

Deep Learning Predictive Models of Molecular Phenotypes for Overall Survival in Cancer

ABSTRACT

Aims: here the study clearly aims to justify the need of deep learning predictive model in obtaining molecular phenotypes of overall cancer survival.

Study design: The study is based on the secondary qualitative analysis of systematic review.

Methodology: methodology of the study deals with the analysis imaging process in deep learning. It also includes the needs of deep learning models to obtain the imaging of the cancer cells. In the study a detailed discussion on deep learning has been made. The analysis of the primary sources has been obtained by evaluating the quality of the resources in the study. The study also comprises of the thematic analysis that enlightens the benefits of deep learning. The study is based on the analysis of 14 primary research-based articles out of 112 quantitative articles and structuring of a systematic review from the collected data.

Result: The result deals with the morphological and physiological changes occur in the cancerous cells. The result also justifies that prediction can be made by implementing of deep learning in terms of cancer survival. The results also state the advancements of the deep learning models that are helpful in predicting the model of cancer to determine survival rate.

Conclusion: It has been concluded that there must be proper knowledge of deep learning to conduct imaging process. Need of deep learning models have become invasive and it helps to builds a strong ground of cancer survival.

Keywords: *Mutagenesis, Cancer, Deep learning, Gene expression, CNN*

1. INTRODUCTION

Deep learning models have now become an important part of increasing the prognosis rate in cancer patients. These are considered to be novel frameworks that implement computational algorithms in biology. As illustrated by Rathore *et al.* (2019) tumour cells that take the shape of malignancy require a critical treatment method to get reduced. It is indeed a true statement that all cancers are tumours whereas all tumours are not cancer. The statement states that the initial stage of every cancer is a tumour. It shows that the treatment must be done at the very beginning stage. However, no such diagnosis has been evaluated that can remove the cancerous cells completely without giving any radiation to the body. Computational approaches have become an important domain of microscopic images of tissue specimens that might also deal with cancer. The study aims to determine the characteristics of deep learning predictive models in testing the overall survival rate of cancer patients. The objective of the study is, thus, to introduce the present advancements of deep learning predictive models in testing the hypothesis of overall survival rate in cancer in terms of molecular phenotypes. The objective of the study also deals with the features of molecular anatomical changes that occur in the cancerous cell. In the cancerous cells the molecular structure needs to be determined as it shows several structural changes and chromosomal changes. The point mutations are found in the chromosomes that are hard to be featured and distinguished without proper images. There the need for a deep learning model arises so that it can give a definite structure of the modifications of cancerous cells. However, in the case of survival rate it has done wonders because it would even define the initial stage of the cancer that is the tumor that would help to start the treatment at an immediate base.

Background

Cancer, a very slowly developing disease, does not show any symptoms at the beginning of its formation. Unlike any other diseases, there is not much diagnosis and prognosis that can treat the diseases. As per the view of Chen *et al.* (2020) several decades have passed and there is not much progress in the determination of cancerous stages. The patients are always treated at the intermediate or last stage and never in the initial stage due to less visible reports. A number of limited information can be found near the pathologists, however the number is insufficient. On the other hand, in the complicated cancerous stages such as in case of brain cancer or even in hepatic cancer a clear image is being required to identify the channels of that particular cancer. However, there is no such diagnosis method except deep learning that can build up a clear image of the happenings in the cancerous stages. As illustrated by Cheerla and Gevaert (2019) it is necessary to evaluate the deep learning of predictive models because the present invitations fail to produce proper and suggestive information about cancer. A vast mode of multimodal

data is required to identify the stages of the patients. However, these data are necessary to build a strong perception about the outcomes of survival rate in the very last or intermediate stage. Surprisingly, no such evidence has been identified till date that can show the betterment of the outcomes of cancer patients and that also without any side effects of being susceptible or any other diseases. As demonstrated by Suarez-Ibarrola *et al.* (2020) the advancement on every field of the world is occurring with AI or artificial intelligence. It is thus necessary to implement the same in the medical field to get rid of the typically harsh radiation for treating cancer. In the medical field computational technology stimulates the intellectual process of typical cognitive functioning. It is thus necessary to build a strong base that can provide adequate information about the stages of the cancer that is recurring inside the patient's body. Additionally, adopting computational programming in terms of artificial intelligence in this field would help intelligent entities. The initial stage of tumour is required to be treated so that the malignancy can be stopped. In order to analyse the beginning stage of the tumour microscopic images of the cross-sectional areas of human tissue is needed. As narrated by Kather *et al.* (2019) deep learning can be used to extract the information about the complex stages of cancer. This model helps to develop the predictions of the outcome directly from the histological images of the cancer cells or tissues. It is thus considered to be the most important and innovative learning process in the medical field that helps in the prediction of the survival rate of the cancerous patient. In contrast to this statement it is justified that the initiation of the treatment in the beginning stage might help to determine the survival rate as the faster the treatment the more will be the survival rates of cancer patients. Kather *et al.* (2019) have also cited that there are cancer stages that show complexities with increasing life span. However, it also hampers the immune system and makes the human body ineligible to deal with other common diseases. It is necessary to identify the stage with a proper contrasting image so that the recurrence of cancer cells can be identified. It has been noticed that in many cases even after giving radiation to the body there is no improvement of the diseases. It might be because the origin of the cancerous cells in the body is unknown and cannot be determined by any other technique.

2. METHODS AND MATERIALS

Database

Databases are being used to access the data required to conduct any research. In this study the use of Pub Med and Google scholar has been used to collect the primary quantitative and secondary qualitative data respectively. The collected data are analysed properly in the study in terms of resources to estimate the probable outcome of the study. The databases that have been chosen in this study to collect data have helped to extract the data in an organized way. To conduct any design and modelling techniques, databases show significance as important sources can be collected from the databases to generate the idea of preparing any model [*Refer to appendix 1*].

Inclusion and exclusion criteria

An inclusion and exclusion criterion of this study is based on the fact that there is no article comprising a different language rather than English is included and thus it is excluded. The journal articles that are being selected in this study are not more than 10 years older. That means the articles are being collected from the range of 2011 to 2021. To conduct the thematic analysis 14 primary quantitative articles have been chosen and qualitative articles are excluded. The keywords that deal with the research topic are only included. The study also includes the features and characteristics of deep learning while the features of other techniques have been excluded.

Data collection

The collection of the data is based on the extraction of secondary sources. However, each secondary source consists of primary quantitative research that has been conducted in this study. As described by Pal (2017) data analysis is a way of obtaining real data by analysing the existing data. The variables and the factors in a systematic review can be determined by using secondary sources in terms of journal articles. In this study, secondary sources have been collected to build themes based on the chosen topic. Data collection has been made by using several databases such as Pub Med and Google scholar. It has been taken into account that statistical data is present in every chosen article so that comparative analysis can be drawn. Pal (2017) has also manifested that quantitative data collection mainly focuses on surveys and measurement of the pre-existing data sources.

3. RESULTS

The findings of the study deal with the secondary article that comprises primary quantitative study. In this study a quality review and an axial coding table has been made. The thematic analysis of the study is based on the themes created in terms of axial coding. A Boolean table has also been made that shows the keywords for the study [**Refer to appendix 2**].

Prisma for the selected articles

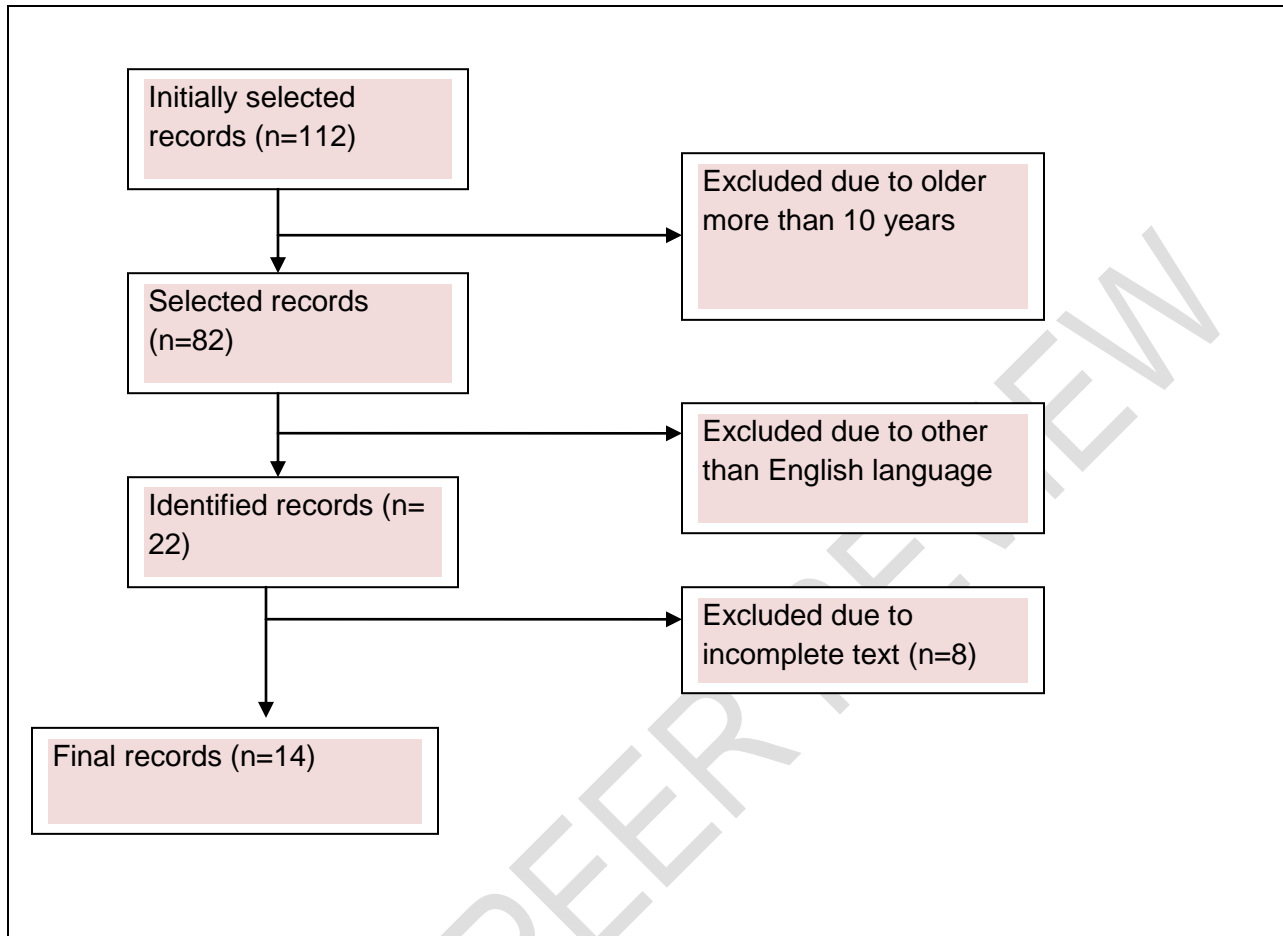


Figure 1: PRISMA diagram

Table 1: Quality review

Authors	Study design	Accuracy in addressing the issue	Accuracy of outcomes	Proper identification of factors	Sufficiency of subjects to meet the objectives	Confounding of the factors have been done
Munir <i>et al.</i> (2019)	Primary quantitative	High	High	Yes	Yes	Yes
Yalaet <i>al.</i>	Primary quantitative	High	High	Yes	Yes	Yes

(2019)						
Schmauch <i>et al.</i> (2020)	Primary quantitative	Medium	High	Yes	Yes	Yes
Smith <i>et al.</i> (2020)	Primary quantitative	High	High	Yes	Yes	Yes
Ardila <i>et al.</i> (2019)	Primary quantitative	High	High	Yes	Yes	Yes
Metovic <i>et al.</i> (2018)	Primary quantitative	Medium	Medium	Yes	Yes	Yes
Brunset <i>et al.</i> (2020)	Primary quantitative	Medium	High	Yes	Yes	Yes
Zhou <i>et al.</i> (2020)	Primary quantitative	High	High	Yes	Yes	Yes
Coudray <i>et al.</i> (2018)	Primary quantitative	High	Medium	Yes	Yes	Yes
Avanzo <i>et al.</i> (2020)	Primary quantitative	High	High	Yes	Yes	Yes

Lee and Fujita (2020)	Primary quantitative	High	High	Yes	Yes	Yes
Xu <i>et al.</i> (2019)	Primary quantitative	High	High	Yes	Yes	Yes
Mobadersanyet <i>al.</i> (2018)	Primary quantitative	High	High	Yes	Yes	Yes
Slavik <i>et al.</i> (2014)	Primary quantitative	High	High	Yes	Yes	Yes

Table 2: Axial coding

Authors	Codes	Sub theme
Munir <i>et al.</i> (2019) Yala <i>et al.</i> (2019)	Deep learning analysis Diagnosis	Analysis of diagnosis with the help of deep learning Uses of deep learning Diagnosis based on deep learning
Schmauch <i>et al.</i> (2020) Smith <i>et al.</i> (2020)	Gene expression Phenotype	Understanding of phenotype prediction from gene expression with the help of deep learning Nature of phenotype of the cancer cells Gene expression or transcriptomics

<p>Ardilaet <i>al.</i> (2019)</p> <p>Metovic <i>et al.</i> (2018)</p>	<p>Screening</p> <p>Cancer</p>	<p>Evaluating the role of deep learning in the screening of cancer stages</p> <p>Screening of cancer cells</p> <p>Screening of stages in lung carcinoma</p>
<p>Brunset <i>al.</i> (2020)</p> <p>Zhou <i>et al.</i> (2020)</p>	<p>Deep learning</p> <p>Activators</p>	<p>Analysing the activators of cancer with the help of introduction deep learning</p> <p>Identification of the activators of cancer cells</p> <p>Role of deep learning in the determination of activators</p>
<p>Coudrayet <i>al.</i> (2018)</p> <p>Avanzoet <i>al.</i> (2020)</p>	<p>Mutagenesis</p> <p>Cancerous cells</p>	<p>Identification of the mutagenesis occurring in the cancer cells with the help of deep learning</p> <p>Stages of cancerous cell</p>
<p>Lee and Fujita (2020)</p> <p>Xu <i>et al.</i> (2019)</p>	<p>Medical imaging</p>	<p>Justification of the uses of deep learning in obtaining medical images</p> <p>Obtaining a medical images</p> <p>Role of deep learning in giving clear overview of the image</p>
<p>Mobadersanyet <i>al.</i> (2018)</p> <p>Slaviket <i>al.</i> (2014)</p>	<p>Histopathology</p> <p>Deep learning</p>	<p>Understanding of the predictions made in the basis of hystopathological observation of cancer cell by deep learning</p>

Critical analysis of the cancer diagnosis using deep learning

The diagnosis of cancer has become a worldwide concern in present days. It has been observed that there is no such advanced procedure that can determine the initial stage of the cancer that is a tumour.

The diagnosis feature thus needed to be improved so that a proper outcome can be achieved in terms of survival rate. As described by Munir *et al.* (2019) raw images of cancer stages might not give a proper solution for the analysis of the stages. On the other hand, it has also been noted that the other processes of obtaining images of cancer cells in terms of pre-processing might create immense noise. It is thus necessary to reduce the noise along with increasing contrast of the images so that they can be analyzed properly. On the contrary, Yalaet *al.* (2019) have elaborated that models have always supported risk-adjusted screening. It means the screening with higher radiation might create disruptions in other somatic cells of the body rather than the cancerous cells. Somatic cells might overcome the issues caused to them however; the radiation might also cause mutations in the chromosomal structure of the somatic cells. In this aspect it can be stated that there must be the implementation of drug related prices so that the patient gets painless treatment. Munir *et al.* (2019) have also discussed that to identify the mutation in the cancerous cells and to resist such mutation by conducting different research requires a handful of proper resources. The resources such as images of cancerous cells and tissues can be obtained from the deep learning model.

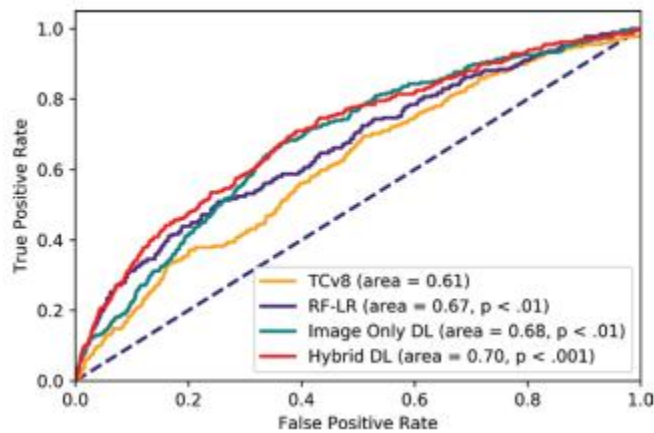


Figure 2. Curve showing true and false positive rates of the models used in the diagnosis procedure of breast cancer

(Source: Yalaet *al.* 2019)

In the given figure as cited by Yalaet *al.* (2019) it can be noticed that the improvement of hybrid deep learning (DL) over other TC or Tyrer-Cuzick tests is more significant. Hence, it can be stated that DL on improvement can help to obtain a much clearer image along with significant value of the histological pathways. The more significant value suggests that there is an accuracy of occurring higher chances of cancer.

Critical analysis of the deep representation of learning on phenotype prediction from gene expression

Determination of the prediction that can confidently give rise to the gene expression in the body due to cancer can be done by deep learning process. As illustrated by Smith *et al.* (2020) that there are various traditional as well as scientific processes that can analyse the expression mechanism in the patients suffering from cancer. It has been analyzed that machine learning methods often provide a clear cut idea about the physiological and morphological changes that are occurring in the cells due to cancer. Smith *et al.* (2020) have also discussed the fact that genes are rarely active and act in isolation. It might be because along with the isolation procedure the physiological changes also happen in the genes in terms of its regulation.

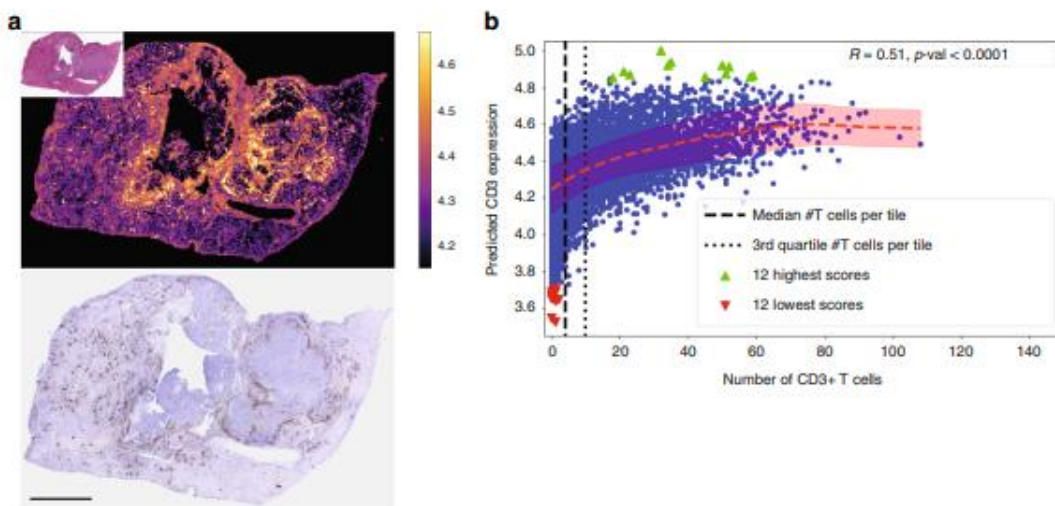


Figure 3. Virtual specialization of the expression of CD3 and CD20

(Source:Schmauch *et al.* 2020)

The above-mentioned figure as opined by Schmauch *et al.* 2020) justifies the presence and expression of CD3 and CD20 genes that are being percent during the formation of cancer. In a word it can be stated that these genes are responsible for giving rise to cancer. Schmauch *et al.* (2020) stated that deep learning models need to be evaluated in terms of RNA sequencing so that expression of these cytokines can be observed.

Critical understanding of screening of lung cancer with three dimensional deep learning and radiomics

Avanzo *et al.* (2020) have demonstrated the fact that the imaging of the cancerous cells has become a crucial challenge in today's world. However, no such evidence has been found that can help in the

formation of better images of cancerous cells. On the other hand, being smaller in size the lung nodules do not get properly imaged on the verge of the detection of lung cancer. Additionally, it has been noted that accuracy of detection of tumour lesions can be improved significantly by implementing the AI interfaces. Avanzoet *al.* (2020) have also demonstrated the idea of histological results that are being obtained from biopsy. However, radiomics features by describing the intensity, shape along with heterogeneity of the tumour. As per the view of Coudrayet *al.* (2018) it has been noted that the American Cancer society and the Cancer statistic Centre has reported over 150,000 patients suffering from lung carcinoma. It has been noted that there are many diagnosis methods that can be used to determine lung cancer yet deep learning is the most accurate one that determines the histopathology of lung cancer by obtaining its proper image.

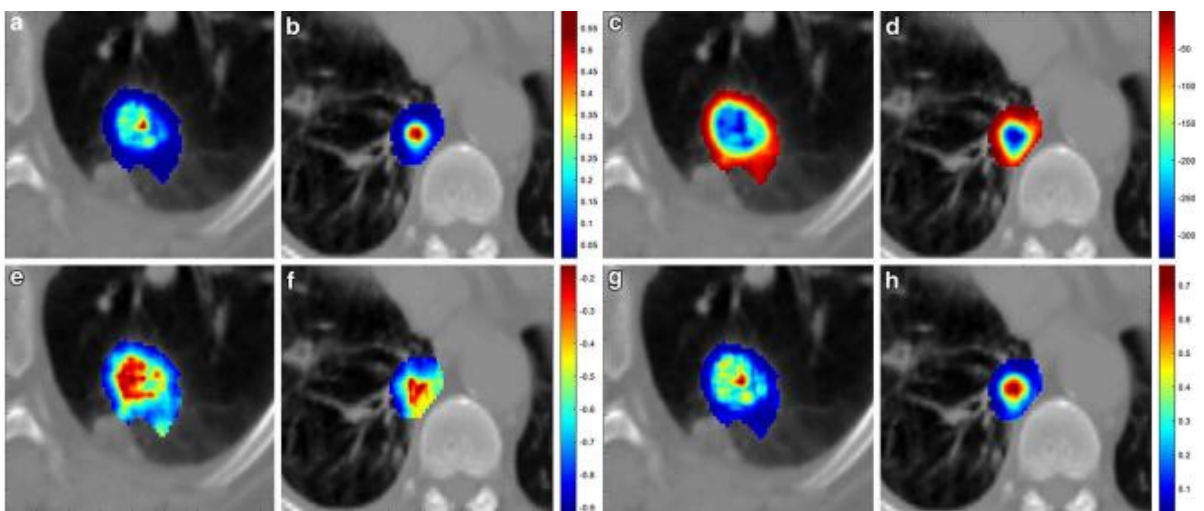


Figure 4. Image obtained by radiomics and calculated from CT scan

(Source: Avanzoet *al.* 2020)

Avanzoet *al.* (2020) have elaborated that chromosomal rearrangements can lead to gene fusion. Therefore, radiomics helps to determine the rearrangement of anaplastics lymphoma kinase or ALK that potentially makes connotative as a multi target.

Critical justification of activators of cancer cells that is synthetic by deep learning

As illustrated by Brunset *al.* (2020) it has been noted that convolution neural channels are the important method to recognize the choice of the image. It has been noted that in such imaging a protein activator has been identified. CNN models are thus used to identify chemokines receptor CXCR4 modulators that consist of high accuracy.

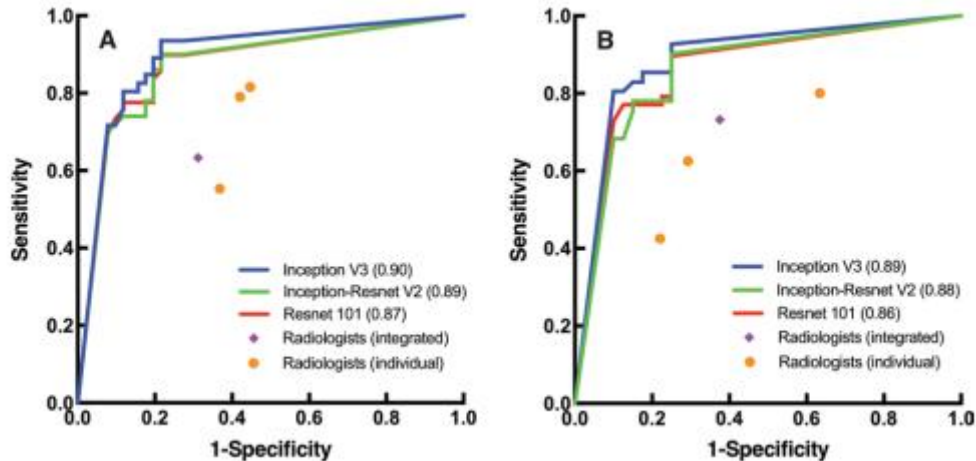


Figure 5. Receiver operating the curves by deep learning convolution models

(Source: Zhou *et al.* 2020)

Brunset *al.* (2020) have also cited that there are channels that consist of G-protein coupled receptors and are observed with the help of deep learning princesses. On the other hand, Zhou *et al.* (2020) have argued on the fact that deep learning also has exhibited excellence in the performances of imaging the quality image in breast cancer. Additionally, in the present day convolution neural networks or CNNs act as the most important deep learning process in generating medical images. However, identifying CNN images is indeed difficult. It needs the most innovative approach so that the images can be analysed properly. Brunset *al.* (2020) have discussed the receptors that are present in the cancerous cells. It is thus necessary to determine such receptors with a proper imaging system to get the idea of molecular morphology and their survival rates.

Critical analysis of the mutagenesis occurring in small cell lung cancer by observing hystopathological images via deep learning

There are several changes that occur in case of morphological changes of cancerous cells. As discussed by Ardilaet *al.* (2019) it has been noted that low doses of computed tomography could not properly establish the changes of the cancerous cells. In contrast to this statement it can be stated that accuracy of the cancerous cell and mutagenesis can only be achieved implementing deep learning methods. Deep returning method on the other hand, by analysing the initial stage helps the patients to survive with proper treatment methods. Ardilaet *al.* (2019) have also cited that the deep learning model provides an additional approach of enlightening the world by detecting the mutagen of the cancerous cells.

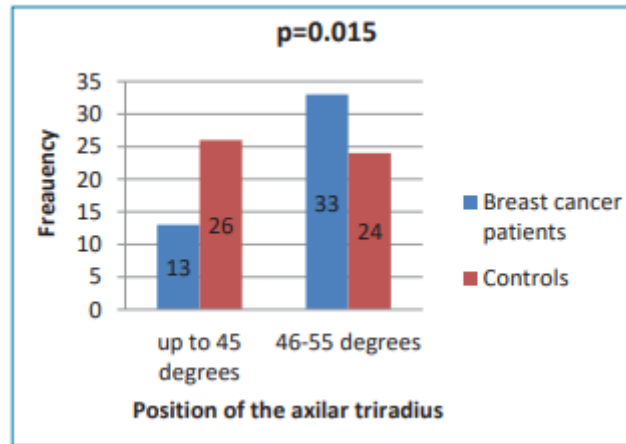


Figure 6. Accuracy in determining the position of axillary triradius in the palm because of dermatoglyphics

(Source: Metovic *et al.* 2018)

Metovic *et al.* (2018) have cited that the positioning of the dermatoglyphics are the determining properties of breast cancers in women. It can be stated that the positioning of dermatoglyphics has been incurred by a deep learning process. In some cases the changes in the hand structure such as the dermatoglyphics might give an idea of such diseases.

Critical evaluation of deep learning in obtaining medical images

Medical imaging is an important tool in the determination of the images. As per the view of Lee and Fujita (2020) it has been noted that there are several aspects to obtaining a medical image for the determination of the diseases. On the other hand, it has been noted that conventional machine learning spark or deep learning has become more advanced in comparison to other magnetic resonance obtaining images or any other radiology method. Lee and Fujita (2020) have also discussed about the fact that the effectiveness of the description of the image depends on the domain expertise of CAD learning model.

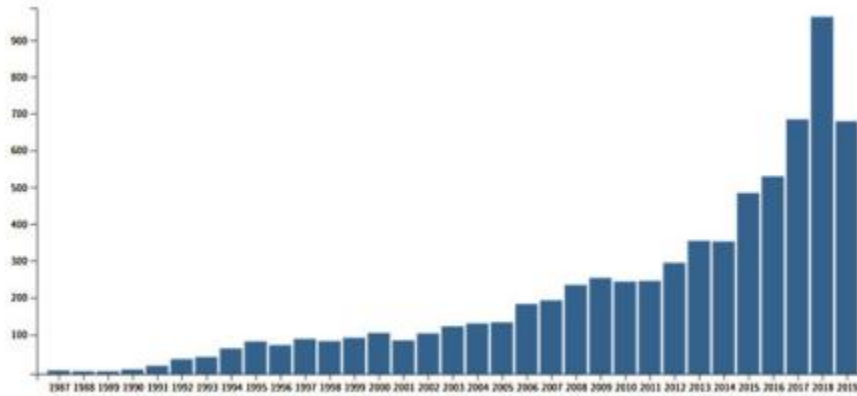


Figure 7. Data records suggests the result of search engine of machine or deep learning journals

(Source: Lee and Fujita (2020))

Xu *et al.* (2019) have discussed the fact that as tumours are continuously enveloping it is necessary to improve the imaging effects too. To obtain a healthy image of the cancerous cell it is necessary to implement advancements. The advancement would be in terms of the improvement of the techniques of image obtaining of cancerous cells and tissues. However, there are many other diagnostic methods that can also create issues in the determination of the mutagenesis in the cancerous cells.

Critical understanding of the predictions that are made by observing outcomes from histology using genomic convolution

The predictions are always made on the basis of the images obtained in the diagnostic methods. However, to understand the initial stage of cancer it is necessary to determine the formation of tumours so that the treatment can proceed with proper pathways. As per the view of Mobadersany *et al.* (2018) it has been noted that cancer histology reflects the molecular progression in the body along with changes in the cell structure.

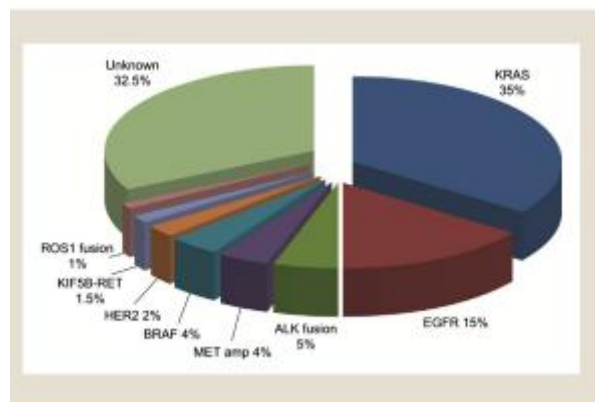


Figure 8. Analysis of oncogenes drivers in the cancerous cells

(Source: Slavik *et al.* 2014)

Identification of the cancerous factor with the help of histology has become an important tool. On the contrary, Slavik *et al.* (2014) have evaluated that where drugs are available the predictions can be made on the basis of survival rate. However, the effectiveness of drugs and other radiations can only be achieved by determining the cancer genomics at the very initial stage. The genomic evolution of cancerous cells is indeed difficult to analyse. Because it has been observed that the mutations that are found in the cancerous cells are never be able to repair. Mobadersany *et al.* (2018) have illustrated that the histological structure of the tissues are also responsible for determination of the cancerous cells. However, a tumor formation might give an overview of turning into malignant tumours and cancer rapidly. On the other hand, as cancerous cells are immortal they might show several variations without getting damaged even after getting radiation.

4. DISCUSSION

The entire study deals with the fact that there are many ways to generate imaging process. However, the only applicable and innovative process is the deep learning process. As per the view of Zhou *et al.* (2020) it has been noted that deep learning helps in building two or even three dimensional images of cancer cells. It is thus expected that in the diagnostic process this model can be a promising approach. In the topic it has been mentioned that deep learning is the method can determine the survival rate. It might be because it deals with analysis of complex images of neural networks. It also determines the stage of the cancer. The results states that axillary triradius can be determined by using deep learning process and it is the symptom of breast cancer. Hence, the treatment of breast cancer can be initiated at an early stage. On the other hand, it has been noticed that there are protein activators that get expressed along with the raising of cancer. As stated by Brunset *et al.* (2020) it has been noticed CXCR4 modulators are such protein kinase that gets expressed in the presence of cancerous cells. The size of protein activators and their receptors on the cancerous cells are indeed smaller. However, those can be determined only by analysing the accurate imaging of the cancerous cells. As per the view of Avanzo *et al.* (2020) rearrangement of the chromosomes also helps to determine the presence of cancer. From the findings it has been evaluated that oncogenes driver can be predicted through deep learning model. In corresponds to the aim, it can be stated that the characteristics of the deep learning method suggest that it is an advanced process to predict the cancerous model. In respect to the objective of the study also helps to understand the modification and advancements of the deep learning process in the medical field. From the results it can thus be determined that deep learning model has become the most important topic for research for predicting cancerous model as the graphical data of the search engine suggest the advantages. One of it important feature is the determination of histological images. The prediction of histological models thus can be made using deep learning method. However, the rearrangements can only be evaluated by

sharpening of the image obtained by deep learning. As the cancerous cells are immortal it is thus necessary to identify them at the very initial stage of their development. As per the view of Ardila *et al.* (2019) deep learning models are an essential part that can even detect the smallest mutation in the cancerous cells. It is thus necessary to evaluate the approaches of cancer detection in terms of imaging so that the proper diagnosis method can be reached. In cancerous tissues or cells the main thing that is to be determined is the molecular and morphological changes occurring in the cell. In corresponds to the objectives the finding suggests that it has several recent advancements of the deep learning process that are needed to determine the molecular morphology of the cancerous predictive model. The survival rate thus can be determined by analyzing the initial impact of the cancerous cell.

5. CONCLUSION

The study concludes the benefits of the deep learning and imaging process that help to determine the changes in the cancerous cells. However, along with deep learning, radiomics can also be introduced as an improved method for the deep learning process. In a conclusive term it can be stated that the deep learning model can contribute in the early determination of the cancer stages. The results suggests that in very cancerous stages it can be proved to be helpful as it determines the stages of the tissue consisting of cancers. It has been evaluated in the study that the imaging process can be generated properly by obtaining the gene expression and activity of protein kinase. In short it can be concluded that there must be incorporation of the improved deep learning model so that the survival rate of the cancerous patients can be estimated. The initial stage can thus be analysed and treated with proper diagnosis as well. It can thus be concluded that when there is a need of opting for cancerous diagnosis method one must opt for the deep learning event. In a nutshell it is concluded that deep learning has become the most important model in the field of cancer detection and it is the only thing that can bring advancement.

ETHICAL CONSIDERATION

The technical consideration of this systematic review can be justified as the maintenance of proper and authentic data. The validation of every research depends on the ethical issues that are being considered properly. Very sources that are being selected from the databases are acknowledged in this study. The extracted data are being analyzed properly and it has been observed that every source is authentic and did not cause any harm to the moral or social culture of humans. It has been kept into account that there is not any wrong symbol or sign being used in this study that can give rise to ethical challenges of the study. For ensuring the ethical concern, throughout the research, every author's names have been acknowledged. It has been kept into account that no single belief of any community is harmed in the study. The data that is included in the study as resources are also not the copyright of anything.

FUTURE SCOPE

The study opens up pathways of using the improved technique of deep learning in the medical field. It has been noted that the study enlightens all the benefits of deep learning that are being evaluated in different clinics and path labs for obtaining accurate and contrasting images of cancerous cells. The necessary implementations that are required to be made for getting prior images of cancerous cells are also being evaluated in the study. The study would also enlighten the necessity of opting for a diagnostic method at the very beginning stage of the cancer. It has been noted that many people considered tumours not to be cancerous. However, it is indeed a wrong perception and its need to be modified properly the study will also open up the broad ideas of deep learning that are necessary for getting proper images of cancerous cells. The developmental stages of a cancerous cell in terms of molecular morphology have also been determined in the study.

UNDER PEER REVIEW

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APPENDICES

Appendix 1: Databases

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Cite Zhang Z, Wang S, Liu Y, Meng Z, Chen F. Oncol Rep. 2019 Sep;42(3):1110-1124. doi: 10.3892/or.2019.7238. Epub 2019 Jul 16. PMID: 31322274 **Free PMC article.**

Share Cox **analysis** identified ZNF385D-AS2 low-expression as an independent prognostic variable (AUC=0.594) for overall survival in liver **cancer** patients. ...In conclusion, our results suggests that low expression of ZNF385D-AS2 is **predictive** of a poor prognosis of ...

2 **Diagnosis and predictive molecular analysis of non-small-cell lung cancer in the Africa-Middle East region: challenges and strategies for improvement.**

Cite Slavik T, Asselah F, Fakhruddin N, El Khodary A, Torjman F, Anis E, Quinn M, Khankan A, Kerr KM. Clin Lung Cancer. 2014 Nov;15(6):398-404. doi: 10.1016/j.clcc.2014.06.005. Epub 2014 Jun 21. PMID: 25113711

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Appendix 2: Boolean table

Keywords	And/or	Keywords
Deep learning	And	Machine learning
Mutagenesis	And	Cancer cells
Molecular testing	And	Carcinoma
CT scan	And	Radiomics
CNN	And	X-ray
Dermatoglyphs	And	Breast cancer
Gene expression	And	Genomics