The roles of cloud-based systems on the cancer-related studies: a systematic literature review

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Abstract The advances in Wireless-based technologies and intelligent diagnostics and forecasting such as cloud computing have significantly affected our lifestyle, observed in many fields, especially healthcare. Also, since the number of new cases of cancer has become very high, there is a need to investigate this matter deeply. Still, there is no systematic review on the application or implementation of the cloud in cancer-care services. Hence, this paper has introduced a comprehensive review of a cloud-centered healthcare system that emphasizes treatment ways in different types of cancer until Sep 2021. The results have shown that the largest study was about the relationship between cancer and the cloud associated with breast cancer. Also, the results have shown that cloud computing facilitates data protection, privacy, and medical record access. Using cloud computing in hospitals, physicians will use advanced programs and tools, and nurses will quickly access patients' information with new Wireless-based technologies. A strong understanding of the practical aspects of cloud computing will help researchers effectively navigate the vast data ecosystems in cancer research. So, by highlighting the advantages and drawbacks of analyzed articles, this study provides a comprehensive and up-to-date report on the field of cloud-based cancer studies to fill the previous gaps.

INDEX TERMS Cloud Computing; Artificial Intelligence; Wireless-based Technologies; Cancer; Intelligent Diagnostics.

I. INTRODUCTION

Recently, public health and research in this area have gotten much attention [1-3]. Cancer is a significant public health issue globally and is a sickness that endangering the Quality of Life (QoL) [4, 5]. It is a kind of malevolent neoplasms, usually attacking the adjacent tissues [6, 7]. On the other hand, Information Technology (IT) is crucial in significantly changing lifestyles [8, 9]. The medical industry has also played its part and introduced many medical designs to support the personnel throughout the process, from the detection to the treatment [10-12]. As a new vanguard IT-based technology, cloud computing refers to presenting an IT service allowing on-demand network access to a shared category of processing resources anytime and anywhere [13-15]. Cloud computing has led to dramatic growth in the volume, variety, and velocity of cancer data [16]. So the main research question is whether new technologies such as cloud computing have an impact on cancer diagnosis and treatment? On the other hand, with the increased number of data and data-generating devices in healthcare settings, the health monitoring systems have started to experience issues, such as efficient processing and latency. Several health-monitoring systems have been designed using wireless sensors networks, cloud computing, fog computing, and the Internet of Things (IoT). Most of the health monitoring systems have been designed using the cloud computing architecture [17, 18]. The development of computer and Internet-oriented tools has changed the nature of healthcare services using cloud computing [19-21]. Conventional patient-physician detection has been reached to a stronger cutting-edge notion of electronic health, in which remote online/offline therapy and detection is possible [22, 23]. Therefore, the information age's appearance has produced novel
chances for data gathering, computing, and representation in cancer studies [24, 25]. The developments in bioinformatics, automated data recovery mechanisms, and data storage have enhanced data availability and the capability for making critical decisions based on the investigations of usually intricate and multivariable data [26]. However, the problem is still compressing and filtering this data to be readily interpretable for qualified experts, physicians, the general public, and funding institutions [27]. Also, precision medicine is the main focus of the systematic and empirical analysis of time-sensitive detections and therapies like acute cancer cases [28, 29]. As cancer therapies and the likelihood of survival rates are grown, the QoL of cancer-related patients and survivors should be increasingly investigated.

On the other hand, health-associated QoL is a multidimensional block defined as physical, mental, and social performance and wellbeing [30, 31]. A cloud-based medical healthcare system is a standard platform that supports the medical experts’ emergency treatment over Internet communication [32, 33]. The widespread acceptance of cloud-based services in the healthcare sector has resulted in a cost-effective and convenient exchange of personal health records among several participating entities of the e-health systems. Since medical records are susceptible, security protection is much necessitated [34]. The cloud-oriented platform can merge different off-the-shelf and custom gadgets to maintain and improve health-associated services, practical competencies, self-confidence, and safety [35-37]. Also, it is in charge of explicit and implicit communication with the primary operators [30]. The incorporation of cloud services in the field of cancer guarantees the accessibility of real-time patient data constantly streamed out of different sources [38-40]. This, in turn, allows the ever-increasing data to be managed and shared across the healthcare network systems upon deployment into the cloud [41-43].

The following are some charts (Figure 1 and Figure 2) based on the latest data from cancer statistics in the world (2018 is the year that cancer information was updated in the US). According to this statistic, 1708921 new cases and 599265 deaths have been reported. In fact, there are 436 new cases of cancer and 149 deaths per 100,000 people [44].

![FIG.1. Top 10 cancers by rates of cancer deaths (US, 2018, all races and ethnicities, male and female, rate per 100,000 people)](image1)

![FIG.2. The leading cancer types for the estimated deaths by sex, US, 2021](image2)

Concerning the effective role of new technologies in the treatment of all types of cancer, authors have highlighted how cloud computing can help the cancer treatment process. The structure of this review paper is as follows. In the next section, the paper’s motivation has been presented. Then the method has been presented. We have provided an overview of the previous works, the evolution of the cloud, and several types of cancer in Section 4. After that, the discussion, findings, open issues, and limitations have been...
presented. Finally, the conclusion has been presented.
Table 11 in the appendix provides the abbreviations.

II. PAPER'S MOTIVATION

Various review articles have been published around cancer and the cloud. But only one review article was found to examine the role of cloud-based systems on the success of cancer. This study will highlight the advantages and disadvantages of the investigated article. In a recent study, Vetova and Borovska [6] have reviewed medical imaging designs and cloud answers for the case study of cancer detection. They have proposed the medical breast cancer imaging notion explaining the medical devices for breast cancer diagnosing and checking, the characteristics of the images they generate, and the image processing required to mining the important information for the detection. They have also studied the categorization of the medical imaging designs for breast cancer based on the used processing technology. They have investigated the standalone class of medical imaging designs and the cloud-oriented ones alongside their features. Despite this article's useful information about breast cancer imaging, the authors have focused only on one disease. Also, the effect of cloud computing has only been investigated in one way. So, this study is not comprehensive. In this article, we are going to fill these gaps and provide an extensive study on the role of cloud computing in cancer.

Since there is no SLR article reviewing the cloud in the therapeutic systems and cancer diagnosis, newly published works have not been reviewed systematically. Consequently, this study has attempted to fill this gap and provide a systematic review on the cloud-related articles in therapeutic and diagnosis systems published from Feb 1, 2012, to Sep 2021 to identify the sources for the investigation of the applications of cloud computing in cancer domains to guide a predictor analysis. In addition, challenges have been explored, and some lines have been suggested for future studies. Therefore, the research questions are presented as follows:

1. What are the prevailing therapeutic ways currently applied using the cloud in the field of cancer?
2. What are the best opportunities for the future treatment and diagnosis of cancer?
3. To what extent can we use cloud computing to prevent, treat, and detect cancer?

III. METHOD

The present paper used an SLR [3, 45, 46] and narrative review [47], according to the primary rules introduced by Kitchenham [48]. The authors have designed a protocol to review the technique, research questions, and data mining.

A. SEARCH STRATEGY

We have used several strategies to make the search terms. Extracting the main terms out of the questions by detecting the population, intervention, and result has led to the initial search string: “Cloud” AND “Cancer”. Authors have limited the exploration to the works published from Feb 1, 2012, until Sep 2021. Also, authors have done a study with the mentioned terms in digital libraries: The Scopus, Google Scholar, MEDLINE, Embase, CiteSeer Library, ScienceDirect, ISI Web of Science, IEEE Xplore, PsycINFO, Emerald, and ACM Portal [49]. So, we have confirmed the exploration strings through their capability to identify several famous main works. We have used this list of publications and the ones specified by Legris, et al. [50] to confirm the exploration strings before performing the review.

B. STUDY SELECTION CRITERIA AND PROCEDURES

We have assessed all of the main works using a group of inclusion-exclusion parameters. We have used the inclusion parameters (Publications, technical accounts, or literature reviewing practical works of any specific study model, where cloud computing has been applied to any cancer type, are included.) So studies that met the following criteria have been excluded (Studies not reporting cloud computing applications in cancer; pure theoretical publications; Publications/reports for which only an abstract or a slideshow are available.) So, the whole process of data analysis and article classifications is reported in the
next section. We have coded 38 articles via a data mining design introduced by investigating the related works categorized cloud computing in cancer. According to the performed investigation, cloud computing has been utilized in seven types of cancer. So, in this study, the previous studies have been categorized into the following groups (See Fig. 3):

![Diagram of cancer types and cloud utilization in cancer treatment]

**FIG.3.** The categorization of the cloud-based articles for cancer treatment

## C. STATISTICAL REPORT

The searches have produced 143 papers found, of which 1 was duplicate, and 43 were citations. After investigating the ninety-six abstracts, 30 articles are excluded based on the title. After investigating the sixty-six full-text papers, we have removed 29 more articles. But, one further article has been detected from the reference lists and/or the associated papers’ function. At last, we have had 38 articles. In addition, we have classified the analyzed articles into eight categories. Also, Table 1 lists the number of articles in each category. See the following articles for further studies about this part [51-53].

| Category          | Articles |
|-------------------|----------|
| Colon Cancer      | [54-57]  |
| Lung Cancer       | [58-62]  |
| Ovarian Cancer    | [63-66]  |
| Skin Cancer       | [67-70]  |
| Breast Cancer     | [22, 71-78] |
| Prostate Cancer   | [79-82]  |
| General survey    | [83-91]  |

### IV. OVERVIEW OF SELECTED CLOUD-BASED ARTICLES FOR CANCER TREATMENT

Many researchers have recently studied the impact of cloud-based systems on diagnostic, prevention, and treatment applications [92]. This section has reviewed the main approaches to solve cancer patients' problems in diagnosis and treatment using cloud-based systems. On-time illness detection enables physicians to manage appropriate therapy and enhance survival [93]. In the old diagnosis, skilled physicians have visually tested individual medical images for any nodule growth symptoms in the body. Nevertheless, this type of detection is usually difficult and extremely subjective because of inter-observer inconsistency and the huge bulk of the medical image data [60, 94]. Scholars have done many studies in the last few decades to propose Computer-Aided Diagnosis (CAD) systems for physicians to diagnose any type of cancer, motivated by the cutting edge computing technologies like cloud computing executing intricate image processing and the ML [95, 96]. For instance, producing a microbiome data analysis pipeline with amazon web services becomes possible. This pipeline is quite trustworthy, strong, and inexpensive. The mentioned pipeline helps perform microbiome data analysis [97].

The seven bridges Cancer Genomics Cloud (CGC1) allows scholars to quickly access and cooperates on huge communal cancer genomic datasets like The Cancer Genome Atlas (TCGA). It offers safe and on-demand access to data, examination tools, and calculating resources. All different scholars can effortlessly and programmatically see, demand, and search the mentioned datasets. One can quickly analyze the cloud's desired data using over 200 preinstalled, curated bioinformatics tools and workflows. Scholars can also spread the platform's scope by adding data and devices via an intuitive software development kit. By co-localizing these resources, the CGC allows scalable and reproducible analyses. Scholars can incorporate the CGC to examine cancer genomics' main questions [98]. Some

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1 www.cancergenomicscloud.org
used terms are explained below before investigating the selected studies (Table 2).

**TABLE 2.** The terms used in tables

| Terms                  | Description                                                                                       |
|------------------------|---------------------------------------------------------------------------------------------------|
| **Timeliness**         | It is the fact or quality of happening at best possible time or at the right time to treat and diagnose disease [99]. |
| **Resolution**         | The meaning of resolution is the image view quality in the treatment and diagnosis of the disease [100]. |
| **System usefulness**  | Usefulness is the extent to which an information system will enhance a user’s performance [101]. System's usefulness is shaped by the context in which it is used [102]. |
| **Ease of use**        | Ease of use is a fundamental concept describing how easily users can use a product. It shows the user-friendliness of the final medical product [103]. |
| **Quality**            | Quality is the ongoing building and sustaining relationships by assessing, anticipating, and fulfilling stated and implied needs. It is from enhancing the products, services, mechanisms, and procedures to ensure that the process is fit and effective [104]. |
| **Open data infrastructures** | Data like statistics, maps, and real-time sensor readings are useful in decision-making, service creation, and understanding. Data infrastructure has data resources backed by people, procedures, and technology [105]. |
| **Accuracy**           | Accuracy is the degree to which the result of a measurement, calculation, or specification conforms to the correct value or a standard. It is the quality of being near to the real value of accuracy in treating and diagnosing the disease [106]. |
| **Efficiency**         | It is the capacity to prevent wasting resources, energy, efforts, money, and time in the treatment and diagnosis of the disease or in producing the desired result [107]. |
| **Cost**               | The cost of an object or action requires the payment of a specified sum of money before it can be acquired or done [108]. In this paper, the cost is patients' medical equipment and treatment. |
| **Scalability**        | It is the quality of a mechanism to deal with an increasing bulk of work by adding assets to it [109]. |
| **Automat**            | Working by itself with little or no direct human control. |
| **Early detection**    | The diagnosis of the disease before its progression was suggested. |
| **Remote detection**   | Information mining, particularly at audio/video frequencies, is out of an electromagnetic wave. |
| **Decision Support System (DSS)** | It is an information mechanism backing corporate’s decision-making [110]. |

Zhang, et al. [54] have used a network pharmacological approach to identify anti-CRC targets of Formononetin (FN) and the molecular mechanisms of FN against the CRC. They have used a tool of the DisGeNET database for the collection of CRC-based targets. A protein-protein interaction network of FN against the CRC has been obtained utilizing a STRING. All top biological functional processes and signaling pathways of FN against the CRC have been identified using a database for annotation, visualization, integrated discovery, and Omicsshare cloud platform. The anti-CRC molecular mechanisms of the FN have been implicated in the suppression of cellular proliferation and regulation of cancer-related metabolic pathways.

### A. COLON CANCER

This section reviewed the articles that investigated the cloud's role in colon cancer treatment. Colon cancer is a prevalent tumor worldwide [111]. In the last 70 years, the frequency of colon and rectum cancers has noticeably risen; they have ranked the 2nd and 3rd (in females and males, correspondingly) among the prevalent kinds of cancer in the West [112]. Although it is rare in individuals under the age of 45, its possibility grows with age. The average age of its detection is a bit above 70 [113]. The Colorectal Cancer Research (CRC) is a known neoplasm where the essential genetic modifications of illness development, from normal epithelium to metastatic disease, have been explained [114]. It is organized from thin hyperplastic epithelium to adenoma and then to carcinoma. These successive genetic alterations appear in colon carcinogenesis, proto-oncogenes, tumor suppressor genes, and Deoxyribonucleic Acid (DNA) repair genes. CRC is cancer that appears in the colon or the rectum. Physicians can also call them colon cancer or rectal cancer, considering their place of appearance. These two are usually teamed up as they have numerous shared characteristics. Cancer appears if body cells begin to grow in an uncontrolled manner. Almost all body cells can become cancer and extend to other parts [115]. This section has analyzed 4 colon cancer articles related to cloud-based systems. After reviewing the main features of each one, the authors have summarized them in Table 3. As can be seen, the researchers have tried to reduce the costs, maximize the diagnosis time, and enhance colon cancer resolution, using treatment programs and cloud-based systems.
Xia, et al. [55] have investigated the cloud-based characterization of microbial landscape in CRC and presented a novel cloud-based bioinformatics tool, iGRAMMy, that accurately, efficiently, and robustly estimates relative microbial abundance in the sequenced tumor and matched normal samples. They have identified a significantly higher abundance of overall bacterial infiltration in tumors as compared to normal samples. They have found that species like Bacteroides fragilis, Bacteroides dorei, and Fusobacterium nucleatum were meaningfully higher in tumors, corroborated by the previous reports. They have identified that Bacteroides intestinalis was also significantly more abundant in tumor samples.

Also, Simjanoska, et al. [56] have examined the platform's structure for studying the CRC in the cloud. They have presented a novel design for the CRC gene expression analysis aiming at scholars and clinical individuals as the microarray tests' availability has been raised. Their structure benefits from the cloud's speed and flexibility to do significant calculations, be effortlessly upgraded with new tools, and prevent the local infrastructure's restrictions.

Yoshida [57] has proposed a new cloud supercomputing oriented detection mechanism for colon cancer, according to the laxative free virtual colonoscopy check. A high-quality mobile display system has been linked to the cloud supercomputing virtual colonoscopy to enable on-demand visualization of the whole colonic lumens and detection of colonic lesions. The initial outcomes have indicated that the cloud-supercomputing-oriented virtual colonoscopy system with motion-oriented piloting can help the workflow and effectiveness of understanding virtual colonoscopy images to screen the CRCs.

| Papers | Main aim: | Advantage and Disadvantage |
|--------|----------|-----------------------------|
| [54]   | Investigating the rule of cancer-related metabolic pathways. | Advantage: Optimal biological accuracy |
| [55]   | Investigating the cloud-based characterization of microbial landscape in CRC and present a novel cloud-based bioinformatics tool, iGRAMMy. | Advantage: High accuracy, High efficiency |
| [56]   | Examining the platform's structure for proposing tools for the oncologists to effortlessly notice molecular goals for the therapy and conduct a quick detection. | Advantage: High performance, Low cost of treatment, High scalability |
| [57]   | Proposing a new cloud supercomputing oriented detection mechanism according to the laxative free virtual colonoscopy check. | Advantage: Easy navigation, Localization of colonic lesions, High resolution, Timeliness |

### B. LUNG CANCER

In this section, we have reviewed the articles about the cloud's role in the treatment of lung cancer. Scholars have recognized lung cancer as a dangerous illness that raises the universal mortality rate yearly [116]. Lung cancer has been histologically categorized into small-cell and big-cell lung cancers. Its prevalent signs are cough, dyspnea, hemoptysis, and systemic signs like weight loss and anorexia [117]. High-risk patients having symptoms should take chest radiography. If there is no other detection, physicians should use computed tomography and positron emission tomography [118]. Lung cancer has numerous causes like active cigarette smoking, being in contact with cigarette smoke (passive smoking), pipe-smoking, occupational contact with agents like asbestos, nickel, chromium, and arsenic, being in contact with radiation (like radon gas in homes and mines), and being in contact with air pollution (internal and external).

Despite recognizing this collection of organized fundamental risk factors, lung cancer's universal epidemic is mainly due to a solo one: cigarette smoking. The significance of marketing and promotion of an addicting and fatal product by international companies, considering cigarette smoking supremacy, can be perceived [119]. A reduction in lung cancer rate has been reported twice as fast in men as in women, showing the historical variances in tobacco acceptance and stoppage and the increases in women smoking occurrence in some birth cohorts [120]. In the last decade, the exponential growth of cloud computing has upgraded the healthcare facilities regarding lung cancer. In this section, five lung cancer articles related to cloud-based systems were analyzed. After reviewing the main features, they were summarized in Table 4. As shown in this table, the researchers have tried to reduce the detection time, maximize the accuracy, and enhance...
the resolution and early detection in lung cancer using treatment programs and cloud-based systems.

Masood, et al. [58] have introduced a new computer-assisted DSS for lung nodule diagnosis, according to the 3D Deep Convolutional Neural Network (3DDCNN), to help radiologists. The results have shown that the proposed system has achieved the following: sensitivity, septicity, area under the receiver operating characteristic, and precision of 98.4 percent, 92 percent, 96 percent, and 98.51 percent, respectively, with 2.1 false positives per scan. They have combined cloud computing and trained and validated their cloud-centered 3DDCNN, using Shanghai sixth people’s hospital datasets. The proposed system has a better performance than the cutting-edge ones and achieved a remarkable 98.7 percent sensitivity at 1.97 false positives per scan.

Valluru and Jeya [59] have presented an optimal Support Vector Machine (SVM) for lung image grouping in which the factors of SVM are improved and characteristic choosing done by the revised grey wolf optimization algorithm integrated into the Genetic Algorithm (GA). They have also done the tests in 3 aspects: factor optimization, characteristic choosing, and optimal SVM. They have used a benchmark image database with 50 low-dosage kept lung CT images to evaluate the proposed method's functionality. It has shown its dominance on all the used images regarding a few dimensions. Also, it has reached normal exactness for the categorization meaningfully better than the other ones.

Furthermore, Junior, et al. [60] have offered a public non-relational document-based cloud-centered database of pulmonary nodules having 3D texture qualities, detected and categorized into 9 diverse subjective features by skilled radiologists. They have aimed at enhancing computer-assisted lung cancer detection, pulmonary nodule detection, and categorization research, using the proposed database in a cloud database as a service outline. They have offered pulmonary nodule data by the lung image database consortium and image database resource initiative. The extended database has excellent applicability for combining many diverse CAD mechanisms. The introduced database now has 379 tests, 838 nodules, 8237 images, 4029 CT scans, and 4208 manually-segmented nodules. Moreover, this nodule database has high applicability in the big data because NoSQL has low coupling by combining it into the patients’ e-archive and other databases.

Also, Sueoka-Aragane, et al. [61] have assessed a cloud-oriented local-read pattern for imaging assessments in oncology medical tests for lung cancer. They have done two studies: The KUMO I and KUMO I Extension. KUMO I was a pilot study to show the practicability of cloud execution and detecting problems around the diversity of the assessments. 2 oncologists (Japan) and one radiologist (France) have independently assessed the chest Computed Tomography (CT) scans at 3 time-points from the starting point to development, from ten patients having lung cancer treated with EGFR tyrosine kinase inhibitors, using a cloud-oriented software answer. The KUMO outcomes have indicated the discordance rates of 40 percent for the desired lesion selection, 70 percent for the total reaction at the first time-point, and 60 percent for the whole response at the second time-point. The KUMO I extension has added a cloud-oriented quality control service to reach an agreement on choosing the desired lesions, leading to an enhanced rate of agreement of reaction assessments. The key cause of the discordance has been the variances in choosing the desired lesions.

Ma, et al. [62] have presented a model to evaluate the disease-associated sign burden and QoL in Chinese chemo-naïve acute lung cancer patients. The mentioned patients suffering from grade III/IV lung cancer have been registered. They have used the functional assessment of cancer therapy-lung scale and cloud QoL system. The outcomes have indicated that 376 qualified patients have been studied. The top 3 severe signs were appetite loss, trouble in breathing, and cough. There was a meaningful association between the QoL and signs. Regression analysis of the QoL has shown that nearly all symptoms (but the trouble in breathing) have been the QoL’s negative pointer.
TABLE 4. The main features of the selected lung cancer articles.

| Papers | Main aim | Advantage | Disadvantage |
|--------|----------|-----------|--------------|
| [58]   | Main aim: Introducing a new computer-assisted DSS for lung nodule diagnosis, according to the 3DDCNN. | - Advantage: Accurate diagnosis, High resolution, High performance | - Disadvantage: 1.97 false positives per scan |
| [59]   | Main aim: Presenting an optimal SVM for lung image grouping. | - Advantage: High accuracy, Parameter optimization | - Disadvantage: Low number of samples |
| [60]   | Main aim: Proposing a public non-relational document-based cloud-centered database of pulmonary nodules with 3D texture qualities. | - Advantage: Early detection | - Advantage: High imaging evaluations |
| [61]   | Main aim: Assessing a cloud-oriented local-read pattern for imaging assessments in oncology medical tests for lung cancer. | - Advantage: Early detection | |
| [62]   | Main aim: Presenting a model to evaluate the disease-associated sign burden and QoL in Chinese chemo-naïve acute lung cancer patients. | - Advantage: High resolution, Parameter optimization | - Disadvantage: Low number of samples |

C. OVARIAN CANCER

In this section, the articles are reviewed, which investigate the role of the cloud in the treatment of ovarian cancer. Ovarian cancer is the 5th key reason for cancer death. Regarding the mortality rate, it is the 1st among gynecologic cancers. Ovarian carcinomas are a diverse set of neoplasms conventionally subcategorized consistent with the kind and extent of differentiation. The existing medical management of ovarian carcinoma could not consider this diversity, but each primary histological type has distinctive genetic flaws deregulating certain signaling lanes in the tumors [121, 122]. In 2018, clinicians had detected nearly 22,240 new instances of ovarian cancer and documented 14,070 deaths as a result of that in the United States. A human can help decrease the death rate and frequency of ovarian cancer by dropping the racial inequalities and fostering knowledge of etiology and tumorigenesis to reinforce tactics for inhibition and on-time diagnosis [123]. In this section, 4 ovarian cancer articles related to a cloud-based system were analyzed. Then, the key features of the articles were summarized in Table 5. As can be seen, the researchers have tried to reduce the detection time and maximize the power of predicting platinum resistance, access, and diagnosis of the tumor in ovarian cancer, using treatment programs and cloud-based systems.

Nwagwu, et al. [64] have assessed the non-clinical endpoint using a digital vivarium cloud paradigm in an ovarian cancer xenograft design. There was a strong relationship between the translation of pre-clinical data and the validness of the parameters for evaluating the illness development and endpoint in mouse oncology cases. A digital cloud paradigm would offer an objective and non-invasive technology enabling real-time evaluation of numerous metrics like movement, breathing, and activity. They have determined the motion loss post-induction and motion loss from the endpoint and compared them with the traditional metrics regarding forecasting illness endpoint. The motion loss post-induction has had a meaningful association with the endpoint after graphed on a linear regression plot. The traditional parameters have had insignificant associations with the endpoint. They have also found that the endpoint's motion loss was meaningfully higher than when the initial medical symptoms to the endpoint have appeared. The outcomes have shown their better capability in forecasting the endpoint than the traditional parameters; before the documented medical symptoms.

Zehra, et al. [63] have provided a short overview of three types of cancer genomics datasets transformed from raw formats into a set of linked datasets within the Linked Open Data (LOD) cloud. The three genomics datasets (Copy Number Variation (CNV), Methylation, & Gene Expression) have been related to ovarian cancer studies and archived initially in three different repositories: The TCGA, Catalogue of Somatic Mutations in Cancer (COSMIC), and CNV in Disease (CNVD)). They have provided these three genomics datasets as a set called LOD for CG (LOD4CG), of five interlinked publicly-accessible SPARQL endpoints that will help researchers and practitioners to explore these datasets and links across them.

Also, Isoviita, et al. [65] have developed a cloud-based ML system (CLOBNET), with the streamlined collection and real-time analysis of rich clinical data derived from the electronic health records, and used the CLOBNET to forecast platinum resistance in patients with High-Grade Serous Ovarian Cancer...
(HGSOC). They have shown the viability of accessing clinical data from live electronic health records and using ML to analyze it over traditionally-restricting barriers caused by manual steps and interfaces between different organizations and systems. Thus, they have shown that the automated ML approaches such as the CLOBNET are promising as clinical tools in predicting challenging outcomes such as platinum resistance in the HGSOC.

Latip, et al. [66] have tried to enhance the healthcare offerings to patients who have cancer. The O-

| Papers | The main aim, Advantage, and Disadvantage |
|--------|------------------------------------------|
| [64]   | Main aim: Assessing the non-clinical endpoint using a digital vivarium cloud paradigm in an ovarian cancer xenograft design. | Advantage: High assessing disease progression, Improving the ability of a digital platform to predict. |
|        |                                       | Disadvantage: Failure to perform experiments on humans. |
| [63]   | Main aim: Providing a short overview of three types of cancer genomics datasets transformed from raw formats into a set of linked datasets within the LOD cloud. | Advantage: Presenting open data infrastructures. |
| [65]   | Main aim: Developing a cloud-based machine learning system (CLOBNET) to predict platinum resistance in high-grade serous ovarian cancer. | Advantage: High power predicts platinum resistance. |
| [66]   | Main aim: Enhancing the healthcare offerings to patients who have cancer. | Advantage: High-quality service, Improving the access and diagnose of the tumor. |

### D. BREAST CANCER

This section reviews the articles that utilize cloud computing in breast cancer treatment. Breast cancer has increasingly become a crucial worldwide health problem since its occurrence is growing, particularly in developing states [124, 125]. It appears in breast cells grown oddly and reproduced, creating a lump or tumor [126]. Its initial phase is non-invasive, limited to the breast's ducts or lobules, and not extended to the healthy tissues (named in situ carcinoma) [127]. The invasive breast cancer extends past the ducts or lobules to the breast's healthy tissues or even more to the lymph nodes or other organs. Breast cancer has the highest rank among the cancers regarding the women's mortality rate. It mainly appears in postmenopausal women above 50 years old [128]. However, it appears in men, too, although quite infrequently (about 1% of all breast cancer instances) [129]. Breast cancer is a prevalent type of cancer in developing states. Scholars have usually diagnosed it at the lateral phases. The cancer diagnosis at later stages leads to pain and suffering and brings so many expenses for the caregivers [76]. Today, the prevalent breast cancer diagnosis method is X-ray mammography because of its easiness, portability, and low expenses [74]. We can quicken the decrease in breast cancer mortality by increasing access to top inhibition, on-time diagnosis, and therapeutic services to all women [130]. In this section, 9 breast cancer articles related to cloud-based systems were analyzed. Then the main features of the articles were summarized in Table 6. As can be seen, the researchers have tried to reduce the detection time, make the diagnostic process automated and standardized, maximize the accuracy, promote the image enhancement methods, and enhance the characteristic mining and selection methods in breast cancer using treatment programs cloud-based systems.

Lahoura, et al. [78] have examined cloud computing-based framework for breast cancer diagnosis using extreme learning machine. The framework proposed amalgamated three research domains: Firstly, extreme learning machine is applied for the diagnosis of breast cancer. Secondly, to eliminate insignificant features, the gain ratio feature selection method has employed. Lastly, a an extreme learning machine has proposed cloud computing-based system for remote diagnosis of breast cancer uThe performance of the cloud-based
extreme learning machine has compared with some state-of-the-art technologies for disease diagnosis. The results have achieved on the Wisconsin diagnostic breast cancer dataset have indicated that the cloud-based extreme learning machine technique outperforms other results. The important findings of the experimental results have indicated that the accuracy achieved has 0.9868, the recall has 0.9130, the precision has 0.9054, and the F1-score has 0.8129.

BHOSALE [71] have proposed a web application showing the cancer prediction outcomes and offering them to clinicians. He has done that based on the notions of cloud computing, ML methods, and web services. Their breast cancer Wisconsin dataset has been pre-computed. He has performed the ML methods (a decision tree, multi-layer perceptron, and SVM algorithm) and used them on the dataset to improve the precision of the outcomes for forecasting breast cancer. The accuracy achieved for them has a decision tree -94.74 percent, SVM -63.55 percent, and multilayer iii perceptron -58.31 percent. So, the decision tree algorithm was the most accurate one.

Saba, et al. [22] have introduced an outline using a cloud-oriented DSS to diagnose and categorize malevolent cells in breast cancer employing breast cytology images. They have used shape-oriented characteristics for the diagnosis of tumor cells. They have also investigated the grading of the affected cells, useful for the grade level needed clinical processes for the patients in the course of the detection. They have also used a cross-validation method to assess the categorization exactness, indicating 98 percent exactness compared to the physical techniques incorporated by a pathologist for the diagnosis and categorization of the malevolent cells. The outcomes have suggested that the introduced method has meaningfully enhanced the diagnosis and categorization of the malevolent cells in breast cytology images.

Agarwal [72] have proposed a web-oriented multi-platform answer for improving the predictive tactics for detecting breast cancer out of diverse examinations like histology, mammography, cytopathology, and fine-needle aspiration cytology, all automatically. The corresponding application incorporates tensor-oriented data illustrations and deep learning architectural algorithms to generate optimized designs for forecasting innovative examples against each of these clinical trials. He has proposed this mechanism to combine all its calculations effortlessly into a medical environment, not to affect the doctors' efficiency or workflow, instead of improving his competencies. This system can make the detection procedure automated, consistent, quicker, and more precise than the existing standards reached by both pathologists and radiologists, making it helpful from a medical viewpoint to detect expertly with minimal resources. This method can effectively diagnose breast cancer in a standard and optimal way, using the computational intuition of the artificial intelligence algorithms, as confirmed by the precisions, losses, and associations processed on each design's confirmation parameters. It can diagnose patterns far too intricate to be detected by even skilled radiologists and pathologists.

Furthermore, Jiang, et al. [73] have designed and realized a model for distant detection mechanisms in mammography, according to the cloud paradigm. They have used technologies like clinical image information construction, cloud infrastructure, and human-machine detection design to make this model. In contrast, they have designed the storing mechanism using the Hadoop distributed file system technology, allowing users to effortlessly create and activate huge data utilizations and make the most of the cloud computing; its high effectiveness, its scalability, and its cost-effectiveness. Also, the CAD has been conducted by the MapReduce frame. Its detection segment has done the algorithms of fusion of the machine and human intelligence. They have particularly integrated the outcomes of detections extracted from the clinicians’ experience and those out of the old CAD, using the man-machine intelligent fusion design, based on the alpha-integration and multi-agent algorithm. The proposed mechanism will be useful for the adjusted health resource, better cost-effectiveness, and enhancement of the detection precision in primary health centers.

Mulimani and Kulkarni [74] have proposed expanding cloud in the detection of breast cancer. Cloud computing offers a common pool of assets like storing areas for data, networks, computer computing power, and expert usages for organizations and users. The introduced design has mainly aimed at a cloud-oriented DSS for monitoring breast cancer through digital mammograms. They can use the machine in a private cloud as a service. The integration of image enhancement methods, characteristic mining and characteristic selection ones, the collective of neural
networks for the categorization, outcomes’ confirmation procedure, and application in the private cloud has been useful for the efficiency of the mechanism.

Also, Kao, et al. [75] have introduced an Internet-oriented mechanism for calculating the longitudinal variations in the QoL and a cloud-oriented mechanism for managing patients after breast-conserving operation. They have investigated 657 breast cancer patients treated at three tertiary scientific centers. They have indicated that all the mentioned patients had meaningfully better Quality of Life Questionnaire (QLQ-C30) and its additional breast cancer measure (QLQ-BR23) subscale scores during the 2-year follow-up (p<0.05). In the research, the QoL commonly had a negative relationship with older age, high Charlson comorbidity index point, tumor grade III or IV, prior chemotherapy, and extensive postoperative Length of Stay (LoS). However, the QoL had a positive relationship with prior radiotherapy and hormone therapy. Also, having high points for the preoperative QoL inclined to have high points for the QLQ-C30, QLQ-BR23, and SF-36 subscales. According to the feasibility examination outcomes, the 5 blocks have been rated on a Likert scale from 1–7: The system usefulness, ease-of-use, information quality, interface quality, and overall satisfaction.

Also, Bhat, et al. [76] have developed useful tools for physicians to detect breast cancer on-time. They have assessed the adaptive resonance theory to detect breast cancer, using Wisconsin as the dataset. They have done many examinations on a different amount of training and examining datasets and found that assuming the vigilance as 0.5 and the ratio of data as 90 percent for training and 10 percent for the examination has led to improved outcomes. They have shown how Art 1 network is useful in the categorization of breast cancer.

Aruna, et al. [77] have proposed a cloud-based breast cancer DSS for detecting breast cancer through digital mammograms. They have used the proposed mechanism in a private cloud computing setting and conduct it to guarantee data security and back beginners and specialists. After that, the mammograms have been divided into areas, and their characteristics have been derived out of the desired area. They have applied the selected features to the categorization using collective neural networks. They have confirmed the outcomes and presented the reports.

| Papers  | The main aim, Advantage, and Disadvantage |
|---------|------------------------------------------|
| [78]    | **Main aim:** Examining cloud computing-based framework for breast cancer diagnosis using extreme learning machine. **Advantage:** High accuracy, Improving recall, Improving precision |
| [71]    | **Main aim:** Proposing a web application showing the cancer prediction outcomes and offering them to clinicians. **Advantage:** High accuracy |
| [22]    | **Main aim:** Introducing an outline using a cloud-oriented DSS to diagnose and categorize malevolent cells in breast cancer employing breast cytology images. **Advantage:** High-performance accuracy, Improving detection, Generalization of results is limited |
| [72]    | **Main aim:** Proposing a web-oriented multi-platform answer for improving the predictive tactics for detecting breast cancer out of diverse examinations. **Advantage:** High accuracy, Timeliness, The diagnostic process automated and standardized |
| [73]    | **Main aim:** Designing a remote diagnosis system **Advantage:** High efficiency, High scalability, Low cost of treatment, high accuracy |
| [74]    | **Main aim:** Proposing expanding cloud in the detection of breast cancer. **Advantage:** Developing DSS, Improving image enhancement techniques, Improving feature extraction techniques, Improving feature selection techniques |
| [75]    | **Main aim:** Introducing an Internet-oriented mechanism for calculating the longitudinal variations in the QoL and a cloud-oriented mechanism for managing patients after breast-conserving operation. **Advantage:** High system usefulness, High ease-of-use, High information quality, High interface quality, High overall satisfaction |
| [76]    | **Main aim:** Developing useful tools for physicians to detect breast cancer on-time. **Advantage:** Early detection, Remote detection |
| [77]    | **Main aim:** Proposing a cloud-based breast cancer DSS for detecting breast cancer through digital mammograms. **Advantage:** High diagnosing, High ensures data security, Supporting both novice and expert users |
E. SKIN CANCER

This section has reviewed the selected skin cancer-related articles where cloud computing played an important role. Skin cancer, a dermatological illness, appears due to the occupational ultraviolet irradiation affecting a substantial number of employees, particularly in agriculture and construction [131]. Skin cancer is a prevalent type of cancer worldwide, and its frequency is growing. In spite of low frequency, the possibility of melanoma metastasize to other parts of the body shows that it is the cause of up to 75 percent of the mortality due to skin cancer. 5-year survival can be as high as 91-95 percent for melanoma if it is detected in primary stages. So, on-time diagnosis and treatment have positive effects on survival. The risk of metastatic spread is lower in the cutaneous Squamous Cell Carcinomas (SCC) [132]. Skin cancer diagnostics is a clinical field where on-time detection enables a better survival rate. Usually, dermatologists detect skin cancer. The number of deaths (due to skin cancer) is high, as there is a limited number of dermatologists [133]. By introducing cost-effective and user-friendly detection tools, scholars make possible the early detection of skin cancer for the primary care doctors and enable monitoring a lot more patients. CuPhysicians currently have many tools available to offer skin cancer detection [134]. They may process the skin images locally and have restricted detecting abilities; a few transfer the images to the dermatologists for manual analysis to better detect quality. So, we can see an absence of detection quality or high response duration. Skin cancer malignancy is a fatal type of cancer-based on EU statistics. Altogether, it has up to 95 percent chance for treatment in case of on-time detection. The on-time detection is difficult due to low accessibility to expert dermatologists and a low number of patients taking frequent detections [70]. In this section, four skin cancer articles related to cloud-based systems were analyzed. After reviewing the main features, the authors have summarized them in Table 7. As can be seen, the researchers have tried to reduce the detection time, maximize the accuracy, and improve the classification of the dermal cell images in skin cancer using treatment programs and cloud-based systems.

Kadampur and Al Riyae [67] have proposed a non-programming background tool to develop complex deep learning models to categorize dermal cell images and diagnose skin cancer. They have used a design-driven structure in the cloud, employing deep learning algorithms, to develop useful designs for better forecasting of skin cancer regarding the exactness. They have observed the metric area under the curve of 99.77 percent. The dynamic light scattering designs have reached an AUC of 99.77 percent in diagnosing cancer cells based on the images. They have referred to achieving the programming code for the design for supplementary searching by the programmer.

Akar, et al. [68] have developed a cloud-based skin cancer diagnosis system using CNN. Their design is cloud-oriented. They have done the detection using a 2-phase CNN pipeline in which a primary CNN is in charge of quality check on the demands and detection CNN whose precision is close to that of the dermatologists. The outputs possibilities over seven diverse lesion groups, consistent with the groups in the international standard industrial classification 2018 dataset, have been employed for training. For training, they have used transfer learning in a ResNet50 network trained on the ImageNet competition dataset.

Osipovs, et al. [69] have introduced a distributed cloud-oriented mechanism to employ the newest detection algorithms for skin cancer and achieve a quick automated detection mechanism. They can process the images using the MATLAB algorithms [135] the skin cancer research group is employing. So, it is necessary to adopt each algorithm to a certain structure of the detection tool. Also, the introduced mechanism relates to several skin analyses of each patient. It has applied central load-balancing server that receives detection demands and transfers image processing demand to the MATLAB processing station. If there is a high load, the balancing server can activate an extra processing station. So, it has the key benefits of a cloud system, including effective resource consumption and quick adopting of the existing requirements, by raising the computing power.

Blinzuk, et al. [70] have implemented portable automated diagnostic devices available to a wide range of medical institutions to deal with the early diagnostics unavailability. They have focused on image segmentation methods and problems and extend
portable imaging device flexibility by using cloud-based solutions. They have worked on image segmentation techniques, challenges, and improving a mobile imaging device's adaptability, using cloud-oriented answers. The introduced image segmentation techniques have had positive effects on spectral images. They can be applied to the automated diagnosis of skin cancer.

### TABLE 7. The main features of the selected skin cancer articles.

| Papers | Main aim | Main aim | Advantage | Advantage | Advantage |
|--------|----------|----------|-----------|-----------|-----------|
| 67     | • Main aim: Proposing a non-programming background tool to develop complex deep learning models to categorize dermal cell images and diagnose skin cancer. | • Main aim: Developing a cloud-based skin cancer diagnosis system using CNN. | • Advantage: Classifying dermal cell images, Detecting skin cancer, High accuracy | • Advantage: Raising in diagnosis power, Raising the speed of processing submitted lesion images | • Advantage: Non-invasive skin cancer high diagnostics |
| 68     | • Main aim: Introducing a distributed cloud-oriented mechanism to employ the newest detection algorithms for skin cancer and achieve a quick automated detection mechanism. | • Main aim: Developing portable automated diagnostic devices available to a wide range of medical institutions to deal with the early diagnostics unavailability. | | | |

### F. PROSTATE CANCER

In this section, the selected articles that investigated the cloud's role in prostate cancer treatment are reviewed. Prostate cancer is a prevalent kind of cancer among men, the 2nd top reason for death, particularly in developed states [136]. Prostate cancer is the top kind of cancer in older men (> 70) across the world. It is a key health issue, particularly in developed states, as they have a bigger percentage of aging men. Age and family background are the key risk factors. The clinicians can detect it by prostate biopsy in patients having irregularities in their prostate-specific antigen levels or digital rectal exam [137]. The researchers have not yet found all the parameters determining the risk of emerging clinical prostate cancer, though they have recognized some of them [138]. One can name 3 known risk factors for prostate cancer: rising age, ethnicity, and inheritance. If there is a background of prostate cancer in the person’s close relative, at a minimum, the risk is twofold. If there is more than one background, the risk grows to 5-11 times [139, 140]. In this section, the authors have analyzed four prostate cancer articles related to cloud-based systems. After reviewing the main features, we have summarized them in Table 8. As can be seen, the researchers have tried to reduce the detection time, improve the predictive analysis for cancer growth, increase the collaboration to design, and develop clinical trial data management in prostate cancer using treatment programs and cloud-based systems.

Eguzo, et al. [79] have studied the application of cloud computing and the role of social media for prostate cancer support in Nigeria. The results have shown that cloud computing allows having 1 spokesperson; it resolves the necessity to find a spokesperson for each company. Audience-appreciated shortened videos have been applied to describe the illness procedure and the necessity for modified on-time diagnosis. Facebook live presentation has gained the attention the most, with the majority of comments indicating that individuals liked the interference. The reviews have indicated that adding support cellphone video by a survivor has assisted in clarifying prostate cancer.

Gangwal, et al. [80] have surveyed big data predictive examination for diagnosing prostate cancer on a cloud-oriented design and getting the taste of a cloud-oriented device. They have done a trial based on prostate Magnetic Resonance Imaging (MRI) scans' segmentation results for the SVM's predictive analysis. Performance analysis with the ROC, exactness, and confusion matrix offer the visual artifacts to the analysis. The introduced test can statistically forecast cancer development using the trained design.

Dowling, et al. [81] have proposed MRI techniques-alone prostate cancer radiation therapy program. They have studied a cloud solution for research goals to facilitate the medical confirmation of the workflow. The advantages of cloud computing are higher scalability, functionality, extensibility, and lower overall ownership cost. They have shown the generation of Digital Imaging and Communications in
Medicine- Radiation Therapy (DICOM-RT) directories having an automatic average atlas-oriented electron density image and quick pelvic organ contouring from the overall pelvis MR scans. They have used the cloud setting as there was a necessity to raise the scalability, functionality, and extensibility, decrease the total cost of the ownership and give access to powerful Central Processing Unit (CPU) and graphics processing unit clusters for practical parallel approaches in clinical image analysis. They have used the cloud structure to show a former technique operating on a cloud interface and generate DICOM-RT files ready for integrating into a commercial treatment planning mechanism.

Wang [82] has presented a model of a cloud-based prototype of a proactive surveillance system for prostate cancer. Using cloud design, diverse cooperating parties can easily design and create medical experimental data management. Even though the Google App Engine (GAE), Amazon Web Services (AWS), and Microsoft Windows Azure can assure high dependability and accessibility, there have still been outages at cloud computing providers in the past. All these cloud computing paradigms employ exclusive Application Programming Interfaces (API), making interoperability more challenging. The results have indicated that cloud computing paradigms like the GAE are appropriate solutions for the upcoming multi-center medical tests.

| Papers | The main aim, Advantage, and Disadvantage |
|--------|------------------------------------------|
| [79]   | Main aim: Studying the application of cloud computing and the role of social media for prostate cancer support in Nigeria. | Advantage: Enhancing learning and retention, Content developing-diagnosis of cancer |
| [80]   | Main aim: Surveying big data predictive examination for diagnosing prostate cancer on a cloud-oriented design and getting the taste of a cloud-oriented device. | Advantage: Predictive analysis for the cancer growth |
| [81]   | Main aim: Proposing MRI techniques-alone prostate cancer radiation therapy program. | Advantage: Decreasing the overall cost, Clinical image analysis |
| [82]   | Main aim: Presenting a model of a cloud-based prototype of a proactive surveillance system for prostate cancer. | Advantage: Increasing in collaborating to design and develop Clinical trial data management |

G. GENERAL STUDY

In this section, we have reviewed surveys and articles that investigated the cloud's role in treating any cancer. The detection is important for the effective treatment of the patients [141]. Also, precise cancer categorization is a difficult challenge as the microarray test offers numerous features but a small number of samples [83]. New technologies play an important role in diagnosing diseases. The classifier mechanism has generally applied to cancer categorization to assist the specialists in making a correct detection. The DNA microarray for cancer detection has recently become a famous research field [142]. The main features of each article were summarized in Table 9. The results have shown that the detection and classification of treatment methods are problematic in the field of cancer. So, only skilled experts should do them. The computer-oriented devices should be combined with the identification, diagnosis, and interpretation procedures for that purpose. But, computer-assisted detection encounters the challenge of not having sufficient shared clinical reference data for the introduction, examination, and assessment of processing techniques.

Anuradha, et al. [91] have focusing on one such application in the field of IoT together with cloud computing. Encryption has been done on the blood results of cancer-affected patient and stored it in the cloud for quick reference through the Internet for the doctor or healthcare nurse to handle the patient data secretly. They have provided a framework to enhance the performance of the existing health care industry across the globe. Encryption and decryption has been done using advanced encryption standard algorithm in order to provide authentication and security in handling cancer patients. The task completion time has been greatly reduced from 400 to 160 by using VMs. CloudSim have given an adaptable simulation structure that empowers displaying and reproduced results.

Kečo, et al. [83] have proposed a method for cancer categorization. They have extended it into a parallel algorithm dispersely computing the microarray data using the Hadoop MapReduce outline to enhance the introduced algorithm's functionality. They have tested the presented algorithm on 11 GEMS datasets and achieved 100% accuracy for less than 25 selected features. Also, its scalability was unrestricted due to
the basic Hadoop MapReduce. The outcomes have shown that the introduced algorithm can be useful for the cloud's actual microarray data. Also, the Hadoop MapReduce outline has shown a significant reduction in the processing duration.

Sadhasivam, et al. [84] have surveyed cancer detection epigenomics scientific workflow set up in the cloud computing, using an Improved Particle Swarm Optimization (IPSO) algorithm. They have used the IPSO to achieve appropriate resources and assign epigenomics jobs to minimize the overall expenses of the diagnosis of epigenetic irregularities of probable application in the field of cancer. The outcomes have indicated that the IPSO-oriented job of resource mapping has decreased the overall cost by 6.83% compared to the old PSO. The outcomes of different cancer detections have indicated that the IPSO-oriented job of resource mapping can reach lower expenses in comparison to the PSO-oriented mapping for epigenomes scientific application workflow.

Also, Kou, et al. [78] have achieved a cancer prediction model based on mobile healthcare. They have first collected the data from the smart gadgets. After that, they have sent the data to the server and used the proposed technique at the server to forecast the illness. The main parameters have been recognized, and the predictive categorization has been done, by combining the PCA and SVM as pre-processing phase and post-processing phase, respectively. In the test, a dataset has been created by smart gadgets. The size of the feature subgroup generated by the introduced technique has been decreased by 99.3 percent. Precision, sensitivity, and specificity were assessment pointers; the introduced technique has achieved 82 percent, 82.5 percent, and 81.7 percent, correspondingly. The introduced technique has outperformed the others regarding precision, sensitivity, and specificity.

Zhang, et al. [87] have proposed an intelligent cancer prediction technique based on mobile cloud computing. They have first used the primary component analysis to achieve representative characteristics. After that, a simplified characteristic subgroup has been used on SVM based on the sigmoid kernel function. The introduced technique has decreased the size of the produced subgroup by 99.3 percent. It has integrated the cloud's high processing power to the huge storage capacity to make it better and more suitable. They have used the SVM based on the sigmoid kernel function to allocate the suspected cancers in the patients and healthy individuals. The results have shown that the presented model has outperformed the others regarding precision, sensitivity, and specificity.

Kaushik, et al. [88] have suggested a method to create a cancer cloud platform including collaborative tools, security permissions, data harmonization, and made the data easier to query, using metadata curation, resource description frameworks, and visual means. Additionally, they have implemented the common workflow language, an emerging standard for describing computational workflows, to support computational reproducibility. In addition to the motivation, inception, and development of the CGC, they have also presented a case study on applying unsupervised learning methods to identify individual cell types within tumors, using the RNA Sequencing data from TCGA cohorts. They have demonstrated how these computationally-intensive methods make the most of the cloud and how researchers can apply open pipelines to interrogate cancer subtypes and install the software or plug-ins. In addition, using AWS saves users thousands of dollars by avoiding the expenses of purchasing and maintaining an in-house IT storage system.

Furthermore, Thiebes, et al. [86] have employed the technique used by Nickerson et al. to propose a taxonomy of genome datasets to help the scholars decide whether to keep and process their genome data in the cloud. Their taxonomy has 10 aspects: (1) organism, (2) access, (3) identifiable, (4) file size, (5) processing necessities, (6) transfer necessities, (7) mutable, (8) API access, (9) software accessibility, and (10) the application limitation. The examination of their taxonomy and dataset categorizations from a cloud computing perspective shows the variety of the parameters and contextual impacts beyond just privacy and security issues that can encourage or discourage cancer genomics scholars from sending their genome data to the cloud.
mixed cell populations from the TCGA data on their data.

| Papers | Main aim | Advantage | Disadvantage |
|--------|----------|-----------|--------------|
| [91]   | Examining cancer detection epigenomics scientific workflow set up in cloud computing, using an IPSO algorithm. | Advantages: Minimizing total cost for detection of epigenetic abnormalities | |
| [83]   | Examining cloud computing-based parallel genetic algorithm for gene selection in cancer classification. | Advantage: Real parallelism, Low computation time | |
| [84]   | Examining image acquisition, processing, storage, and online viewing features | Advantage: High flexibility, High faster | |
| [85]   | Examining image acquisition, processing, storage, and online viewing features | Advantage: High flexibility, High faster | |
| [86]   | Examining image acquisition, processing, storage, and online viewing features | Advantage: High flexibility, High faster | |
| [87]   | Examining image acquisition, processing, storage, and online viewing features | Advantage: High flexibility, High faster | |
| [88]   | Examining image acquisition, processing, storage, and online viewing features | Advantage: High flexibility, High faster | |

V. DISCUSSION AND RESULTS

This study studied and summarized the effects of cloud-based systems on cancer-related studies' success. Accordingly, the scientific articles published until Sep 2021, were reviewed. Consequently, the chosen papers were classified based on the publication year, aim, outcomes, and findings. This study has identified six cancers the cloud affected: colon cancer, lung cancer, ovarian cancer, breast cancer, skin cancer, prostate cancer, and general survey (It has explored cloud computing in cancer generally, not specifically). Table 10 summarizes each article's important features, in which the tick mark denotes that the approaches have tested the desired factors and the cross mark denotes that the approaches have not been tested. As can be seen, the researchers have tried to focus more on the early detection of the sickness, increasing the accuracy and open data infrastructures. The results have shown that most cloud computing studies have been done about breast and colon cancers. We have also concluded that the most common types of cancer in women are breast and ovarian cancers, and the most common one among men is prostate cancer. Therefore, the researchers have tried to develop cloud computing applications to help diagnose diseases faster and improve diagnosis and treatment accuracy [143]. Also, the results have shown that cloud computing is helpful for remotely checking the patients. It is reinforced by the cloud's virtual unrestricted capabilities and resources to remove the technical restrictions such as memory, processing power, etc. Also, the IoT centric-cloud design is useful for introducing novel applications and facilities in healthcare [144, 145]. Combined with advancements in cloud computing, telemedicine, and artificial intelligence, the on-demand IoT electrocardiograms sensor can potentially help high-risk patients reduce prehospital delays and seek timely life-saving interventions [146]. Also, the studies have shown the most prevalent types of cancer likely to be detected in men and women in 2020; the prostate, lung, and bronchus, and CRCs comprising 43 percent of all instances in men; the prostate cancer alone comprising over 1 in 5 new cases. For women, the three most prevalent types of cancer are breast, lung, and colorectal, including 50 percent of all new cases; breast cancer alone comprises 30 percent of all cases in women [120].
TABLE 10. The comparison of the main features of all types of cancer

| Papers | Timeliness | Resolution | System usefulness | Ease-of-use | Quality | Open data infrastructures | Accuracy | Efficiency | Cost | Scalability | Autom | Early detection | Remote detection | Decision support system | Imaging evaluations | Enhance learning |
|--------|------------|------------|-------------------|-------------|---------|--------------------------|---------|------------|------|-------------|-------|----------------|-------------------|----------------------|------------------|-----------------|
| Colon Cancer |
| [54] | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Lung Cancer |
| [58] | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Ovarian Cancer |
| [64] | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Breast Cancer |
| [71] | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Skin Cancer |
| [67] | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Prostate Cancer |
| [79] | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| General survey |
| [83] | ✓ | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| [84] | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| [85] | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| [86] | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| [87] | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| [88] | x | x | x | ✓ | ✓ | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| [90] | ✓ | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |

Also, authors have observed that high-performance cloud computing has combined high-performance processing with cloud computing to propose an informatics architecture that delivers the supercomputing power needed for computing and bringing...
high-quality, multidimensional diagnostic images PCs or mobile gadgets [57, 147]. Also, presently, the SVM is an efficient image categorization device, particularly in clinical imaging and traditional medicine [148, 149]. Characteristic selection and metric optimization help enhance the SVM outcomes [59].

Fig. 4 shows the number of selected articles in each category that are studied cancer using cloud computing. As can be seen, the highest number of studies in the field of cancer and cloud was related to breast cancer.

![Number of selected articles](image)

**FIG. 4.** The number of research articles on the role of cloud computing on cancer types

VI. OPEN ISSUES AND FUTURE WORKS

We have also found that cancer research is producing a massive amount of data in heterogeneous formats and repositories. Scholars have forecasted that 2–40 exabytes of storing capacity will be required by 2025 exclusively for the human genomes, which will continuously grow nearly 40 petabytes of further genomic information per year [150]. Therefore, these data's heterogeneous nature and their widespread distribution over numerous databases make searching and pattern discovery a tedious and cumbersome task [151]. From a researcher's perspective, a network of coherent and well-interlinked datasets opens the possibilities of advanced search and analysis across such datasets sources to identify novel and meaningful correlations and mechanisms. On the other hand, studying cancer has a strong relationship with histopathology analysis for detection, prognosis, and healing. Nevertheless, most of the important histology data is kept in private documentations on glass slides and hard drives; they don’t share them like bioinformatics data. Lack of centrally-located data leads to repetitive, redundant research and makes it difficult for cancer researchers to work collaboratively by limiting widespread access and image sharing. The introduction of a virtual slide database on a scalable IT architecture will help cancer histology data observe and explore, leading to better worldwide scientific teamwork against cancer [152]. The cloud service provider aggregates the consumers’ needs for computational power to minimize the total resource requirements, and the overall efficiency is optimized [153, 154]. While resources are automatically provisioned and released just-in-time, there is only minimal to no need for auxiliary management effort or service provider interaction. On the other hand, blockchain-based security can also be used to increase security and privacy in medical systems [155, 156].

On the other hand, the national cancer institute has recently started searching for chances to work with molecular data in cloud environments. Considering this, scholars can use their tools to work on the data and so prevent huge data sending. In the last 10 years, public cancer collections have significantly contributed to recognizing genomic, transcriptomic, proteomic, and epigenome parameters affecting tumor beginning, development, and healing reactions. Scholars can hire virtual machines in these settings and use processing tools on the data, not requiring data transference to or from anywhere else [157]. This design aims to accelerate the procedure of scientific discovery, decrease the hurdles to entry, and publicize access to the data [158]. So, with the appearance of next-generation sequencing technology, modern medical datasets have much important genomic information associated with a variety of illnesses like cancer. Physicians should investigate, control, keep, visualize, and combine this data to make it medically helpful. Numerous physicians and scholars required to understand these datasets have no IT skills and need efficient and simple mechanisms to work with [116].

Dynamic thermography holds excellent promise as an adjunct modality for breast cancer detection. Many authors are continuing their research and exploring various experimental, clinical and numerical studies to improve the efficacy of this method. However, there are many additional factors to consider before thermography can be used for detection. For example,
Numerical simulations provide insight into the thermal interactions within the breast. They also provide a way to study different factors such as metabolic activity, tumor position and depth of tumors within the breast. Although numerical simulations provide valuable information on the thermal field resulting from the presence of a cancer, the actual breast shape and other factors such as blood perfusion are challenging to estimate. Therefore, simplified breast models have been used. A validated model with the exact breast shape is needed in the literature. This model may be used to predict more accurately the surface temperature distribution of the female breast [159].

The innate difficulties of the traditional healthcare industry are small physical storage, security and privacy, and medical errors [160, 161]. As records of the patients contain very important data which should be protected all the time. Existing system is facing lot of inconsistencies in protecting patient’s data. The big data has many security challenges and it is increased when it is related to the IoT medical data. Big data management security is the major issue in cloud computing, which usually focuses on data classification and encryption mechanisms [162, 163]. It occupies more memory space to store the medical data, which is not cost-effective. Cloud provides high security in order to protect patient’s data [164]. The storage costs around multiple times lesser than the server storage, equipment materials, and preparing of HR to keep up and bolster the framework in day by day activities. Since the patient’s information is available in the cloud, patient can easily retrieve the prescription from the cloud anywhere any time [91].

According to Fig. 5, when intruders try to illegally see and steal the data, the intruders must jailbreak the security system beforehand. Thus the system will record the attempt and track it down and send the notification to the user using this method, the user will know the who, when, how and where the intruders attempt to attack the system.

Finally, nowadays, scholars have extraordinary access to human genomic and proteomic data, quickly improving our present understanding of the complete coverage. Integrating genomic information to shotgun proteomics is still a problem because of the huge increase in the proteomics exploration area [166]. The appearance of next-generation sequencing has changed our capability to produce genomic data. Nowadays, scholars have access to petabytes of multi-dimensional information from numerous patients. Nevertheless, it makes the investigation of this information more difficult since the bulk of data is increasing [167]. Moreover, the huge bulk of whole-genome sequencing data have been offered by big consortium plans like the TCGA, COSMIC, etc., making unbelievable chances for studying the functional gene and uncovering the cancer-related system. Although the current web servers are useful and prevalent, we should investigate numerous whole-genome analysis functions that are necessary for trial biologists [168].

VII. LIMITATIONS

Authors have limited the search to Scopus, Google Scholar, MEDLINE, Embase, CiteSeer Library, ScienceDirect, ISI Web of Science, IEEE Xplore, PsycINFO, Emerald, and ACM Portal. It is possible that other academic journals provide a good picture of the related articles, too. This study has only reviewed the articles extracted based on keywords such as “cloud” AND “cancer”. Cloud computing in cancer might not have been published with those specific keywords. Also, there is a necessity for more pieces of research using other methodologies. Lastly, non-English publications have been ignored. There could be some related papers published in languages other than English.
VIII. CONCLUSION

This study has presented an SLR about the roles of cloud-based systems in the success of cancer-related studies. Six important types of cancer have been surveyed that cloud computing is the most widely used in their diagnosis and treatment. We have also illustrated and debated open issues using an exhaustive analysis of 38 essential papers among the basic 142 papers obtained from the search automatically. The results have also demonstrated that most researchers have studied breast cancer.

On the other hand, authors have found that cloud computing eases data protection, privacy, and medical record access. Also, the implementation of cloud computing improves the efficiency and accuracy of diagnosis. Cancer is an important disease across the world, mostly diagnosed in the lateral phases. Its diagnosis in later phases will lead to pain and suffering for the patient and the caregivers' exhaustive expenses. So, cloud computing can detect this disease using new devices at an early stage. The outcomes have also indicated that the cloud-super-based virtual system with motion-oriented navigation enhances the workflow and effectiveness of understanding virtual images for cancer screening. So, cloud computing improves diagnosis, accuracy, treatment, and image resolution and therefore facilitates medical work.

APPENDIX 1

Abbreviation table

| State                        | Abbreviations                        |
|------------------------------|--------------------------------------|
| Application Programming Interface | API                                  |
| Ammonium Pyrrolidine Dithio Carbamate | APDC                               |
| Auto Fluorescence Imaging    | AFI                                  |
| Amazon Web Services          | AWS                                  |
| Area Under the ROC curve     | AUC                                  |
| Copy Number Variation        | CNV                                  |
| Catalogue of Somatic Mutations in Cancer | COSMIC                           |
| CNV in Disease               | CNVD                                 |
| Computer-Aided Diagnosis     | CAD                                  |
| Cancer Genomics Cloud        | CGC                                  |
| Colorectal Cancer Research   | CRC                                  |
| Convolutional Neural Networks | CNN                                 |
| Central Processing Unit      | CPU                                  |
| Computer Tomography          | CT                                   |
| Digital Imaging and Communications in Medicine- Radiation Therapy | DICOM-RT |
| Diffuse Large B Cell Lymphoma | DLBCL                               |
| Decision Support System      | DSS                                  |
| Deoxyribonucleic Acid        | DNA                                  |
| Epidermal Growth Factor Receptor | EGFR                               |
| Flame Atomic Absorption Spectrometry | FAAS                           |
| Formononetin                 | FN                                   |
| Google App Engine            | GAE                                  |
| Genetic Algorithm            | GA                                   |
| Hyper Text Markup Language   | HTML                                 |
| Information Technology       | IT                                   |
| Internet of Things           | IoT                                  |
| Improved Particle Swarm Optimization | IPSO                            |
| Linked Open Data             | LOD                                  |
| Length of Stay               | LoS                                  |
| Machine Learning             | ML                                   |
| Magnetic Resonance Imaging   | MRI                                  |
| Nickel                       | Ni                                   |
| Not Only Structured Query Language | NoSQL                         |
| Performance Computer Architecture | PCA                            |
| Polarized White Light Imaging | PWLI                               |
| Quality of Life              | QoL                                  |
| Quality of Life Questionnaire | QLQ                                 |
| Ribonucleic Acids            | RNA                                  |
| Receiver Operating Character | ROC                                  |
| Smokeless Tobacco            | SLT                                  |
| Support Vector Machine       | SVM                                  |
| Squamous Cell Carcinomas     | SCC                                  |
| Small Round Blue-Cell Tumor  | SRBCT                                |
| Systematic Literature Review | SLR                                  |
| The Cancer Genome Atlas      | TCGA                                 |
| Tumor Protein                | TP                                   |
| 3D Deep Convolutional Neural Network | 3DDCNN                         |
| Whole-Genome                 | WGS                                  |

Conflict of Interest: The authors declare no conflict of interest.

Data Availability statement: All data are reported in the paper.

References

[1] T. Roshanzamir and S. Vahdat, "The Relation between Serum Levels of Oxidants and Antioxidants with Asthma Severity," Journal of Isfahan Medical School, vol. 28, 2011.

[2] A. E. Naeini, F. Moeinzadeh, S. Vahdat, A. Ahmadi, Z. P. Hedayati, and S. Shahzeidi, "The effect of vitamin D administration on intracellular adhesion molecule-1 and vascular cell adhesion molecule-1 levels in hemodialysis patients: a placebo-controlled, double-blinded clinical trial," Journal of Research in Pharmacy Practice, vol. 6, p. 16, 2017.

[3] M. Esmailiy, A. Amerizadeh, S. Vahdat, M. Ghodsi, R. I. Doewes, and Y. Sundram, "Effect of different types of aerobic exercise on individuals with and without hypertension: An updated systematic review," Current problems in cardiology, p. 101034, 2021.
service composition using particle swarm optimization algorithm," *Journal of Ambient Intelligence and Humanized Computing*, vol. 10, pp. 1851-1864, 2019.

[15] N. Nasser, Q. Emad-ul-Haq, M. Imran, A. Ali, I. Razzak, and A. Al-Helali, "A smart healthcare framework for detection and monitoring of COVID-19 using IoT and cloud computing," *Neural Computing and Applications*, pp. 1-15, 2021.

[16] J. G. Ronquillo and W. T. Lester, "Practical Aspects of Implementing and Applying Health Care Cloud Computing Services and Informatics to Cancer Clinical Trial Data," *JCO Clinical Cancer Informatics*, vol. 5, pp. 826-832, 2021.

[17] A. Asghar, A. Abbas, H. A. Khattak, and S. U. Khan, "Fog based architecture and load balancing methodology for health monitoring systems," *IEEE Access*, vol. 9, pp. 96189-96200, 2021.

[18] J. M. M. Marin, D. De Oliveira-Dias, N. J. Navimipour, B. Gardas, and M. Unal, "Cloud computing and human resource management: systematic literature review and future research agenda," *Kybernetes*, 2021.

[19] A. Khayer, M. S. Talukder, Y. Bao, and M. N. Hossain, "Cloud computing adoption and its impact on SMEs’ performance for cloud supported operations: A dual-stage analytical approach," *Technology in Society*, vol. 60, p. 101225, 2020.

[20] L. de Almeida Botega, M. V. Andrade, and G. R. Guedes, "Brazilian hospitals’ performance: an assessment of the unified health system (SUS)," *Health Care Management Science*, pp. 1-10, 2020.

[21] G. Nagasubramanian, R. K. Sakthivel, R. Patan, A. H. Gandomi, M. Sankayya, and B. Balusamy, "Securing e-health records using keyless signature infrastructure blockchain technology in the cloud," *Neural Computing and Applications*, vol. 32, pp. 639-647, 2020.

[22] T. Saba, S. U. Khan, N. Islam, N. Abbas, A. Rehman, N. Javaid, *et al.*, "Cloud-based decision support system for the detection and classification of malignant cells in breast cancer using breast cytology images," *Microscopy Research and Technique*, vol. 82, pp. 775-785, 2019.

[23] A. Miranda-Filho, F. Bray, H. Charvat, S. Rajaraman, and I. Soerjomataram, "The world cancer patient population (WCPP): An updated standard for international
comparisons of population-based survival,"  
_Cancer epidemiology_, vol. 69, p. 101802, 2020.

[24] S. Hettige, E. Dasanayaka, and D. S. Ediriweera, "Usage of cloud storage facilities by medical students in a low-middle income country, Sri Lanka: a cross-sectional study," _BMC medical informatics and decision making_, vol. 20, p. 10, 2020.

[25] W. S. Alansari and A. A. Eskandani, "The Anticarcinogenic Effect of the Apple Polyphenol Phloretin in an Experimental Rat Model of Hepatocellular Carcinoma," _Arabian Journal for Science and Engineering_, vol. 45, pp. 4589-4597, 2020.

[26] A. Abugabah, A. A. AlZubi, F. Al-Obeidat, A. Alarifi, and A. Alwadain, "Data mining techniques for analyzing healthcare conditions of urban space-person lung using meta-heuristic optimized neural networks," _Cluster Computing_, vol. 23, pp. 1781-1794, 2020.

[27] J. Efird, S. Davies, T. Biswas, W. O’Neal, and E. Anderson, "The Need for Novel Graphical Presentation of Cancer Data: Mushroom Cloud and Floating-Bar Plots," _Trop Med Surg_, vol. 1, p. e104, 2013.

[28] L. Wu, D. Bruns-Smith, F. A. Nothaft, Q. Huang, S. Karandikar, J. Le, et al., "FPGA Accelerated INDEL Realignment in the Cloud," in _2019 IEEE International Symposium on High Performance Computer Architecture (HPCA)_, 2019, pp. 277-290.

[29] F. Bertucci, A.-G. Le Corroller-Soriano, A. Monneur, S. Fluzin, P. Viens, D. Maraninchi, et al., "Santé numérique et «cancer hors les murs», Big Data et intelligence artificielle," _Bulletin du Cancer_, vol. 107, pp. 102-112, 2020.

[30] S. Kyriazakos, V. Valentini, A. Cesario, and R. Zachariae, "FORECAST—A cloud-based personalized intelligent virtual coaching platform for the well-being of cancer patients," _Clinical and translational radiation oncology_, vol. 8, pp. 50-59, 2018.

[31] J. J. Hathaliya and S. Tanwar, "An exhaustive survey on security and privacy issues in Healthcare 4.0," _Computer Communications_, vol. 153, pp. 311-335, 2020.

[32] B. D. Deebak and F. Al-Turjman, "Smart mutual authentication protocol for cloud based medical healthcare systems using internet of medical things," _IEEE Journal on Selected Areas in Communications_, vol. 39, pp. 346-360, 2020.

[33] P. Bhattacharya, S. Tanwar, U. Bodke, S. Tyagi, and N. Kumar, "Bindaaas: Blockchain-based deep-learning as-a-service in healthcare 4.0 applications," _IEEE Transactions on Network Science and Engineering_, 2019.

[34] M. Ali, A. Abbas, M. U. S. Khan, and S. U. Khan, "SeSPHR: a methodology for secure sharing of personal health records in the cloud," _IEEE Transactions on Cloud Computing_, vol. 9, pp. 347-359, 2018.

[35] E. Serván-Mori, C. Chivardi, F. Fene, I. Heredia-Pi, M. A. Mendoza, and G. Nigenda, "Tackling maternal mortality by improving technical efficiency in the production of primary health services: longitudinal evidence from the Mexican case," _Health Care Management Science_, pp. 1-14, 2020.

[36] A. Albahri, J. K. Alwan, Z. K. Taha, S. F. Ismail, R. A. Hamid, A. Zaidan, _et al._, "IoT-based telemedicine for disease prevention and health promotion: State-of-the-Art," _Journal of Network and Computer Applications_, vol. 173, p. 102873, 2021.

[37] M. De Donno, K. Tange, and N. Dragoni, "Foundations and evolution of modern computing paradigms: Cloud, iot, edge, and fog," _IEEE Access_, vol. 7, pp. 150936-150948, 2019.

[38] C. Abid, M. Kessentini, and H. Wang, "Early prediction of quality of service using interface-level metrics, code-level metrics, and antipatterns," _Information and Software Technology_, vol. 126, p. 106313, 2020.

[39] M. Tanha, M. H. Shirvani, and A. M. Rahmani, "A hybrid meta-heuristic task scheduling algorithm based on genetic and thermodynamic simulated annealing algorithms in cloud computing environments," _Neural Computing and Applications_, pp. 1-34, 2021.

[40] D. C. Nguyen, P. N. Pathirana, M. Ding, and A. Seneviratne, "Blockchain for secure ehrs sharing of mobile cloud based e-health systems," _IEEE access_, vol. 7, pp. 66792-66806, 2019.

[41] A. Onasanya and M. Elshakankiri, "Secured cancer care and cloud services in IoT/WSN based medical systems," in _International Conference on Smart Grid and Internet of Things_, 2018, pp. 23-35.

[42] M. Sharma and R. Sehrawat, "A hybrid multi-criteria decision-making method for cloud adoption: Evidence from the
healthcare sector,” *Technology in Society*, p. 101258, 2020.

[43] S. K. Sood, V. Sood, and I. Mahajan, “An intelligent healthcare system for predicting and preventing dengue virus infection,” *Computing*, pp. 1-39.

[44] R. L. Siegel, K. D. Miller, H. E. Fuchs, and A. Jemal, "Cancer statistics, 2021," *CA: a cancer journal for clinicians*, vol. 71, pp. 7-33, 2021.

[45] S. Vahdat and S. Shahidi, "D-dimer levels in chronic kidney illness: a comprehensive and systematic literature review," *Proceedings of the national academy of sciences, india section b: biological sciences*, pp. 1-18, 2020.

[46] R. I. Doewes, G. Gharibian, B. A. Zaman, and R. Akhavan-Sigari, "An updated systematic review on the effects of aerobic exercise on human blood lipid profile," *Current problems in cardiology*, p. 101108, 2022.

[47] S. Vahdat, "Vitamin D and kidney diseases: A narrative review," *International Journal of Preventive Medicine*, vol. 11, p. 195, 2020.

[48] B. Kitchenham, "Procedures for undertaking systematic reviews: Joint technical report," *Computer Science Department, Keele University (TR/SE-0401) and National ICT Australia Ltd.(0400011T. 1)*, 2004.

[49] S. Vahdat, "The role of IT-based technologies on the management of human resources in the COVID-19 era," *Kybernetes*, 2021.

[50] P. Legris, J. Ingham, and P. Collerette, "Why do people use information technology? A critical review of the technology acceptance model," *Information & management*, vol. 40, pp. 191-204, 2003.

[51] F. Charlson, M. van Ommeren, A. Flaxman, J. Cornett, H. Whiteford, and S. Saxena, "New WHO prevalence estimates of mental disorders in conflict settings: a systematic review and meta-analysis," *The Lancet*, vol. 394, pp. 240-248, 2019.

[52] M. Drolet, É. Bénard, N. Pérez, M. Brisson, H. Ali, M.-C. Boily, et al., "Population-level impact and herd effects following the introduction of human papillomavirus vaccination programmes: updated systematic review and meta-analysis," *The Lancet*, vol. 394, pp. 497-509, 2019.

[53] D. K. Chu, R. A. Wood, S. French, A. Fiocchi, M. Jordana, S. Waserman, et al., "Oral immunotherapy for peanut allergy (PACE): a systematic review and meta-analysis of efficacy and safety," *The Lancet*, vol. 393, pp. 2222-2232, 2019.

[54] L. Zhang, Y. Gong, S. Wang, and F. Gao, "Anti-Colorectal Cancer Mechanisms of Formononetin Identified by Network Pharmacological Approach," *Medical science monitor: international medical journal of experimental and clinical research*, vol. 25, p. 7709, 2019.

[55] L. C. Xia, D. Ai, M. Guo, and H. Ji, "iGRAMMY: Cloud-based characterization of microbial landscape in colorectal cancers," ed: AACR, 2019.

[56] M. Simjanoska, M. Gusev, and S. Ristov, "Platform's Architecture for Colorectal Cancer Research in the Cloud," *Procedia Engineering*, vol. 100, pp. 1099-1107, 2015.

[57] H. Yoshida, "Cloud-super-computing virtual colonoscopy with motion-based navigation for colon cancer screening," in *2013 IEEE Third International Conference on Consumer Electronics; Berlin (ICCE-Berlin)*, 2013, pp. 165-167.

[58] A. Masood, P. Yang, B. Sheng, H. Li, P. Li, J. Qin, et al., "Cloud-Based Automated Clinical Decision Support System for Detection and Diagnosis of Lung Cancer in Chest CT," *IEEE Journal of Translational Engineering in Health and Medicine*, vol. 8, pp. 1-13, 2019.

[59] D. Valluru and I. J. S. Jeya, "IoT with cloud based lung cancer diagnosis model using optimal support vector machine," *Health care management science*, pp. 1-10, 2019.

[60] J. R. F. Junior, M. C. Oliveira, and P. M. de Azvedo-Marques, "Cloud-based NoSQL open database of pulmonary nodules for computer-aided lung cancer diagnosis and reproducible research," *Journal of digital imaging*, vol. 29, pp. 716-729, 2016.

[61] N. Sueoka-Aragane, N. Kobayashi, E. Bonnard, C. Charbonnier, J. Yamamichi, H. Mizobe, et al., "Evaluation of a cloud-based local-read paradigm for imaging evaluations in oncology clinical trials for lung cancer," *Acta radiologica open*, vol. 4, p. 2058460115588103, 2015.

[62] Y. Ma, Y. Yang, Y. Huang, H. Zhao, X. Hou, Y. Tian, et al., "An investigation of symptom burden and quality of life in Chinese chemo-naïve advanced lung cancer patients by using the Instrument-Cloud QOL System," *Lung cancer*, vol. 84, pp. 301-306, 2014.
cancer in mammography by fusion of machine and human intelligence,” in *Medical Imaging 2016: PACS and Imaging Informatics: Next Generation and Innovations*, 2016, p. 97890S.

[74] V. Mulimani and D. Kulkarni, "A proposed model for the implementation of cloud based decision support system for diagnosis of breast cancer using digital mammograms," *International Journal of Latest Trends in Engineering and Technology (IJLTET)*, vol. 5, pp. 276-281, 2015.

[75] H.-Y. Kao, W.-H. Wu, T.-Y. Liang, K.-T. Lee, M.-F. Hou, and H.-Y. Shi, "Cloud-Based service information system for evaluating quality of life after breast cancer surgery," *PloS one*, vol. 10, 2015.

[76] J. A. Bhat, V. George, and B. Malik, "Cloud computing with machine learning could help us in the early diagnosis of breast cancer," in *2015 Second International Conference on Advances in Computing and Communication Engineering*, 2015, pp. 644-648.

[77] S. Aruna, L. Nandakishore, and S. Rajagopalan, "Cloud based decision support system for diagnosis of breast cancer using digital mammograms," *International Journal of Computer Applications (IJCA)*, vol. 1, pp. 01-03, 2012.

[78] V. Lahoura, H. Singh, A. Aggarwal, B. Sharma, M. A. Mohammed, R. Damaševičius, et al., "Cloud computing-based framework for breast cancer diagnosis using extreme learning machine," *Diagnostics*, vol. 11, p. 241, 2021.

[79] K. Eguzo, A. Jacob, C. Okwuosa, F. Mbogu, N. Owuenyi, I. Okoye, et al., "Exploratory Use of Cloud Computing and Social Media for Prostate Cancer Advocacy in Nigeria," *ed: American Society of Clinical Oncology*, 2018.

[80] R. A. Gangwal, R. R. Deshmukh, and M. Emmanuel, "Big Data Predictive Analysis for Detection of Prostate Cancer on Cloud-Based Platform: Microsoft Azure," in *Privacy and Security Policies in Big Data*, ed: IGI Global, 2017, pp. 259-278.

[81] J. Dowling, N. Burdett, P. Greer, J. Sun, J. Parker, P. Pichler, et al., "Automatic atlas based electron density and structure contouring for MRI-based prostate radiation therapy on the cloud," in *Journal of Physics: Conference Series*, 2014, p. 012048.

[82] H. Wang, "C-PASS-PC: A Cloud-driven Prototype of Multi-Center Proactive..."
Surveillance System for Prostate Cancer," arXiv preprint arXiv:1209.2641, 2012.

[83] D. Kečo, A. Subasi, and J. Kevric, "Cloud computing-based parallel genetic algorithm for gene selection in cancer classification," *Neural Computing and Applications*, vol. 30, pp. 1601-1610, 2018.

[84] N. Sadhasivam, R. Balamurugan, and M. Pandi, "Cancer Diagnosis Epigenomics Scientific Workflow Scheduling in the Cloud Computing Environment Using an Improved PSO Algorithm," *Asian Pacific journal of cancer prevention: APJCP*, vol. 19, p. 243, 2018.

[85] L. Kou, Y. Yuan, J. Sun, and Y. Lin, "Prediction of Cancer Based on Mobile Cloud Computing and SVM," in *2017 International Conference on Dependable Systems and Their Applications (DSA)*, 2017, pp. 73-76.

[86] S. Thiebes, G. Kleiber, and A. Sunyaev, "Cancer genomics research in the cloud. A taxonomy of genome data sets," in *Proceedings of the 4th International Workshop on Genome Privacy and Security, Orlando, Florida, USA*, 2017.

[87] G. Zhang, L. Kou, Y. Yuan, J. Sun, Y. Lin, Q. Da, et al., "An intelligent method of cancer prediction based on mobile cloud computing," *Cluster Computing*, pp. 1-9, 2017.

[88] G. Kaushik, Y. Li, E. Lehnert, Z. Onder, D. Locke, B. N. Davis-Dusenberg, et al., "Enabling petabyte-scale cancer genomics with the NCI Cancer Cloud Pilots," ed: AACR, 2017.

[89] R. Malhotra, I. Seth, E. Lehnert, J. Zhao, G. Kaushik, E. H. Williams, et al., ", "Using the Seven Bridges Cancer Genomics Cloud to Access and Analyze Petabytes of Cancer Data," *Current protocols in bioinformatics*, vol. 60, pp. 11.16.1-11.16.32, 2017.

[90] K. C. Cheng, G. Chu, R. Sivak, and D. Dao, "Abstract A15: Development of a cloud-based histology database for collaborative cancer research," ed: AACR, 2014.

[91] M. Anuradha, T. Jayasankar, N. Prakash, M. Y. Sikkandar, G. Hemalakshmi, C. Bharatiraja, et al., "IoT enabled cancer prediction system to enhance the authentication and security using cloud computing," *Microprocessors and Microsystems*, vol. 80, p. 103301, 2021.

[92] J. Gong and N. J. Navimipour, "An in-depth and systematic literature review on the blockchain-based approaches for cloud computing," *Cluster Computing*, pp. 1-18, 2021.

[93] F. Liu, G. Zhang, and J. Lu, "Heterogeneous domain adaptation: An unsupervised approach," *IEEE transactions on neural networks and learning systems*, vol. 31, pp. 5588-5602, 2020.

[94] M. Larre-Bolanos-Cacho, S. Hernandez-Alamilla, R. Fuentes-Valdez, and P. Najera-Garcia, "Data Analytics and Cloud Computing vs Breast Cancer: Learning That Helps," *International Journal of Information and Education Technology*, vol. 10, 2020.

[95] H. Lee and Y.-P. Chen, "Image based computer aided diagnosis system for cancer detection," *Expert Systems with Applications*, vol. 42, pp. 5356-5365, 2015.

[96] S. K. Mishra, B. Sahoo, and P. P. Parida, "Load balancing in cloud computing: a big picture," *Journal of King Saud University-Computer and Information Sciences*, vol. 32, pp. 149-158, 2020.

[97] J. Bai, I. Jhaney, and J. Wells, "Developing a Reproducible Microbiome Data Analysis Pipeline Using the Amazon Web Services Cloud for a Cancer Research Group: Proof-of-Concept Study," *JMIR medical informatics*, vol. 7, p. e14667, 2019.

[98] J. W. Lau, E. Lehnert, A. Sethi, R. Malhotra, G. Kaushik, Z. Onder, et al., "The Cancer Genomics Cloud: collaborative, reproducible, and democratized—a new paradigm in large-scale computational research," *Cancer research*, vol. 77, pp. e3-e6, 2017.

[99] R. Zanetti, I. Schmidtmann, L. Sacchetto, F. Binder-Foucard, A. Bordoni, D. Coza, et al., "Completeness and timeliness: cancer registries could/should improve their performance," *European journal of cancer*, vol. 51, pp. 1091-1098, 2015.

[100] S. A. Forbes, D. Beare, H. Boutselakis, S. Bamford, N. Bindal, J. Tate, et al., "COSMIC: somatic cancer genetics at high-resolution," *Nucleic acids research*, vol. 45, pp. D777-D783, 2017.

[101] C. M. MacDonald and M. E. Atwood, "What does it mean for a system to be useful? An exploratory study of usefulness," in *Proceedings of the 2014 conference on Designing interactive systems*, 2014, pp. 885-894.

[102] C. Y. Yun, N. Kim, J. Lee, J. Y. Lee, Y. J. Hwang, H. S. Lee, et al., "Usefulness of OLGIM system not only for intestinal type but also for diffuse type of
gastric cancer, and no interaction among the gastric cancer risk factors," *Helicobacter*, vol. 23, p. e12542, 2018.

[103] C. M. De Klerk, E. Wieten, A. van der Steen, C. R. Ramakers, E. J. Kuipers, B. E. Hansen, et al., "Participation and Ease of Use in Colorectal Cancer Screening: A Comparison of 2 Fecal Immunochemical Tests," *American Journal of Gastroenterology*, vol. 114, pp. 511-518, 2019.

[104] E. Andritsch, M. Beishon, S. Bielack, S. Bonvalot, P. Casali, M. Crul, et al., "ECCO essential requirements for quality cancer care: soft tissue sarcoma in adults and bone sarcoma. A critical review," *Critical reviews in oncology/hematology*, vol. 110, pp. 94-105, 2017.

[105] S. Leonelli, "Global data for local science: Assessing the scale of data infrastructures in biological and biomedical research," *BioSocieties*, vol. 8, pp. 449-465, 2013.

[106] H. U. Ahmed, A. E.-S. Bosaily, L. C. Brown, R. Gabe, R. Kaplan, M. K. Parmar, et al., "Diagnostic accuracy of multi-parametric MRI and TRUS biopsy in prostate cancer (PROSIM): a paired validating confirmatory study," *The Lancet*, vol. 389, pp. 815-822, 2017.

[107] A. Wiener, *European integration theory*: Oxford University Press, 2019.

[108] M. Jegers, D. Edbrooke, C. Hibbert, D. Chalfin, and H. Burchardi, "Definitions and methods of cost assessment: an intensivist's guide," *Intensive care medicine*, vol. 28, pp. 680-685, 2002.

[109] A. B. Bondi, "Characteristics of scalability and their impact on performance," in *Proceedings of the 2nd international workshop on Software and performance*, 2000, pp. 195-203.

[110] P. G. Keen, "Decision support systems: a research perspective," in *Decision support systems: Issues and challenges: Proceedings of an international task force meeting*, 1980, pp. 23-44.

[111] R. Labianca, G. D. Beretta, B. Kildani, L. Milesi, F. Merlin, S. Mosconi, et al., "Colon cancer," *Critical reviews in oncology/hematology*, vol. 74, pp. 106-133, 2010.

[112] C. R. Lichtenstern, R. K. Ng, S. Shalapour, and M. Karin, "Immunotherapy, Inflammation and Colorectal Cancer," *Cells*, vol. 9, p. 618, 2020.

[113] P. Ragnhammar, L. Hafström, P. Nygren, and B. Glimeilius, "A systematic overview of chemotherapy effects in colorectal cancer," *Acta oncológica*, vol. 40, pp. 282-308, 2001.

[114] L. Chen, M. He, M. Zhang, Q. Sun, S. Zeng, H. Zhao, et al., "The Role of non-coding RNAs in colorectal cancer, with a focus on its autophagy," *Pharmacology & Therapeutics*, p. 107868, 2021.

[115] C. M. Craig, "Biofilms of Colorectal Cancer," Johns Hopkins University, 2015.

[116] P. Walsh, B. Lawlor, B. Kelly, T. Manning, T. Heuss, and M. Leopold, "Visualizing Next-Generation Sequencing Cancer Data Sets with Cloud Computing," in *Advanced Visual Interfaces. Supporting Big Data Applications*, ed: Springer, 2016, pp. 50-62.

[117] S. Wang, P. Ma, G. Ma, Z. Lv, F. Wu, M. Guo, et al., "Value of serum tumor markers for predicting EGFR mutations and positive ALK expression in 1089 Chinese non-small-cell lung cancer patients: A retrospective analysis," *European Journal of Cancer*, vol. 124, pp. 1-14, 2020.

[118] K. Latimer and T. Mott, "Lung cancer: diagnosis, treatment principles, and screening," *American family physician*, vol. 91, pp. 250-256, 2015.

[119] A. J. Alberg and J. M. Samet, "Epidemiology of lung cancer," *Chest*, vol. 123, pp. 21S-49S, 2003.

[120] R. L. Siegel, K. D. Miller, and A. Jemal, "Cancer statistics, 2020," *CA: A Cancer Journal for Clinicians*, vol. 70, pp. 7-30, 2020.

[121] K. R. Cho and I.-M. Shih, "Ovarian cancer," *Annual Review of Pathology: Mechanisms of Disease*, vol. 4, pp. 287-313, 2009.

[122] Y.-J. Ho, J.-P. Li, C.-H. Fan, H.-L. Liu, and C.-K. Yeh, "Ultrasound in tumor immunotherapy: current status and future developments," *Journal of Controlled Release*, 2020.

[123] L. A. Torre, B. Trabert, C. E. DeSantis, K. D. Miller, G. Samimi, C. D. Runowicz, et al., "Ovarian cancer statistics, 2018," *CA: a cancer journal for clinicians*, vol. 68, pp. 284-296, 2018.

[124] M. Corbex, S. Bouzbid, and P. Boffetta, "Features of breast cancer in developing countries, examples from North-Africa," *European Journal of Cancer*, vol. 50, pp. 1808-1818, 2014.

[125] H. Pham and D. H. Pham, "A novel generalized logistic dependent model to predict the presence of breast cancer based
on biomarkers,” *Concurrency and Computation: Practice and Experience*, vol. 32, p. e5467, 2020.

[126] G. Toledo, C. Y. Ochoa, and A. J. Farias, “Religion and spirituality: their role in the psychosocial adjustment to breast cancer and subsequent symptom management of adjuvant endocrine therapy,” *Supportive Care in Cancer*, pp. 1-8, 2020.

[127] M. Frasca, C. Sabathe, S. Delaloge, A. Galvin, A. Patsouris, C. Levy, et al., “Palliative care delivery according to age in 12,000 women with metastatic breast cancer: Analysis in the multicentre ESME-MBC cohort 2008–2016,” *European Journal of Cancer*, vol. 137, pp. 240-249, 2020.

[128] R. Sánchez-Cauce, J. Pérez-Martín, and M. Luque, “Multi-input convolutional neural network for breast cancer detection using thermal images and clinical data,” *Computer Methods and Programs in Biomedicine*, p. 106045, 2021.

[129] Y. Park, E. Senkus-Konefka, S.-A. Im, G. Pentheroudakis, S. Saji, S. Gupta, et al., “Pan-Asian adapted ESMO Clinical Practice Guidelines for the management of patients with early breast cancer: a KSMO-ESMO initiative endorsed by CSCO, ISMPO, JSMO, MOS, SSO and TOS,” *Annals of Oncology*, 2020.

[130] C. E. DeSantis, J. Ma, M. M. Gaudet, L. A. Newman, K. D. Miller, A. Goding Sauer, et al., “Breast cancer statistics, 2019,” *CA: a cancer journal for clinicians*, vol. 69, pp. 438-451, 2019.

[131] A. Bauer, K. E. Adam, P. H. Soyer, and K. W. J. Adam, "Prevention of Occupational Skin Cancer," *Kanerva’s Occupational Dermatology*, pp. 1685-1697, 2020.

[132] K. Freeman, J. Dinnes, N. Chuchu, Y. Takwoingi, S. E. Bayliss, R. N. Matin, et al., "Algorithm based smartphone apps to assess risk of skin cancer in adults: systematic review of diagnostic accuracy studies," *bmj*, vol. 368, 2020.

[133] J. Ferlay, E. Steliarova-Foucher, J. Lortet-Tieulent, S. Rosso, J. Coebergh, H. Comber, et al., "Dosimetric implications of inter-and intrafractional prostate positioning errors during tomotherapy: comparison of gold marker-based registrations with native MVCT," *Eur J Cancer*, vol. 49, pp. 1374-1403, 2013.

[134] D. Bliznukes, D. Jakovels, I. Saknite, and J. Spigulis, "Mobile platform for online processing of multimodal skin optical images: Using online Matlab server for processing remission, fluorescence and laser speckle images, obtained by using novel handheld device," in *2015 International Conference on BioPhotronics (BioPhotronics)*, 2015, pp. 1-4.

[135] P. L. Wizinowich, D. S. Acton, O. Lai, J. Gathwright, W. Lupton, and P. J. Stomski Jr, "Performance of the WM Keck observatory natural guide star adaptive optic facility: the first year at the telescope," in *Adaptive Optical Systems Technology*, 2000, pp. 2-13.

[136] Z. Khazaei, M. Sohrabivafa, V. Momenabadi, L. Moayed, and E. Goodarzi, "Global cancer statistics 2018: Globocan estimates of incidence and mortality worldwide prostate cancers and their relationship with the human development index," *Advances in Human Biology*, vol. 9, p. 245, 2019.

[137] V. Alonso, A. F. Neves, K. Marangoni, P. C. de Faria, E. R. Cordeiro, A. P. P. Freschi, et al., "Gene Expression Profile of Prostate Cancer Patients by Chemiluminescent Analysis," *Analytical letters*, vol. 42, pp. 166-177, 2009.

[138] A. Heidenreich, P. J. Bastian, J. Bellmunt, M. Bolla, S. Joniau, M. Mason, et al., "Guidelines on prostate cancer," *European association of urology*, p. 45, 2012.

[139] K. F. Jansson, O. Akre, H. Garmo, A. Bill-Axelson, J. Adolfsson, P. Stattin, et al., "Concordance of tumor differentiation among brothers with prostate cancer," *European urology*, vol. 62, pp. 656-661, 2012.

[140] K. Hemminki, "Familial risk and familial survival in prostate cancer," *World journal of urology*, vol. 30, pp. 143-148, 2012.

[141] J. Quackenbush, "Computational analysis of microarray data," *Nature reviews genetics*, vol. 2, pp. 418-427, 2001.

[142] B. A. Garro, K. Rodríguez, and R. A. Vázquez, "Classification of DNA microarrays using artificial neural networks and ABC algorithm," *Applied Soft Computing*, vol. 38, pp. 548-560, 2016.

[143] A. Heidari and N. J. Navimipour, "Service discovery mechanisms in cloud computing: a comprehensive and systematic literature review," *Kybernetes*, 2021.

[144] Z. Khandezamin, M. Naderan, and M. J. Rashiti, "Detection and classification of breast cancer using logistic regression feature selection and GMDH classifier,"
considering congestion management and exchange in a power transmission system in cloud computing," P. Kumari and P. Kaur, "A survey of fault tolerance in cloud computing environments," L. B. A. Rabai, M. Jouini, A. B. Aissa, and A. Mili, "A cybersecurity model in cloud computing environments," Journal of King Saud University-Computer and Information Sciences, vol. 25, pp. 63-75, 2013.

[154] P. Kumari and P. Kaur, "A survey of fault tolerance in cloud computing," Journal of King Saud University-Computer and Information Sciences, 2018.

[155] M. Dehghani, M. Ghasi, T. Niknam, A. Kavousi-Fard, M. Shasadeghi, N. Ghadimi, et al., "Blockchain-based securing of data exchange in a power transmission system considering congestion management and social welfare," Sustainability, vol. 13, p. 90, 2021.

[156] M. Dehghani, M. Ghasi, T. Niknam, A. Kavousi-Fard, M. Shasadeghi, N. Ghadimi, et al., "Blockchain-based securing of data exchange in a power transmission system considering congestion management and social welfare," Sustainability, vol. 13, pp. 1-1, 2020.

[157] L. Zhong, Z. Fang, F. Liu, B. Yuan, G. Zhang, and J. Lu, "Bridging the theoretical bound and deep algorithms for open set domain adaptation," arXiv preprint arXiv:2006.13022, 2020.

[158] P. Tatlow and S. R. Piccolo, "A cloud-based workflow to quantify transcript-expression levels in public cancer compendia," Scientific reports, vol. 6, pp. 1-11, 2016.

[159] J.-L. Gonzalez-Hernandez, A. N. Recinella, S. G. Kandlikar, D. Dabydeen, L. Medeiros, and P. Phatak, "Technology, application and potential of dynamic breast thermography for the detection of breast cancer," International Journal of Heat and Mass Transfer, vol. 131, pp. 558-573, 2019.

[160] H. Kong, L. Lu, J. Yu, Y. Chen, and F. Tang, "Continuous Authentication through Finger Gesture Interaction for Smart Homes Using WiFi," IEEE Transactions on Mobile Computing, 2020.

[161] J. Yan, Y. Meng, X. Yang, X. Luo, and X. Guan, "Privacy-Preserving Localization for Underwater Sensor Networks via Deep Reinforcement Learning," IEEE Transactions on Information Forensics and Security, vol. 16, pp. 1880-1895, 2020.

[162] A. Vineela, N. Kasiviswanath, and C. ShobaBindu, "Theoretical analysis on applications aspects of smart materials preserving the security and privacy in medical big data and cloud," Materials Today: Proceedings, 2021.
usage," *Advanced Science and Technology Letters*, vol. 38, pp. 27-31, 2013.

[166] A. Prakash, S. Majumder, S. Ahmad, M. Varkey, T. Anish, C. Jenkins, et al., "Detection and verification of 2.3 million cancer mutations in NCI60 cancer cell lines with a cloud search engine," *Journal of proteomics*, vol. 209, p. 103488, 2019.

[167] B. N. Davis-Dusenbery, "Petabyte-scale cancer genomics in the cloud," *Cancer Genetics*, vol. 208, p. 360, 2015.

[168] J.-H. Bi, Y.-F. Tong, Z.-W. Qiu, X.-F. Yang, J. Minna, A. F. Gazdar, et al., "ClickGene: an open cloud-based platform for big pan-cancer data genome-wide association study, visualization and exploration," *BioData mining*, vol. 12, p. 12, 2019.