JOURNAL OF CULTURAL ANALYSIS AND SOCIAL CHANGE
Journal of Cultural Analysis and Social Change,
2025, 10(2), 4920-4932
ISSN: 2589-1316

Prediction of Pancreatic Cancer Based on Data and Artificial Intelligence

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Citation: Dante, C. A. W., Enrique, N. T. S., Elias, V.-C. J., Mileydi, F. F., & Alberto, O. O. L. Prediction of Pancreatic Cancer Based on Data and Artificial Intelligence. Journal of Cultural Analysis and Social Change, 10(2), 4920–4932. https://doi.org/10.64753/jcasc.v10i2.2363

Published: November 25, 2025

ABSTRACT

This research explores the importance of implementing intelligent systems based on artificial intelligence and data science for the prediction and diagnosis of pancreatic cancer, addressing a critical problem related to the high mortality rate and the difficulty of early diagnosis of this disease. It underscores its crucial role in improving survival rates and is aligned with Sustainable Development Goal 3 (SDG 3), which seeks to ensure healthy lives and promote well-being for all, as well as with SDG 9, which promotes the construction of resilient infrastructure and innovation. The overall objective of this research was to identify the best technological tools for preventive diagnosis of pancreatic cancer based on artificial intelligence and data science. This research was basic, with a qualitative approach and descriptive design, using databases such as Scopus and ScienceDirect to collect relevant information and performing documentary analysis of secondary sources. The main results reveal significant challenges, such as the selection of optimal cutoffs to balance sensitivity and specificity, the integration of clinical and genomic data, and the need for explainable models that can handle multimodal data. Notable benefits include early detection of pancreatic cancer, reduced workload for healthcare professionals, and improved diagnostic accuracy. Success stories demonstrating high levels of accuracy in pancreatic cancer classification using advanced techniques such as convolutional neural networks and deep learning are highlighted. In conclusion, the implementation of intelligent systems based on artificial intelligence is essential to improve the detection and treatment of pancreatic cancer, as they improve diagnostic accuracy and efficiency and also contribute to the creation of technological innovations with great social impact.

Keywords: Artificial Intelligence, Data Science, Deep Learning, Pancreatic Cancer, Prediction Models.

INTRODUCTION

Predicting pancreatic cancer using data and artificial intelligence (AI) is a crucial field of research due to the high mortality associated with this disease and the difficulty of early diagnosis. Siegel et al. (2021) report: “Pancreatic cancer is one of the most lethal cancers, with a five-year survival rate of approximately 10%.”(p.127).This low survival rate is largely due to late detection, as symptoms often appear in advanced stages of the disease. Roser (2021) indicates: “As of 2019, cancer deaths reached 10 million, representing 18% of the causes of death worldwide that year.” (p. 3).

Pancreatic cancer prediction using data and artificial intelligence aligns directly with the United Nations Sustainable Development Goal 3 (SDG-3), which seeks to "Ensure healthy lives and promote well-being for all at all ages." This goal includes the specific target of reducing premature mortality from non-communicable diseases, such as cancer, by one-third by 2030. The application of AI in pancreatic cancer prediction is a powerful tool to achieve this goal, improving early detection and personalizing treatment (Jin et al., 2025). Given the pathogenicity of pancreatic cancer, early detection is crucial to improving patient outcomes, and AI offers an unprecedented opportunity to make progress on this front. According to Huang et al. (2022), "Machine learning algorithms can analyze large volumes of medical data, such as MRI images and CT scans, to identify subtle patterns that indicate the presence of pancreatic cancer in its early stages" (p. 114). This approach can lead to earlier diagnoses and therefore improved survival rates. Furthermore, the integration of clinical and genomic data allows for a more comprehensive assessment of a patient's risk profile. Arokia et al. (2024) demonstrated: "Combining imaging data with genomic biomarkers significantly improves the accuracy of pancreatic cancer prediction" (p. 291). This multimodal approach not only"It not only facilitates early detection, but also contributes to the personalization of treatment". (Jan, Z., 2023, p.31).

Likewise, the research also aligns with SDG 9, which seeks to "build resilient infrastructure, promote inclusive and sustainable industrialization, and drive innovation." The application of AI in the health field represents a significant innovation that can transform healthcare infrastructure and improve the efficiency and effectiveness of health systems. Currently, AI enables the rapid and accurate analysis of large volumes of medical data, which is crucial for the early detection of pancreatic cancer. "The use of deep learning algorithms can improve the interpretation of medical images, such as CT scans, identifying pancreatic lesions more accurately than traditional methods" (Liu et al., 2024; Yao et al., 2023). This technological advancement not only improves diagnosis but also optimizes the use of medical resources, aligning with the goal of building resilient infrastructure. The implementation of AI systems in clinical practice can also improve the operational efficiency of hospitals and healthcare centers. According to Davenport (2018), "AI can automate administrative and clinical tasks, freeing up time for healthcare professionals to focus on patient care" (p. 173). This optimization of resources contributes to a more robust and efficient healthcare infrastructure. All this technological implementation would be vital to save more lives from this disease in time, given that Cuesta (2020) indicates: "The pathogenicity of pancreatic cancer makes it the most lethal in the world, only 5% of patients survive more than 5 years after being diagnosed and 75% do not survive more than a year" (p. 16). He also emphasizes: "Every day, worldwide, 1,000 people are diagnosed with this disease, of which 985 will die" (p. 16). Given this, as Yu et al. (2024) indicate: "with the use of AI, this situation can be reversed, providing preventive diagnoses and better treatments" (p. 79).

In Peru, the increase in cases and deaths from pancreatic cancer is worrying. The National Institute of Neoplastic Diseases (INEN, 2019) reports that "from 2000 to 2019 there was an increase in cases of 126%, making a total of 3,005 new cases of pancreatic cancer, counting from 2000 to 2019", but EsSalud (2024) indicates that "it performed more than 7,000 for pancreatic cancer until November 2024, with women having a higher incidence with 73% and men 27%", showing a large increase in new cases in our country.

Given the problems encountered, this study refers to the global impact of the lack of technological tools for the preventive diagnosis of pancreatic cancer, since when the disease is detected in an advanced stage, little can be done, thus contributing to the high mortality rate of this disease. Singhi et al. (2019) indicate:

> Preventive diagnosis is notoriously difficult due to a combination of biological and clinical factors. This challenge is reflected in the mortality rate associated with the disease, as most patients are diagnosed in advanced stages when treatment options are limited. (p. 14)
>
> One of the main obstacles to preventive diagnosis is the lack of specific symptoms in the early stages of the disease. Singhi et al. (2019) indicate:
>
> Pancreatic cancer often presents no clear symptoms until it has spread to other organs. Initial symptoms, such as weight loss, abdominal pain, and jaundice, are often nonspecific and can be attributed to other, less serious conditions. This lack of specific symptoms makes early identification of the disease difficult. (p. 10)

Furthermore, the anatomical location of the pancreas contributes to the difficulty of diagnosis. The pancreas is located deep within the abdomen, making it difficult to visualize using standard imaging techniques. Ungkulpasvich et al. (2023) noted that "current imaging techniques, such as computed tomography and magnetic resonance imaging, may not detect small or early lesions, delaying diagnosis" (p. 27).

Another factor complicating diagnosis is the biological aggressiveness of pancreatic cancer. This type of cancer tends to grow and spread rapidly. The rapid progression of the disease and its tendency to metastasize early mean that even relatively early diagnoses are often made after the cancer has already spread beyond the pancreas, limiting the window of opportunity for early detection (Takikawa, 2022; Trikudanathan, 2021).

For all the above reasons, it is essential to seek a solution, otherwise mortality rates will remain alarmingly high, and the impact on health systems and society will be significant. One of the most immediate consequences is the continued increase in mortality associated with pancreatic cancer. Rahib et al. (2020) project that "pancreatic cancer will become the second leading cause of cancer-related death by 2030 without significant advances in early detection and treatment" (p. 91). This increase in mortality not only affects patients and their families but also imposes a considerable economic burden on health systems.

Furthermore, the lack of early diagnosis limits effective treatment options. Without preventive screening tools, patients are often diagnosed in advanced stages when curative surgery is no longer a viable option. According to Kolbeinsson et al. (2020), "Most patients with advanced pancreatic cancer are only eligible for palliative treatments, which significantly reduces their quality of life and life expectancy" (p. 8).

Another important consequence is the psychological and emotional impact on patients and their families. A late diagnosis often means a grim prognosis, which can lead to a higher incidence of depression and anxiety in both patients and their caregivers. According to Van Beek et al. (2021), "the psychological stress associated with a late diagnosis can exacerbate symptoms and negatively affect the remaining quality of life" (p. 47)).

Thus, the following research problems were considered: What are the challenges for researchers?create modelsprediction and diagnosis of pancreatic cancer? What are the benefits?to create models ofPrediction and diagnosis of pancreatic cancer? And what are they?Success stories in creating prediction and diagnostic models for pancreatic cancer?

For all the above reasons, this research was justified from a social perspective, as it would demonstrate tools that aid in preventive diagnosis, whose potential to save lives and improve patients' quality of life is extremely high, and which would be of significant importance to society due to their impact.

Given that this type of cancer is one of the most lethal, with an extremely low survival rate due to the difficulty of early diagnosis, the implementation of AI-based prediction models can revolutionize the detection and treatment of this disease, offering significant hope to patients and their families (Gasser, 2024, p. 28).

The research was justified theoretically because it filled a significant gap in existing knowledge by addressing the challenges associated with early detection of this disease. Traditionally,"The diagnosis of pancreatic cancer has been complicated due to the lack of specific symptoms in its early stages and the anatomical location of the pancreas, which makes it difficult to visualize using standard imaging techniques."(Ungkulpasvich et al., 2023, p. 37). The implementation of AI-based prediction models offered an innovative solution to these problems, allowing"The analysis of large volumes of medical data and the identification of subtle patterns that indicate the presence of pancreatic cancer in its early stages"(Huang et al., 2022, p.78).

The study showed that"The integration of clinical and genomic data significantly improved the accuracy of pancreatic cancer prediction."(Arokia et al., 2024, p.71), facilitating early detection, improving treatment and increasing patient well-being.

The research would contribute by providing ideas and recommendations for future research. One suggestion would be to develop more robust algorithms that can handle variability in medical data and improve the interpretability of AI models. In addition, it was recommended"Integrating data from different sources, such as electronic medical records and wearable sensor data, to enrich prediction models"(Davenport, 2018, p.49).

Another promising suggestion for future research is the exploration of additional biomarkers that can complement imaging and genomic data."The identification of new biomarkers could further improve the accuracy of prediction models and provide valuable information for the development of personalized treatments."(Singhi et al., 2019, p.23).

The research was justified from a practical perspective because the article showed how the identified models helped solve real, tangible problems in the fields of public health and oncology."Early detection of pancreatic cancer has historically been challenging due to the lack of specific symptoms in the early stages and the anatomical location of the pancreas, which complicates its visualization using standard imaging techniques."(Ungkulpasevich et al., 2023, p.51). The implementation of AI-based prediction models offered a practical solution to these challenges, enabling the analysis of large volumes of medical data and the identification of subtle patterns that indicate the presence of pancreatic cancer in its early stages (Huang et al., 2022, p. 37).

The research was justified on technological grounds, as it revealed that the use of deep learning algorithms improved the interpretation of medical images, such as CT scans, identifying pancreatic lesions with greater accuracy than traditional methods (Liu et al., 2024; Yao et al., 2023). This technological advancement not only improved diagnosis but also optimized the use of medical resources.

It is from the questions mentioned above that the objectives arose and were defined as follows: The general objective was to identify the best technological instruments for preventive diagnosis of pancreatic cancer, based on artificial intelligence and data science, and the following were chosen as specific objectives:Describethe challenges that researchers had tocreate modelsprediction and diagnosis of pancreatic cancer, also describe the benefits ofcreate modelsprediction and diagnosis of pancreatic cancer and finally describe the success storieswhen creating modelsprediction and diagnosis of pancreatic cancer.

METHODOLOGY

This literature review article made it possible to collect scientific and empirical information related to the research "Prediction of Pancreatic Cancer Based on Data and Artificial Intelligence", with a descriptive research, Hernandez-Sampieri and Mendoza (2018), define scientific research as: "set of systematic and empirical processes that are applied to the study of a phenomenon" (p. 34). On the other hand, the Documentary Analysis of Secondary Sources methodology was used, according to Marcelino et al. (as cited in Arias-Odón, 2023), describe documentary analysis as: "a process of knowledge construction in which the work inputs are mainly written documents, however, due to technology, documentary analysis has evolved: today, they are also texts in digital or electronic format" (p. 3), similarly, the search was carried out in databases such as Scopus, ScienceDirect, Springer, Dialnet whose search criteria covered the time interval between 2018 and 2025. Documents such as research reports, research articles, books, as well as reviews or reflections published in journals were prioritized. The collected studies were selected based on their availability in languages such as English, German and Spanish, also ensuring that they were openly accessible.

The following terms were used as descriptors, derived from the research question: "Pancreatic cancer", "Early Detection", "Preventive Diagnosis", "Machine Learning", "Deep Learning", "Data Science", Due to the specificity of the search, established terms and Boolean operators: [("Pancreatic cancer") AND ("Early Detection" OR "Preventive Diagnosis") AND ("Machine Learning" OR "Deep Learning") AND ("Data Science")].

In light of this, the following search criteria are proposed for the different databases:

Scopus [("Pancreatic cancer") AND ("Early Detection" OR "Preventive Diagnosis") AND ("Machine Learning" OR "Deep Learning") AND ("Data Science")].

(TITLE-ABS-KEY ("pancreatic cancer") AND TITLE-ABS-KEY ("Early Detection") AND TITLE-ABS-KEY ("Deep Learning") OR TITLE-ABS-KEY ("DATA SCIENCE"))

ScienceDirect [("Pancreatic cancer") AND ("Early Detection" OR "Preventive Diagnosis") AND ("Machine Learning" OR "Deep Learning") AND ("Data Science")].

Subsequently, a detailed review of the documents was conducted, selecting 45 articles that met the established requirements and were appropriate for study and analysis in line with the proposed objectives.

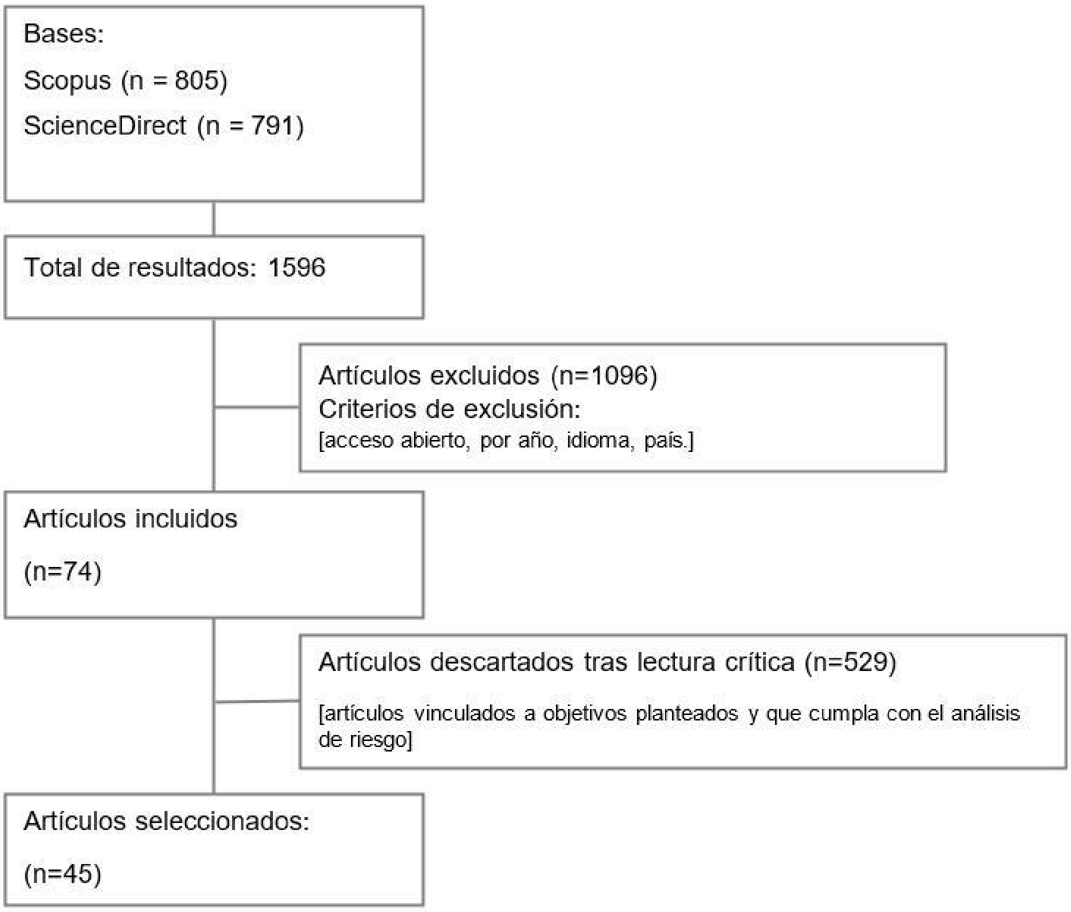

Figure 1. Flowchart of the literature article.

RESULTS AND DISCUSSION

This section presents the results obtained during the research, focusing on the scope and development of the objectives set. These objectives seek to form a comprehensive view of the implementation ofintelligent systems for prediction and diagnosis of pancreatic cancer.This will be achieved by focusing research on topics such as deep learning for diagnosing pancreatic cancer, early detection through prediction models, and the accuracy of diagnosis by intelligent systems.

Description OFTHE Challenges Researchers Faced in Creating Prediction and Diagnostic Models for Pancreatic Cancer

Table 1. Challenges forcreate modelsprediction and diagnosis of pancreatic cancer.

Year	Author(s)	Challenges
2025	Dzemyda, G., Kurasova, O., Medvedev, V., Šubonienė, A., Gulla, A., Samuilis, A., Jagminas, D., & Strupas, K.	• One of the main challenges is the appropriate selection of an optimal cutoff point, which acts as a threshold for evaluating the model's results. This cutoff point is crucial, as it directly influences diagnostic accuracy, balancing the system's sensitivity and specificity. • Evaluating system accuracy using multiple metrics, such as the Youden index, the (0, 1) criterion, the Matthews correlation coefficient, the F1 score, LR+, LR−, balanced accuracy, and the geometric mean. Each of these metrics provides a different perspective on model performance, and finding the right balance between them is essential for developing a reliable system.
2024	Kavitha, A., Sriram, D.R., & Arunkumar, R.	• Combining histopathological images with genomic data is crucial for capturing both morphological and genetic variations in cancer. However, these data are inherently different in nature and scale, complicating their integration. • Develop a convolutional neural network (CNN) architecture that can leverage the strength of multiple networks to improve prediction accuracy. • Using clinical data to predict patient survival after surgery using models such as Cox Proportional Hazards and deep learning techniques. • Implement a mechanism that enables detailed representation of features at multiple scales and contextual understanding of complex tumor morphology and individual genomic variations.
2024	Bhargavi, K., Prasad, M.L., Arun, G., Shaker Reddy, P.C., Yuvalatha, S., & Triveni, M.N.	• Medical image preparation, such as those obtained by computed tomography (CT) or magnetic resonance imaging (MRI), is crucial to improve image quality and facilitate accurate analysis. • Segmenting medical images to identify and delineate areas of interest, such as tumors, is an essential but complex step. The proposed technique uses a K-NN Fuzzy Equality code, which must be robust enough to handle variability in tumor appearance and image quality. Accuracy at this stage is critical for extracting relevant features and correctly classifying tumor cells. • Extracting meaningful features from segmented images and using them to classify tumor cells is a process that requires advanced algorithms and extensive computational power. • Combining Deep Convolutional Neural Networks (DCNN) with Deep Belief Networks (DBN) to improve diagnostic accuracy.
2024	Ramaekers, M., Viviers, CGA, Hellström, TAE, Ewals, LJS, Tasios, N., Jacobs, I., Nederend, J., Sommen, FVD, & Luyer, MDP	There is a need to integrate clinically relevant secondary features to improve diagnostic accuracy. Furthermore, the variability in CT images and the complexity of pancreatic tumors make the models difficult to generalize.
2024	Yu, G., Zhang, Z., Eresen, A., Hou, Q., Amirrad, F., Webster, S., Nauli, S., Yaghmai, V., & Zhang, Z.	Predicting and monitoring immune checkpoint inhibitor therapy in pancreatic cancer faces the complexity of interpreting atypical responses such as pseudoprogression. Furthermore, the integration of multimodal data and the need for explainable models are significant challenges.
2025	Nadeem, A., Ashraf, R., Mahmood, T., & Parveen, S.	Implementing an automated CAD system for the early detection and classification of pancreatic cancer requires handling large volumes of image data and improving the accuracy of tumor segmentation and

		detection. Variability in tumor appearance and the need for rapid processing are additional challenges.
(2024).	Ahmed, T.M., Lopez-Ramirez, F., Fishman, E.K., & Chu, L.	Models must be trained with optimal data that adequately represents the diversity of the population, including different demographics and variations in imaging protocols. A lack of representative data can lead to poor performance when models are applied to new patients or different clinical contexts.
2025	Jin, D., Khan, N.U., Gu, W., Lei, H., Goel, A., & Chen, T.	A significant challenge is the integration of genetic testing and biomarkers into clinical practice for early detection. Furthermore, implementing artificial intelligence tools to analyze large data sets and improve diagnostic accuracy requires overcoming technological and cost barriers.
2025	Moglia, V., Johnson, O., Cook, G., de Kamps, M., & Smith, L.	• Electronic health record (EHR) data quality is a significant challenge due to variability in data recording across clinics and sites. • The lack of consensus on the appropriate prediction windows for each type of cancer, which can affect the effectiveness of predictive models. • The high rate of bias in studies due to inappropriate study designs and small sample sizes. • The need to compare longitudinal approaches with cross-sectional methods to assess whether longitudinal data actually improve predictive capabilities.

Research has identified several challenges ranging from data quality to clinical integration of technologies. Dzemyda et al. (2024) highlight the importance of selecting an optimal cutoff to balance system sensitivity and specificity, a crucial challenge for diagnostic accuracy. Evaluating system accuracy using multiple metrics, such as the Youden index and the Matthews correlation coefficient, provides different insights into model performance, and finding the right balance between them is essential for developing a reliable system. Kavitha et al. (2024) emphasize the complexity of integrating histopathological and genomic data, which are inherently different, to capture both morphological and genetic variations in cancer. Developing a convolutional neural network (CNN) architecture that can exploit the strength of multiple networks to improve prediction accuracy is a significant challenge. Bhargavi et al. (2024) point out the need for robust medical image preparation and accurate segmentation to identify areas of interest, such as tumors, which is essential for extracting relevant features and correctly classifying tumor cells. The proposed technique uses a Fuzzy Equality K-NN code, which must be robust enough to handle variability in tumor appearance and image quality. Ramaekers et al. (2024) underline the need to integrate clinically relevant secondary features to improve diagnostic accuracy, while Yu et al. (2024) mention the complexity of interpreting atypical responses to therapies and the need for explainable models that can handle multimodal data. Nadeem et al. (2024) address the challenge of handling large volumes of image data and improving the accuracy of tumor segmentation and detection in automated CAD systems. Variability in tumor appearance and the need for fast processing are additional challenges. Ahmed et al. (2025) and Jin et al. (2025) agree on the importance of training models with representative and diverse data, and on the need to overcome technological and cost barriers to implement artificial intelligence tools in clinical practice. Finally, Moglia et al. (2024) highlight the challenges related to the quality of data from electronic health records and the lack of consensus on the appropriate prediction windows for each cancer type, which can affect the effectiveness of predictive models. Together, these challenges reflect the complexity of implementing intelligent systems in pancreatic cancer diagnosis, underscoring the need to address both technical and clinical aspects to improve the accuracy and effectiveness of these technologies.

Describe The Benefits of Creating Prediction and Diagnostic Models for Pancreatic Cancer

Table 2. Benefits of creating prediction and diagnostic models for pancreatic cancer.

Year	Author(s)	Benefits
2024	Shukla, R.P., Jain, S., Sakshi, & Shrivastav, A.K.	• Early detection of pancreatic cancer is crucial for improving patient survival rates. By identifying the disease in its early stages, doctors can intervene with more effective and less invasive treatments, thus increasing the chances of a full recovery. • Models can help reduce the workload of healthcare professionals by automating part of the diagnostic process, allowing them to focus on direct patient care and more informed clinical decision-making.
2024	Deepthi, G., Anusha Bamini, A.M., & Praveen, Y.J.	• The ability to detect tumors in early stages is crucial for increasing survival rates. When pancreatic cancer is identified in its early stages, the chances of

		cure are significantly higher, allowing for more effective and less invasive interventions. • Image classification models such as VGG16, ResNet, and DenseNet improve diagnostic accuracy and also enable clinicians to intervene in a timely manner, which is vital for improving patient outcomes. The high accuracy and recall values achieved by these models underscore their potential to correctly identify cases of pancreatic cancer, thereby reducing false negatives that could delay treatment.
2023	Vishnudas, C.K., & Gnana King, G.R.	• Computer-aided diagnosis (CAD) models utilize advanced deep learning techniques to segment and classify pancreatic tumors with high accuracy. These models not only facilitate more precise diagnoses but also enable healthcare professionals to develop more informed and timely treatment plans. These models' ability to process computed tomography (CT) images and extract relevant features using techniques such as Enhanced Anisotropic Diffusion Filtering (BADF) and Contrast-Limited Adaptive Histogram Equalization (CLAHE) significantly improves image quality and, consequently, diagnostic accuracy. • The use of 3D convolutional neural networks optimized with techniques such as Enhanced Harris Hawk Optimization (IHHO) allows for impressive levels of accuracy, sensitivity, and specificity. These models outperform more traditional approaches, proving to be superior tools for the early detection and accurate classification of pancreatic cancer.
2023	Faur, A.C., Lazar, D.C., & Ghenciu, L.A.	• One of the main benefits is the ability to identify neoplastic lesions at early stages, which is crucial for increasing survival rates. When these lesions are detected early, patients are more likely to be candidates for surgeries that offer a better prognosis. • By integrating biomarkers and medical data from different sources, AI models can improve the accuracy of screening programs, which is essential for identifying at-risk patients within the general population.
2023	Geetha, R., Vidhya, S., Rani, PJI, Meenaabarna, K.T., Sudhaakar, K., & Mohan, E.	• Deep learning models, such as convolutional neural networks (CNNs) and recurrent neural networks (RNNs), can identify precancerous lesions or small tumors that might otherwise be missed during routine examinations. This allows doctors to intervene with more effective treatments, such as surgery, that offer better prognoses and increase survival rates. • By providing a detailed analysis of each patient's tumor-specific characteristics, these models allow physicians to design personalized treatment plans. This may include selecting specific therapies that are most effective for the patient's genetic or molecular tumor profile.
2023	Manesh, VM, & Subramoniam, M.	• Computer-aided diagnosis (CAD) models allow radiologists to identify abnormalities in medical images, such as computed tomography (CT) scans and magnetic resonance imaging (MRI), more quickly and accurately. This is crucial for detecting pancreatic cancer in its early stages, when treatment options are most effective and prognoses are most favorable. • CAD systems help radiologists assess cancer stage more accurately, which is critical for determining the most appropriate course of treatment. By providing accurate nodule segmentation and identifying different stages of cancer, these models facilitate a more complete disease assessment.
2023	Ravi, K.C., Dixit, R.R., Indhumathi, T., Singh, S., Gopatoti, A., & Yadav, A.S.	• Advanced models, such as those that combine Multilayer Perceptrons (MLP) and Support Vector Machines (SVM), can detect disease when it is most treatable, enabling more effective and timely interventions. • By extracting complex features from medical data and utilizing the discriminative power of SVMs, the likelihood of false positives and negatives is reduced, ensuring that patients receive appropriate treatment.
2023	Upreti, K., Mittal, S., Vats, P., Haque, M., Pawar, V., & Haque, M.	• AI-based systems can analyze large volumes of medical images, such as computed tomography (CT) scans, magnetic resonance imaging (MRI), and positron emission tomography (PET) scans, to identify pancreatic cancer in its early stages. This early detection is crucial for increasing survival rates, as it allows for more effective and timely interventions. • Deep learning models, such as convolutional neural networks, demonstrate high accuracy and sensitivity in identifying pancreatic tumors. This reduces the likelihood of false negatives and positives, ensuring that patients receive an accurate diagnosis and appropriate treatment.

		• Early and accurate detection of pancreatic cancer can lead to better treatment outcomes. By identifying the disease in its early stages, doctors can offer more effective treatment options, thereby improving the patient's chances of recovery.
2023	Shi, Y., Tang, H., Baine, M.J., Hollingsworth, M.A., Du, H., Zheng, D., Zhang, C., & Yu, H.	• The 3DGAUnet model enables the generation of high-quality synthetic images of pancreatic tumors, which is crucial for improving early detection of pancreatic cancer. • By generating synthetic data, the model helps overcome the scarcity of clinical data, enabling more robust training of deep learning models. • The model's ability to maintain spatial coherence in 3D images improves the accuracy of computer-aided diagnostic systems.
2024	Mandal, S., Balraj, K., Kodamana, H., Arora, C., Clark, J.M., Kwon, D.S., & Rathore, A. S.	• The weakly supervised learning approach enables accurate detection of pancreatic tumors using computed tomography (CT) images, even with limited data. • Integrating artificial intelligence results into clinical workflows can improve decision-making by providing faster and more accurate diagnoses.
2024	Chhikara, J., Goel, N., & Rathee, N.	• Identifies the most effective imaging modalities for detecting pancreatic cancer, such as computed tomography (CT), magnetic resonance imaging (MRI), and endoscopic ultrasound (EUS), so that healthcare professionals can optimize the use of available resources and technologies, thereby improving diagnostic accuracy. • The implementation of deep learning techniques can significantly improve the accuracy of pancreatic cancer diagnosis by identifying patterns and characteristics that might otherwise go unnoticed by healthcare professionals.
2023	Placido, D., Yuan, B., Hjaltelin, J.X., Zheng, C., Haue, AD, Chmura, P.J., Yuan, C., Kim, J., Umeton, R., Antell, G., Brunak, S., & Sander, C.	• Deep learning models can identify a small group of high-risk patients, allowing surveillance resources to be focused on those who would benefit most from early diagnosis. • The models not only predict whether cancer is likely to occur, but also provide a risk assessment at incremental time intervals. This allows for more personalized surveillance tailored to each patient's individual needs.
2023	Reddy, CRP, & Srinagesh, A.	The implementation of a Computer Aided Diagnostic System (CAD) based on UNet++ architecture enables accurate detection and classification of pancreatic cancer using magnetic resonance imaging (MRI).

The research showedthe benefits of implementing intelligent pancreatic cancer prediction and diagnosis systems, which indicatesignificantly improves healthcare and patient outcomes. Shukla et al. (2024) highlight the importance of early detection, which is crucial for increasing survival rates by enabling more effective and less invasive interventions, while also pointing to the ability of these systems to reduce the workload of healthcare professionals by automating part of the diagnostic process. Deepthi et al. (2024) underline the ability of image classification models, such as VGG16 and DenseNet, to improve diagnostic accuracy and enable timely interventions, thereby reducing false negatives that could delay treatment. Furthermore, Vishnudas and Gnana King (2023) emphasize the use of computer-aided diagnosis (CAD) models that employ advanced deep learning techniques to segment and classify pancreatic tumors with high accuracy, facilitating more precise diagnoses and more informed treatment plans. Faur et al. (2023) mention the ability of these systems to identify neoplastic lesions at early stages, which is essential to improve survival rates and enable more effective treatments. Geetha et al. (2023) highlight how deep learning models, such as CNNs and RNNs, can identify precancerous lesions or small tumors, enabling more effective and personalized interventions. Similarly, Manesh and Subramoniam (2023) point out that CAD systems allow radiologists to identify anomalies in medical images more quickly and accurately, which is crucial for the early detection of pancreatic cancer. Ravi et al. (2023) and Upreti et al. (2023) agree that advanced models can analyze large volumes of medical images to identify cancer at its early stages, thus improving survival rates and diagnostic accuracy. Shi et al. (2023) highlight the ability of the 3DGAUnet model to generate high-quality synthetic images, which helps overcome the scarcity of clinical data and improves the accuracy of computer-aided diagnosis systems. For this reason, Mandal et al. (2024) emphasize the accuracy in detecting pancreatic tumors using CT images, even with limited data, and the improvement in clinical decision-making by integrating artificial intelligence results. Chhikara et al. (2024) identify the most effective imaging modalities for pancreatic cancer detection and underline how deep learning techniques can significantly improve diagnostic accuracy by identifying patterns and features that might otherwise be missed by healthcare professionals. Placido et al. (2023) mention the ability of deep learning models to identify high-risk patients,allowing for more personalized surveillance tailored to each patient's individual needs. Finally, Reddy and Srinagesh (2023) highlight the implementation of a CAD system based on the UNet++ architecture for the accurate detection and classification of pancreatic cancer using magnetic resonance imaging.

Describe The Success Stories in Creating Prediction and Diagnostic Models for Pancreatic Cancer

Table 3. Success stories in creating pancreatic cancer prediction and diagnostic models.

Year	Author(s)	Models
2024	Chhikara, J., Goel, N., & Rathee, N.	The 3DGAUnet model, which uses generative adversarial networks (GANs) with a 3D U-Net-based generator, has demonstrated an accuracy of 98.41% in the early detection of pancreatic cancer.
2021	Abbas, SK, & Obied, RS	The system was created by a Computer Aided Diagnosis (CAD) system, using a deep neural network architecture Synergic Inception ResNet-V2 to identify cases of pancreatic cancer from publicly available CT images, achieving an accuracy of 99.23% in patient detection.
(2023).	Acer, İ., Orhanbulucu, F., Içer, S., & Latifoglu, F.	The study found that ensemble learning models, especially the Gradient Boosting Classifier (GBC), were most successful in classifying healthy controls and PDAC patients, achieving an accuracy of 92.99% and an AUC of 0.9761.
2023	Bahado-Singh, R.O., Turkoglu, O., Aydas, B., & Vishweswaraiah, S.	The model used DNA methylation analysis and deep learning to detect pancreatic cancer by analyzing circulating cell-free DNA (cfDNA). Highly accurate detection of pancreatic cancer was achieved with an AUC of 1.00, a sensitivity of 100%, and a specificity of 100% using a deep learning approach.
2022	Mikdadi, D., O'connell, KA, Meacham, PJ, Dugan, MA, Ojiere, MO, Carlson, TB, & Klenk, JA	The deep learning model for diagnosing pancreatic cancer precursor lesions, achieving an AUC of 0.98, a sensitivity of 95.7%, and a specificity of 92.6%.
2021	Bakasa, W., & Viriri, S.	The use of machine learning (ML) algorithms as effective tools for predicting pancreatic cancer survival. The authors mention that techniques such as support vector machines and convolutional neural networks have shown significant potential in improving our understanding of cancer progression.
2021	Enriquez, JS, Chu, Y., Pudakalakatti, S., Hsieh, KL, Salmon, D., Dutta, P., Millward, NZ, Lurie, E., Millward, S., McAllister, F., Bhattacharya, PK, & Shams, S.	The integration of hyperpolarized magnetic resonance imaging (HP-MR) and artificial intelligence (AI) to improve early detection of pancreatic cancer. The authors highlight that HP-MR can detect metabolic changes in early stages of cancer, while AI can analyze large imaging datasets to identify suspicious patterns.
2020	Pereira, SP, Oldfield, L., Ney, A., Hart, PA, Keane, MG, Pandol, SJ, Li, D., Greenhalf, W., Jeon, CY, Koay, EJ, Lennon, AM, & Costello, E.	• The model based on patients with recent-onset diabetes in Minnesota, USA, achieved a sensitivity of 78% and a specificity of 80% (AUC 0.87). • The model based on a UK population with recent-onset diabetes achieved a sensitivity of 11% and a specificity of 99.7% (AUC 0.82).
2020	Weisberg, E.M., Chu, L.C., Park, S., Yuille, A.L., Kinzler, K.W., Vogelstein, B., & Fishman, E.K.	The proposed model was designed to assist in the interpretation of pancreatic CT images, with the goal of reducing diagnostic errors and detecting pancreatic cancer at early stages. The project has achieved a sensitivity of 94.1% and a specificity of 98.3% in classifying pancreatic cancer using radiomic features.
2023	Reddy, CRP, & Srinagesh, A.	The system created is called a Computer-Aided Detection (CAD) system based on the UNet++ architecture for the early detection of pancreatic cancer using MRI images. Its approach, which includes image enhancement techniques such as CLAHE and BADF, as well as precise segmentation of the pancreatic region, has demonstrated 94% accuracy, 98% sensitivity, and 99% specificity in tumor classification.
2022	Laxminarayanamma, K., Krishnaiah, R.V., & Sammulal, P.	The proposed model achieved an accuracy of 95%, outperforming the existing artificial neural network (ANN) model, which only achieved 70%. The precision of the proposed model was 96%, compared to 65% for the existing model, and it achieved a recall of 96%, while the existing model achieved 65%. The F1 score of the proposed model was 96%, compared to 65% for the existing model, it achieved an AUC of 97%, outperforming 85% for the existing model, and it achieved an ROC of 98%, compared to 82% for the existing model.

Research has shown the effectiveness of various artificial intelligence models, each highlighting different approaches and technologies to improve the early detection and diagnostic accuracy of pancreatic cancer. Chhikara et al. (2024) implemented the 3DGAUnet model, which uses generative adversarial networks with a 3D U-Net-based generator, achieving an accuracy of 98.41% in the early detection of pancreatic cancer, highlighting the ability of GANs to improve diagnostic accuracy through synthetic data generation. Abbas and Obied (2021) developed a Computer-Aided Diagnosis (CAD) system using the Synergic Inception ResNet-V2 deep neural network architecture, achieving an accuracy of 99.23% in identifying pancreatic cancer cases from CT images, underscoring the potential of deep neural networks in medical image analysis. Acer et al. (2023) found that ensemble learning models, especially the Gradient Boosting Classifier (GBC), were more successful in classifying healthy controls and PDAC patients, achieving an accuracy of 92.99% and an AUC of 0.9761, demonstrating the effectiveness of ensemble learning approaches in improving diagnostic accuracy. Bahado-Singh et al. (2023) used DNA methylation analysis and deep learning to detect pancreatic cancer by analyzing circulating cell-free DNA (cfDNA), achieving highly accurate detection with an AUC of 1.00, a sensitivity of 100%, and a specificity of 100%, highlighting the potential of epigenetic biomarkers and deep learning in early cancer detection. Mikdadi et al. (2022) developed a deep learning model to diagnose precursor lesions of pancreatic cancer, achieving an AUC of 0.98, a sensitivity of 95.7%, and a specificity of 92.6%, demonstrating the ability of AI to identify early stages of cancer from medical images. Bakasa and Viriri (2021) explored the use of machine learning algorithms to predict pancreatic cancer survival, highlighting the potential of techniques such as support vector machines and convolutional neural networks in improving the understanding of cancer progression. Enriquez et al. (2020) integrated hyperpolarized magnetic resonance imaging (HP-MR) and artificial intelligence to improve the early detection of pancreatic cancer, underlining the ability of HP-MR to detect early metabolic changes and AI to analyze large imaging datasets. Pereira et al. (2020) developed a model based on patients with recent-onset diabetes, achieving a sensitivity of 78% and a specificity of 80% in a study in Minnesota, USA, and a sensitivity of 11% and a specificity of 99.7% in a UK population, demonstrating the potential of clinical data-driven models for early detection. Weisberg et al. (2020) proposed a model to assist in the interpretation of CT images of the pancreas, achieving a sensitivity of 94.1% and a specificity of 98.3%, indicating the ability of AI to reduce diagnostic errors and detect pancreatic cancer at early stages. Reddy and Srinagesh (2022) created a Computer Aided Detection (CAD) system based on the UNet++ architecture for the early detection of pancreatic cancer using MRI images, achieving an accuracy of 94%, a sensitivity of 98% and a specificity of 99%, demonstrating the effectiveness of advanced image enhancement and segmentation techniques in cancer diagnosis. Finally, Laxminarayanamma et al. (2022) proposed a model that outperformed an existing artificial neural network (ANN) model on several metrics including precision, recall, and AUC, achieving an AUC of 97% and an ROC of 98%, underscoring the superiority of advanced machine learning approaches in pancreatic cancer prediction and diagnosis. These studies collectively illustrate the diversity and effectiveness of AI applications in improving pancreatic cancer detection and diagnosis, highlighting the importance of integrating multiple technologies and approaches to address the challenges in early and accurate cancer detection.highlighting the importance of integrating multiple technologies and approaches to address the challenges of early and accurate cancer detection.highlighting the importance of integrating multiple technologies and approaches to address the challenges of early and accurate cancer detection.

CONCLUSIONS

Research has shown that the integration of clinical and genomic data has proven crucial in improving the accuracy of pancreatic cancer prediction models. This combination allows for a more comprehensive assessment of a patient's risk profile, facilitating early detection and personalized treatment. The ability of these models to process large volumes of medical data and extract relevant features using advanced techniques underscores their potential to transform clinical practice.

Research has identified several AI models that excel in the prediction and diagnosis of pancreatic cancer. Among them, the 3DGAUnet model, which uses generative adversarial networks (GANs) with a 3D U-Net-based generator, achieved an accuracy of 98.41% in the early detection of pancreatic cancer. Other successful models include the Synergic Inception-based Computer-Aided Diagnosis (CAD) system ResNet-V2, which achieved an accuracy of 99.23% in identifying pancreatic cancer cases from CT images. Furthermore, the Gradient Boosting Classifier (GBC) showed an accuracy of 92.99% and an AUC of 0.9761 in classifying healthy controls and PDAC patients. These models underscore AI's ability to significantly improve early detection, which is crucial for increasing patient survival rates.

The study identified several challenges, such as the selection of optimal cutoff points to balance sensitivity and specificity, the integration of clinical and genomic data, and the need for explainable models that can handle multimodal data. These challenges reflect the complexity of implementing intelligent systems in pancreatic cancer diagnosis, but also highlight the importance of addressing both technical and clinical aspects to improve the accuracy and effectiveness of these technologies.

The identified benefits include early detection of pancreatic cancer, which is essential for improving survival rates by enabling more effective and less invasive interventions. Furthermore, these models can reduce the workload of healthcare professionals by automating part of the diagnostic process, allowing them to focus on direct patient care and more informed clinical decision-making. The ability of these models to process large volumes of medical data and extract relevant features using advanced techniques underscores their potential to transform clinical practice.

Research has shown several successful cases in the implementation of AI models for the prediction and diagnosis of pancreatic cancer. For example, the 3DGAUnet model achieved an accuracy of 98.41% in early detection. A CAD system based on the UNet++ architecture achieved an accuracy of 94%, a sensitivity of 98%, and a specificity of 99%. The deep learning model of Bahado-Singh et al. (2023) achieved highly accurate detection with an AUC of 1.00, a sensitivity of 100%, and a specificity of 100%. Mikdadi et al. (2022) developed a deep learning model to diagnose precursor lesions of pancreatic cancer, achieving an AUC of 0.98, a sensitivity of 95.7%, and a specificity of 92.6%. Reddy and Srinagesh's (2023) UNet++-based model achieved 94% accuracy, 98% sensitivity, and 99% specificity. These success stories illustrate the effectiveness of artificial intelligence applications in improving pancreatic cancer detection and diagnosis.

The development of prediction models and the implementation of intelligent pancreatic cancer prediction and diagnosis systems have the potential to revolutionize clinical practice by significantly improving diagnostic accuracy and enabling earlier and more effective interventions. These advances not only improve patient outcomes but also optimize the use of medical resources, aligning with the Sustainable Development Goals of improving health and well-being for all.

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