The Impact of AI in Breast Cancer

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Intro

About 10 million deaths globally are the result of the widely known disease, cancer (Morgan, 2024). Cancer is one of the most prominent diseases of today, having a recorded number of 609,820 cancer related deaths occurring within the United States during the year of 2023 alone (Siegel et al., 2023). One of the most common forms of cancer in women (See figure 1) is cancer of the breast which holds responsibility for the most cancer related deaths in women (Akran et al., 2017). Breast cancer alone was reportedly present in 272,454 women as of 2022, resulting in the death of 42,211 women (CDC, 2024). Cancer is a result of irregular cell growth, in many cases, resulting in failure of functional organs leading to death if left untreated (Hausman, 2019). Despite exacerbated efforts to manage such a globally fatal illness, it's estimated that Americans retain a 40% chance of developing cancer during some point in their life (Weintraub et al., 2024). Cancer remains a lingering factor in American mortality rates due to the variability and mostly unpredictable activity of cancer making it difficult to effectively produce treatment that is accessible to numerous cancer patients (Chakraborty et al., 2012). Even in a single type of cancer, such as lung, breast or skin, a patient's reaction to treatment remains variable, dependent upon cancer type, hereditary factors, physical health, etc (Stein et al., 2008). The primary forms of traditional treatment remain, surgery, chemotherapy and radiation therapy (Gersten et al., 2023). These forms of treatment, however, are not guaranteed cures and are only accessible to certain patients, depending upon your cancer type, genetics and medical history (Debela et al., 2021). More modernized treatment types are consistently being developed, including methods such as immunotherapy, targeted drug therapy and gene therapy (Gersten et al., 2023). These methods of treatment target the cause of a malignancy and aim to eradicate or replace the problem through intravenous insertion of altered genes or developed drugs each specific to a patient (Debela et al., 2021). These radical treatments are highly efficient, however, oftentimes the insertion of a vector can cause detrimental side effects as a result of violent immune reaction to the foreign invasion or even from accompanied damage to healthy cells (Horn et al., 2024). Not to mention one of the largest contributing factors to the limited data and treatment options available for high risk cancer patients is the extensive economical impact it has (Saltz, 2015).

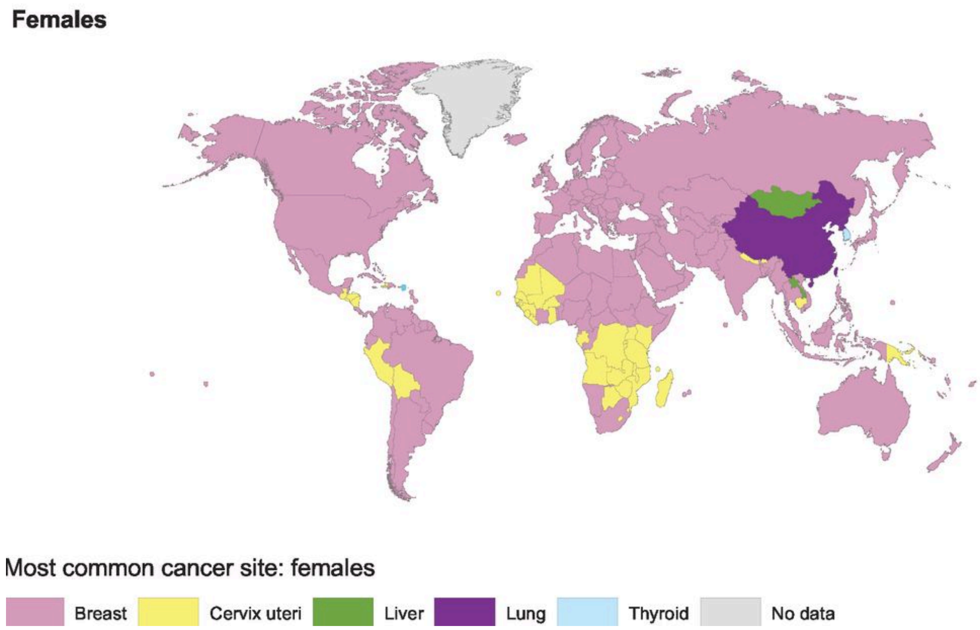

Figure 1. Most Common Cancer in Females Globally
The pink highlights represent areas at which breast cancer is the most commonly diagnosed cancer type (Torre et al., 2016).

Breast cancer is a result of cell abnormality usually within the lining of the ducts or lobular glands of the breast (Katsura et al., 2022). There are numerous types of breast cancer which are defined by the origin and activity of the cancer (Weigelt et al., 2010). The most common of these types include invasive ductal carcinoma (IDC), the most common subtype, invasive lobular carcinoma (ILC), ductal carcinoma in situ (DCIS) and triple negative breast cancer (Weigelt et al., 2010). DCIS and IDC can be differentiated by IDC's malignancy, though both share a location of development within the ducts of the breast (Weigelt et al., 2010). Triple negative breast cancer is a fast growing invasive form of breast cancer and is often common in those who inherit a BRCA gene mutation. This form of breast cancer is not characterized by its location, having the ability to develop in the ducts, lobules or tissue, but instead by its inability to express three major receptor proteins which enable immune responses, making it increasingly more difficult to treat with developed drugs or hormonal therapies (Yin et al., 2020). Breast cancer can be present in women and in very rare cases, men, having 99% of recorded breast cancer cases occurring in women making it increasingly less likely for men with breast cancer to get diagnosed during earlier stages (Zehr, 2019). Early stage detection is extremely significant in the type and efficiency associated with the treatment received (Asangaedem et al., 2019).

There are a numerous amount of impactful conditions that contribute to an increased chance of developing cancer. These conditions often result in actions regarding secondary prevention techniques, a form of preventative measure taken prior to a direct diagnosis of breast cancer after an identification of potentially cancer causing traits (Kisling et al., 2023). Other preventative measures include primary prevention such as breast exams, which occur prior to any signification of cancer, and tertiary prevention such as chemotherapy, surgery, and radiation, which occurs after a diagnosis of cancer (Kisling et al., 2023). One of the most prominent of these conditions is the BRCA gene mutation, inherited by about .3 percent of the population, disposing them to an increased rate of breast cancer development, giving them an

85% chance of developing breast cancer compared to the average women's 12% chance. (Balmana et al., 2011).The BRCA gene is a tumor suppressor gene responsible for regulating tumor growth and repairing DNA breaks in order to prevent cancer development (Hu et al., 2020). A mutation in this gene or an inheritance of a mutated BRCA gene can prevent tumor suppression, increasing a person's disposition to both ovarian and breast cancer. This gene is such a heightened risk that many of the carriers of this mutation receive prophylactic mastectomies, a form of secondary prevention in which the breast is removed prior to a diagnosis of breast cancer, having an estimated 93% reduced risk of breast cancer development (Euhus, 2015). In addition, a condition named LiFraunemi Syndrome is the result of an inheritance of a mutation to the TP53 gene, responsible for developing functioning tumor suppressing proteins (Correa, 2016). An inheritance of LiFraunemi Syndrome causes extensive malignancy and an inheritance within women results in a near guarantee of developing breast cancer (Correa, 2016). Another rare hereditary condition includes HNPCC (Hereditary Non-polyposis Colorectal Cancer), also known as Lynch syndrome, which is an inheritance of mutation in the gene regulating the repair of DNA mismatching (MMR genes) leading to a heightened risk of developing cancer especially at a younger age (Win et al., 2013). This mutation increases the rate of cancer, not only of the colon but of stomach, pelvis, brain and notably the breast (Win et al., 2013).

For the diagnosis of breast cancer, a leading contribution to diagnosis in later stages is inaccuracy in mammogram evaluation (Timins, 2005). Mammograms are effective screening methods which examine the tissues and glands of the breast through imaging and are used to detect harmful lesions or signs of malignancy among the breast (Zhou et al., 2023). Mammograms are one of the most prominent examples of primary prevention of breast cancer. A large aspect contributing to the inaccurate diagnosis of breast cancer is the false negatives and positives associated with readings from mammograms (Nelson et al., 2016). Mammograms are the identifying factor in breast cancer detection and false negatives are extremely common due to the lack of prevalent signs of cancer revealed within a mammogram leading to oversights that can deter detection (Gandomkar et al., 2023). Many women, as a result, are being diagnosed during later stages of cancer, when treatment is harder to implement (Hickey et al., 1976). Diagnosis for breast cancer is a prominent conflict due to the large numbers of women who are at high risk to develop cancer. The increasing chance that someone could develop breast cancer is related to harmful environmental aspects and characteristics of a person's health and genetics (Obeagu et al., 2023). Despite this, minimal actions have been contributed to the environmental aspect relating towards the increase in cancer formation (McGuinn et al., 2011). To treat types of breast cancer tertiarily, immunotherapy methods are commonly used, exploring the use of developed immune infiltrates to aid in the bodies detection and destruction of malignant cancerous cells (Zhang et al., 2020). When using immunotherapeutic methods to treat breast cancer, many methods prove ineffective due to current difficulty in approximating the immune environment of the cancer based on classification of breast cancer (Onkar et al., 2023). When treating cancer, the classification system used to determine treatment options lacks the ability to incorporate efficient factors to identify treatment plans, making developed infiltrates difficult to use in reference to the large specificity associated with cancer type (Onkar et al., 2023).

When considering how these factors contribute to the rise in cancer mortality, more modernized approaches can be incorporated, including approaches that utilize tools such as artificial intelligence or AI. AI is a computer based technology developed to emulate human thinking and reasoning. When using AI in medicine, there are numerous models which can be employed including a subset called Machine Learning (Rahul, 2015). Machine learning models rely on a set of data used to derive predictive abilities based on pattern recognition (Rahul, 2015). A prominent form of machine learning in the medical field is called supervised machine learning (SML) where the input of data is labeled and algorithms used are applied towards new data to identify patterns based on learned relationships from labeled inputs (Rahul, 2015). Another form of prominent artificial intelligence is the subset of deep learning which utilizes artificial neural networks to derive information from data as opposed to sets of data. These models can be used to determine abnormalities within mammograms in addition to readings done by radiologists to produce more accurate results (Lang et al., 2023). While maybe not socially acceptable or reliable enough to be used alone, in addition to trained specialists, SML models can screen patient mammograms to compare against radiologists for any lesions or abnormalities that could have been overlooked (Lang et al., 2023). With relation to prevention, SML algorithms can be contributed towards the identification of harmful environmental asbestos resulting in a reduced exposure to cancer causing substances in the air (Iida et al., 2021). While asbestos in the air contributes to a development of breast cancer, the largest contributing factors remain a person's lifestyle and genetics. Hereditary factors contributing to the development of breast cancer, such as the inheritance of a mutated BRCA gene, can also be improved through the use of a SML. Many developing models have the ability to assess the mutability of high risk genes and identify patients at high risk of developing cancer based on specific patient characteristics (Nero et al., 2022). When treating breast cancer the idea that specificity cannot be calculated and predicted, SML modes can be incorporated for predictive analysis of the body's reaction to certain treatment forms and has the ability to example which patients are qualified for developed and effective infiltrates, resulting in an approach at precision medicine and specific treatment plans for individual patients (Jin et al., 2023).

This review gathers data on a futuristic approach at the incorporation of deep learning AI models within the field of medicine relating to the improvement of prevention, treatment and diagnosis of breast cancer. This review will explore the current conflict relating to the ethical and medical complications that are associated with the use of AI in medicine, along with the prospects of using an AI in comparison to a standardized doctor.

Methods

Articles, using PUBMED, were searched with relevance to machine learning and breast cancer treatment, prevention and diagnosis. Around 100 studies were identified and reduced to 40. The articles included were limited to those which utilized machine learning, prioritizing supervised machine learning and deep learning models, in their studies. Included articles were peer reviewed and published after 2010. Studies which focused on cancer including, but not limited to, breast cancer were incorporated if findings were applicable to research in breast cancer as well.

Excluded articles were those published prior to 2010 and focused more on unsupervised machine learning than supervised. Articles were mainly studies or clinical trials, omitting any literature reviews from the data. Articles which were not peer reviewed and detailed learning models other than deep or machine were excluded. The remaining 40 articles were grouped based on relevance in treatment, prevention, diagnosis and futuristic application of breast cancer using artificial intelligence models.

Results

Prevention

Carcinogens, cancer causing substances, have inspired numerous studies and programs all with the objective of identifying carcinogenic agents in attempts to reduce their exposure (Cogliano et al., 2004). A study utilizing the AI, Metabokiller was developed to accurately identify carcinogens at a higher rate than existing methods of identification (Mittal et al., 2022). This model is based on the combination of 6 separate machine learning classification models, each having been fed information of varying carcinogenic factors such as anti apoptotic properties, proliferation, genomic stability, oxidative stress, electrophilic properties and epigenetic modifications (Mittal et al., 2022). Metabokiller effectively applies each machine learning model to identify compounds which resemble provided carcinogenic traits (Mittal et al., 2022). To test its accuracy, Metabokiller examined numerous potentially carcinogenic human metabolites and accurately determined predictive insight into the rate of carcinogenicity (Mittal et al., 2022). Due to its ability to accurately detect carcinogenic factors in universally available compounds such as drugs or common medicines and analyze the predictive rate of carcinogens, Metabokiller is largely applicable towards developing prevention methods (Mittal et al., 2022). Similarly, a study focused on the use of the platform ProTox-II, demonstrates a predictive ability to determine a compound's carcinogenicity (Banerjee et al., 2018). ProTox-II utilizes machine learning algorithms which are provided with chemical structures with identified rates of toxicity (Banerjee et al., 2018). Using this data, the machine learning model is able to comparatively output the acute toxicity levels of a compound provided which in turn can be used to identify median lethal dosage and carcinogens present (Banerjee et al., 2018). ProTox-II's ability to conclude a toxicity review and their potential in tumor inducing traits is applicable towards preventative measures, contributing to a reduced rate of toxicity in medical and food company products (Banerjee et al., 2018). Through the use of ProTox, breast cancer can be overall prevented with a general decrease in carcinogens in modern medicine.

Another common carcinogen, other than those found in compounds, are atmospheric asbestos which exist as mineral fibers in the air (Yamamoto et al., 2024). The inhalation of such fibers are a contributing factor in breast cancer since fibers can easily permeate towards the chest and breast tissue (Yamamoto et al., 2024). A study developing the AI, Mask R-CNN, explores atmospheric detection of asbestos through the isolation of fibers from provided samples of asbestos (Yamamoto et al., 2024). Mask R-CNN is an instance segmentation model, a type of deep learning AI, which utilized 10 slides of asbestos sampling to identify and isolate toxic fibers from the original image to further classify such fibers as toxic or not (Yamamoto et al., 2024). This study also developed a semantic segmentation model, MA-net to compare to the Mask R-CNN to determine the most accurate and beneficial method of isolation (Yamamoto et al., 2024). Each deep learning segmentation model is aimed towards classifying each pixel in the provided sample and determining the extent of toxicity of fibers (Yamamoto et al., 2024). The MA -net was determined to more accurately determine the differing features of varying fibers during classification (Yamamoto et al., 2024). Additionally, a study which developed a deep learning model called AI-SEM, performed a similar experiment for fiber detection (Yamamoto et al., 2024). Through the utilization of such models, areas with high concentrations of asbestos can be altered to maintain materials such models determine are less carcinogenic (Iida et al., 2021). Similar to the previous study, this study aims to develop a method at which a machine learning program can assist in fiber detection along with microscopy equipment which was achieved through firstly providing scanned images to the deep learning machine then allowing for the machine learning model to detect fibers (Iida et al., 2021). Results of both were compared and shown that the deep and machine learning models were able to scan increasingly more rapidly, though, it was observed that such models and the analyst shared high conclusive agreements, with the AI having much more false negatives and positives which could assumably be overcome through extensive training data (Iida et al., 2021). However, the common PCM method also pertains to a low accuracy rate at a much more tedious speed (Iida et al., 2021). This study contributes to the previous idea of asbestos and fiber reduction in a known atmosphere (Iida et al., 2021). With more rapid and accurate asbestos counting by AI machinery, more environments can be tested for fibers, reducing the amount of unsafe work environments and carcinogens workers are exposed to.

Alternatively, prevention can be approached through the lens of risk assessment, using methods which prioritize the assessment of variation probability to allow for preventative treatment methods to be used prior to such harmful mutations (Senturk et al., 2021). A study utilizing varying models of artificial intelligence, including deep and machine learning, were applied towards the prediction of variations in high risk breast cancer inducing genes (Senturk et al., 2021). Varying patient data was assessed and inputted towards a logic based deep learning model which classified features based on pathogenicity and the malignancy of a tumor (Senturk et al., 2021). This provided a 995.5% success rate in comparison to a machine learning AI which predicted risk scores with a 99.9% rate of accuracy with the same inputted data (Senturk et al., 2021). This study examples detection and prediction abilities primarily focused on the mutation of the BRCA1 and BRCA2 genes (Senturk et al., 2021). This heavily encourages more accurate detection of breast cancer, seeing as those with mutations in their BRCA gene are at high risk of contracting breast cancer, this study demonstrates the accuracy of artificial intelligence assessments in the field of larger data sets. In addition, a study was conducted utilizing a deep learning model and whole slide images (WSI) inputs of tissue to output a predictive mutational analysis in the BRCA gene (Nero et al., 2022). Their deep learning model, CLAM, is trained with a large dataset of BRCA mutated tissue samples to determine genomic characteristics of mutation (Nero et al., 2022). CLAM was able to extract basic differences in tumor cells though was unable to produce optimal accuracy readings on tumor tissue cells, providing insight into ideas of tumor regions for extraction in the future (Nero et al., 2022). CLAM can be used to characterize genetic traits for predictive somatic mutations allowing for more personalized and radical treatment options (Nero et al., 2022).

Finally, prevention can be relevant when applying the risk of treatments and their differing effect on patients based on genomic structure to predictive methods (Iwamoto et al., 2020). A study highlights the differential breast cancer subtypes and their varying reactions to separate chemotherapeutic and hormonal treatments providing means for a separate biomarker for each breast cancer subtype (Iwamoto et al., 2020). The tests utilized to identify genomic signatures in their relation to low or high risk can be used to determine a patient's prognosis in relation to chemotherapy (Iwamoto et al., 2020). For the prevention of cancer recurrence of the breast, both post and pre operation, testing and extensive treatment are necessary to confirm the lasting effects (Iwamoto et al., 2020). A study performed utilizes a deep learning model for the prediction and assessment of a person’s tumor microenvironment (TME) for an estimated total of 300 patients (Jiang et al., 2023). The deep learning model showed an increasing improvement in prognostic accuracy of a TME which holds large significance in a person’s response to certain therapeutic cancer treatments (Jiang et al., 2023). The AI evaluates radiological images to construct a prognostic on the TME’s status and classify the predictive status into negative and positive reaction results towards chemotherapeutic treatment and combined immunotherapy treatment forms, outperforming clinical prognostics (Jiang et al., 2023). This deep learning model's accuracy in classification of treatment prosperity demonstrates a form of prevention against utilizing harmful and cancer causing treatment methods (Jiang et al., 2023).

Also addressing the assessment of treatment risk, a separate study uses a deep learning model to predict beneficial combination and utilization of treatment forms based on differential risk factors (Howard et al., 2020). This study demonstrates that machine learning identifies and customizes the ideal adjuvant treatment after surgery for a specific individual regarding age, cancer type and HPV status (Howard et al., 2020). Although significantly more accurate than past adjuvant therapy which wasn't personalized to this extent, the machine learning model is not capable of implementing ideals such as smoking history, diseases, hereditary factors etc, like a trained professional could (Howard et al., 2020). This source in particular provides the information needed for the preventative treatment used against breast cancer after the tumor has been removed (Howard et al., 2020). Once adjuvant therapy is needed, this model can be used to customize one which could better and more accurately eradicate the cancer for lower chances of recurrence (Howard et al., 2020). The utilization of adjuvant chemotherapy is prominent and similarly described in a separate study which also incorporates a deep learning model to determine peritoneal recurrence through the assessment of CT images and their predictive survival in accordance with chemotherapeutic treatment (Jiang et al., 2022). Peritoneal recurrence is the pattern determinant of a recurrence of gastric cancer (Jiang et al., 2022). The deep learning model outputs a highly accurate assessment of recurrence and association of risk factors with the use of chemotherapy to allow for improved levels of disease free survival (Jiang et al., 2022). Results of patients with predicted low rates of Peritoneal recurrence were shown to have little to no improvement when applied towards chemotherapeutic treatment allowing for the deep learning model to better classify into beneficial response to treatment (Jiang et al., 2022). While this study is applicable directly to the prediction of recurrence of gastric cancer, these results can similarly be used for the assessment of any cancer indicating pattern such as a BRCA gene mutation as well (Jiang et al., 2022).

Treatment

A key component in the treatment of such prominent forms of cancer such as breast cancer is chemotherapeutic treatment that, while highly effective, can have unpredictable side effects on each patient (Gersten et al., 2023). A study analyzes the prominence of both deep and machine learning AI models in the field of predictive model response for the treatment of chemotherapy (Russo et al., 2022). Through the use of a combination of radiomic data and genomic information derived from various patients, both deep and machine learning models were able to output accurate and applicable data towards chemotherapeutic treatment (Russo et al., 2022). Both models were shown to provide the ability to discriminate between genomic characteristics for indication of response versus non response to treatment to an overwhelming accuracy (Russo et al., 2022). This study demonstrates a more cost effective and noninvasive analysis for outcomes in relation to chemotherapy and combination therapy with targeted drugs as well (Russo et al., 2022). Chemotherapy treatment was also the basis of a study focused on a machine learning mode based on an AI rainforest (RF) algorithm which could predict the effective recurrence of breast cancer after neoadjuvant chemotherapy (Jin et al., 2023). The clinical pathology data from breast cancer recurrence and stable disease occurrence post treatment were gathered to train RF to analyze tumor recurrence, secondary tumor formation and overall fatality (Jin et al., 2023). RF was shown to have outperformed traditional methods of prediction using logarithmic recession in both long term and short term breast cancer stages with higher accuracy (Jin et al., 2023). RF provided impressive predictive success when providing predictive analysis of patient reaction to neoadjuvant chemotherapy post treatment (Jin et al., 2023). Breast cancer is high in malignancy, allowing for RF to provide safer reassurance of low rates of recurrence and allow for those with higher rates of recurrence to be heavily monitored for safer and earlier treatment (Jin et al., 2023).

Another common treatment form includes surgery and/or radiotherapy which could also be classified as locoregional therapy (Kaidar-Person et al., 2023). A study conducted utilizing a cloud-based AI program (CINDERELLA) to assess a patient's tumor data to output imaging to provide a graphic aspect to the informed consent of treatment (Kaidar-Person et al., 2023). This study incorporates a radical approach to shared consent on selected treatment forms by allowing for an alternative form of comprehension to be provided through developed graphics (Kaidar-Person et al., 2023). This study aims to directly compare a patient's respected expectations of treatment prior and after graphics were provided and apply that towards patient treatment decisions. This study was also designed to compare imaging to treatment outcome for accuracy readings (Kaidar-Person et al., 2023). CINDERELLA was shown to be a cost effective tool efficiently used to improve patient quality of life through the more intensive application of informed consent and comprehension of future treatment outcome (Kaidar-Person et al., 2023).

One of the most radical forms of cancer treatment is immunotherapy treatment which, however, regards highly variable response based on patient type and cancer (Sinha et al., 2024). A study focused on Immune checkpoint inhibitors (ICI) with ability to identify biomarkers for use in patient treatment plans, utilizes a machine learning program to predict response to treatment while also providing survival rate (Sinha et al., 2024). This study incorporates medical imaging, PET scans, immunohistochemical markers and patient genomic data for personalized assessment of patient response which was also affected by the learned metrics included in the learning algorithm (Sinha et al., 2024). The machine learning model was shown to identify an accurate patient response assessment without the use of an invasive biomarker test (Sinha et al., 2024). The conclusion drawn showed that the machine learning model was successfully able to integrate diverse sets of data to output accurate readings of patient response but the data provided example difficulties in application towards clinical practices (Sinha et al., 2024). Immunotherapy, however, is extensively diverse in application while also selective . A study illustrates the emerging technique of checkpoint inhibition immunotherapy for targeting and mutating cancerous cells to allow for the immune response to be more effective which is only applicable to certain cancerous cells (Chang et al., 2024). The development of a machine learning model, LORIS, which incorporates aspects of patient data into learning was shown to produce results with higher accuracy than others (Chang et al., 2024). While existing methods of testing such as biomarkers and testing are usable, this study tested the accuracy of a machine learning system’s ability to assess a patient's compatibility with selective but effective immunotherapy drugs (Chang et al., 2024). Using patient medical data, LORIS showed accuracy in determining a rate of patient survival response (Chang et al., 2024). This study assesses a separate approach to treating cancer using sensitive immunotherapeutic treatments through the use of a machine learning system to evaluate a patient’s personal response rather than based on subtype and imaging (Chang et al., 2024).

Another study focused on ICI differs from the previous through the incorporation of deep learning models to resolve patient selection in addition to the studied supervised machine learning models, and through the application of these models to the development of new biomarkers to aid in the process of immunotherapy checkpoint inhibitors rather than predict survival rate (Prelaj et al., 2023). Both models in the study were provided with labeled data including imaging and genomic signatures to be applied towards the development of biomarkers and the identification of usable biomarkers (Prelaj et al., 2023). The study goes more in depth towards the usage of genomics towards deep learning to allow for gene identification, radiomics in ML for analyzing radioimaging and health records to allow for more personalized treatment planning which While immunotherapy drugs many have been developed and effective, not many patients are eligible and development is difficult and slow (Prelaj et al., 2023). With the usage of deep and machine learning programmes a personalized immunotherapy drug can be developed without the excess time or risk (Prelaj et al., 2023).

Similar to immunotherapy drugs, target drug therapy was used as a basis for a study utilizing a machine learning model, PERCEPTION, to assess cancerous cells using single cell expression profiles to determine their respective response treatment (Sinha et al., 2024). A common concern when using immunotherapy drugs is the risk that the patient is unresponsive or develops immunity, especially when trained oncologists select patients based upon tumor cell data and not precise analysis (Sinha et al., 2024). PERCEPTION has the capability to predict an individual cell's response to the drug based upon information RNA sequencing data input and responsive versus unresponsive cell data for algorithmic machine learning (Sinha et al., 2024). When screening for patients eligible for experimental and highly effective drugs to treat breast cancer, AI machine learning programs are shown to have the ability to detect the single cell total responsiveness with high accuracy (Sinha et al., 2024). PERCEPTION showed high accuracy in determining cell response to targeted therapy specifically in two clinical trials focused on breast cancer (Sinha et al., 2024).

Precision medicine is the specific treatment plans that can be developed for a patient based on their personal clinical data for optimal outcomes and response to treatment (Alarcón-Zendejas, et al., 2022). This study focuses on novel biomarkers being applied towards both machine and deep learning models, including markers with the ability to detect variants in the BRCA gene and provide targets and personalized treatment plans in accordance with detection (Alarcón-Zendejas, et al., 2022). They provide insight into novel biomarkers such as non-coding RNAs with the potential for prognostic and diagnostic applications in bodily fluids due to their tissue specific expression in pathways along with biomarkers such as repetitive DNA sequencing with high diagnostic accuracy (Alarcón-Zendejas, et al., 2022). The study goes into further detail on deep learning machines involvement in biomarker research through algorithm pattern recognition used to analyze imaging data and provide higher rates of prognostic accuracy (Alarcón-Zendejas, et al., 2022). This study develops the idea that AI, in accordance with biomarkers, can assess the data more accurately than specialists to provide more effective treatment plans because of its unique ability to produce precision medicine treatment plans based on patient genomic data with heightened accuracy (Alarcón-Zendejas, et al., 2022). Another study which focuses on the development of precision, utilizes an AI which assesses imaging such as MRI's and CT scans to profile molecular biomarkers through noninvasive techniques to allow for smoother evaluation of treatment for breast cancer subtypes (Fu et al., 2024). Studies were conducted using radiomics and deep learning methods to extract features and patterns exhibited in data for assessment based upon ultrasound imaging (Fu et al., 2024). This led to classification of biomarkers prior to surgical procedures which then proved deep learning to have heightened accuracy (Fu et al., 2024). For breast cancer, numerous subtypes have been identified, further altering treatment practices, though molecular biomarkers are able to indicate proper steps to be taken towards illustrating a precision medicine personalized treatment plan (Fu et al., 2024). AI, such as the deep learning model provided in this study, example a more cost effective and medically less invasive process with high accuracy to allow for a prediction of breast cancer subtype, further aiding in the development of a specific treatment plan (Fu et al., 2024).

This source in depthly analyzes precision medicine as a goal to tailor treatment to patients selectively and how deep learning algorithms are able to accurately screen and utilize medical data to provide a comprehensive overview of the risks of recurrence and specific treatment options (Chen et al., 2021). Immunotherapy drug biopsies which allow for an insight to a patient's compatibility (still providing expense and side effects without complete accuracy) can be combated with deep learning usage to review pathology and radiology reports to be able to express more accurate conclusions (Chen et al., 2021). In addition to this, deep learning was shown to accurately determine areas of risk during radiotherapy providing a comprehensive outline of the tumor allowing for a more beneficial treatment plan (Chen et al., 2021)

Diagnosis

The most important step in the journey of breast cancer detection is the mammogram, an X-ray of the breast which, after careful consideration by a trained oncologist, can be used to directly determine an occurrence of breast cancer (Lang et al., 2023). While this step is significant, it is regarded with extensive false negatives and positives due to fault within the judgment of radiologists (Lang et al., 2023). A study In breast cancer detection uses a machine learning algorithm which is learned using varying mammographic labeled data for a more broad information set of comparison when further applied to patient screening for detection. Using an ML model to screen mammographic images was shown to enhance detection due to minor abnormalities constituted by screenings performed by medical professionals. ML systems were shown to reduce the amount of false positives, decrease the number of biopsies and better predict the chance that a woman may conduct breast cancer. This was largely the result of the system's confirmed ability to example screening abnormalities and mutations to a greater degree of accuracy for a cheaper and faster approach. This study’s objective was to outline a well trained ML model’s ability and use towards breast cancer detection, findings included security in cost, time efficiency and improved accuracy which should be further researched using a broadened database.

To execute this process, a study uses deep learning and machine learning algorithms and applies them towards the screening of mammograms to output a breast cancer diagnosis in populated-based randomized trials of high risk patients in comparison to radiologist based double readings (Lang et al., 2023). The system assessed mammograms and determined malignancy using patterns and abnormalities gathered from data using deep learning methods (Lang et al., 2023). The deep learning algorithm categorized rate of malignancy based off of a 10 ranged score with women scored from 8-10 provided with marks from detection for radiologists to assess further along with AI produced risk scores accompanied by every screening (Lang et al., 2023). These screenings were compared to those of traditional evaluations and determined accurate results in reference to false negatives/positives with a determined lowered screen reading work load (Lang et al., 2023). Findings concluded that the use of a deep learning algorithm for screening is relatively safe and in proximity of accuracy to double readings performed by radiologists (Lang et al., 2023). In a similar study, another deep learning system was applied to determine proximal accuracy in breast cancer detection through scanning of mammography screening in comparison and addition to radiologists and biopsies (Freeman et al., 2021). The study utilized a deep learning CNN to assess any bias associating with usage along with the effectiveness of a single assessment, for classification and as an aid to radiologists (Freeman et al., 2021). The system is provided with digital mammograms or in test sets to conclude an overall assessment of malignancy (Freeman et al., 2021). The study exemplified DL CNN's inability to come to a completely accurate consensus alone, though demonstrated its ability to provide adequate aid and ability to triage mammograms with heightened sensitivities (Freeman et al., 2021). This provides an idea that for diagnosis and detection, deep learning systems are useful in addition to traditional readings for heightened accuracy and increased detection, though should not be utilized for breast screening alone (Freeman et al., 2021). Findings determined that with a more vast learning data set, other learning systems can exhibit higher rates of success as an aid, though for detection, is extremely prevalent when classifying cancer type due to the large data set and pattern recognition available in modern machinery (Freeman et al., 2021).

A study utilizing ScreenTrustCAD system was similarly used to compare prospects of double reading between combinations of screening between an independent deep learning system and two radiologists (Dembrower et al., 2023). This study, however, utilized a combination of radiologists and an AI for comparison rather than a separation of the two (Dembrower et al., 2023).The system was provided with the same screening as two independent radiologists and screening for abnormality was run during the first stage of radiological workflow alongside radiologists (Dembrower et al., 2023). If any of the three parties came to a conclusion of abnormality, examination followed through to a consensus study for which the DL system's conclusions were made readily available to radiologists to reach a conclusive decision (Dembrower et al., 2023). This process was repeated with varying combinations of two radiologists and a system with all outcomes recorded for comparison. (Dembrower et al., 2023) The study conducted readings of over 55,000 women having readings performed by a deep learning model and were found only to be approximately equal to that of two radiologists while readings performed with the DL system and radiologists found superior, though increasingly strenuous (Dembrower et al., 2023). Triple readings performed by radiologists and DL systems produced extremely high accuracy outputs, though, as expected, produced high expenses and effort in comparison while the DL algorithm alone produces great accuracy with minimal effort and low recall accounts (Dembrower et al., 2023). This study most directly examples how productive ScreenTestCAD is in mammography screening in numerous combinations, showing the extent at which it can be used in breast diagnosis, demonstrating the large cost benefit along with accuracy that accompanies the use of DL programmes to further benefit greater accurate and ethically moral decisions made within the use of AI (Dembrower et al., 2023).

While numerous studies conclude the benefits of AI incorporated mammogram screening, large ethical concerns are always being raised towards liability and patient confidentiality when using AI in treatment of any kind (Ma et al., 2021). To avoid suspicion raised to the accuracy of mammogram readings, AI can be alternatively incorporated to mammographic readings through the improvement of imaging for radiologists to utilize in their independent evaluation (Ma et al., 2021). A study examples traditional deep learning and machine learning techniques in breast cancer detection in relation to digital mammogram viewing, showing ML models ability to remove unwanted features of imaging to further specify localized region for screening (Ma et al., 2021). This study also demonstrates ML ability in enhancing desired features and separating such features from background qualities, enhancing imaging in areas of low saturation or content for higher quality resonance and identifying malignancy along with features of the breast (size, density etc) (Ma et al., 2021). DL models aptitude to utilize large data fields and apply them towards augmenting data and imaging for smoother diagnosis and screening were shown (Ma et al., 2021). It was found that numerous DL and ML systems used towards mass classification and detection were largely expensive, though accurate and extremely helpful when used in addition to CAD systems of radiologists (Ma et al., 2021). This study shows a collective review of the numerous ways at which DL and ML learning systems provide general improvement to screening while also exhibiting high accuracy and quick pace (Ma et al., 2021). When AI's are being contributed to mammogram screening there is great promise in image improvement and mass detection leading towards high diagnosis accuracy performed in addition to radiologists (Ma et al., 2021). While mammographic imaging is significant in the detection of breast cancer, ultrasound imaging can be used to further classify the lesions found during screening and accurately identify them (Lehman et al., 2024). A study utilizes a deep learning system, MIRAI, which is learning using patient data and labeled imaging to develop improved assessment of ultrasound imaging (Lehman et al., 2024). This study develops their objective in developing MIRAI, also, for the process of enhancing ultrasound imaging for dense breast tissue and for applications in MRI screening data (Lehman et al., 2024). This source provides the ways at which deep learning systems can be contributed to traditional imaging and the rate at which they benefit from diagnosis (Lehman et al., 2024). Results found that, once significant labeled data quantities were provided, MIRAI was able to model personalized and cost effective additions to traditional risk assessments consistently (Lehman et al., 2024).

Image assessment can also be improved upon through the use of digital breast tomosynthesis (DBT) which was specifically developed for the purpose of creating multilayered three dimensional interpretation of screenings to allow for increased detection rates (Magni et al., 2023). This study focuses on the application of deep learning models as well as convolution neural networks (CNN) in DBT to produce lesion segmentation and accurately detection lesions of mammographic abnormalities based on data derived from DBT lesion detection along with 2D images as well (Magni et al., 2023). Findings in lesion detection were used in comparison and addition to radiologists to demonstrate an efficiency rate (Magni et al., 2023). Models used in addition to radiologist readings allow for a more rapid reading time along with higher accuracy, though were shown to be extremely sensitive (Magni et al., 2023). Results found numerous different readings in comparison to radiologists causing concern due to extensive discrepancy in data (Magni et al., 2023). This study establishes the type of digital testing needed to separate and identify abnormal breast masses as a necessity and how such tests can be easily sped up and made more accurate in order to give a quicker and more significant diagnosis of breast cancer using AI (Magni et al., 2023). Similarly, a study utilizes deep learning models to enhance double reading detection processes with radiologists and DBT to allow for enhanced tissue imaging to reduce the excessive rate of false positives (Seok Khan et al., 2023). This study also incorporates aspects of computer aided detection systems working alongside deep learning algorithms for the assessment of mammograms at a faster rate (Seok Khan et al., 2023). Deep learning systems were used in addition to radiologists and results were compared to findings when systems were applied towards ultrasound and MRI screening of dense breast tissue to produce isolated assessments (Seok Khan et al., 2023). Findings found heightened accuracy in assessments including a reduced rate of false positives when used to screen imaging during double reading assessments (Seok Khan et al., 2023).

A varying approach which strays from mammogram screening evaluates a deep learning system's ability to examine and predict breast cancer subtypes of women diagnosed with breast cancer using mammogram and ultrasound imaging to apply towards a more accurate diagnosis process (Ma et al., 2022). This method of applying modern AI to detection is solely applicable after mammograms have been determined abnormal to heighten classification of breast cancer to further specify diagnosis into a specific subtype (Ma et al., 2022). 5 constructed deep learning models were trained with clinical data of patient characteristics and imaging such as mammography and ultrasonography (Ma et al., 2022). These highly trained models were then applied towards subtype assessment with accuracy evaluated based on precision, specificity and sensitivity (Ma et al., 2022). The model displayed the highest level of accuracy was used for assistance with assessment in addition to radiologists (Ma et al., 2022). It was shown that the Decision Tree model provided the greatest accuracy in prediction of subtype and that when used to assist specification of subtype in addition to radiologists, there was an overwhelming increase in accuracy (Ma et al., 2022). The Decision Tree model demonstrated aptitude in the distinguishing of triple negative breast cancer from other subtypes which is commonly overlooked during subtyping (Ma et al., 2022). Additionally, Decision Trees example an ability to distinguish luminal breast cancer from other subtypes with heightened accuracy and applicable data output towards radiologist's readings as well (Ma et al., 2022). There are great ethical and accuracy related concerns of utilizing AI for detection alone, though this study provides insight into an ethically moral and highly accurate detection method which allows for a combination of both efforts showing the Decision Tree's ability to example high accuracy and precision when used in addition to radiologists (Ma et al., 2022). While still varying from mammographic detection, a study found that CAD systems (computed aided detection) have significantly larger amounts of cancer detection accuracy in comparison to the conclusions made by radiologists (Cole et al., 2012). This study illustrates the greater sensitivity of CAD systems in screening mammography to abnormalities without being directly affected by lesions of subject characteristics(Cole et al., 2012). This study utilizes two CAD systems to evaluate screening whose outputs were reviewed by three trained breast-imaging specialists for the marks of abnormalities made and their corresponding accuracy of mark location and relevance(Cole et al., 2012). Findings suggest that the interpretation of CAD outputs in mammograms constituted heightened sensitivities to lesions found in film and digital screen mammography with a lower rate of false diagnosis (Cole et al., 2012). These results are applicable towards the incorporation of CAD and AI systems for heightened accuracy reads (Cole et al., 2012).

Futuristic Applications

Much of the usage in relevance to AI is limited by the lack of datasets required to make an accurate and reliable usable machine or deep learning algorithm (Radvanyi et al., 2024). So while studies are currently limited, there are numerous methods of application that can be futuristically envisioned to determine the direction of AI's development (Radvanyi et al., 2024). A source develops this idea further by exemplifying machine learning models heightened futuristic ability to identify abnormal growth to monitor high risk areas and develop personalized treatment planning in mere minutes (Radvanyi et al., 2024). This source emphasizes the current low rates of accuracy and efficiency in this field along with the errors in accountability and safety regarding a prognostic process developed by a machine learning algorithm rather than a radiologist (Radvanyi et al., 2024). Further developing this, the consistency of errors were depicted and related to the difficulty in identification and comprehension of output data especially with results finding heavy bias in deep learning data input (Radvanyi et al., 2024). This study also provides insight into deep learning's futuristic influence on lesser developed areas with minimal resources, though considering the minimal data for deep learning accessible for such areas, utilization of such tools in remote areas could be insufficient (Radvanyi et al., 2024). The idea of how deep learning can be utilized to impact treatment planning for those at high risk and those in unfortunate medical areas and the features that need to be improved towards the future for domestic usage were also incorporated into findings. Overall, results found that much of the application futuristically was hindered by the lack of reliable data and unbiased learning (Radvanyi et al., 2024).

A study approaches a futuristic take on imaging and MRI screening by demonstrating a deep learning model being used for research regarding ideas such as the accurate identification of cancerous areas through the utilization of MRI imaging in comparison to radiologists screenings along with use towards mammograms and detection through the use of DL and ML techniques (Jaber et al., 2022). The study assesses the outputs of a deep-learned algorithm, trained by MRI scanning with gene mutations, and its ability to output nearly identical areas of cancer development in MRI scanning to those made by a radiologist (Jaber et al., 2022). This study however, is more focused on the development which can eventually lead to results which conclude presence and reduce rates of false detection for further use in less qualified radiologists (Jaber et al., 2022). Deep learning’s potential in analysing complex patterns and relationships in varying data sets which are unspecific to the human eye were determined (Jaber et al., 2022). The idea, however, that such findings are not entirely trusted by researchers because learning systems display difficulties in demonstrating a process in conclusion, making further progress in imaging detection difficult (Jaber et al., 2022). In a similar study, application of machine and deep algorithms in MRI imaging for characterization of legion location along with a radicalized futuristic method of 3D replication in breast tumor segmentation and fusing are illustrated (Al-Karawi et al., 2024). Prospects in applications in segmenting and classifying lesions to heightened accuracy along with improved image quality (Al-Karawi et al., 2024). This study details a method of 3D automatic level propagation to enhance accuracy and efficiency of the tumor volume reconstruction in MRI data using a deep learning model. Findings developed the difficulties faced due to limited and unbalanced datasets and the interpretability of outputs even with accurate findings (Al-Karawi et al., 2024). Conclusions found that conclusive collaboration between healthcare and researchers could develop an ethically sound AI for detection (Al-Karawi et al., 2024).

Furthering the topic of futuristic research of AI, a study focusing on the use of high dimensional trained deep learning datasets in identifying optimal drugs for repurposing and output of predictive efficiency and structural similarity to approved medical drugs for cancer treatment (Bhinder et al., 2021). This study assesses deep learning algorithms potential in personalized treatment development and highlights prospects in the discovery of novel target drugs at a cost effective rate (Bhinder et al., 2021). The study develops application of these new drugs in higher variety and lower costs of personalized drug usage in cancer such as that of the breast (Bhinder et al., 2021). Futuristic application is detailed, and mentions an alternative assessment pattern based on genetics and lifestyle information factors rather than solely patient data (Bhinder et al., 2021). Application to this extent could allow for extensive monitoring to conclude a beneficial treatment plan rather than intrusive methods of detection (Bhinder et al.,

2021) An alternative study focuses on the evolving neural networks being developed and their importance in the classification and diagnosis of cancer such as learning algorithms produced by machine learning systems for cancer detection and how they can be futuristically applied to IoT technologies along with a DL's ability to extract survival rate and mutations from imaging to be used in the future for development of biomarkers with pathology used in tandem (Kumar et al., 2023). Along with future usage, this study illustrates features such as a limited data size, accuracy, high dimensionality etc (Kumar et al., 2023). which are working towards being resolved in order for learning models to be put to use in clinical practice (Kumar et al., 2023). This source provides insight towards methods of usage and their current status clinically providing assessment of what needs to be altered in order for both machine and deep learning models to be implemented into clinical practice regarding breast cancer (Kumar et al., 2023).

Many of these futuristic ideals are currently unreachable due to the current flaws and inconsistencies within modern AI systems (Nasser et al., 2022). This source focuses on the common methods of deep learning in relation to breast cancer detection along with the determining the most common flaws associated with deep learning models as the imbalance of data available for models (Nasser et al., 2022). This study examines a deep learning system's effective ability to assess genomics and histopathological imaging data, determining extensive difficulties in determining results concluded without bias (Nasser et al., 2022). Having many deep learning datasets private due to the extensive labor associated with a larger dataset therefore encourages diagnostic bias suggesting future research to focus upon diverse data without overcompensating to address data imbalance (Nasser et al., 2022). This source in depthly addresses the lack of attention mechanisms for model precision along with hybrid algorithms for combination of networks for a larger dataset and increasingly more accurate results for future prospects (Nasser et al., 2022). This study provides an established checkpoint of deep learning in the modern world and improvements needed to be made/alterations underway in reference to current DL models to develop futuristic utilization of AI in breast cancer (Nasser et al., 2022). Similarly, a study focusing on highlighting the overall conflict within the use of AI in medicine, specifically cancer detection was used to examine overall bias and lack of data in niche diseases and conditions (Thomas, 2024). This study contributes an analysis of the difficulties associated with incomplete data leading to undetected bias and how to further mitigate such concepts, research should aim to indulge patient perspective and bias towards AI along with establishing a system of judgment for error (Thomas, 2024). The pattern of automation bias was incorporated in finding by example the lack of judgement and overall immediate acceptance of computer generated results, hindering any alteration or recognition of errors in results (Thomas, 2024). The largest disadvantage that bias contributed to a learning algorithm's outputs was the clear lack of sufficient information in datasets regarding less common diseases regarding inaccurate results in certain patient data (Thomas, 2024). Overall this study develops ideas of the current use of computed aided algorithms in application towards medicine and consistent discrepancies, further detailing how machine and deep is being used and how it can be benefited in the future (Thomas, 2024).

Currently, radiology using deep learning focuses on the interpretation of screening and images through deep learning systems and CNNs in order to classify legions largely because they have a larger range of sensitivity to abnormalities in comparison to radiologists, however, deep learning systems have yet to be largely approved for clinical use because of the lack of information and data available to be given to such learning machines (Froelich et al., 2019). A study illustrates a deep learning system's potential in specifying the extent of risk a tumor presents based upon a calculated volume (Froelich et al., 2019). This study also utilizes CNN to determine the most beneficial model in determining lesions of malignancy and non malignancy to conclude the overall determinant of inconclusive data. Findings determined a conclusive CNN as most optimal with successfully accurate results, however a conclusive interpretation of screening was hindered by lacking data for algorithms to learn from (Froelich et al., 2019). This source gives a comprehensive rundown of futuristic ideals of machine learning through the tumor classification and lesion segmentation for breast cancer through radiology giving insight to how breast cancer could be greatly impacted in the future through a more perfect version of learning systems (Froelich et al., 2019). Similarly, a study analyzes a developing deep learning model's ability to analyze CT and MRI screenings as well and its methods of implementation towards treatment outcomes based completely on learning data with no human input or additional aid (Zheng, 2023). This source developed a deep learning model to process medical imaging for cancer prognosis in rapid speed by analyzing patterns and patient response, while also exploring the idea of biology guided deep learning utilizing biomarkers and the internal tumor environment (Zheng, 2023). While the previous study concluded data sets were respectively not approved for clinical use due to bias and lack of clinical data, this study emphasizes the idea that the futuristic outlook of machine learning will never exemplify a replacement of human medicine, though it will provide incredible aid in detection and oncologist practice once developed with diverse data and patient confidentiality for implementation into clinical practice (Zheng, 2023). Breast cancer is seen to be further benefited through the development of biological AI development, providing a more specific and accurate reading of a tumor's internal environment for a precise prediction and treatment plan (Zheng, 2023).

Finally, a study was used to examine the overall insight towards the future of AI in terms of medical cancer care through a survey method comprising the opinions of 1,006 experts and their views on AI in the future with a majority of participants believed that AI will largely benefit radiology, a few saying pathology and very little saying gynecology (Cabral et al., 2023). The study concluded influence in medical imaging and screening towards detection through the implementation of patient data and previous imaging to lead towards a more accurate and comprehensive report of cancer detected and treatment plans (Cabral et al., 2023). Many of the experts who participated, encouraged the use of AI in drug production and discovery, while also contributing to the legal concerns regarding machine bias through data inclusion and less diverse information along with concerns relating to the management of data privacy and implementation towards patient care (Cabral et al., 2023). Overall this study permits a great overview of the influence of AI in the eyes of the medical field to provide a more accurate and sustainable grasp of what AI can provide in the future (Cabral et al., 2023). This study allows for a perspective view on how AI is not largely accepted and not generally perceived as machinery that will soon replace all doctors, however this study mainly provides the idea that breast cancer treatment and detection in relation to AI is being significantly more accepted and made a more generalized reality (Cabral et al., 2023).

Discussion

Prevention

The contributions made by Metabokiller in the field of carcinogenic detection can be further applicable towards the prevention of cancer causing substances made available to the public (Mittal et al., 2022). The use of the machine learning AI, MetaboKiller, through its demonstrated abilities in identifying the genotoxicity of provided metabolites can be used similarly towards the assessment of everyday drugs and medicine (Mittal et al., 2022).

Metabokiller's additional aptitude in determining effective rate of carcinogenicity of provided compounds based on identification of learned apoptotic traits are specifically influential in the field of breast cancer prevention, providing a basis for determining objective risk in the use of such medicines. The heightened accuracy of MetaboKiller in the identification of approximate toxicity in compounds shows large promise in future applications in the field of cancer causing drug prevention. The varying approach that ProTox-II contributes in relation to the analysis of chemical structure for the determination of toxicity levels demonstrates significantly more insight into the development of carcinogenic compound prevention (Banerjee et al., 2018). ProTox-II's predictive ability in determining median lethal dosage in carcinogenic compounds can be accurately incorporated into the screening of drugs and medical compounds (Banerjee et al., 2018). Current methods of screening remain long and expensive, yielding results that are based on in vitro testing methods which are nonspecific to the human response and dosage (Oku et al., 2022). Both Metalbokill and ProTox-II screen based on learning data based on human patterns of apoptotic traits, resulting in objective determinations of carcinogens that analysts and in vitro testing cannot provide (Banerjee et al., 2018) (Mittal et al., 2022). The screening of both existing and radically developing forms of medical compounds can be enhanced with AI sampling and analysis, further eliminating aspects of detected toxicity in widespread medicine (Banerjee et al., 2018).

Deviating from carcinogenic factors in drugs and medical compounds, atmospheric asbestos existing in the air allowing for increased rates of breast cancer, similarly, remain difficult to accurately identify (Yamamoto et al., 2024). The use of Mask R-CNN for segmentation and isolation, in comparison to the MA-net, used similarly with heightened accuracy in determining toxicity of varying features, determined conclusively effective accuracy in both models (Yamamoto et al., 2024). Additionally, findings by Iida et al., determine that results by both a machine and deep learning system were closest to that of a trained analyst, determining this incorporation of supervised learning to be optimal for asbestos screening (Iida et al., 2021). The collective determination illustrates the potential of asbestos assessment through the use of multiple specialized learning systems, namely through the use of a deep learning system such as the MA-net in addition to a supervised machine learning system (Yamamoto et al., 2024). With more rapid and accurate asbestos counting by AI machinery, more environments can be tested for fibers, reducing the amount of unsafe work environments and carcinogens workers are exposed to (Turati et al., 2023). This optimal method to screen for asbestos can contribute to the development of additional protection or eradication of certain work environments for those deemed extensively toxic, furthering aspects of cancer prevention (Turati et al., 2023). However, findings by Iida et al., determine that even with the use of an AI, the need for microscopy equipment and isolation of samples for the assessment performed are still required. While the use of learning systems provide heightened accuracy and speed, there is still little incentive to perform the expensive process to screen a suspected environment due to the comparatively lower rates of recognition (Iida et al., 2021). There is little widespread awareness of environmental asbestos, making the prevention of breast cancer less of a priority in the field of healthcare when rivaled with radical treatment methods used to help those who are currently in need of medical attention (Caceras et al., 2023).

While carcinogens can increase the risk of breast cancer, preventative methods are also inclusive of early action against those predisposed to malignancy (Senturk et al., 2021). Most notably in breast cancer, being predictive capacities in BRCA gene mutations (Senturk et al., 2021). Findings by Senturk et al., demonstrate both deep and machine learning's aptitude in predictive assessment of variation in BRCA genes (Senturk et al., 2021). The displayed machine learning abilities in mutational identification show potential in furthering prevention of unexpected mutations in high risk breast cancer patients (Senturk et al., 2021). By applying a trained model with a logic based trained dataset, patients flagged with high mutability in BRCA genes can be enlisted for preliminary treatment to avoid developing cancer entirely (Dillner, 2019). In addition, findings by CLAM determined the deep learning models ability to effectively identify genomic characteristics of mutated cells with great accuracy, specifying in mutational analysis of the BRCA gene (Nero et al., 2022). CLAM's ability to determine the identifying traits of mutated BRCA cells can similarly be applied to prevention through the assessment of tissue samples to determine if they possess aspects of tumorous characteristics (Nero et al., 2022). While, however, the inheritance of a mutated BRCA gene in general denotes a necessity for treatment, through the use of a logic based deep learning model, patients can conclude a more focused assessment of their extent of malignancy and how their treatment should proceed in response (Hu et al., 2020). It is significant to note that while the assessment of malignancy in breast cancer inducing genes can provide at-risk patients with the needed attention, little measures can be done to entirely prevent malignancy in the cells mutated enough to flag the learning system, as datasets were trained in pattern recognition using data from breast cancer patients (Nero et al., 2022). Applications of learning systems are primarily to impose early treatment methods to quell malignancy (Schiffman et al., 2015).

Cancer recurrence is a large contributing factor to the treatment forms available to be used due to the variability of patient reaction, limiting the number of effective therapies accessible to patients (Iwamoto et al., 2020). Results from Iwamoto et al., illustrate the prominence of machine learning algorithms in the evaluation of genomic signatures for the determination of acute response to highly effective tumor biomarkers (Iwamoto et al., 2020). Patient response was also shown to be evaluated more efficiently through a deep learning model's assessment of TME using radiological imaging (Iwamoto et al., 2020). This application of AI determines a noninvasive form of testing, avoiding normal expensive methods of testing such as biopsies, eliminating the risk associated with such processes (Jiang et al., 2023). Through the usage of either a machine learning system in the evaluation of genomic signatures or a deep learning algorithm's assessment of a patient's TME, the determinable predictive accuracy in the assessment of response and lasting effect demonstrates a potential in development of an effective treatment plan (Jiang et al., 2023). This outline of a personalized risk assessment of treatment contributes to the prevention of recurrence, furthering the effectiveness of treatment to combat developed malignancy and allowing for treatments to avoid causing harmful side effects or overall rejection (Iwamoto et al., 2020). However, the necessity of patient data, such as radiological imaging, hereditary information etc, constitutes a conflict of liability due to issues regarding privacy (Amann et al., 2020). Because learning assessment is being derived from personalized data to be applied directly towards a patient's treatment, risk of inaccuracy in conclusions or distrust in nonhuman methods of deliberation are more prominent than in usage for carcinogenic reduction, regarding difficulty in furthering common usage (Amann et al., 2020).

Similarly, the usage of learning algorithms, according to findings by Howard et al., in the determination of effective adjuvant chemotherapy is explored through the use of an individual's personal health information, determining a lack of incorporation of varying health aspects a radiologist could easily apply (Howard et al., 2020). Methods such as these, however, are not as reliable comparatively, as no data regarding tumor or internal status is incorporated into assessments (Wu et al., 2017). Findings detail how application after recurrence is raised as a heightened risk and adjuvant chemotherapy is determined necessary (Howard et al., 2020). This machine learning algorithm, therefore, shows significance in contributions to further specifying a broad assessment of effective forms of chemotherapy (Howard et al., 2020). This machine learning model regards pattern recognition processes which can be furthered with a broadened learning set, demonstrating usage in preventative measures of recurrence (Chan et al., 2020). These findings, however, demonstrate the overall necessity in the use of imaging rather than overall data alone (Howard et al., 2020). Without data regarding tumor/genetic assessment, results remain inconclusive and easily performed through low risk genetic testing (Wu et al., 2017). Prospects in pattern recognition and such application towards the specificity of selective treatment methods can be derived from conclusions and further applied towards a machine learning system with a more developed dataset, developing promise in preventative measures regarding acute response (Froelich et al., 2019). Jiang et al., explores the use of a deep learning system in a similar assessment, providing findings of accuracy in determination of acute risk assessment of recurrence and an overview of effective risk and rates of improvement post treatment (Jiang et al., 2022). This demonstration of accuracy in treatment effectiveness as well as determinable risk can be equally contributed to a developed treatment plan, incorporating that a low predictive rate of improvement is not worth the additive risk, allowing for more effective treatment methods to be applied in earlier stages of recurrence (Schiffman et al., 2015). Earlier application of treatments, especially prior to a full development of malignancy, provides heightened rates of recurrence reduction (Schiffman et al., 2015). Alternatively, the determination of high effectiveness with large scale risk regards the discretion of trained oncologists, promoting an appeal to the solely algorithmic based assessment (Jiang et al., 2022).

Treatment

Findings from Russo et al., determine conclusive accuracy displayed by both machine and deep learning models in analysing patient response to chemotherapeutic treatment based on learning from radiomic and genomic data (Russo et al., 2022). While high in accuracy, the unpredictable side effects of chemotherapy regard large reduction in usage (Gersten et al., 2023). The demonstrated effectiveness of extensive trained learning algorithms in determining an overall assessment of positive or negative predictive response furthers the rapidness of decision making (Russo et al., 2022). Findings utilize radiomic imaging for learning to apply towards the effective pattern reconciliation abilities based on the labeled datasets of patient response (Russo et al., 2022). The accuracy in assessment parallels the efforts of oncologists who optimize the use of invasive and expensive testing methods while both learning systems demonstrate an ability to provide assessments using patient imaging through a noninvasive method (Russo et al., 2022). The contributions made by this study to chemotherapeutic treatment develop a rapid paced method of determining the effectiveness of chemotherapy through a unique ability to discriminate genomic characteristics in genomics (Russo et al., 2022). If increased in commonality, treatment options can become more readily applicable to patients with a reduced time of conclusive results to allow for early action treatment, furthering determined effectiveness (Jin et al., 2023). The RF machine learning model examples direct application of similar processes in the specificity of breast cancer (Jin et al., 2023). Findings concluded predictive accuracy in determining acute fatality in breast cancer patients after usage of neoadjuvant chemotherapy using clinical pathology data (Jin et al., 2023). The demonstrated accuracy in determining acute response relating to fatality along with predictive risk of recurrence post treatment presents a specificity in analysis that even trained radiologists could not determine(Jin et al., 2023) . RF presents the accuracy and predictive precision necessary to contribute to a rapidly placed method of treatment determinants, furthering the treatment process (Jin et al., 2023). RF's application also makes it possible for results found to be contributed to the discretion of radiologists who can further the models findings in risk assessment towards a subjective perspective based on a patient's personal situation (Jin et al., 2023). Both learning systems have no conclusive output of determined optimal usage, which shows beneficial opportunities for evading liability in cases of fatality in determined treatment plans while still contributing faster and objective aspects of data using pattern recognition (Jin et al., 2023).

The radical approach to locoregional treatment by Kaidar-Person et al., provides a development in informed consent through predictive development of graphic based on patient data to further a patient's accuracy in perception of determined outcomes (Kaidar-Person et al., 2023). The development of accurate treatment plans and rapid paced application often neglect the contributions in determination that a patient must make (Kaidar-Person et al., 2023). This cloud-based AI provides a furthering of accuracy in patient understanding by developing graphics which relate to a patient's data specifically and provides imagery for patients to contribute to their decision (Kaidar-Person et al., 2023). CINDERELLA's determined increase in patient comprehension, while not an alteration to effectiveness of treatment, allows for determined increase in patient quality of life (Kaidar-Person et al., 2023). The accuracy of determined imaging also allows for the transition post surgery, to any lingering effects or alteration in appearance, to commence prior to treatment (Kaidar-Person et al., 2023). By providing accurate imaging specific to a patient, the process of acceptance with treatment outcome can occur once a determined treatment plan is made, allowing for a more positive response to treatment compared to an immediate and unexpected change post treatment (Kaidar-Person et al., 2023). This method of assessment also provides a patient with an increased sense of control over their personal reaction to treatment, furthering the determination of an optimal outcome personally to a patient's discretion (Kaidar-Person et al., 2023).

Findings by Sinha et al., using a machine learning system to determine accuracy in the development of predictive response to the use of ICI's through the application of large patient datasets and imaging, specific to the exclusion of invasive testing (Sinha et al., 2024). Similarly, the machine learning system LORIS shows accuracy in identifying specific patient responses and applying results towards predictive assessment of those suitable for treatment for the use of highly effective and selective ICI's (Chang et al., 2024). The largest conflict associated with immunotherapy is the extent of selectiveness which makes finding inhibitors suited to a patient difficult (Zhang et al., 2020). The contributions made by both studies demonstrate the accuracy of machine learning through the application of genomic and tumorous data in determining those qualified for treatment, LORIS specifically demonstrating capabilities in exemplifying specific inhibitors based on risk assessment (Chang et al., 2024). The heightened accuracy of such results displayed in both systems provides prospects in application furthering the use of immunotherapeutic treatment that is not as commonly used due to the extensive invasive testing methods associated with determination of accessibility (Sinha et al., 2024) Because of the numerous risks and low rate of determining an applicable ICI constituted by biomarker testing, treatment plans often disregard immunotherapy as an option without testing (Sinha et al., 2024). This rapid method of assessment without any form of invasive testing allows for immunotherapy to increase in commonality and increase in production as a result (Sinha et al., 2024).

Furthermore, immunotherapy, when determinably inapplicable to patients, often causes unpredictable side effects (Zhang et al., 2020). The accuracy displayed by machine learning systems in both studies for determining patient response can further a patient's personal treatment plan by providing a predictive assessment of risk, allowing for a patient to further their treatment according to their specific condition, determining usage even in cases of detrimental effects (Sinha et al., 2024). LORIS shows unique accuracy in conclusions of effective inhibitors which can be furthered towards invasive testing measures performed, prompting biomarker testing to be performed for ICI's determined effective by models (Chang et al., 2024). While immunotherapy is high in risk, machine learning algorithm outputs can effectively provide encouragement to test for ICI's for patients who could benefit most effectively and eliminate the rate of inconclusive invasive testing on those who would not (Sinha et al., 2024).

The deep learning model findings in ICI by Prelaj et al., determine heightened abilities in the development of radical biomarkers for the process of checkpoint inhibition rather than predictive applications through the use of imaging and genomic signatures (Prelaj et al., 2023). This study provides insight to radical methods of application, including the determination of overlooked though usable biomarkers (Prelaj et al., 2023). This alternative approach focuses on furthering methods of identifying viable patients for developed ICI's through the development of trusted testing forms rather than performing assessments utilizing machine learning systems (Prelaj et al., 2023). The accuracy displayed by the deep learning system largely implicates contributions towards furthering immunotherapeutic treatment in usage and commonality (Prelaj et al., 2023). The increased number of biomarkers developed, ultimately further ICI's due to an increased number of approved patient types (Prelaj et al., 2023). The application of deep learning in biomarker development also decreases involvement with patients directly, minimizing conflicts of liability, allowing for increased usage and furthered applications within the medical field (Prelaj et al., 2023).

Alternatively, the findings derived from the machine learning system, PERCEPTION, determine acute accuracy in evaluating cancerous breast cancer cell response to targeted drug therapy (Sinha et al., 2024). The capabilities described by PERCEPTION illustrate machine learning's contribution to furthering the accuracy of breast cancer treatment by focusing patient type to those specific to response by targeted drugs (Sinha et al., 2024). A large contributing factor that is often disregarded in the improvement of treatment is the issue of expense, which constitutes an inability to apply any possible treatment types to a cancer patient (Dembrower et al., 2023). Additionally, while treatments can be applied and ineffective, they can still provide lingering detrimental side effects while simultaneously neglecting to reduce malignancy (Horn et al., 20204). PERCEPTION demonstrates applications of a machine learning system towards the assessment of effectiveness for targeted drug therapy based on a patient's specific cells and determined expressions, allowing for those who would remain unaffected by targeted drugs to reevaluate, avoiding unnecessary cost and lasting side effects (Sinha et al., 2024). Current methods of efficiency based assessment for targeted drugs are based on tumor cell based analysis performed by an oncologist (Sinha et al., 2024). These methods require extensive time with lessened conclusions in accuracy, while machine learning systems, as exemplified by PERCEPTION, show conclusive accuracy due to learned pattern recognition through a varied dataset allowing for an objective perspective based specifically on determined expression (Sinha et al., 2024). Additionally, findings can be paralleled to those of an oncologist for further accuracy in readings. The assessments performed by PERCEPTION widen the commonality of targeted drugs by determining effectiveness of patients to contribute increased rates of accuracy among treated patients (Sinha et al., 2024).

Exploring contributions to precision medicine, findings by Alarcón-Zendejas et al., determine acute accuracy in applications of both machine and deep learning systems in addition to biomarkers to produce effective patient treatment plans (Alarcón-Zendejas, et al., 2022). Additionally, the AI used in the study by Fu et al., demonstrates an ability to assess imaging for the profiling of biomarkers to further the specification of breast cancer subtype with heightened accuracy (Fu et al., 2024). Treatment accuracy and efficiency is heavily reliant on the coordination and planning derived from image, cancer type and response based precision medicine (Debela et al., 2021). The prospects in patient data assessment due to capabilities, including algorithmic pattern recognition, determine greater effectiveness of use than treatment plans designed by specialists (Fu et al., 2024). Results from both studies concluded extensive capability in biomarker and genomic imaging assessment which is largely due to algorithmic recognition derived from large datasets unparalleled by any amount of professional experience in oncologists (Fu et al., 2024) (Alarcón-Zendejas, et al., 2022). This assessment ability, as described by Alarcón-Zendejas, et al., shows promise in integration with developed biomarkers due to the capability of algorithm based assessment to determine tumor response in addition to similar developments based on imaging (Alarcón-Zendejas, et al., 2022). The results concluded by learning algorithms can be contributed to the subtyping and identification of numerous regions along with the treatment response assessment, each derived from novel biomarkers, in a patient's personalized treatment plan (Iwamoto et al., 2020). The findings from Chen et al., show similarity in application of a deep learning system, displaying an ability to assess radiological imaging to output areas of heightened tumor activity (Chen et al., 2021). The accuracy displayed demonstrates a lessened use of intrusive tumor assessment, allowing for precision medicine to occur rapidly and more precisely (Chen et al., 2021). The presented similarity in findings between precision medicine specialists and the overall tumor assessment performed by machine learning models presents such an opportunity to be applied towards a patient's finalized treatment plan (Chen et al., 2021).

If furthered in research, results can be contributed to an eventual development of a patient treatment plan developed by a learning model entirely (Alarcón-Zendejas, et al., 2022). However, methods of precision medicine are overwhelmingly determinant of treatment effectiveness, leaving large scale responsibility in the hands of an AI for inefficient treatment planning in comparison to precision medicine merely based on readings performed by a learning system (Ma et al., 2021). This conclusive ability in the furthering of biomarker usage and such implementation into the genomic image assessment of tumors can be more specifically applied towards an identification of biomarkers in relation to the BRCA gene, determining increased rates of discovery of novel biomarkers and increased precision in developed clinical strategies (Yin et al., 2020) .

Diagnosis

Findings by Lang et al., in two separate studies demonstrated approximate accuracy of both deep and machine learning algorithms for the assessment of mammograms in comparison to biopsies and double readings along with contributing towards the output of breast cancer diagnosis based on determined rate of malignancy (Lang et al., 2023). In addition, results can be compared to findings from Freeman et al., which determined heightened accuracy in applications of a deep learning CNN towards the improvement of classification through the elimination of bias made towards radiologists and biopsy assessments (Freeman et al., 2021).

Conclusions can be contributed to a finalized assessment of application through the aid of radiologists rather than as a singular method of detection (Freeman et al., 2021). The accuracy depicted by both machine and deep learning in aspects of detection are derived from a large training dataset which produces heightened sensitivity to minor mammographic aspects contributing to malignancy (Freeman et al., 2021) (Lang et al., 2023). Studies demonstrate the large contributions made by learning algorithms due to their unique pattern recognition, allowing for a reduced overall output of false positives and negatives (Lang et al., 2023). The arguably largest aspect of learning algorithms in addition to the process of detection is the acute objectiveness of findings in comparison to single or even double readings performed by radiologists (Salih et al., 2023). Numerous forms of bias are at risk of being applied when readings are performed, including bias related to influence from the recent outcome of an alternative case, bias relating to the avoidance of liability resulting in an overdiagnosis, bias resulting from the impression of an initial diagnosis leading to a disregard of varied conclusions or even lacking confidence in findings leading to an inaccurate conclusion (Salih et al., 2023). However, there is no definitive method of determining objectivity in readings, causing little improvements in a largely prevalent issue in diagnosis (Tee et al., 2021). Therefore the large accuracy displayed by learning algorithms in the determination of malignancy in comparison to patient outcome presents significance in the field of detection (Freeman et al., 2021). Learning systems are solely influenced by their learning datasets which are increasingly objective as more information is fed (Mikhael et al., 2023). This presents a conclusive determination of objectivity due to inability to derive results from information unless it is provided, allowing for a reduced output of conclusions of malignancy based on outside influence (Duffourc, 2023). Learning systems, notably, are not trained in the context of liability allowing for readings to remain unswayed by lacking confidence or opinions resulting from personal risk (Duffourc, 2023).

Similarly, findings from Magni et al., demonstrate accuracy in the application of DL models and CNNs in lesion segmentation and evaluation of DBT and efficiency when contributed to double readings (Magni et al., 2023). Seok Ahn et al., similarly concluded accuracy in DL model application towards assessment of DBT's and effective contributions to the reduction of false positives when utilized in addition to radiologists readings (Seok ahn et al., 2023). The similarity in results determine a conclusive accuracy when DL or CNNs are used for evaluation and segmentation of DBT. (Seok Khan et al., 2023) The accuracy associated with DBT assessment presents an increased utilization of DBT's which present a large-scale improvement of imaging by providing a multilayered representation of data (Seok Khan et al., 2023). Similar issues and prospects of the use of algorithms in mammograms are present in DBT, however the utilization in similar applications demonstrates heightened perspective and an influence towards the field of detection by increasing usage and utilization of DBT's (Chong et al., 2019). The emerging image interpretation presented by an increased utilization of DBT allows for increased opportunity for radicalized and rapidly changing methods of detection to be normalized which can be furthered towards research to improve accuracy of treatment and detection (Chong et al., 2019).

This determined accuracy and objectivity does not demonstrate prospect in singular usage and presents greatest rates of conclusivity when used as an aid to double readings rather than a replacement (Dembrower et al., 2023). The study utilizing ScreenTrustCAD explored the possible combinations between two radiologists and an AI to determine that triple readings provided the greatest accuracy in determining malignancy (Dembrower et al., 2023).

ScreenTrustCAD was determined largely equal in determining conclusive accuracy in comparison to double readings and resulted in a large cost benefit (Dembrower et al., 2023). While the incorporation of triple readings through the use of a deep learning system is comparatively costly, there is little variation from the expense of utilizing traditional double reading methods without the use of AI (Dembrower et al., 2023). Findings by ScreenTrustCAD display how the furthering of learning models as radiological aid in the field of detection, specifying in mammograms, proves extensively prominent for the deterrence of biased or inconclusive diagnosis(Dembrower et al., 2023). Additionally, the use of an AI in the field of medicine, while oftentimes seen as unreliable and a violation of patient privacy, can be better incorporated when findings are accompanied by the double reading of radiologists (Dembrower et al., 2023). This is the largest contributing factor to the issues associated with solely DL based detection (Amann et al., 2020). The liability conflicts with detection based algorithmic application result in issues concerning responsibility with inaccurate detection and unfavorable outcomes (Amann et al., 2020). Findings by Cole et al., further explored mammographic evaluation through the use of a CAD, focusing on the accuracy associated with CAD systems due to heightened sensitivity to detection lesions in imaging (Cole et al., 2012). Through applying CAD systems such as ScreenTrustCAD towards detection and applying findings toward diagnosis made by a radiologists reading, liability can be associated with the radiologist, whose findings are paralleled by the AI (Cole et al., 2012).

To evade complications in liability, image improvement findings by Ma et al., display abilities in ML models to remove or enhance features of mammographic imaging, providing a separation of desired versus unnecessary aspects of imaging to encourage rapid and more conclusive results in diagnosis (Ma et al., 2021). Similarly, findings by MIRAI explore the use of DL systems in the enhancement of breast ultrasound imaging, concluding heightened diagnosis and classification of tumorous lesions (Lehman et al., 2024). This varied approach determines low risk applications of learning systems into detection methods (Lehman et al., 2024). While image improvement does not encourage increased accuracy, diagnosis can be reached more rapidly through the highlighting of specialized characteristics in mammographic and ultrasound imaging by allowing for double reading assessments to be more coherent with less conflicts in diagnosis (Ma et al., 2021). Double reading utilizes the image assessment capabilities of two radiologists to conclude heightened accuracy in diagnosis (Chen et al., 2023). If their views conflict, further consideration and varied perspective is utilized, resulting in an elongated diagnosis process to result in a collective assessment of malignancy (Chen et al., 2023). The prospects of ML in mammographic double reading assessments demonstrate improved image quality and alteration to enhance areas of interest, allowing for decreased aspects of interpretability in imaging which cause discrepancies in assessment (Ma et al., 2021). Applications which alter imaging can further detection methods by providing clearer imaging and eradicating discrepancies in assessments that could be caused by inconclusive imaging (Lehman et al., 2024). While image alteration remains controversial, DL and ML systems also provide beneficial results demonstrating improved image quality rather than an alteration of patient imaging (Lehman et al., 2024). This improvement allows for large-scale improvement in assessments performed by radiologists due to a refinement of malignant indicators that may have been lost by the inconclusivity of data (Ma et al., 2021).

A study by Ma et al., explored an alternative application of DL's towards the examination of imaging post detection of malignancy to predict subtypes (Ma et al., 2022). The Decision Tree model displayed improved accuracy in subtype prediction when used as an aid to radiologists assessment of subtype (Ma et al., 2022). Accuracy displayed by Decision Tree in the assessment of imaging allows for effective application in the field of detection specializing in subtyping, which is arguably just as significant as initial detection, as it heavily influences methods of treatment (Ma et al., 2022). The improvement of subtyping in speed and accuracy allows for a more rapid paced determination of malignancy and increased available treatment options, decreasing the likelihood of recurrence through early detection (Schiffman et al., 2015). The developed algorithmic pattern recognition prospects of the Decision Tree model demonstrate a contribution of malignant assessment that could be missed by even the most skilled clinicians due to the unique ability of DL systems to contribute any consistency in datasets to resulting assessments (Ma et al., 2022). While subtyping varies from initial diagnosis processes, issues concerning patient privacy persist due to the necessity of imaging for subtyping (Park et al., 2019). DL models that contribute influence to a finalized subtype conclusion can be further applied towards the research performed and methods of determining and categorizing forms of breast cancer (Ma et al., 2022). The information gained from processes involving subtyping are uniquely incorporated into a model's learning set, furthering the intelligence and accuracy in image assessment, which can pose issues in relation to patient confidentiality (Gerlach et al., 2022). Additionally, conflicts concerning singular or assisted assessment remain, as findings from Ma et al., contribute heightened accuracy through the application as an aid to radiologists (Ma et al., 2022).

Futuristic Applications

Findings from Mikahel et al., highlight envisionments for machine learning models contributions to developed treatment plans through a broadening of learning datasets and a greater comprehension of results through greater integration into the medical field to allow for increased rates of accuracy in prognostic outcomes (Mikhael et al., 2023). The contributing factors relating to the inaccuracy of machine learning programs remains the interpretation of results and their influence on resulting treatment plans (Mikhael et al., 2023). As ML systems are better incorporated into smaller and miniscule aspects of medicine and algorithmic output is better understood in the field of medicine, the accuracy of ML systems can be further improved and similarly applied towards the development of treatment prognostics (Mikhael et al., 2023). Additionally, there is a limiting factor in the intelligence of learning systems in relation to their limited database (Al-Karawi et al., 2024). In envisioning a futuristic application, datasets are determinably able to be increased, as more cases appear and more information is incorporated into learning (Al-Karawi et al., 2024). This furthers the determined accuracy of ML systems, allowing for findings to be furthered in acceptance and incorporation into treatment planning (Rahul, 2015). Additionally, the increasing perspective and developments made futuristically can be applied towards an alteration of output to produce findings that are parallel to the characteristics of human thinking (Nagi et al., 2023). Learning systems, over time, can be applied towards an increased interpretation of human behavior and thinking, allowing for findings which mimic learned assessments by radiologists for better interpretation (Nagi et al., 2023).

Findings by Jaber et al., demonstrate assessments of developing DL systems which, optimally, possess accuracy in determining cancerous lesions based on MRI screening (Jaber et al., 2022).. Similarly, a study performed by Al-Karawi et al., also focuses on the futuristic influence of MRI screening in deep and machine learning systems (Al-Karawi et al., 2024). Al-Karawi et al., findings focus on lesion segmentation and such applications towards a development of potential 3D replication methods for breast cancer patients (Al-Karawi et al., 2024). Developments in DL systems for further use in MRI screening develops methods of detection, allowing for improved rates of false diagnosis (Al-Karawi et al., 2024). Additionally, the futuristic application towards developing lesion segmentation and identification allows for treatment planning and application to be furthered (Jaber et al., 2022). Specifically, abilities in volume reconstruction demonstrate radical methods of diagnosis which learning systems are uniquely capable of (Al-Karawi et al., 2024). 3D replication derives a varied perspective of derived imaging which can allow for furthered specificity of assessment in tumorous regions (Al-Karawi et al., 2024). Learning systems present the most promising method of pursuing this method of detection due to previously demonstrated aptitude in analysis of complex patterns to derive relationships and consistencies throughout inputted data (Jaber et al., 2022). If datasets are furthered in complexity, potential in MRI reconstruction has likelihood of being pursued with heightened accuracy (Jaber et al., 2022). However, regardless of determined accuracy in findings, patient confidentiality and privacy present consistent conflicts with the use of imaging for AI assessment (Gerlach et al., 2022). The utilization of MRI or CT screenings for detection are entitled to a patient's radiologists and possibly other specialists for alternative perspective, though the sharing of such sensitive medical data with an AI can pose issues relating to informed consent or possible security risks (Gerlach et al., 2022). If increased in commonality, futuristic applications should include a development of appropriate procedure for the detailing of image usage in AI assessment for patient knowledge (Jaber et al., 2022).

Furthermore, results developing the treatment aspect of DL usage highlight potential in the identification of drugs ideal for repurposing as well as drugs with prospective similarities to already usable medical drugs, all for the purpose of developing personalized targeted drugs at a predicted faster rate than traditional methods (Bhinder et al., 2021). Currently, the most challenging aspect of targeted drugs are the selectiveness and inability to create more without extensive time and expense, hindering research potential (Bhinder et al., 2021). Algorithmic development allows for trained systems to provide learned assessment of provided data (Bhinder et al., 2021). The developed assessment of targeted drugs can innovatively be derived and applied towards the development of modern and more inclusive drugs through the inclusion of effective aspects of approved drugs (Bhinder et al., 2021). This method of application reduces necessary research, furthering the development of treatments at a notably lessened expense (Bhinder et al., 2021). The development of targeted drugs presents extensive improvements to the field of cancer treatment due to the extensive accuracy associated with the use of such drugs when a patient is appropriate for usage (Bhinder et al., 2021). Furthered development in repurposing drugs develops potential for cost effective treatment development as it allows for unusable or high risk treatments to be applied towards broadened patient range (Bhinder et al., 2021). Complications, as detailed by Kumar et al., consist of limited data size, accuracy and high dimensionality (Kumar et al., 2023). These findings can be applied towards research by Bhinder et al., developing the perspective issues with such futuristic applications (Kumar et al., 2023). These determinations imply alterations in datasets, primarily, prior to usage in treatment development (Kumar et al., 2023). Currently, the inconsistency and bias associated with learning system-derived findings present complications with relying on such results for the development of treatments due to the extensive aftermath of research and development which occurs afterwards (Bhinder et al., 2021). Through a furthering of training set to reduce discrepancies in data, algorithmic methods can be applied towards developing treatment (Kumar et al., 2023).

Determinations of bias and data imbalance are consistent with findings by Nasser et al., with findings deriving the largest hindrance to AI application being limited datasets (Nasser et al., 2022). Furthermore, findings by Thomas, determine a prospective approach to mitigate such concerns through the incorporation of error assessment systems for the reduction of unrecognized bias in algorithmic outputs (Thomas, 2024). Limited datasets are a sole conflict associated with learning systems, as the issue is not largely relevant for radiologists or specialized doctors (Thomas, 2024). Unique conflicts such as these determine unavoidable patient conflicts with AI applications as many patients prefer assessments to be contributed to by doctor discretion rather than a trained algorithm (Thomas, 2024). While issues such as these are effectively unavoidable, the novelty of AI in this field contributes to the large discrepancies in data, determining that effective furthering of development will conclusively further improvements and reduce limitations (Nasser et al., 2022). The use of algorithms are so entirely based upon the largeness of their dataset that the workload associated with training a learning system effectively encourages smaller learning sets (Rahul, 2015). This idea promotes improvements to be made towards methods of training datasets to further the speed and effective intricacies of data collection (Thomas, 2024). The conflict of unforeseen bias, derived from findings by Thomas., similarly remains prevalent (Nasser et al., 2022). There is often difficulty deriving a conclusion of bias as a prospective analysis of results is often influenced by inability to derive error from results (Thomas, 2024). If results are not scrutinized and error is not noted upon, datasets will remain inconclusive, hindering improvements to data (Thomas, 2024). Futuristic applications should be accompanied by a development in error detection along with broadened training sets which should be applied towards a strict criteria of variability prior to application towards cancer treatment (Thomas, 2024).

Findings from Froelich et al., demonstrate a comprehensive assessment of DL system futuristic application in determining malignancy and tumorous occurrence based on radiological imaging (Froelich et al., 2019). Additionally, a study by Zheng highlights prospects of a developing learning models ability in radiology but contributes methods which provide results without the use of human input or aid, determining that no form of machine learning should be applied without the contributions of a doctor, even with improvements made to the assessment of TME (Zheng, 2023). The use of either DL or ML systems not only provide a predictive inability to produce applicable results without human input, but also do not present potential in patient reliability for sole assessment (Zheng, 2023). Findings from both sources develop this idea further by providing an assessment of lacking accuracy in current fields (Zheng, 2023) (Froelich et al., 2019). Ideas such as these, however, can be further improved, as applications in radiology are influenced by radical imaging methods as well (Froelich et al., 2019). While improvements to AI may never prove effective enough for singular usage, improvements to imaging can alter perspective and provide new potential for learning systems (Zheng, 2023) . However, a conflict involved with radicalizing imaging includes the development of training sets which are increasingly less relevant as more and more patient data is developed (Zheng, 2023). Futuristically, radiological imaging should incorporate nearly all screening to developing learning systems for isolated applications to be considered further (Cabral et al., 2023). This idea is furthered by results from Cabral et al., determining through a survey that experts and specialists find AI to have the largest potential in the field of radiology (Cabral et al., 2023). This idea is arguably the most significant aspect of artificial intelligence in medical improvement, as the support from practicing medical experts provides greater involvement for research along with easier implementation into medical practice (Cabral et al., 2023). The furthering of normality and usage is one of the greatest influencing factors of the improvement of learning systems (Cabral et al., 2023).

Conclusion

Breast Cancer remains a prevalent topic in the field of medicine as it contributes to thousands of deaths annually as one of the most commonly diagnosed cancers in women. In such a growing age of technology, artificial intelligence has shown development which demonstrates prospective usage in healthcare and medicine which can be further attributed to underdeveloped modernized forms of breast cancer treatment (Wiedlich, 2018). Data consisting of the use of artificial intelligence, primarily deep and machine learning systems, within the field of breast cancer treatment were derived from studies found on PUBMED. The results from 40 of these studies are demonstrated in this paper deriving improvement towards prevention, treatment, diagnosis and futuristic usage. AI within the realm of prevention was shown to contribute enhanced screening abilities and increased early detection, with detriments such as cost and patient privacy. Treatment for breast cancer was shown to be improved by providing alternative, non-invasive methods of care with similar accuracy, providing prediction to treatment for beneficial treatment plan and by increasing patient consent through thorough developed imaging. These features also raised concern in liability, acceptance for integration as well as ethical complications which could pose issues when in use. Use in diagnosis was shown to determine breast cancer subtype for more in-depth diagnosis, enhance imaging as well as provide a secondary reading through thorough screening in addition to a radiologist. With similar concerns regarding liability and privacy. Finally, the future of AI was shown to envision the role of treatment planning, 3D reconstruction as well as drug repurposing.

Of these uses, the most prominent and realistically applied would be dual reading in diagnosis as well as image enhancement. While all of these methods have promise towards becoming applicable to patients, the use of these systems in diagnosis regard the least amount of issues in liability (Aung, 2021). AI continues to grow but will generally consist with limitations in acceptance and integration towards human usage, especially within the field of medicine. Additionally, much learning from data input as well as financial dedication is contributed to such systems to constitute high levels of accuracy which can compete with oncologists in the medical field. These limitations will indefinitely slow the growth of radical AI in healthcare which prompts development of increased funding as well as awareness campaigns for high accuracy learning systems to increase usage as well as acceptance in the field of cancer treatment.

References

Akpan, A., Tabue-Teguo, M., & Fougère, B. (2019, January 1). *Neurocognitive disorders: Importance of early/timely detection in daily clinical practice*. Journal of Alzheimer's Disease. https://content.iospress.com/articles/journal-of-alzheimers-disease/jad180381

Alarcón-Zendejas, A. P., Scavuzzo, A., Jiménez-Ríos, M. A., Álvarez-Gómez, R. M., Montiel-Manríquez, R., Castro-Hernández, C., Jiménez-Dávila, M. A., Pérez-Montiel, D., González-Barrios, R., Jiménez-Trejo, F., Arriaga-Canon, C., & Herrera, L. A. (2022, April 14). *The promising role of new molecular biomarkers in prostate cancer: From coding and non-coding genes to artificial intelligence approaches*. Nature News. https://www.nature.com/articles/s41391-022-00537-2

Balmana , J., Diez, O., & Cardoso, F. (2011, September). BRCA in breast cancer: ESMO clinical practice guidelines. https://www.annalsofoncology.org/article/S0923-7534(19)38796-4/fulltext#:~:text=The estimated population frequency of,ethnic groups and geographical areas.

Cancer Research infrastructure . (2024, May). *Ai and cancer*. AI and Cancer - NCI. https://www.cancer.gov/research/infrastructure/artificial-intelligence

Central for Disease Control and Prevention, C. (2024, June 13). *U.S. Cancer Statistics Breast Cancer Stat Bite*. Centers for Disease Control and Prevention. https://www.cdc.gov/united-states-cancer-statistics/publications/breast-cancer-stat-bite.html#:~:text=Based%20on%20the%20most%20recent,females%20died%20from%20breast%20cancer

Chang, T., Cao, Y., Sfreddo, H., Dhruba, S., Lee, S., Valero, C., Yoo, S. K., Chowell, D., Morris, L. G., & Ruppin, E. (2024, July 9). *AI tool predict response to cancer therapy*. National Institutes of Health. https://www.nih.gov/news-events/nih-research-matters/ai-tool-predicts-response-cancer-therapy#:~:text=Scientists%20developed%20an%20AI%20tool,personalized%20cancer%20treatments%20for%20patients.

Chang, T.-G., Cao, Y., Sfreddo, H. J., Dhruba, S. R., Lee, S.-H., Valero, C., Yoo, S.-K., Chowell, D., Morris, L. G. T., & Ruppin, E. (2024, June 3). *Loris robustly predicts patient outcomes with immune checkpoint blockade therapy using common clinical, pathologic and genomic features*. Nature News. https://www.nature.com/articles/s43018-024-00772-7

Chen, Z.-H., Lin, L., Wu, C.-F., Li, C.-F., Xu, R.-H., & Sun, Y. (2021, October). *Artificial Intelligence for assisting cancer diagnosis and treatment in the era of Precision Medicine*. Cancer communications (London, England). https://pubmed.ncbi.nlm.nih.gov/34613667/

Cogliano , V. J., Baan, R. A., Straif, K., Grosse, Y., Secretan, M. B., Ghissassi, F. E., & Kleihues, P. (2004, June 3). *The Science and Practice of Carcinogen Identification and Evaluation*. EHP publishing . https://ehp.niehs.nih.gov/doi/10.1289/ehp.6950

Correa, H. (2016, April 13). *Li–Fraumeni syndrome*. Journal of Pediatric Genetics. https://www.thieme-connect.de/products/ejournals/abstract/10.1055/s-0036-1579759

Dembrower, K., Crippa, A., Colon, E., & Ekland, M. (2023). *Artificial Intelligence for Breast Cancer Detection in ...* the Lancet digital health . https://www.thelancet.com/journals/landig/article/PIIS2589-7500(23)00153-X/fulltext

Deo, R. C. (2015, November 17). *Machine learning in medicine | circulation*. AHA Journal . https://www.ahajournals.org/doi/full/10.1161/circulationaha.115.001593

Euhus, D. M. (2015, March 28). *Risk-reducing mastectomy for BRCA gene mutation carriers - annals of surgical oncology*. SpringerLink. https://link.springer.com/article/10.1245/s10434-015-4537-9

Freeman, K., Geppert, J., Stinton, C., Todkill, D., Johnson, S., Clarke, A., & Taylor-Phillips, S. (2021, September 2). *Use of artificial intelligence for Image Analysis in breast cancer screening programmes: Systematic Review of Test Accuracy*. The BMJ. https://www.bmj.com/content/374/bmj.n1872

Fu, Y., Zhou, J., & Li, J. (4202, May). *Diagnostic performance of ultrasound-based artificial intelligence for predicting key molecular markers in breast cancer: A systematic review and meta-analysis*. PLOS ONE. https://journals.plos.org/plosone/article?id=10.1371%2Fjournal.pone.0303669

Gardezi, S. J. S., Elazab, A., Lei, B., & Wang, T. (2019, July). *Breast cancer detection and diagnosis using Mammographic Data: Systematic Review*. Journal of Medical Internet Research. https://www.jmir.org/2019/7/e14464/

Horn, S., & Fehse, B. (2024, May 15). *Wie sicher ist die gentherapie? - die Innere Medizin*. SpringerLink. https://link.springer.com/article/10.1007/s00108-024-01711-5

Howard , F. M., Kochanny, S., Koshy, M., Spiotto , M., & Pearson , A. T. (2020, November). *Machine learning-guided adjuvant treatment of head and neck cancer*. JAMA network open. https://pubmed.ncbi.nlm.nih.gov/33211108/

Hu, K.-L., Wang, S., Ye, X., & Zhang, D. (2020a, July). *Effects of BRCA gene mutation on female reproductive potential: A systematic review*. Redirecting. https://doi.org/10.1016/j.maturitas.2020.04.011

Hu, K.-L., Wang, S., Ye, X., & Zhang, D. (2020b, July). *Effects of BRCA gene mutation on female reproductive potential: A systematic review*. Redirecting. https://doi.org/10.1016/j.maturitas.2020.04.011

Iida, Y., Watanabe, K., Ominami, Y., Toyoguchi, T., Murayama, T., & Honda, M. (2021, June). *Oxford academic*. Oxford Academic. https://academic.oup.com/

Iwamoto , T., Kajiwara, Y., Zhu, Y., & Iida, S. (2020a, March). *Biomarkers of neoadjuvant/adjuvant chemotherapy for breast cancer*. Chinese clinical oncology. https://pubmed.ncbi.nlm.nih.gov/32192349/

Iwamoto , T., Kajiwara, Y., Zhu, Y., & Iida, S. (2020b, March). *Biomarkers of neoadjuvant/adjuvant chemotherapy for breast cancer*. Chinese clinical oncology. https://pubmed.ncbi.nlm.nih.gov/32192349/

Iwamoto , T., Kajiwara, Y., Zhu, Y., & Iida, S. (2020c, March). *Biomarkers of neoadjuvant/adjuvant chemotherapy for breast cancer*. Chinese clinical oncology. https://pubmed.ncbi.nlm.nih.gov/32192349/

Jiang, Y., Zhang , Z., Yuan , Q., Wang, W., Wang, H., Li, T., Huang, W., Xie, J., Chen, C., Sun, Z., Yu, J., Xu, Y., Poultsides, G. A., Xing, L., Zhou, Z., Li, G., & Li, R. (2022, May). *Predicting peritoneal recurrence and disease-free survival from CT images in gastric* *cancer with Multitask Deep Learning: A retrospective study*. The Lancet. Digital health. https://pubmed.ncbi.nlm.nih.gov/35461691/

Jiang, Y., Zhang, Z., Wang, W., Huang, W., Chen, C., Xi, S., Ahmad, M. U., Ren, Y., Sang, S., Xie, J., Wang, J.-Y., Xiong, W., Li, T., Han, Z., Yuan, Q., Xu, Y., Xing, L., Poultsides , G., Li, G., & Li , R. (2023, August). *Biology-guided deep learning predicts prognosis and cancer immunotherapy response*. Nature communications. https://pubmed.ncbi.nlm.nih.gov/37612313/

Jin, Y., Lan, A., Dai, Y., Jiang, L., & Liu, S. (2023, September 30). *Development and testing of a random forest-based machine learning model for predicting events among breast cancer patients with a poor response to neoadjuvant chemotherapy - European Journal of Medical Research*. BioMed Central. https://eurjmedres.biomedcentral.com/articles/10.1186/s40001-023-01361-7

Kaidar-Person, O., Antunes, M., Cardoso, J. S., Ciani, O., Cruz, H., Micco, R. D., Gentilini, O. D., Gonçalves, T., Gouveia, P., Heil, J., Kabata, P., Lopes, D., Martinho, M., Martins, H., Mavioso, C., Mika, M., Montenegro, H., Oliveira, H. P., Pfob, A., … on behalf of the CINDERELLA Consortium. (2023, August). *Evaluating the ability of an artificial-intelligence cloud-based platform designed to provide information prior to locoregional therapy for breast cancer in improving patient's satisfaction with therapy: The Cinderella trial*. PLOS ONE. https://journals.plos.org/plosone/article?id=10.1371%2Fjournal.pone.0289365

Kisling, L. A., & Das, J. M. (2023, August 1). *Prevention strategies*. StatPearls [Internet]. https://www.ncbi.nlm.nih.gov/books/NBK537222/

Lang, K., Josefsson, V., Larsson, A.-M., Larsson, S., Hogburg, C., Sartor, H., Hofvind, S., Andersson, I., & Rosso, A. (2023a, August). *Artificial Intelligence-supported screen reading versus ...* The Lancet Oncology . https://www.thelancet.com/journals/lanonc/article/PIIS1470-2045(23)00298-X/abstract

Lang, K., Josefsson, V., Larsson, A.-M., Larsson, S., Hogburg, C., Sartor, H., Hofvind, S., Andersson, I., & Rosso, A. (2023b, August). *Artificial Intelligence-supported screen reading versus ...* The Lancet Oncology . https://www.thelancet.com/journals/lanonc/article/PIIS1470-2045(23)00298-X/abstract

Lang, K., Josefsson, V., Larsson, A.-M., Larsson, S., Hogburg, C., Sartor, H., Hofvind, S., Andersson, I., & Rosso, A. (2023c, August). *Artificial Intelligence-supported screen reading versus ...* The Lancet Oncology . https://www.thelancet.com/journals/lanonc/article/PIIS1470-2045(23)00298-X/abstract

Lang, K., Josefsson, V., Larsson, A.-M., Larsson, S., Hogburg, C., Sartor, H., Hofvind, S., Andersson, I., & Rosso, A. (2023d, August). *Artificial Intelligence-supported screen reading versus ...* The Lancet Oncology . https://www.thelancet.com/journals/lanonc/article/PIIS1470-2045(23)00298-X/abstract

Lang, K., Josefsson, V., Larsson, A.-M., Larsson, S., Hogburg, C., Sartor, H., Hofvind, S., Andersson, I., & Rosso, A. (2023e, August). *Artificial Intelligence-supported screen reading versus ...* The Lancet Oncology . https://www.thelancet.com/journals/lanonc/article/PIIS1470-2045(23)00298-X/abstract

Lang, K., Josefsson, V., Larsson, A.-M., Larsson, S., Hogburg, C., Sartor, H., Hofvind, S., Andersson, I., & Rosso, A. (2023f, August). *Artificial Intelligence-supported screen reading versus ...* The Lancet Oncology . https://www.thelancet.com/journals/lanonc/article/PIIS1470-2045(23)00298-X/abstract

Lang, K., Josefsson, V., Larsson, A.-M., Larsson, S., Hogburg, C., Sartor, H., Hofvind, S., Andersson, I., & Rosso, A. (2023g, August). *Artificial Intelligence-supported screen reading versus ...* The Lancet Oncology . https://www.thelancet.com/journals/lanonc/article/PIIS1470-2045(23)00298-X/abstract

Ma, M., Liu, R., Wen, C., Xu, W., Xu, Z., Wang, S., Wu, J., Pan, D., Zheng, B., Qin, G., & Chen, W. (2021, October 13). *Predicting the molecular subtype of breast cancer and identifying interpretable imaging features using machine learning algorithms - european radiology*. SpringerLink. https://link.springer.com/article/10.1007/s00330-021-08271-4

Mittal, A., Mohanty, S. K., Gautam, V., Arora, S., Saproo, S., Gupta, R., S, R., Garg, P., Aggarwal, A., R, P., Dixit, N. K., Singh, V. P., Mehta, A., Tayal, J., Naidu, S., Sengupta, D., & Ahuja, G. (2022, January 1). *Artificial intelligence uncovers carcinogenic human metabolites*. bioRxiv. https://www.biorxiv.org/content/10.1101/2021.11.20.469412v3.full

Morgan, K. K. (2024, June 19). *How many people die of cancer a year?*. WebMD. https://www.webmd.com/cancer/how-many-cancer-deaths-per-year

Nero, C., Boldrini, L., Lenkowicz, J., Giudice, M. T., Piermattei, A., Inzani, F., Pasciuto, T., Minucci, A., Fagotti, A., Zannoni, G., Valentini, V., & Scambia, G. (2022a, September 26). *Deep-learning to predict BRCA mutation and survival from digital H&E slides of epithelial ovarian cancer*. MDPI. https://www.mdpi.com/1422-0067/23/19/11326

Nero, C., Boldrini, L., Lenkowicz, J., Giudice, M. T., Piermattei, A., Inzani, F., Pasciuto, T., Minucci, A., Fagotti, A., Zannoni, G., Valentini, V., & Scambia, G. (2022b, September 26). *Deep-learning to predict BRCA mutation and survival from digital H&E slides of epithelial ovarian cancer*. MDPI. https://www.mdpi.com/1422-0067/23/19/11326

Prelaj, A., Miskovic, V., Zanitti, M., Trovo, F., Genova, C., Viscardi, G., Rebuzzi, S. E., Mazzeo, L., Provenzano, L., Kosta, S., Favali, M., Spagnoletti, A., Castelo-Branco, L., Dolezal, J., Pearson, A. T., Russo, G. L., Proto, C., Ganzinelli, M., Giani, C., … Pedrocchi, A. L. (2023, October). Artificial Intelligence for predictive biomarker discovery in ... https://www.annalsofoncology.org/article/S0923-7534(23)04331-4/fulltext

Priyanka, B., Eckert, A. O., Schrey, A. K., & Preissner, R. (2018, April 30). *Protox-II: A webserver for the prediction of toxicity of chemicals | nucleic acids research | Oxford* *academic*. Nucleic Acids Research . https://academic.oup.com/nar/article/46/W1/W257/4990033

Ruppin, E. (2024, April 18). *NIH researchers develop AI tool with potential to more precisely match cancer drugs to patients*. National Institutes of Health. https://www.nih.gov/news-events/news-releases/nih-researchers-develop-ai-tool-potential-more-precisely-match-cancer-drugs-patients#:~:text=In%20a%20proof%2Dof%2Dconcept,respond%20to%20a%20specific%20drug.

Russo, V., Lallo, E., Munnia, A., Spedicato, M., Messerini, L., D'Aurizio, R., Ceroni, E. G., Brunelli, G., Galvano, A., Russo, A., Landini, I., Nobili, S., Ceppi, M., Bruzzone, M., Cianchi, F., Staderini, F., Roselli, M., Riondino, S., Ferroni, P., … Peluso, M. (2022, August 19). *Artificial Intelligence Predictive models of response to cytotoxic chemotherapy alone or combined to targeted therapy for metastatic colorectal cancer patients: A systematic review and meta-analysis*. MDPI. https://www.mdpi.com/2072-6694/14/16/4012

Senturk, N., Tuncel, G., Dogan, B., Aliyeva, L., Dundar, M. S., Ozemri Sag, S., Mocan, G., Temel, S. G., Dundar, M., & Ergoren, M. C. (2021, November 9). *BRCA variations risk assessment in breast cancers using different artificial intelligence models*. MDPI. https://www.mdpi.com/2073-4425/12/11/1774

Sinha, S., Vegesna, R., Mukherjee, S., Kammula, A. V., Dhruba, S. R., Wu, W., Kerr, D. L., Nair, N. U., Jones, M. G., Yosef, N., Stroganov, O. V., Grishagin, I., Aldape, K. D., Blakely, C. M., Jiang, P., Thomas, C. J., Benes, C. H., Bivona, T. G., Schäffer, A. A., & Ruppin, E. (2024, April 18). *Perception predicts patient response and resistance to treatment using single-cell transcriptomics of their tumors*. Nature News. https://www.nature.com/articles/s43018-024-00756-7

Sinha, T., Khan, A., Awan, M., Bokhari, S. F. H., Ali, K., Amir, M., Jadhav, A. N., Bakht, D., Puli, S. T., Burhanuddin, M., & Jadhav, D. A. N. (2024a, May 28). *Artificial Intelligence and machine learning in predicting the response to immunotherapy in non-small cell lung carcinoma: A systematic review*. Cureus. https://www.cureus.com/articles/256635-artificial-intelligence-and-machine-learning-in-predicting-the-response-to-immunotherapy-in-non-small-cell-lung-carcinoma-a-systematic-review#!/

Sinha, T., Khan, A., Awan, M., Bokhari, S. F. H., Ali, K., Amir, M., Jadhav, A. N., Bakht, D., Puli, S. T., Burhanuddin, M., & Jadhav, D. A. N. (2024b, May 28). *Artificial Intelligence and machine learning in predicting the response to immunotherapy in non-small cell lung carcinoma: A systematic review*. Cureus. https://www.cureus.com/articles/256635-artificial-intelligence-and-machine-learning-in-predicting-the-response-to-immunotherapy-in-non-small-cell-lung-carcinoma-a-systematic-review#!/

Torre , L. A., Siegel , R. L., Ward, E. M., & Jemal , A. (2016, January 12). *Global cancer incidence and mortality rates and trends—an update | cancer epidemiology, Biomarkers & Prevention | American Association for Cancer Research*. American Association for Cancer

Research . https://aacrjournals.org/cebp/article/25/1/16/157144/Global-Cancer-Incidence-and-Mortality-Rates-and

Win, A. K., Lindor, N. M., & Jenkins, M. A. (2013, March 19). *Risk of breast cancer in Lynch Syndrome: A systematic review - breast cancer research*. BioMed Central. https://breast-cancer-research.biomedcentral.com/articles/10.1186/bcr3405

Yamamoto, T., Iwasaki, K., Iida, Y., Yuki, K., Nakaji, F., Yamashiro, H., Toyoguchi, T., & Terazono, A. (2024, March 4). *Rapid fiber-detection technique by artificial intelligence in phase-contrast microscope images of simulated atmospheric samples | annals of work exposures and Health | Oxford academic*. Annals of Work exposures and Health. https://academic.oup.com/annweh/article/68/4/420/7619060

Weidlich, V., & Weidlich, G. A. (2018, April 13). Artificial Intelligence in medicine and radiation oncology. Cureus. https://www.cureus.com/articles/11443-artificial-intelligence-in-medicine-and-radiation-oncology#!/