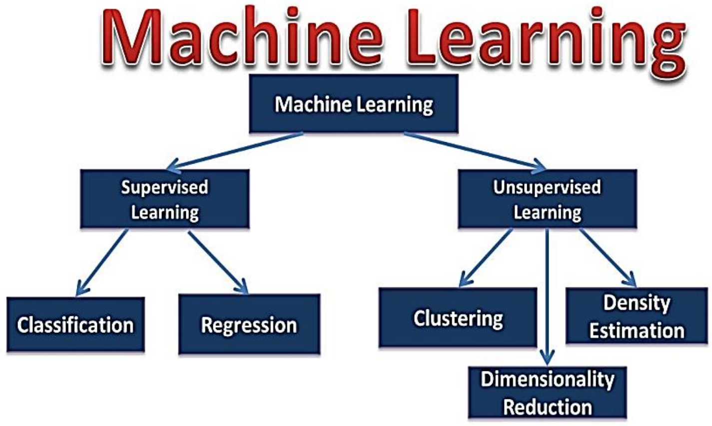

Figure II.1: Types of Machine Learning [4]

Here are comparison Table II.1 between Supervised Learning and Unsupervised Learning [5].

Table II.1. Differences between supervised and unsupervised learning.

Aspect	Supervised Learning	Unsupervised Learning
Data Usage	Uses labeled data (inputs + known outputs)	Uses unlabeled data
Objective	Predict outputs based on given inputs	Discover hidden patterns and relationships in data
Human Intervention	Requires prior data labeling	Does not require labeling, but may need human validation of output
Accuracy	Often higher (when high-quality labeled data is available)	Generally lower, but can reveal unexpected or hidden insights
Common Algorithms	Linear Regression, Decision Tree, SVM, Neural Networks	K-means, Principal Component Analysis (PCA), Hierarchical Clustering

II.3.1.unsupervised Learning:

Unsupervised learning uses machine learning algorithms to analyze and cluster unlabeled data sets. These algorithms discover hidden patterns in data without the need for human intervention (hence, they are "unsupervised"). We will illustrate this with an example in a **Figure II.2** [3]:

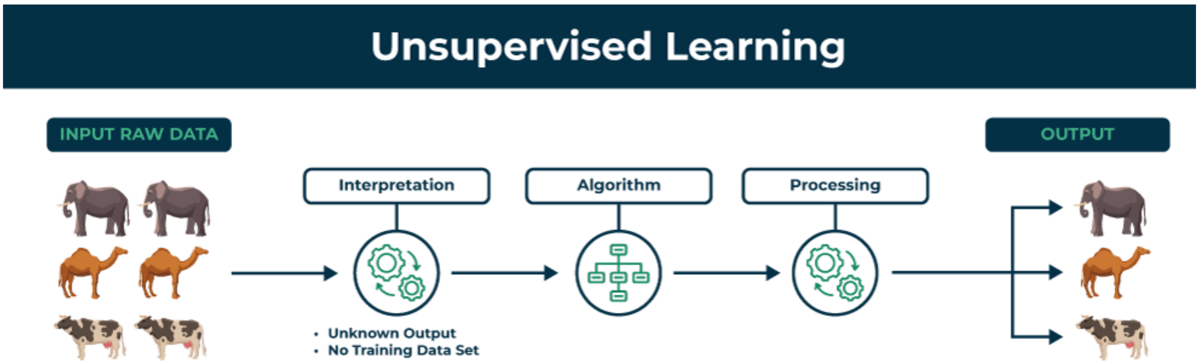

Figure II.2: Unsupervised learning.

Unsupervised learning models are used for three main tasks: clustering, association and dimensionality reduction:

- **Clustering:** Used to group unlabeled data based on similarities, such as with the K-means algorithm. It is applied in areas like market segmentation and image compression.
- **Association:** Identifies relationships between variables using specific rules. It is commonly used in market basket analysis and recommendation systems.
- **Dimensionality Reduction:** Reduces the number of features in a dataset to make processing easier while preserving key information. It is often used in data preprocessing, such as denoising visual data to enhance image quality [5].

II.3.2.Supervised Machine Learning:

Supervised learning is a key subfield of Machine Learning (ML) and Artificial Intelligence (AI), where a model is trained using input data that is labeled with the correct outputs. The goal of this type of learning is to identify patterns and relationships within the data in order to make accurate predictions on new, unseen data.

Supervised learning is based on training. During its training phase, the system is fed labeled data sets, which instruct the system on what output variable is related to each specific input value. The trained model is then presented with test data. This is data that has been labeled, but the labels haven't been revealed to the algorithm. The aim of the test data is to measure how accurately the algorithm performs on unlabeled data. We will illustrate this with an example in a **Figure II.3**.[6]

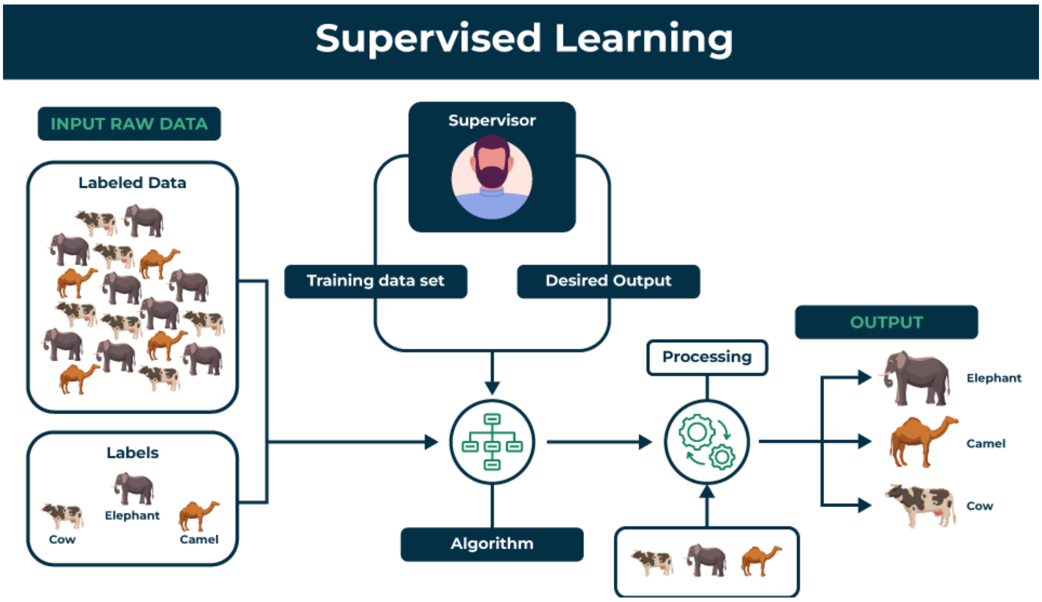

Figure II.3: Supervised learning. [3]

General, basic steps while setting up supervised learning include the following:

- Determine the type of training data that will be used as a training set.
- Collect labeled training data.
- Divide the training data into training, test and validation data sets.
- Determine an algorithm to use for the ML model.
- Run the algorithm with the training data set.
- Evaluate the model's accuracy using different metrics such as the F1 and logarithmic scores. If the model predicts correct outputs, then it's accurate.
- Regularly monitor the model's performance and update it as necessary. The model might require retraining with new data to ensure its accuracy and relevance [6].

II.3.2.1.Types of Supervised Learning Algorithms:

Supervised learning algorithms can be further divided into two categories depending on the type of output they produce [7].

- Classification Algorithms
- Regression Algorithms

a. Classification Algorithms:

Classification algorithms analyze input data to assign it to predefined categories by studying patterns from previously labeled examples. These models excel at tasks where the outputs belong to distinct classes. Common classification techniques include [8]:

- **Support vector machine (SVM):**

Support vector machine (SVM) is a machine Learning algorithme used for classification and regression tasks.the algorithm Works by finding the optimal hyperplan That best séparâtes different classes in the data or predicts continuous outcomes. SVM aims to maximize the distance between classes, which Is the distance between the separating hyperplane and the closest [9] as shown in Figure II.4:

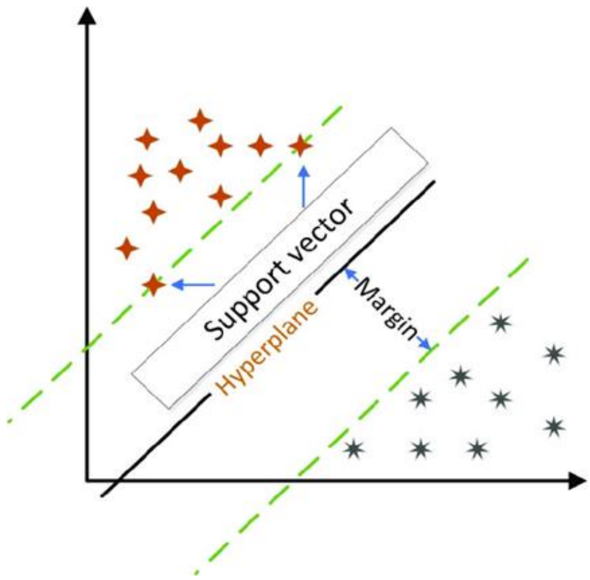

Figure II.4: Graphical representation of the SVM model [9].

For higher dimensional data, other kernels are used as points and cannot be classified easily. They are specified in the next section.

- **Kernel SVM :**

Kernel_SVM takes in a kernel function in the SVM algorithm and transforms it intothe required form that maps data on a higher dimension which is separable [10].

Types of kernel functions:

***Linear Kernel**

- The linear kernel is the simplest and is used when the data is linearly separable.
- It calculates the dot product between the feature vectors.

***Polynomial Kernel**

- The polynomial kernel is effective for non-linear data.
- It computes the similarity between two vectors in terms of the polynomial of the original variables.

***Radial Basis Function (RBF) Kernel**

- The RBF kernel is a common type of Kernel in SVM for handling non-linear decision boundaries.
- It maps the data into an infinite-dimensional space.

***Sigmoid Kernel**

- The sigmoid SVM kernel types can be used as an alternative to the RBF kernel.
- It is based on the hyperbolic tangent function and is suitable for neural networks and other non-linear classifiers[11].

b. Regression Algorithms:

The model learns from a dataset composed of input-output pairs. It identifies patterns in the input features to predict continuous numerical values of the output variable. Regression algorithms help solve regression problems by finding the relationship between data points and fitting a regression model There are several models for regression.

- **Linear regression :**

Linear regression is a fundamental statistical method used to model the relationship between a dependent variable and one or more independent variables. It helps predict outcomes by fitting a straight line to observed data points, making it easy to interpret and apply Simple Formula (for one variable)[12]:

$$\boldsymbol{y = mx + b} \qquad \textbf{\textit{(II.1)}}$$

In which :

- y : Dependent variable (output)
- x : Independent variable (input)
- m : Slope of the line
- b : Y-intercept

❖ **Support Vector Regression (SVR):**

Support vector regression (SVR) is a type of support vector machine (SVM) that is used for regression tasks. It tries to find a function that best predicts the continuous output value for a given input value.

SVR can use both linear and non-linear kernels. A linear kernel is a simple dot product between two input vectors, while a non-linear kernel is a more complex function that can capture more intricate patterns in the data. The choice of kernel depends on the data's characteristics and the task's complexity[13].

- **Kernel SVR :.**

The kernel function is used to transform data from a lower-dimensional space into a higher-dimensional space, which helps the Support Vector Regression (SVR) model find an optimal hyperplane for accurate prediction. This transformation allows the model to handle non-linear data more effectively, while maintaining computational efficiency by reducing the processing cost.

The choice of kernel function is a crucial factor, as it directly impacts the accuracy and flexibility of the SVR model in identifying patterns within the data. There are several types of Support Vector Regression (SVR) algorithms based on the type of kernel used to model the relationship between variables, including [14]:

*** Linear Kernel**

Represents the dot product between vectors:

$$K(x, x') = x * x' \quad \textbf{(II.2)}$$

Ideal for linearly separable data or when a simple straight-line regression is sufficient.

***Polynomial Kernel**

Captures nonlinear relationships by raising the dot product to a polynomial power:

$$\mathrm{K}(\mathbf{x}, \mathbf{y}) = (\mathbf{a} * \mathbf{x} * \mathbf{y} + \mathbf{b})^{\mathbf{d}} \quad \textbf{(II.3)}$$

Useful for modeling complex feature interactions.

***Radial Basis Function (RBF) Kernel**

Maps data to an infinite-dimensional space to capture complex patterns

$$\mathrm{K}(\mathbf{x}, \mathbf{y}) = \mathbf{exp}(-\mathbf{a} * ||\mathbf{x} - \mathbf{x}'||^2) \quad \textbf{(II.4)}$$

The most commonly used kernel due to its strong performance on nonlinear data

***Sigmoid Kernel**

Similar to the activation functions used in neural networks:

$$\mathrm{K}(\mathbf{x}, \mathbf{y}) = \mathbf{tanh}(\mathbf{a} * \mathbf{x} * \mathbf{y} + \mathbf{b}) \quad \textbf{(II.5)}$$

Sometimes used in tasks requiring moderate nonlinearity [13].

II.4.Deep Learning:

Deep Learning is transforming the way machines understand, learn and interact with complex data. Deep learning mimics neural networks of the human brain, it enables computers to autonomously uncover patterns and make informed decisions from vast amounts of unstructured data Among the networks, we find.

❖ **Artificial Neural Network(ANN):**

Artificial neural networks are one of the main tools used in machine learning. As the "neural" part of their name suggests, they are brain-inspired systems that are intended to replicate the way that we humans learn. Neural networks consist of input and output layers, as well as (in most cases) a hidden layer consisting of units that transform the input into something that the output layer can use. They are excellent tools for finding patterns that are far too complex or numerous for a human programmer to extract and teach the machine to recognize as shown in Figure II.5: [15].

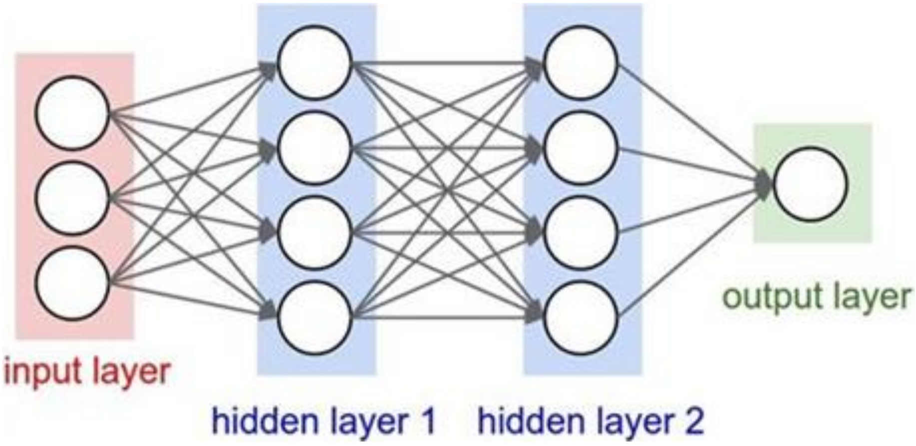

Figure II.5: Artificial Neural Network (ANN)

❖ **Regression Artificial Neural Network (ANN) :**

Regression ANNs predict an output variable as a function of the inputs. The input features (independent variables) can be categorical or numeric types, however, for regression ANNs, we require a numeric dependent variable. If the output variable is a categorical variable (or binary) the ANN will function as a classifier [16].

II.5.Artificial intelligence in medical physics:

In recent years, the integration of artificial intelligence and medical physics has paved the way for revolutionary advancements in healthcare. The convergence of advanced technology with the complex field of medical physics has not only transformed diagnosis and treatment planning but has also opened new horizons for personalized and effective patient care. As we stand on the threshold of a new era in medicine, it is essential to explore and understand the multifaceted impact of artificial intelligence in medical physics.

- **Precision Medicine and Personalized Treatment:**

AI analyzes large datasets to tailor precise treatment plans based on each patient's condition, improving outcomes and reducing side effects.

- **Enhanced Diagnosis and Imaging:**

Machine learning algorithms assist in the rapid and accurate detection of abnormalities in medical images, accelerating diagnosis and improving early treatment opportunities.

- **Automated Treatment Planning:**

AI simplifies the complex calculations involved in treatment planning, reducing errors and saving specialists' time.

- **Real-Time Decision Support:**

Artificial intelligence continuously monitors patient data and alerts physicians to any deviations, enabling quick and effective adjustments to treatment [17].

II.5.Conclusion:

Overall, artificial intelligence technologies offer promising opportunities to advance cancer treatment. With their powerful ability to analyze and process vast amounts of data, these technologies assist medical professionals in making faster and more accurate decisions, enable the development of personalized treatments tailored to each patient's unique characteristics, and open new horizons for discovering innovative therapies. Despite challenges such as data quality and clinical acceptance, AI is considered a revolutionary tool that has the potential to bring about a profound transformation in humanity's fight against cancer.

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Chapter III:

Results and Discussion

III.1.Introduction:

This chapter includes a preliminary statistical study of patient data, with the aim of engaging characteristics that affect the predictive performance of models. Next, we show the results of applying a set of machine learning algorithms: regression and binary classification, with an analysis of the performance of the resulting models, their comparison. In the rest of this chapter, we review the predictive power of these models using the available data sets, employing standard evaluation measures, and then conduct a comprehensive comparison of the achieved results.

III.2.The Practical Part:

Our study was conducted in the interest of the Cancer Control Center (CAC) of Mohammed Boudiaf OUARGLA hospital.

We were allowed to complete this statistical study based on prior authorization from the responsible bodies within the center, and focused on women with uterine tumors, as it included cases that were taken care of during the period from 2007 to 2024.

The information was collected from the department's archive, which contains only paper medical files. During the collection phase, we dealt with a number of challenges, since most of the files were handwritten, and the others were in Spanish, which required additional effort in reading and extracting the data.

We collected about 460 medical files, but we used only the files containing the necessary information 398 files, excluding the files that existed between 2013 and 2015 because they were not available.

The Cancer Control Center aims to provide integrated diagnostic and therapeutic services to cancer patients. The center has witnessed a remarkable development in its infrastructure and medical equipment over the years, to improve its capacity to accommodate patients and improve the quality of services provided.

The center includes multiple units, including: radiotherapy, chemotherapy, oncological surgery, nuclear medicine, and a CT simulator.

The construction of this facility is supervised by an integrated medical and paramedical staff, which includes specialized and general doctors, medical physicists, and nurses.

III.2.1. Data Collection:

Data on patients with uterine tumors were collected from medical files located in the radiotherapy department, where clinical information and therapeutic data were extracted and systematically recorded in Excel, for the purposes of this study as shown in the following Figure III.1.

Q1 fx classification des tumeur (maligne)

	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	état civil	roup sanguir	ATCD	Hémorragie	)ouleurs Pevienne	tes vaginales inhabitue	Urée	Hb	ie a jeun 0.7	C125	ation des tumeur(	tion des tumeur (	classification des
2	mariée	O+	anémie modérée	oui	oui	no	0.24	11.1	1.22	0	oui	no	bénigne
3	mariée	O+	no	no	oui	no	0.12	12.4	0.61	0	oui	no	bénigne
4	mariée	A+	NO	oui	oui	no	0.15	10.9	1.12	0	oui	no	bénigne
5	mariée	A+	NO	oui	oui	no	0.12	13.9	0.8	0	no	oui	maligne
6	mariée	O+	stéatose hépatique	oui	oui	no	0.17	14.2	1.15	0	no	oui	maligne
7	célibataire	A+	no	oui	oui	no	0.36	12.8	0.9	0	oui	no	bénigne
8	mariée	O+	no	oui	oui	no	0.2	13.3	0.91	0	no	oui	maligne
9	mariée	O+	NO	oui	oui	oui	0.32	12.4	0.98	0	no	oui	maligne
10	mariée	B+	no	oui	oui	oui	0.12	12.8	1.07	0	no	oui	maligne
11	mariée	O+	NO	oui	oui	oui	0.21	13.8	1.67	0	no	oui	maligne
12	mariée	A+	no	oui	oui	oui	0.21	11	1.89	0	no	oui	maligne
13	célibataire	O+	no	no	oui	no	0.18	12.3	0.98	167.4	no	oui	maligne
14	mariée	B+	Hypothyroïdie	oui	oui	no	0.13	14.9	1.07	0	no	oui	maligne
15	mariée	O+	NO	no	OUI	NO	0.21	13.5	1.22	267	no	oui	maligne
16	mariée	A+	NO	oui	oui	no	0.1	12.3	1.23	0	no	oui	maligne
17	mariée	A+	NO	no	oui	oui	0.26	13.4	0.79	0	oui	no	bénigne
18	mariée	O+	NO	OUI	NO	NO	0.11	12.4	0.97	0	no	oui	maligne
19	mariée	O+	cardiaque ischémique	oui	oui	oui	0.23	11.2	1.21	0	no	oui	maligne
20	mariée	B+	NO	no	OUI	NO	0.14	10.3	1.2	332	no	oui	maligne
21	mariée	O+	NO	OUI	OUI	OUI	0.13	13.9	1.08	0	no	oui	maligne
22	mariée	B+	NO	no	OUI	no	0.18	13.1	1.1	523	no	oui	maligne
23	célibataire	O+	NO	OUI	OUI	NO	0.22	11.6	0.65	0	oui	no	bénigne
24	mariée	A+	hypertrophie rénale	oui	oui	no	0.3	9.4	0.8	0	no	oui	maligne
25	mariée	O+	NO	OUI	OUI	NO	0.2	8.3	1.2	0	oui	no	bénigne
26	mariée	O+	NO	OUI	OUI	NO	0.2	8.3	1.2	0	oui	no	bénigne
27	célibataire	A+	L'anémie	NO	OUI	NO	0.1	7.7	1.1	148.23	no	oui	maligne

Feuil1 / Feuil2 / Feuil3

Figure III.1: Some data extracted from medical records.

In this study, the following variants common to female patients were used:

- **Age:** the patient's age is in years.
- **Clique:** the type of the patient's blood group.
- **Marital status:** Married or single.
- **G (Gravida):** the number of times a woman became pregnant.
- **P (Paragraph):** the number of times a woman gave birth.
- **A (abortion):** the number of incomplete embryos (miscarriages).
- **Medical analysis:**

- **CA 125:** caner antigen typically less than 35 units / mL.
- **Hemoglobin** : to diagnose anemia or bleeding[12-15.5]g/dL.
- **Urea:** to assess renal function before and after treatment, its normal limits in women are from [0.17-0.43] g/dL.
- **Fasting Blood Glucose:** monitoring blood sugar levels, especially in diabetic patients in ranges between [0.7 -1.1] g/L
- **HTA:** arterial hypertension
- **DA:** diabetes.
- **Other diseases:** which some infected women suffer from.
- **Bleeding:** abnormal vaginal blood coming out.
- **Pain in the pelvis:** a feeling of pressure and pain in that area.
- **Vaginal discharge:** discharge that is abnormal.
- **The nature of the tumor:** benign or malignant.
- **Histological classification of the tumor:** the type of cells that make it up.
- **FIGO classification:** used to determine the stages of cancer.
- **TNM classification:**
    - **T:** describes the size of the primary tumor and its spread.
    - **N:** indicates infection of nearby lymph nodes.
    - **M:** describe if it has spread to distant places in the body.
- **The organs from which the tumor originated and infiltrated into the uterus :** the body, cervix, endometrium. The right ovary, the left and right fallopian tubes and the vagina.
- **Proposed treatment for each case:** surgery, radiotherapy, or chemotherapy.
- **Total dose 2:** the total amount of radiation therapy given to the patient during the treatment period, measured in gray units.
- **Dose per Session 2:** the amount of radiation given per session.
- **Number of Sessions 2:** the number of times the treatment is given.
- **Organs to which the tumor has spread:** whether tissue, nodes or others.
- **Removed organs:** may include the uterus and its appendages, lymph nodes, or any organ to which the tumor has spread.

III.2.1.1.Statistical Analysis of the Results:

Data on cases of uterine tumors were collected and recorded using Excel. They were analyzed using appropriate descriptive statistical methods, and the results were presented in the form of tables and illustrative graphs.

1. wilayas: According to the statistics, the largest percentage of cases of uterine tumors appeared in the states of southern Algeria, the first of which is the state of Ouargla and the geographical distribution may be due to the geographical location of the hospital where the study was conducted in the South, which may contribute to an increase in the representation of patients coming from neighboring regions compared to other states. As shown in Table III.1 and FigureIII.2.

Table III.1: Geographical distribution of patients.

wilayas	Number	Percentage ratio %
OUARGLA	170	43.70
GARADAYA	56	14
TAMENRASSET	16	4
TAIRET	12	3
ELOUED	27	6.70
DJELFA	20	5
LAGOUAT	7	1.70
ADRAR	8	2
TOUGOURT	16	4
The other states	66	16.60

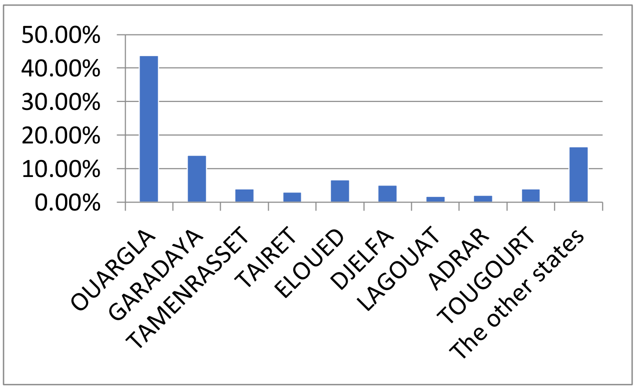


Figure III.2: Bar chart for the distribution of states.

2. Age: The ages of the individuals included in the study ranged between 16 and 89 years. As shown in Table III.2 and Figure III.3.

Table III.2: Distribution of patients by age groups.

Age	Number	Percentage ratio%
[16_27]	7	1.75
[28_35]	28	7
[36_40]	50	12.50
[41_50]	93	23.00
[51_58]	79	19.90
[59_65]	59	15
[66_70]	26	6.50
[71_75]	25	6
[76_89]	31	8

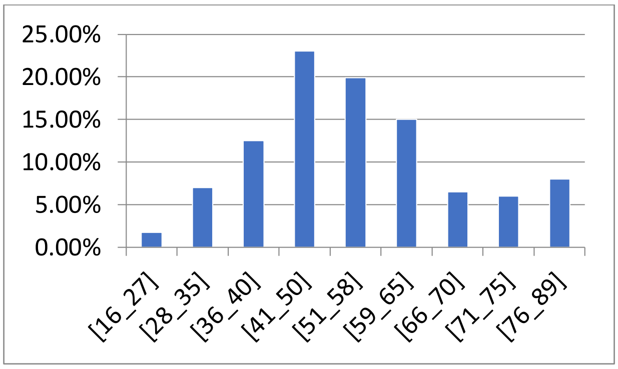


Figure III.3: Bar chart for the ages of the patients

3. Marital status: the statistical results indicated that the largest percentage of women with uterine tumors are married, with 91%, while single women accounted for only 9% of the total cases. As shown in Table III.3and Figure III.4:

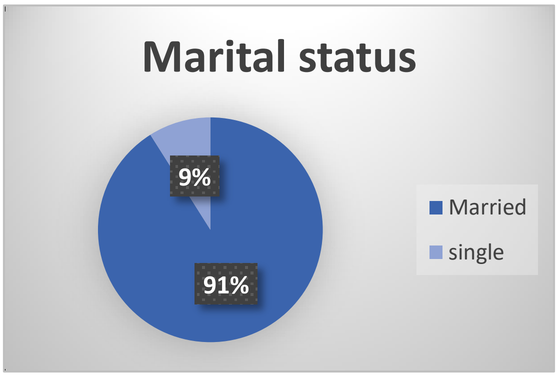


Figure III.4: Marital Status of Patients

Table III.3: Distribution of patients by marital status.

Marital status	Number	Percentage ratio%
Married	364	91
Single	34	9

4. The diseases: the results of the statistical analysis showed that a large number of patients with concomitant chronic diseases .As 66% of cases were recorded with arterial hypertension, while obesity was observed in 27% of patients, which is one of the risk factors. As shown in Table III.4 and Figure III.5.

Table III.4: Distribution of patients according to their chronic or non-chronic diseases.

The diseases	Number	Percentage ratio%
HTA	262	66
DA	68	17
HPV	9	2.26
Other diseases	30	7.53
Obesity	107	27

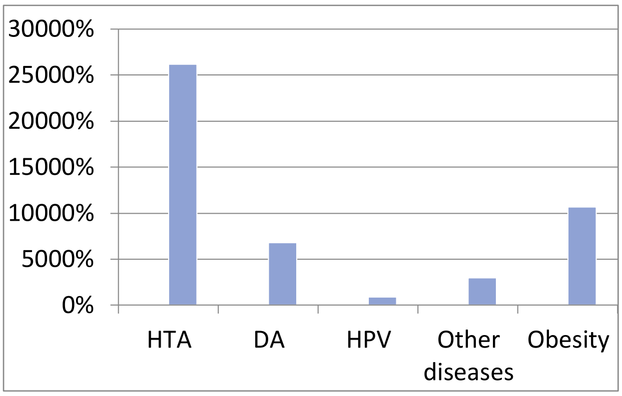


Figure III.5: Bar chart for associated diseases.

5. The distribution of blood groups: the statistical results obtained during this study showed that the blood group O positive (O+) is the most common among the sample, with 44%, followed by other blood groups in varying proportions, and is the most common Group globally. As shown in Table III.5 and FigureIII.6:

Table III.5: Distribution of patients by blood groups.

the blood group type	Number	Percentage ratio%
O+	176	44
A+	115	29
B+	78	20
AB+	6	1.50
A-	4	1
B-	5	1.25
AB-	1	0.25
O-	13	3.20

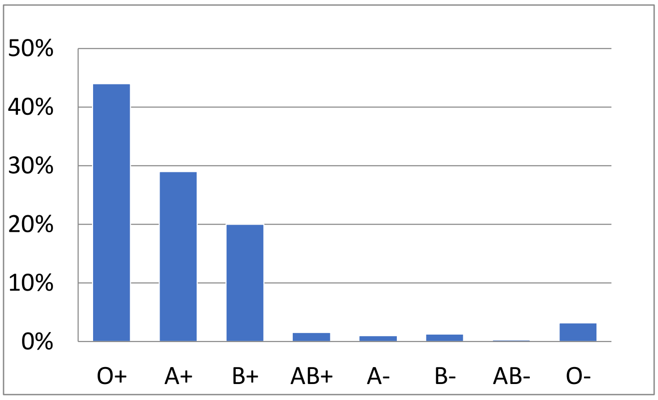


Figure III.6: Distribution of Patients According to Blood Group.

6. Symptoms: Most cases with uterine tumors showed predominant symptoms represented by abnormal metrorrhagia and pelvic pain. As shown in Table III.6 and Figure III.7.

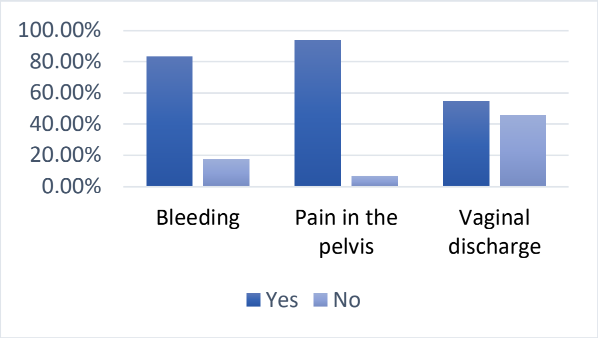


Figure III.7: Bar chart for symptoms experienced by the patients.

Table III.6: Distribution of patients according to the symptoms they experience.

Symptoms	Yes	Percentage ratio %	NO	Percentage ratio %
Bleeding	330	83.00	68	17
Pain in the pelvis	372	93.47	26	6.53
Vaginal discharge	217	54.52	181	45.48

7. The nature of the tumor: The results prepared to clarify the nature of metastatic tumors in the uterus showed that the percentage of malignant tumors accounts for the majority at 61%, while benign tumors account for 39% of the studied cases. This ratio reflects a significantly higher prevalence of malignant tumors compared to benign. As shown in Table III.7 and Figure III.8.

Table III.7: Distribution of patients by the nature of the tumor**.**

The nature of the tumor:	Number	Percentage ratio%
Benign	154	38.69
Malignant	244	61.30

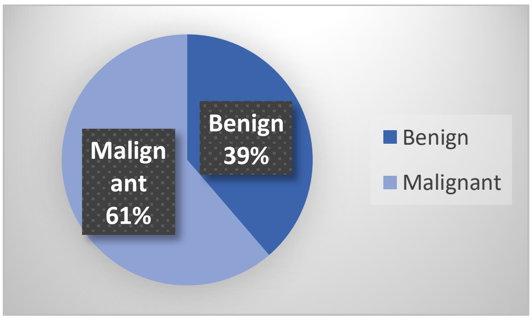


Figure III.8: Distribution analysis of The nature of the tumor.

8. Histological classification of the tumor: Statistical analysis showed that benign tumors in the uterus were mostly fibroids, with a percentage of 66% of the studied cases. As shown in Table III.8 and Figure III.9.

Table III.8: Distribution of patients by histological classification of benign tumors.

Histological classification	Number	Percentage ratio %
Fibroid	103	66.88
Polyp	28	18.18
Cystadenoma	17	11.03
Mature Ovarian Teratoma	4	2.59
Uterine prolaps+ Fibroid	1	0.64
Diffuse adenomyosis	1	0.64

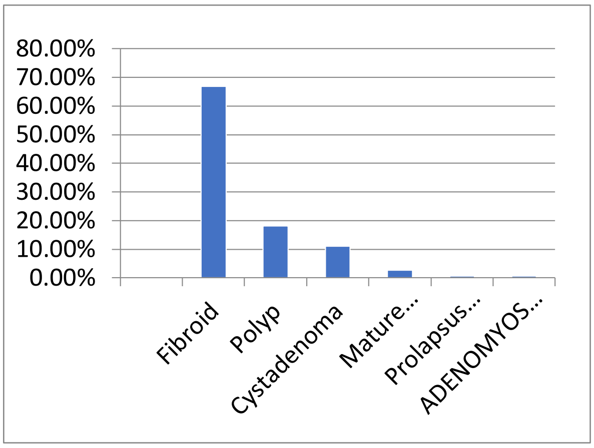


Figure III.9: Histopathological Classification of Benign Uterine Tumors.

As for malignant tumors, squamous carcinoma was the most common, accounting for 68% of cases. As shown in Table III.9 and Figure III.10.

Table III.9: Distribution of patients by histological classification of malignant tumors.

Histological classification	Number	Percentage ratio%
Squamous cell carcinoma	166	68
Adenocarcinoma	62	25.40
Cystadenocarcinoma	9	3.68
Sarcoma	6	2.45
Granulosa cell tumor	1	0.40

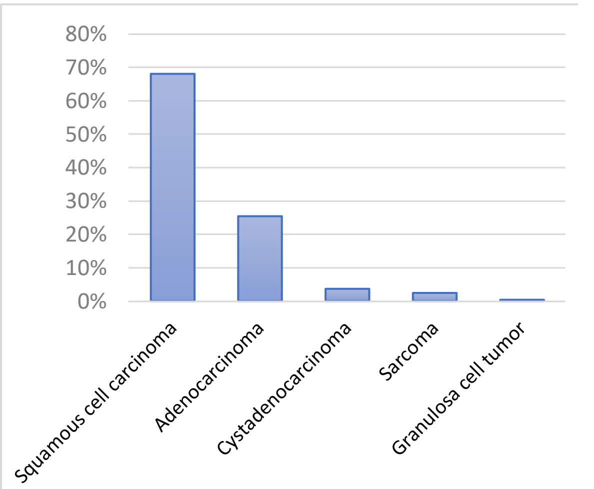


Figure III.10: Histopathological Classification of Malignant Uterine Tumors.

9. Organs to which the tumor has spread: Through the study and the statistical results we have reached, it turned out that the highest statistic is the cases in which the tumor has infiltrated the periarticular parametrium, which indicates its classification within the second stage of the development of cervical cancer As shown in Table III.10 and Figure III.11.

Table III.10: Distribution of patients by organs to which the tumor has moved .

Organs to which the tumor has spread	Number	Percentage ratio%
Parametrail tissues	62	25.40
Pelvic walls	26	10.60
Bladder wall	5	2
Rectum	4	1.63
Pelvic lymph nods	19	7.78
Bladder and rectalwall	20	8.19
Peritoneal	3	1.22
Pulmonary lymph nodes	1	0.40
Bladder,rectal walls and Pelvic lymph nods	3	1.22
No evidence of spread	102	41.80

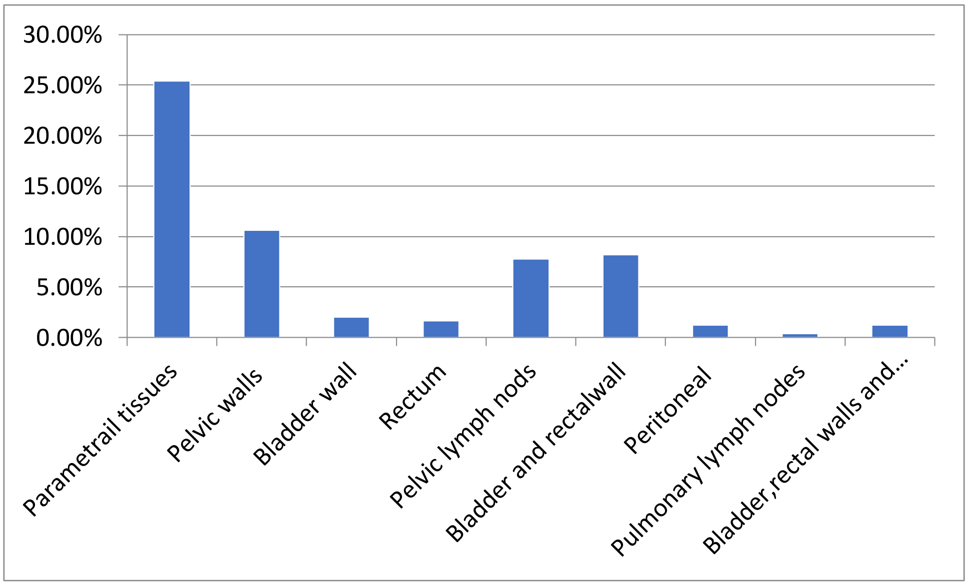


Figure III.11: Bar chart for the organs to which the tumor has spread.

10. Treatment plan: the results of the statistic showed that benign tumors were completely cured only by surgical intervention. As for malignant tumors, the treatment methods varied between surgery, chemotherapy, and radiation therapy; chemotherapy and radiation therapy accounted for a large proportion of the treatment, while almost half of the malignant cases also underwent surgery. As shown in Table III.11 and Figure III.12.

Table III.11: Distribution of treatment for patients with benign and malignant tumors.

Treatment plan	Number	Percentage ratio%
Surgery for benign tumors	154	100
Surgery for malignant tumors	122	50
Chemotherapyfor malignant tumors	216	88.52
Radiothrapy for malignant tumors	201	82.37

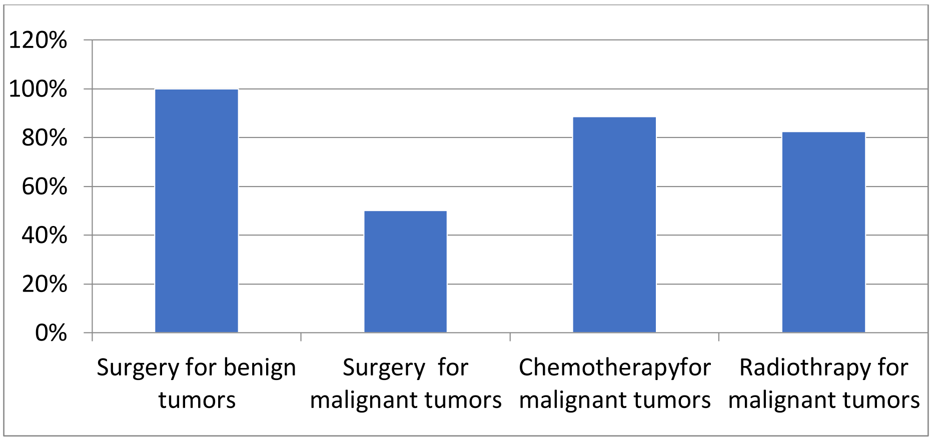
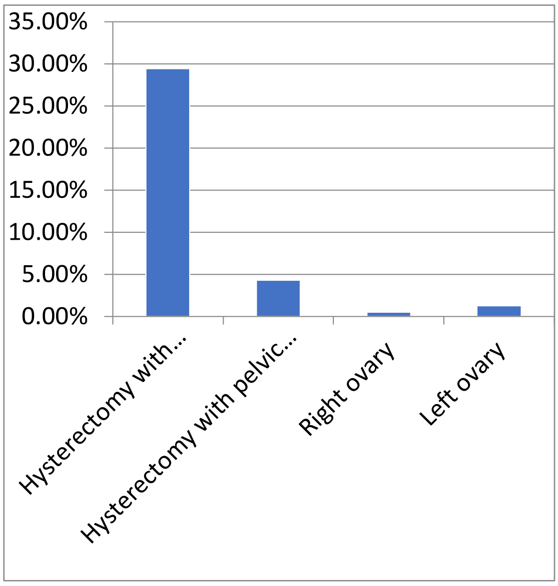


Figure III.12: Therapeutic Plans for Uterine Tumors.

11. Removed organs: The results of the concluded study showed that total hysterectomy with its appendages was the most common treatment option in a number of cases of uterine tumors. As shown in the Table III.12 and the Figure III.13.

Table III.12: Distribution of organs that have been removed in some patients.



Removed organs:	Number	Percentage ratio%
Hysterectomy with adnexectomy	117	29.39
Hysterectomy with pelvic lymphadenectomy	17	4.27
Right ovary	2	0.50
Left ovary	5	1.25

Figure III.13: Bar chart for the organs that were removed.

III.3.Programmingg language:

Python is an easy to learn, powerful programming language. It has efficient high-level data structures and a simple but effective approach to object-oriented programming. Python's elegant syntax and dynamic typing, together with its interpreted nature, make it an ideal language for scripting and rapid application development in many areas on most platforms. The Python interpreter and the extensive standard library are freely available in source or binary form for all major platforms from the Python Web site, http://www.python.org/, and can be freely distributed. The same site also contains distributions of and pointers to many free third party Python modules, programs and tools, and additional documentation [1].

Google Colaboratory:

Google Colaboratory is a project that has the objective of disseminating machine learning education and research. Colaboratory notebooks are based on Jupyter and work as a Google Docs object: can be shared and users can collaborate on the same notebook, Colaboratory provides either Python 2 and 3 runtimes pre-configured with the essential machine learning and artificial intelligence libraries, such as TensorFlow, Matplotlib, and

Keras. The virtual machine under the runtime (VM) is deactivated after a period of time, and all user's data and configurations are lost. However, the notebook is preserved, and it is also pos-sible to transfer files from the VM hard disk to the user's Google Drive account. Finally, this Google service provides a GPU-accelerated runtime, also fully configured with the soft-ware previously outlined. The Google Colaboratory infras-tructure is hosted on the Google Cloud platform [2].

III.4 Binary Classification:

III.4.1 Algorithm evaluation metrics:

Selecting an appropriate performance evaluation metric is crucial for training an optimal classifier. For binary classification problems, the confusion matrix, as shown in Table III.13, is often considered the best solution for model evaluation. The confusion matrix provides four necessary measures: true positive (TP), which occurs when the classifier predicts a positive class correctly; true negative (TN) when the classifier predicts a negative class correctly; false positive (FP), when the model predicts a positive class but the sample is actually negative; and false negative (FN), when the model predicts a negative class but the sample is actually positive [3].

Table III.13: Confusion matrix for binary classification.

	Real positive class	**Real negative class**
Positive Prediction Class	True Positive (VP)	False Positive (FP)
Negative Prediction Class	False Negative (FN)	True Negative (VN)

III.4.2 The performance metric:

Performance evaluation metrics are critical for determining the efficacy of machine learning models.key performance measures include:

a .A**ccuracy:** which measures the proportion of correct predictions over the total number of evaluated instances, as expressed by Equation:

$$\textbf{Accuracy} = \frac{VP+VN}{VP+FP+FN+VN} \qquad \textbf{III.1}$$

b. Precision: is another important metric that represents the proportion of positively predicted values in relation to the total of all positive classes, as expressed by Equation:

$$\textbf{Precision} = \frac{\text{VP}}{(\text{VP}+\text{FP})} \qquad \textbf{III.2}$$

c. Recall: , indicates the proportion of positively predicted cases among all cases that are actually positive, as described by Equation:

$$\textbf{Recall} = \frac{\text{VP}}{(\text{VP}+\text{FN})} \qquad \textbf{III.3}$$

d. F1-score: is a harmonic mean of accuracy and sensitivity, penalizing extreme values for both metrics. It is not symmetric between classes and depends on which class is considered positive and which is considered negative. The F1-score varies between [0, 1], assuming a maximum value of 1 when both precision and recall (sensitivity) are high, and 0 otherwise. A high F1-score indicates high precision and recall, medium when one is high and the other is low, and low when both are low. as described by Equation:

$$\textbf{F1 Score}=\frac{2\times(\text{Precision}\times\text{Recall})}{(\text{Precision}+\text{Recall})} \qquad \textbf{III.4}$$

III.5 Regression:

III.5.1 Evaluation Metrics:

We have evaluated these models against certain metrics:

a.Mean Squared Error (MSE): is also called the Mean Squared Deviation is the squared difference between the actual values and the predicted values. That is MSE tells us how close the line of best fit is to the set of points. MSE is always a positive value. The square is taken to eliminate negative signs. The closer the MSE is to 0, the more accurate is the prediction [4].

The formula for Mean Squared Error is given as:

$$\textbf{MSE} = \frac{1}{n}\sum_{i=1}^{n}(Y_i - \hat{Y}_i)^2 \qquad \textbf{III.5}$$

b. Root Mean Squared Error (RMSE): is also called the Root Mean Squared Deviation is the square root of the mean of squares of all the errors. In other words, the RMSE is simply the Standard deviation of the errors. RMSE again tells us how close the line of best fit is to the set of points. The formula for RMSE is given as:

$$\textbf{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(Y_i - \hat{Y}_i)^2} \qquad \textbf{III.6}$$

c. Mean Absolute Error (MAE): is also called the Mean Absolute deviation provides us the average of the absolute difference between the observed value and the predicted values. The difference between the MAE and MSE is that MAE takes the absolute difference between the predicted values and the observed values whereas the MSE takes the squared difference. The formula for MAE is given as:

$$\mathbf{MAE} = \frac{1}{n}\sum_{i=1}^{n}|(Y_i - \hat{Y}_i)| \qquad \textbf{III.7}$$

d. R-Squared (R^2): is called the coefficient of Determination. R-Squared determines the proportion of variance in the dependent variable that can be explained by the independent variables. R^2 provides us with the goodness of fit (the extent to which the observed values match the predicted values) for the regression model.

The formula for R^2 is given as:

$$\mathbf{R^2} = 1 - \frac{SSE}{SST} \qquad \textbf{III.8}$$

SSR: Sum of Squares of residuals, TSS: Total Sum of Squares.

n: Number of predictions .

Y_i: Observed values .

$\hat{Y}_i$: Predicted values .

III.6 Medical Application:

Our model was developed using the Google Colab platform, within an environment based on the Python 3 programming language, using machine learning technologies. The data was divided into two groups: the first represented the training group accounting for 80% of the total data, for Model Education. The second group, representing 20% of the data, is the test group, to assess the ability of the model to generalize and predict when dealing with previously unrecognized data.

- In the first part, we used binary classification to predict whether a patient has a malignant tumor and treatment: surgical, chemotherapy and radiotherapy.
- In the second part, we used regression to predict the number of servings needed to receive therapeutic doses**.**

III.6.1The first part: binary classification:

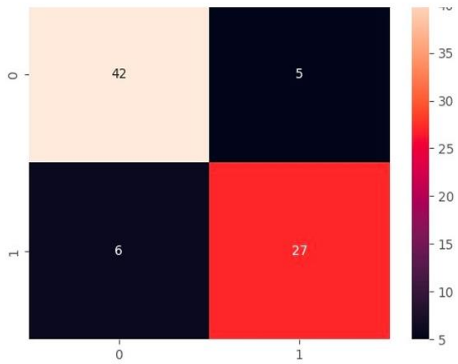
In this part, binary classification models were tried in order to achieve the prediction of whether a patient has a tumor type (malignant) and type treatment using the following algorithms:

- Artificial Neural Network (ANN).
- Support Vector Machine (polynomial).
- Support Vector Machine (linear)

III.6.1.1.Tumor type (malignant):

a. Artificial Neural Network: Implementation of ANN algorithm Figure III.14:

Figure III.15 shows the training and prediction results obtained from the same model.



	precision	recall	f1-score	support
0	0.88	0.89	0.88	47
1	0.84	0.82	0.83	33
accuracy			0.86	80
macro avg	0.86	0.86	0.86	80
weighted avg	0.86	0.86	0.86	80

Figure III.14: the confusion matrix resulting from the application of the ANN algorithm.

Figure III.15: Classification report of the ANN algorithm.

Figure III.16 shows the obtained results of the accuracy and loss curves for the ANN model during the training process.

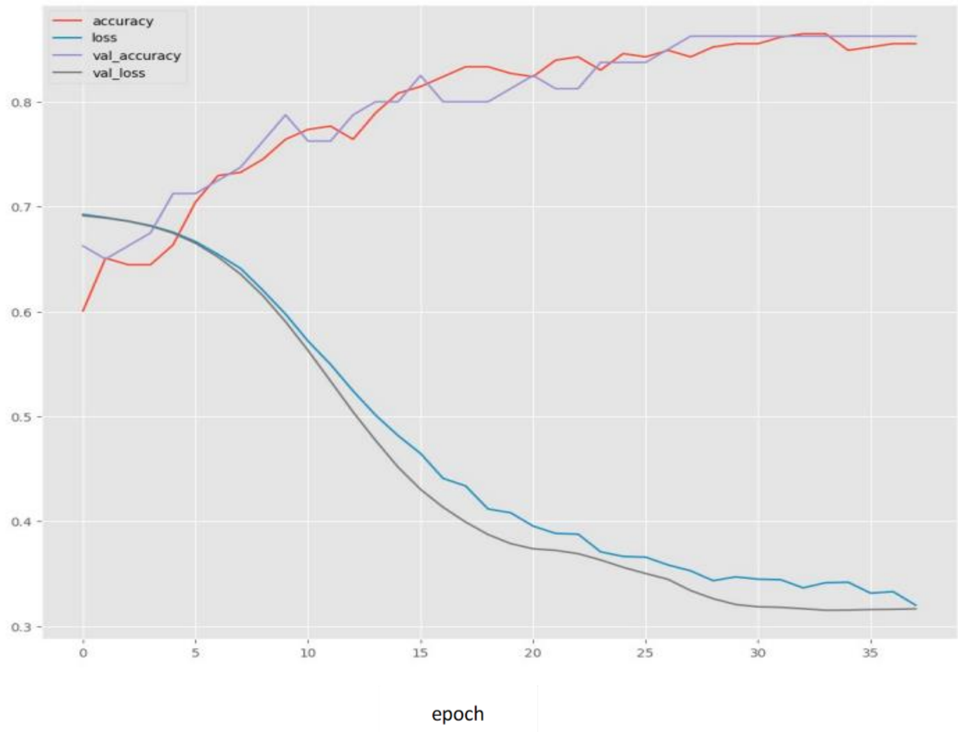
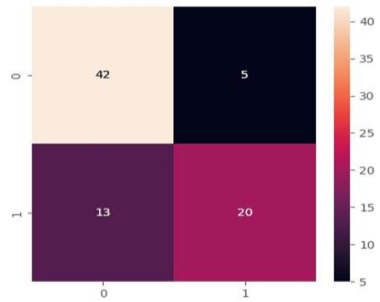


Figure III.16: Analysis of the Training and Validation Accuracy Curve for the ANN Model.

b.Support Vector Machine (polynomial): Implementation of SVM (polynomial) algorithm Figure III.17.

Figure III.18 shows the training and prediction results obtained from the same model.



	precision	recall	f1-score	support
0	0.76	0.89	0.82	47
1	0.80	0.61	0.69	33
accuracy			0.78	80
macro avg	0.78	0.75	0.76	80
weighted avg	0.78	0.78	0.77	80

Figure III.17: presents the confusion matrix resulting from the application of the SVM (polynomial) algorithm.

Figure III.18: Classification report of the SVM (polynomial) algorithm.

The following Table III.14 illustrates the performance of the algorithmic models based on the adopted evaluation metrics:

Table III.14: Performance comparison binary classification for tumor type.

Model	Accuracy%	MAE	MSE	RMSE
ANN	86.25	0.210	0.101	0.317
SVM Polynomial	77.5	0.225	0.225	0.474

Comparison of algorithms:

Based on the evaluation results, it turned out that the ANN algorithm performed the best in terms of accuracy (86.25%), Polynomial core SVM showed good performance in which the accuracy exceeded 77%.

III.6.1.2.Surgical treatment:

a. Artificial Neural Network: Implementation of ANN algorithm Figure III.19.

Figure III.20 shows the training and prediction results obtained from the same model.

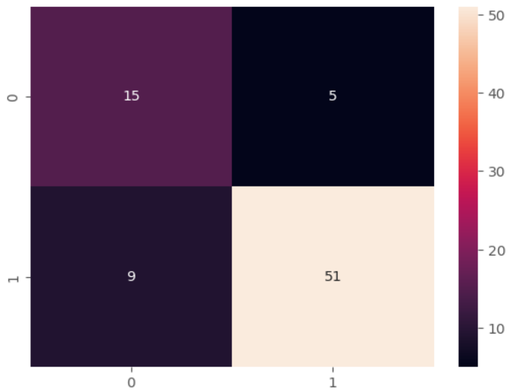


Figure III.19: the confusion matrix resulting from the application of the ANN algorithm.

	precision	recall	f1-score	support
0	0.62	0.75	0.68	2
1	0.91	0.85	0.88	60
Accuracy			0.82	80
macro avg	0.77	0.80	0.78	80
weighted avg	0.84	0.82	0.83	80

Figure III.20: Classification report of the ANN algorithm.

The Figure III.21 shows the obtained results of the accuracy and loss curves for the ANN model during the training process.

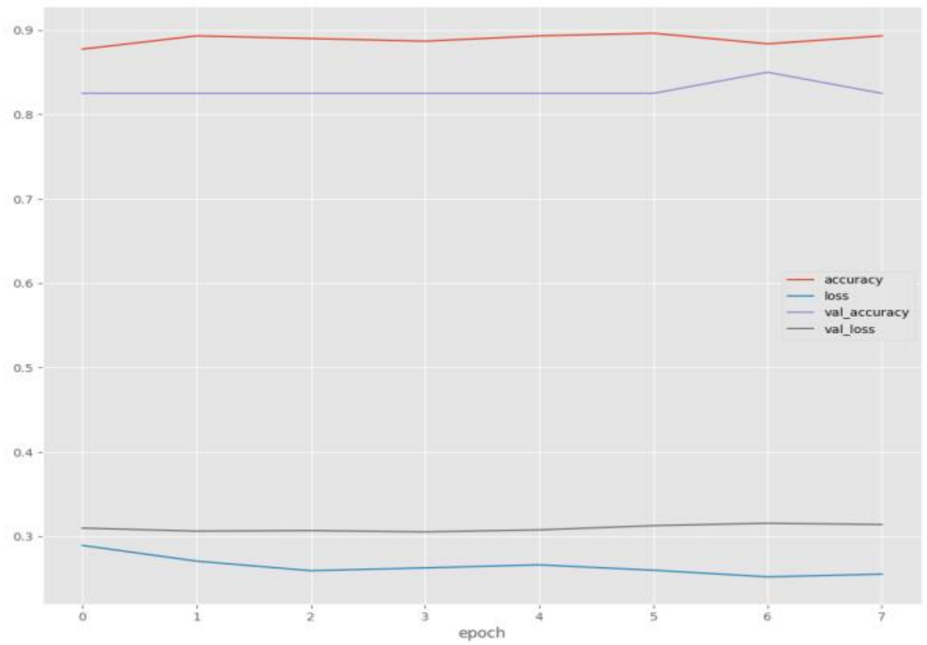
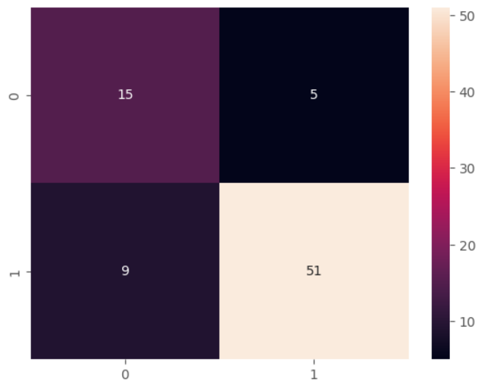


Figure III.21: Analysis of the Training and Validation Accuracy Curve for the ANN Model

b.Support Vector Machine (linear): Implementation of SVM (linear) algorithm Figure III.22.

Figure III.23 shows the training and prediction results obtained from the same model.



	precision	recall	f1-score	support
0	0.62	0.75	0.68	20
1	0.91	0.85	0.88	60
accuracy			0.82	80
macro avg	0.77	0.80	0.78	80
weighted avg	0.84	0.82	0.83	80

Figure III.22: the confusion matrix resulting from the application of the SVM (linear) algorithm.

Figure III.23: Classification report of the SVM (linear) algorithm.

The following Table III.15 illustrates the performance of the algorithmic models based on the adopted evaluation metrics:

Table III.15: Performance comparison surgical treatment prediction.

Model	Accuracy%	MAE	MSE	RMSE
ANN	82.5	0.197	0.109	0.331
SVM (Linear)	82.5	0.175	0.175	0.418

Comparison of algorithms:

Based on the results, both models achieve the same accuracy 82.5%. However, the ANN model outperforms in terms of reducing the Mean Squared Error (MSE) and Root Mean Squared Error (RMSE), indicating that it is better at minimizing large errors. On the other hand, the SVM model performs slightly better in reducing the Mean Absolute Error (MAE). Overall, the ANN model is considered to have better performance in this comparison.

II.6.2.The second part: Regression:

In this part of the study, techniques for predicting the target values (the number of sessions for dose 2). To achieve this purpose, a number of algorithms have been applied:.

- Support Vector Regression (sigmoid).
- Artificial Neural Network (ANN).

To determine which model is most efficient at predicting target values, we compared the performance of the models using a set of common evaluation indicators: R^2, MSE, RMSE and MAE.

III.6.2.1. Prediction of the number of radiotherapy sessions:

a .Artificial Neural Network: Implementation of ANN algorithm Figure III.24.

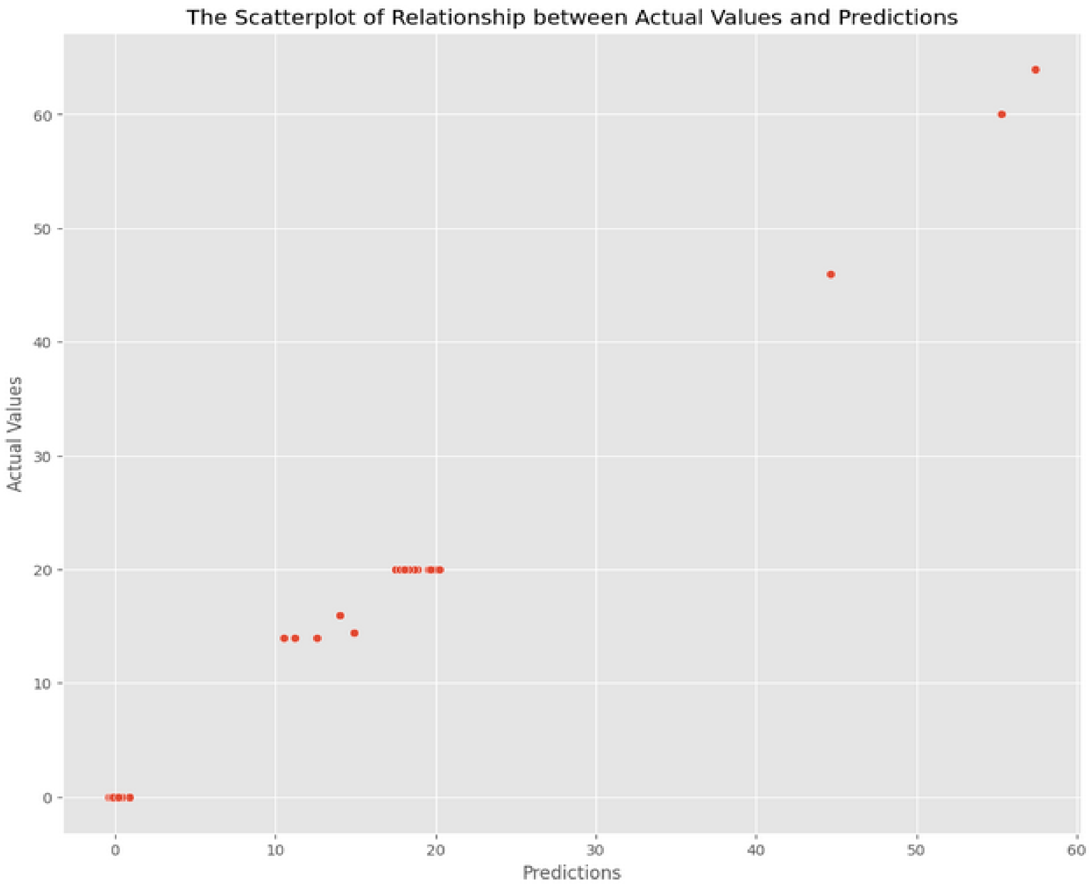


Figure III.24: Regression report of the ANN algorithm.

The following Table III.16 summarizes the results obtained for each model:

Table III.16: Performance Comparison Regression Algorithms for Number of Sessions.

Model	R2	MAE	MSE	RMSE
ANN	0.990	0.585	1.535	1.239
SVR (Sigmoid)	0.033	6.202	154.127	12.415

Comparison of algorithms:

Considering the results obtained, we note that the model closest to the real values is ANN, as it showed high performance and excellent accuracy in forecasting.

The Sigmoid SVR model, which recorded the highest error rates in the MSE, RMSE and Mae indices, and showed a very low value for R^2.

III.7.Conclusion:

At the end of this work, we were able to present a statistical and practical study on uterine tumors in women by processing real medical data and applying artificial intelligence algorithms to support medical decision-making. The study led to several important findings, which can be summarized as follows:

In terms of statistical analysis:

- The most affected age group: 41–50 years, with a rate of 23%.
- Marital status: The majority of patients were married, at a rate of 91%.
- Most common cancerous tissue:
- In malignant tumors: Squamous cell carcinoma, with a rate of 68%.
- In benign tumors: Fibroid, with a rate of 66.88%.
- In terms of treatment:
  - Treatment types for malignant tumors: chemotherapy 88.52%, radiotherapy 82.37%, surgery 50%.
  - Complete treatment for benign tumors was exclusively surgical: 100%.
- Removed organs: hysterectomy with appendages 29.39%.

In terms of Applied results of artificial intelligence models:

Classification:

- Type of tumor (malignant or not):The best model is ANN algorithm, accuracy of 86.25%.
- Surgical treatment:Best model is SVM (Linear) and ANN algorithms, accuracy 82.5%,and the smallest error.

Regression:

- Prediction of the number of Sessions (dose 2): The best model ANN. $R^2 = 0.999$, RMSE = 1.239; outperforme in terms of accuracy and low error.

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General Conclusion

Uterine tumors are among the most significant challenges to women's health, due to their serious physical effects, especially when they turn into malignant tumors that may lead to total hysterectomy, affecting fertility if the woman has not reached menopause, or may lead to death in cases of rapidly spreading cancers. Through this research, the subject was addressed from various aspects, starting from the histopathological classification of uterine tumors, going through their causes, symptoms, diagnostic methods, and associated risk factors, and ending with the treatment strategies available for each type.

The practical part of the study, which was based on real data from the Cancer Control Center in Ouargla, showed the great importance of medical statistics in understanding the nature of the spread of uterine tumors and their relationship to demographic and clinical factors. The results showed a higher percentage of malignant tumors compared to benign ones, and we highlighted the type of tumor and the adopted treatment methods. We showed that the tumor was detected at a non-early stage, which calls for the improvement of early detection and diagnosis methods, and this was our objective during this study.

The research also showed that integrating artificial intelligence and machine learning techniques in the analysis of medical data has effectively contributed to raising the level of tumor prediction, improving the accuracy of diagnosing the type of tumor (malignant), and speeding up treatment decision-making, whether surgical treatment, or determining the number of radiotherapy sessions in case of a malignant tumor. This indicates that technological advancement has become an important tool in developing healthcare and combating tumors in general.

Accordingly, the future of combating uterine tumors largely depends on the integration between traditional medical knowledge and modern intelligent technologies, and on activating machine learning programs in early screening, especially in resource-limited areas, as it is considered a low-cost tool compared to other diagnostic methods. The earlier the detection, the greater the chances of recovery for patients.

Abstract:

Uterine tumors are among the most common tumors affecting women, and they are classified into benign and malignant tumors. To support medical decision-making and improve the accuracy of diagnosis and selection of appropriate treatment, this research relied on machine learning techniques to conduct a statistical study on real data of patients with uterine tumors, collected from Mohamed Boudiaf Hospital in Ouargla.

Binary classification was used to determine the type of tumor (benign or malignant), where the Artificial Neural Network (ANN) algorithm was chosen with an accuracy of 86.25%.

As for the classification of the type of treatment (surgical), both ANN and Linear SVM algorithms were selected, achieving an accuracy of 82.5%.

Regarding the prediction of the number of appropriate treatment sessions for each case, the ANN algorithm demonstrated its efficiency by achieving the lowest error rate.

This work aims to provide an intelligent model that helps doctors make accurate and quick decisions.

Keywords: Uterine tumors, Deep learning, Binary classification, Regression .

Résume :

Les tumeurs de l'utérus sont parmi les tumeurs les plus courantes chez les femmes, et elles sont classées en tumeurs bénignes et malignes. Pour soutenir la prise de décision médicale et améliorer la précision du diagnostic ainsi que le choix du traitement approprié, cette recherche s'est appuyée sur des techniques d'apprentissage automatique afin de mener une étude statistique sur des données réelles de patientes atteintes de tumeurs utérines, recueillies à l'hôpital Mohamed Boudiaf de Ouargla.

La classification binaire a été utilisée pour déterminer le type de tumeur (bénigne ou maligne), où l'algorithme du réseau de neurones artificiels (ANN) a été choisi avec une précision de 86.25 %.

En ce qui concerne la classification du type de traitement (chirurgical), les algorithmes ANN et SVM linéaire ont été choisis, avec une précision de 82.5 %.

Concernant la prédiction du nombre de séances de traitement appropriées pour chaque cas, l'algorithme ANN a démontré son efficacité en enregistrant le taux d'erreur le plus bas.

Ce travail vise à fournir un modèle intelligent aidant les médecins à prendre des décisions précises et rapides.

Mots-clés : Tumeurs utérines, Apprentissage profond, Classification binaire, Régression.

الملخص:

أورام الرحم من أكثر الأورام شيوعًا بين النساء، وهي تنقسم إلى أورام حميدة وأخرى خبيثة. ولدعم القرار الطبي وتحسين دقة التشخيص واختيار العلاج الأنسب، تم في هذا البحث الاعتماد على تقنيات التعلم الآلي لإجراء دراسة إحصائية على بيانات حقيقية لمريضات مصابات بأورام الرحم، جُمعت من مستشفى محمد بوضياف في ورقلة.

تم استخدام أسلوب التصنيف الثنائي لتحديد نوع الورم (حميد أو خبيث)، حيث تم اختيار خوارزمية الشبكة العصبية الاصطناعية، وبلغت دقتها 86.25% .

وفيما يتعلق بتصنيف نوع العلاج (الجراحي)، تم اعتماد كل من خوارزمية الشبكة العصبية الاصطناعية وخوارزمية آلة الدعم النقطية ذات النواة الخطية، وحققتا معًا دقة بلغت82.5% .

أما بخصوص التنبؤ بعدد جلسات العلاج المناسبة لكل حالة، فقد أثبتت خوارزمية الشبكة العصبية الاصطناعية فعاليتها من خلال تسجيل أقل نسبة خطأ في النتائج.

يهدف هذا العمل إلى تقديم نموذج ذكي يُسهم في مساعدة الأطباء على اتخاذ قرارات دقيقة وسريعة.

الكلمات المفتاحية: أورام الرحم، التعلم العميق، التصنيف الثنائي، الانحدار.