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Predicting Patient Attrition in Prostate Cancer Treatment Programmes across Africa Using Artificial Intelligence

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Abstract

Attrition remains a significant factor to be considered during the treatment of cancer for patients; however, it has become a very critical concern across Africa as a continent leading to interruptions during treatment, progressions of the disease as well as poor survival rate. Artificial intelligence provides an emerging vision in identifying patients at risk of discontinuing treatment plans. Thus, the study explores the existing literature on its application and machine learning algorithm for the prediction of patient's attrition in the treatment of prostate cancer as a programme across the African continent. It involved a systematic review approach using the important literatures. Studies which delve on artificial intelligence application, machine learning and predictive analytics were identified to unveil the factors related to the discontinuation of treatment, follow up loss, attrition in patient having prostate cancer were searched and reviewed accordingly. The performance of the model, artificial intelligence techniques as well as the predictors were taken into consideration. The outcome revealed significant artificial intelligence techniques, demography, socio-economic factors that are connected to patient with attrition including their performance. These findings established the benefits and limitations in the application of artificial intelligence driven predictive tools within the African prostate cancer care system.

Keyword: Artificial Intelligence, Prostate Cancer, Attrition, Africa, Prediction, models

Introduction

Treatment attrition is experienced by patient having metastatic castration resistant prostate cancer. About 56% of these patients have been established to be in second line therapy treatment while 26% is currently being advanced to third line therapy [1-3]. In second to third line therapy, there will be steepness in the attrition with about 26-35% approaching the main patient cohorts reaching the third line treatment. Some regimens include the androgen receptor pathways inhibitors which are well deployed during the first and second lines while taxanes are more prevalent in

the later lines [4-5]. Attrition drivers include radical clinical aggressive tumour behaviour that prevents patients from achieving tolerance around the subsequent lines [6-7]. Toxicity treatment and side effects which involve cumulative physical declines, fatigue and adverse event that render therapy difficult [8]. Also, there is medical complications and frailty where there is an involvement of age and concurrent health problems [9], thus limiting the reserve [10]. Also, there are logistics and financial challenges such as access to specialised care, insurance issues as well as geographical constraints which reduces continuity [11-12]. The growing therapeutic landscape for metastatic castration resistance prostate cancer has led to an increase in the difficulty of treatment methods and sequencing [13-14]. But several studies available have not given a detail description of treatment patterns and the rate of attrition in clinical treatment of this type of disease. Based on this, a study investigated the treatment pattern and the rate of attrition in patients having the disease from 2021-2025 [15]. The methodology involves the use of multicentre cohort study deployed by the United state electronic health record which is a deidentified flatiron health research database so as to be able to come up with patients with metastatic castration resistant prostate cancer that comes with first line therapy in January 1 2021 and June 30, 2025 using 280 centers, particularly the community oncology practice. The outcome revealed that out of 27,979 patients known to have the disease within the dataset, 5096 were established to have met the criteria for eligibility which were part of the analyses as depicted in Figure 1. The median interquartile range was observed to be 75 years as analysed in the range of 68-82 years. Of these patients, 79.3% were found to have progressed from mHSPC while 20% experienced from non-metastatic castration resistance prostate cancer and 38% equally had an experience of progression from non-metastatic HSPC to metastatic castration resistance prostate cancer [16]. It was observed that in terms of their races, 86 patients representing 1.7% were Asians while 7.5% were Hispanic or Latino. About 12.1% were not Hispanic black, 55.5% were non-Hispanic white while 7.3 were from another ethnic group and 16% were from unknown race as well. In general, about 76% of patients were treated within the community practices having a commercial health plan. Generally, the characteristics of patients, lost demography of patients in terms of communication and the behaviour of the patient by the first line therapy initiation were all presented [17-19]. In terms of the trends in attrition rate and the overall treatment patterns, 5096 patients received first line therapy while about 2731 representing 53.65 received line therapy and 26.2% received third line therapy. Only 11.5% of the patients received the fourth line therapy and 4.4% received fifth line therapy. The common treatments used is the taxanes and the androgens receptor pathways inhibitors (ARPI). There was decrease inn the usage of ARPI with subsequent line. However, generally,43% of the patients received taxane having regimen

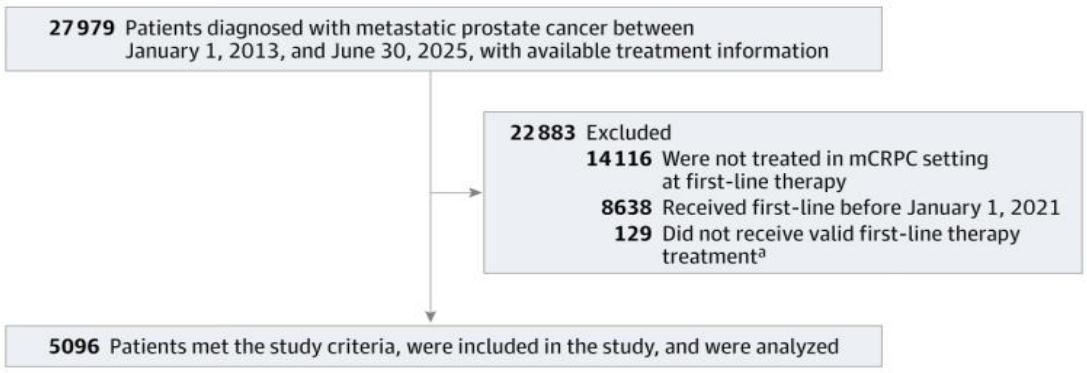


Figure 1: Patients flow diagram [15]

The androgen receptor pathways inhibitors used within the first line treatment was observed to have a significant variation in all the period of study, showing a decrease from 83.4% to 66.9% between 2021 and 2025 respectively. The fraction of patients that received Lu-177 for first line treatment was 2.2% which was 113 out of 5096. This varies significantly across the years increasing from zero of 1395 patients in 2021 to 25 of 248 patients in 2025 as depicted by Figure 3. The analyses revealed that half of the patients never received second line therapy, based on the fact that the attrition almost approached about 75% during the third line setting [20-22]. The most frequently used treatment was the ARPI during the first- and second-line settings [23]. Taxanes were mainly deployed in third- and fourth-line settings. Attrition rate was observed to be consistent compared as compared to the existing studies. attrition in metastatic castration resistant prostate cancer usually occur based on several reasons [24-25]. This could be the preference of the patient, toxicity, progression of the disease, financial stress or death from the disease and others [26]. Even if there is no death of patient, the impact of the disease as well as the treatment could result in increase in attrition. In fact, a study established that disease progressions and critical events represent the most common reasons for the discontinuation of treatment [27-28]. Thus, progression in the symptoms of the disease together with accumulated toxicity from the former treatments usually challenge patients to continue in another treatment therapy [29-30].

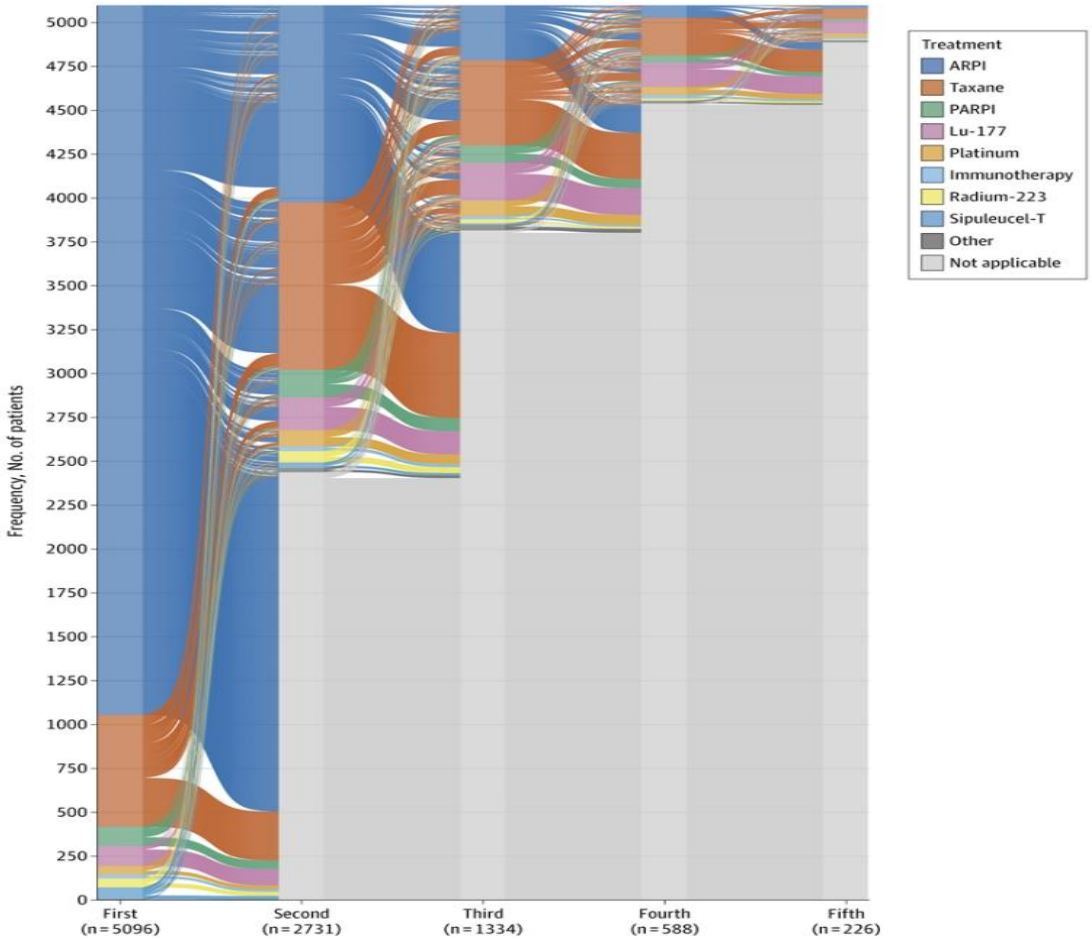


Figure 2: Variation in treatment patterns in first line through fifth line therapies in patients having the cancer [15]

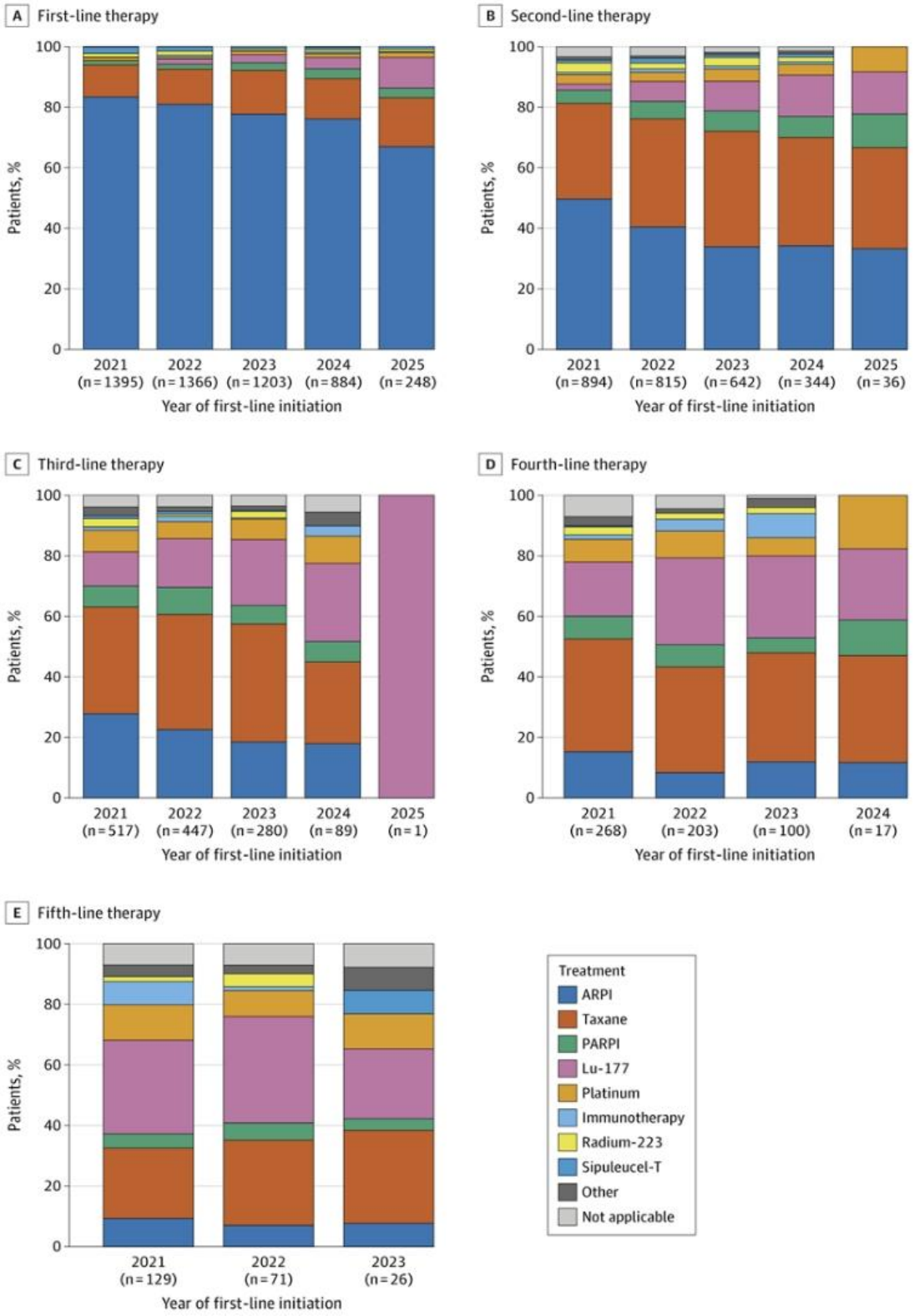


Figure 3: Treatment trends in first line through fifth line treatment for patients having the cancer based on the year of first line treatment [15]

Methodology

The study focused on a systematic review approach to identify literatures that are relevant to patient attrition in prostate cancer treatments programs in Africa. Relevant database was searched; Google Scholar, Scopus, PubMed and Web of Science using the selected keywords related to prostate cancer, treatment and patient's attrition. Studies on Africa were given ultimate priority. The results obtained on the study characteristics were analysed and discussed with inference drawn accordingly. Artificial intelligence techniques and their performance were also analysed and synthesised to evaluate the potentials for prediction and reduction of treatment attritions.

Prostate Cancer Treatment Programmes in Africa

Prostate represents a critical cancer related mortality across the globe especially the Sub-Saharan African regions. The countries in this region are known to operate under low and medium income, thus, making them to experience the burden of the disease. It was established that one barrier to this problem is the genetic factor and early diagnoses and treatment, thus, leading to the decreasing outcomes for patients in those marginalised regions when compared with the US. The available solutions in the form of therapies have been explored in the past years. The outcome of the impact of these therapies could help in managing the patients currently. Goals may need to be prioritised for drugs to be made available to treat the patients [31].

A review of the type of treatment administered by the United States food and drug administration was carried out for the disease. It was established that the treatment regimens may not be applicable in the sub-Saharan African countries due to the barriers to medication access, adequate follow up and scarce technological improvement that is required to diagnose and treat patients. It was revealed that abiraterone gave a significant benefit in the advanced stage of prostate cancer and well accepted [32]. Its combination with prednisone has shown significant survival outcome to patients in multiple stages and it is a new therapy that is available with the availability of generic options that is cost effective for treatment options.

Studies have equally established the same efficacy during the administering of low dose abiraterone when taken with low fat meal can result in cost savings when the drug is at lower dose. Both drugs were established to be meaningful clinically for patients in sub-Saharan Africa having a favourable and manageable side effect factor. In addition to this, there are meaningful benefits. But, its absolute benefit (abiraterone) as well as its ease of administration would favour its pursuit as an option to produce similar generation hormone therapy that could be available to patients in the marginalised areas [33].

The options of chemotherapy for treating the disease includes the cabazitaxel, docetaxel or their combination of the agents together with the next generations of hormone therapy. When it comes to the second generation antihydrogens, abiraterone together with prednisone has proved to improve the overall survival rate for patients having the disease. Indications were revealed later around 2012 of its application before chemotherapy based on the trial data, however, there was delay in the progression of the pain as well as life improvement [34]. Also, there was an expansion of abiraterone indication again so as to include patients having metastatic castrate sensitive prostate cancer based on the improvement in overall survival, radiographic PFS and the management of the pain. Generally, the therapy is well tolerated with only hypertension and hyokalemia as side effects. Apalutamide, enzalutamide and darolutamide have shown survival benefit for patients having the disease with enough tolerance with manageable side effect. All these drugs have been established to be good in several settings of the disease including the metastatic castration prostate cancer prechemotherapy, post chemotherapy as well as metastatic castrates sensitive during the initial diagnoses [35]. Patients which usually receive these

drugs have benefited both survival outcome and in quality of life as well as delay in pain. A typical study of the prostate cancer among men in Eastern cape, south Africa revealed that there was increase in the trend rate of prostate cancer using the mean age of 64 years and standard deviation of 9.9. the increase was observed to be from 7.4 to 12.6% between 2010 and 2017. Incidence of this was established to have vary in this region with the lowest of 4.5% for every 100,000 in 1998 to that of 21.4% per 100,000 in 2017. Figures 4 -5 depicts the age rate of cancer and the risk at different period.

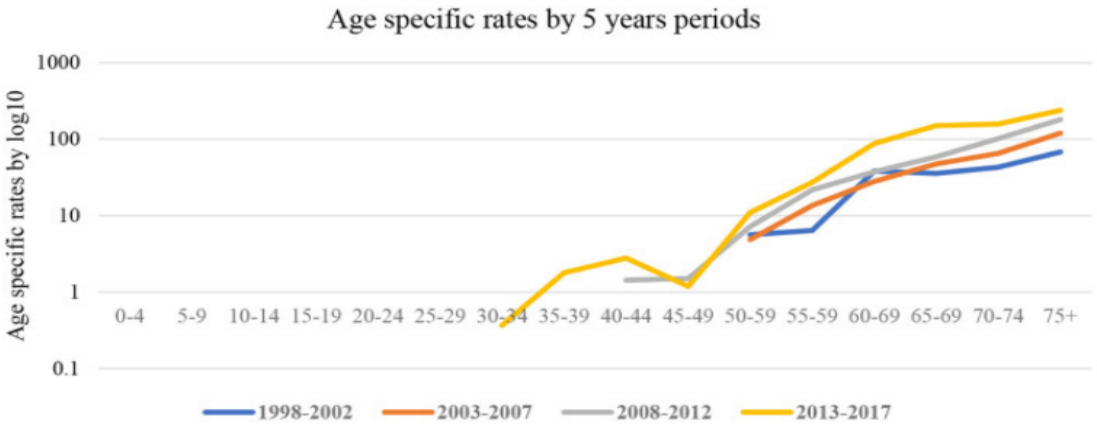


Figure 4: Age rate in four periods [36]

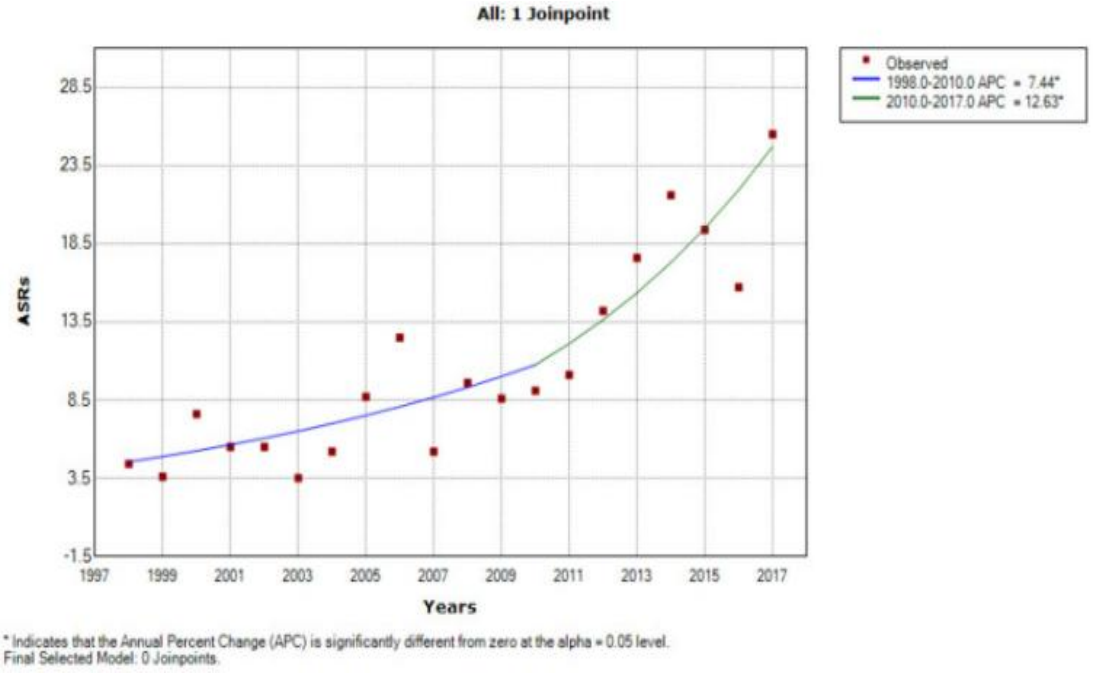


Figure 5: Risk of prostate cancer over time [36]

Prediction of Attrition in Prostate Cancer Patients using Artificial Intelligence

Artificial intelligence deploys machine learning models in analysing clinical data, demographic data as well as data obtained from side effect for the identification of prostate cancer patients which are at the risk of dropping off or stopping treatment. Attrition prediction is carried out through the forecasting of

toxicity with the aid of artificial intelligence models [37]. This is done by evaluating the baselines of the health, anatomy as well as the dosage of radiation so as to predict the side effects such as the fatigue that usually push the patients to end their therapy.

Also, it can be done through the socio-demographic mapping that involves using algorithm processes, socio-economic factors, travel distance to clinic and age to move vulnerable people that may not meet up with appointments. Also, there is adherence scoring in which the machine learning is capable of tracking visits missed, lab delay in real time to calculate the dropout risk cumulatively for personalised interventions [38]. Some of the clinical benefits of artificial intelligence include the deployment of the care team to use support services like counselling, financial aids before a patient stops care. Management of symptoms through proactive actions to treat side effect so as to improve their comforts and rate of completion.

Artificial intelligence has the potential to provide an innovative framework, in the past years, several systems have been developed which start from pattern recognition tools to a detail analytical structure with the potential of integrating diverse biomedical data. Artificial intelligence consists of machine learning such as random forest, deep learning that deploys convolutional neural network for image analyses [39]. When it comes to urologic oncology, convolutional neural network models have shown great performance in the detection of lesion and grading of Gleason on multiparametric MRI and also in the segmentation activities which usually need expert radiologist. Machine learning models have been very successful when it come to their applications in clinical and biochemical datasets to advance diagnostic and prognostic accuracy.

In terms of intraoperative support, deep learning models are capable in real-time segmentation of semantic of surgical videos, which helps it to identify the significant anatomical areas and assist with the tracking of instrument as shown in Figure 6 [40]. It was established that artificial intelligence systems are expected to behave as intelligent copilots in future helping to analyse surgical video stream so as to make provision for automated performance metrics, potential error detection and deliver real-life feedback on the approach. Such development has the capacity to standardise the performance of surgery, improve training and subsequent improvement in postoperative functional outcomes as well as the oncologic outcome.

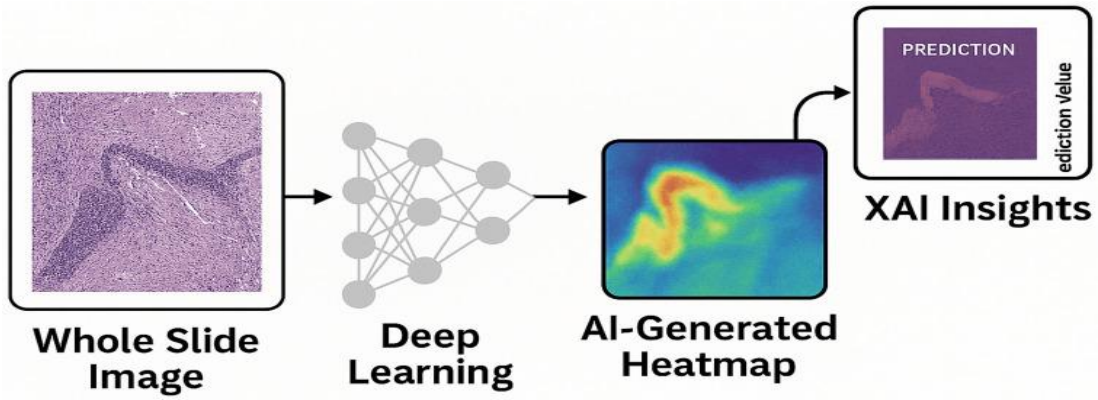


Figure 6: Deep learning structure in digital pathology [40]

According to a study by [41], in the area of prostate cancer management, machine learning models have been developed to analyse data objectively in the area of tumours, thereby helping the urologists to improve the efficacies of therapeutic solutions as well as forecasting clinical outcome, enables

healthcare providers to plan personalised treatment regimens to patients' profile as depicted by Figure 7.

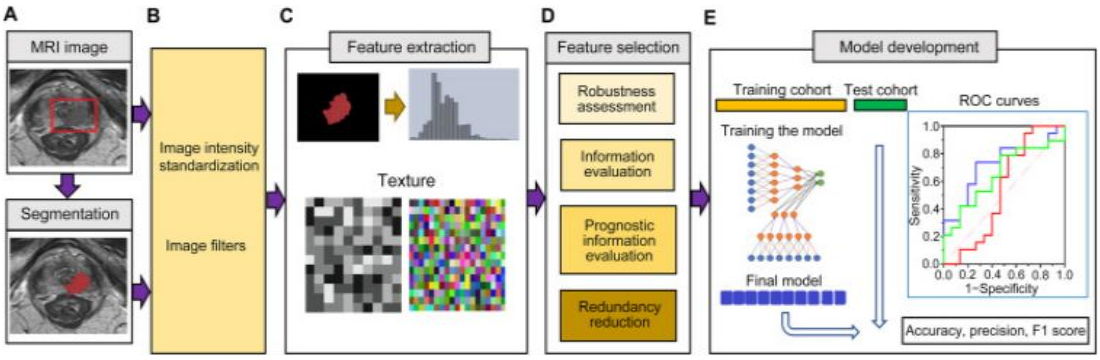


Figure 7: Artificial intelligence radiomic diagrams for primary prostate cancer [41]

Further validation of artificial intelligence models facilitates a more personalised solution in the management of multimodal treatments of prostate cancer. Figure 8 depicts the visual workflow of artificial intelligence applications right from the stage of diagnosis to treatment, showing the integration of artificial intelligence across the continuum of the patient.

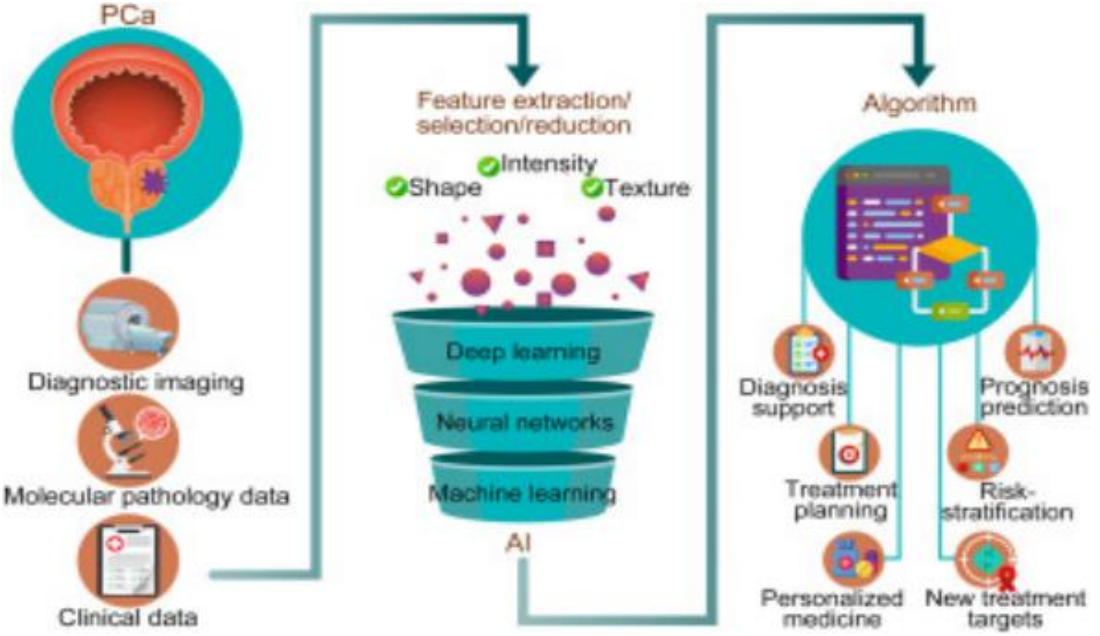


Figure 8 : Artificial Intelligence in Prostate cancer care [41]

The concept of multimodal artificial intelligence in urological oncology

Within the concept of multimodal artificial intelligence in urological oncology, there is a paradigm shift in the area of computational synthesis, heterogeneity, high dimensional datasets obtained from clinical variables with radiological, pathological, laboratories and molecular datasets to improve the accuracy of diagnoses, precision of prognostics and individual planning. This method, helps for the modelling of tumour biology, analyses of the disease evolution outcomes as well as advancement of the clinical implementations of precision urologic oncology as shown in Figure 9. The multimodal artificial

intelligence depends on cross domain characteristics interactions, helping a more diligent representation of the biological and clinical complexities of urological malignancy, with the inclusion of prostate, renal, bladder, testicular and upper tract urothelial cancers [42].

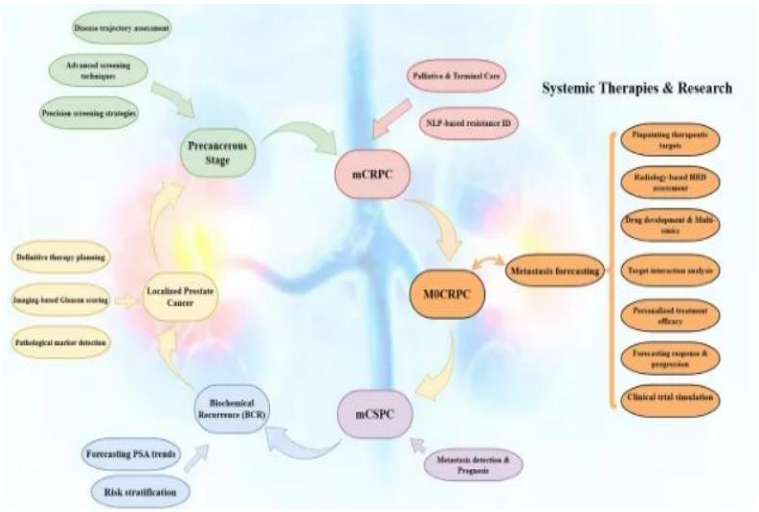


Figure 9: Multimodal Artificial Intelligence in precision urologic oncology [42]

Demonstration across the area of prognostics, diagnostics and treatment planning has been demonstrated by artificial intelligence in urologic oncologic [43]. Based on the complex nature of manual checks ups of nuclear segmentations and the broad intraclass disparities in histopathology images under high resolution microscopes, there is a need for the development of artificial intelligence-based approach in diagnostic uro-oncology and its integration into radiomic model using statistical and machine learning models [44]. Thus, contouring radiations targets, which is a significant step in prostate radiation oncology, to be accelerated automatically [45]. In prostate cancer, integrating the mpMRI derived prostate cancer endotype, histopathology, and genomic classifiers has importantly enhanced the detection of clinically significant prostate cancer that was protected biopsies and modified active surveillance procedures Figure 10.

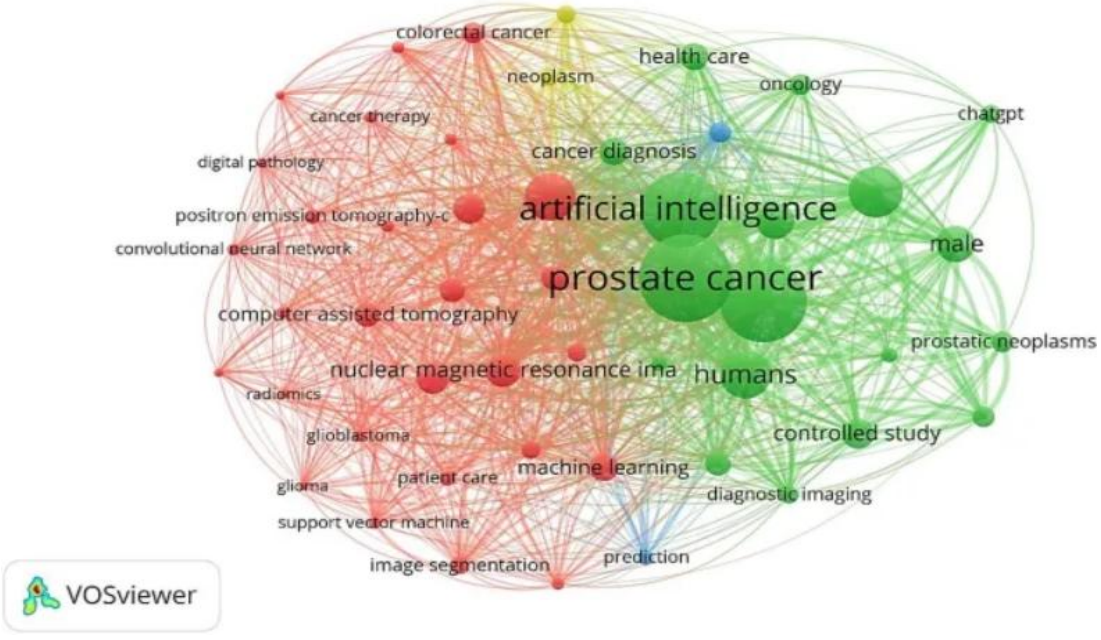


Figure 10: Application of artificial intelligence and emerging trends in Prostate cancer care [42]

Summary of Findings

At the introduction section, the use of patient data obtained from a broad multicenter database reflects the contemporaries in clinical practices. The data has the potential to inform the control of the selection of arms as well as the design of the trials for subsequent studies regarding the metastatic castration resistance prostate cancer settings. Some studies have limitations which include the nature that can be influenced through bias selection. In addition to this there was no characterisation of some data when it come to the foundation and clinical characteristics, preferences of the physicians, patients as well as the reasons behind attrition. Also, it was observed that that the patients in the study were basically US based which were treated using the community practices with health insurance that affects the generalisation of findings. The study described the treatment trends without the outcome of the treatment or the effect of the event data that may have impact on the sequencing of the treatment. It is also important to establish that an assessment of the predominance of prostate cancer among black men in a particular region in South Africa shows that trends vary based on geographical location. It was observed that it is high in the northern region compared to the South based on surveillance. It was found that there was increase in the disease in Lusikisiki from 4.4% per 100,000 to 53.4% having an annual increase of 20.4%. however, around Butterworth, there was decrease in incidence rate from 15.2 to 11.5%. artificial intelligence through the use of deep learning models represents a potential for transforming forces in the landscape of prostate cancer. It has shown that it carries potential to go beyond the limitations of the subjectivity of diagnoses as well generalised treatment procedures, especially through the improvement of the accuracy of diagnosis. The successful deployment of this technology is related to the precision uro-oncology.

Conclusion

Based on the study of patients having the metastatic castration resistance prostate cancer, it was found that half of the patients received second line therapy with a decline in subsequent lines. ARPIs taxane dominated the first line of the treatment. Regardless of the main therapeutic solutions, and the availability of several drug categories, clinical treatment approach in the disease showed substantial underuse as well as increased attrition. These outcome underscores the increasing complexities of the cancer disease care, revealed significant gaps in gaining access and sequence that may limit the effect of therapeutic innovations, with direct implication for health policy as well as designing the future clinical trials. Generally, abiraterone and prednisone combinations have good and manageable side effects with both clinical impacts. Prioritisation of the abiraterone as an option for treatment of patients is emphasised in sub-Saharan African countries. It was established that there could be change in cancer profiles and the increase in cancer incidence around the Eastern cape were observed in the area and the cause of the increase is attributed to the aging population and other risk factors. Therefore, investigation of the risk factors is significant with the inclusion of monitoring of important areas. From the studies reviewed, it was observed that ethical and equitable integration of artificial intelligence in uro-oncology requires interdisciplinary collaborations pathologists, urologists and radiologists as well as data scientist and radiation oncologist. The prioritisation of adequate validation, transparency of explainable artificial intelligence and detail regulatory oversight, its potentials can be harnessed by the medical community to deliver a standard, efficient and patient centered prostate cancer care. In general, artificial intelligence predictive models has the potential to provide a significant solution for the early identification of prostate patients at risk of attrition, helping to target solutions, improvement in continuity of treatment and better outcome.

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