The Research of Medical Science Review
ISSN: 3007-1208 & 3007-1216 Volume 4, Issue 4, 2026

NOVEL DIAGNOSTIC MARKERS FOR EARLY CANCER DETECTION WITH EMPHASIS ON CA-125 AND PSA

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DOI: https://doi.org/10.5281/zenodo.19813381

Keywords
Diagnosis of cancer at its early stage and biomarkers and CA-125, PSA and liquid biopsy and ctDNA, multi-omics.

Article History
Received: 02 March 2026
Accepted: 09 April 2026
Published: 27 April 2026

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Abstract

Background:
Early cancer diagnosis is shown to greatly enhance survival and lightening the burden of the disease, but there are only a few cancers that have effective screening tools. The biomarkers used in the screening of ovarian and prostate cancer have mainly been protein-based biomarkers, including cancer antigen-125 (CA-125) and the prostate-specific antigen (PSA).

Objective:
This review will critically assess the emergent diagnostic biomarkers in the early detection of cancer with specific reference to CA-125 and PSA as conventional models of one-analyte and multi-analyte respectively

Methodology:
A systematic review of the literature was carried out based on peer-reviewed publications, which covered studies that reported the use of liquid biopsy technologies and protein biomarkers. The review involves the circulating tumor DNA, DNA methylation signatures.

Results:
Recent research indicates that the biomarkers of liquid bio-psies, especially ctDNA and methylation-based tests, are more specific and capable of detecting a variety of cancer types with only a single sample.

Conclusion:
The new diagnostic biomarkers are a significant improvement in the detection of early cancer, and questions of sensitivity, standardization, cost, and mass prospective validation persist. CA-125 and PSA are used to demonstrate the possibilities and the limitations of single-marker screening.

INTRODUCTION

The health burden of cancer is huge and increasing worldwide, taking up a significant proportion of morbidity and mortality. Cancer has caused approximately 14.6% of all deaths worldwide in 2021, and it is a leading cause of death in most countries. The social and economic effects of these deaths on people and the health care systems are immense. It is important to note that a significant portion of cancer deaths are theoretically avoidable; the World Health Organization has highlighted that a significant proportion of cancer deaths are preventable by providing earlier diagnosis and prompt treatment.[1]

Cancer detection at an early stage greatly enhances patient outcomes. Research indicates that an earlier diagnosis is much more effective in enhancing overall and recurrence-free survival. Indicatively, in one study, the median survival was 38 months in early-diagnosed patients compared to 14 months in late-diagnosed patients, as well as improved quality of life and reduced side effects. Early detection can be used to treat the disease less invasively and more efficiently and can significantly increase five-year survival rates. In comparison,

late-stage diagnosis implies a poor prognosis - in fact, about half of the cancers are diagnosed only at an advanced stage, at which point they are not treated as much as possible.[2]

The effectiveness of the already set screening programs emphasizes the importance of early diagnosis. Stringent screening programs of breast, cervical and colorectal cancer (e.g. mammography, Pap tests, colonoscopy) have had quantifiable effects on the prevalence of advanced disease and survival of screened populations. The percentage of late-stage diagnosis has significantly decreased in cancers where good screening tests exist, which results in improved outcomes and decreased mortality. The successes have led to the development of other malignancies to have comparable tests, yet many cancers (ovarian, pancreatic etc) do not have sensitive screening methods and are therefore only diagnosed when they are already showing symptoms.[3]

Cancer antigen CA-125 is one of the classical serum markers that have been in place in the management of ovarian cancer. CA-125 (high molecular weight glycoprotein) was discovered in the early 1980s and is found to be elevated in most advanced epithelial cancers of the ovary. It is normally cut off at 35 U/mL. Practically CA-125- is applicable in the monitoring of therapy and to determine recurrence because a common result is that the levels tend to increase with tumor load. The role of CA-125 in screening or early diagnosis is, however, limited: only approximately half of all patients with stage I ovarian cancer present a elevated CA-125 level and its sensitivity (approximately 79) and specificity (approximately 87) are not sufficient to detect early disease in the general population.[4]

CA-125 has long been known to have limitations. It is not very specific due to the fact that benign diseases (ovarian cysts, endometriosis, menstruation, benign liver or pelvic disease) and other cancers (endometrial, breast, gastrointestinal) may also elevate CA-125. As a result of this, CA-125 screening has numerous false positives. The weaknesses of CA-125 screening have been established in large trials: a large randomized trial in the UK reported no significant mortality with annual CA-125 and ultrasound screening of ovarian cancer. Therefore, CA-125 alone cannot be used to screen a population, but it is useful in the management of known ovarian cancer and recurrence.[5]

Likewise, prostate-specific antigen (PSA) has a long history as a cancer biomarker. PSA is an enzyme secreted by the prostate gland which is increased in prostate cancer but equally in benign prostatic hyperplasia as well as prostatitis. It can be detected in blood and age-adjusted cutoff values (usually 2.5-4.5 ng/mL according to the age) have been used to indicate potential cancer. PSA testing was rapidly adopted in the late 20 th century as a way of detecting and monitoring prostate cancer. Serial PSA measurements in men who have prostate cancer who are already diagnosed with prostate cancer are a sensitive way of monitoring the treatment response or recurrence. Due to its ease and measurability, PSA has been widely applied in clinical practice, as well as in large screening studies.[6]

PSA screening, however, has its significant weaknesses. On top of elevations due to benign conditions, PSA levels change with age, ethnicity and prostate volume. A high number of non-cancerous men have slightly high PSA, which results in unneeded biopsies. More importantly perhaps, the results of randomized trials of PSA screening were less clear cut: e.g. in a large trial the benefits were small - approximately 1.3 deaths of prostate cancer and 3 lower metastatic cases per 1000 men screened after 13 years - and overall mortality was not decreasing significantly. These results have rendered PSA-based screening contentious; an example of this is the USPSTF guidelines recommending the use of individualized decision-making when screening men aged 55-69 and do not recommend screening men aged 70 and above. Overall, similar to CA-125, PSA demonstrates that the clinical utility of a biomarker is critically dependent on sensitivity, specificity and effect on mortality, rather than simply being easily measurable.[7]

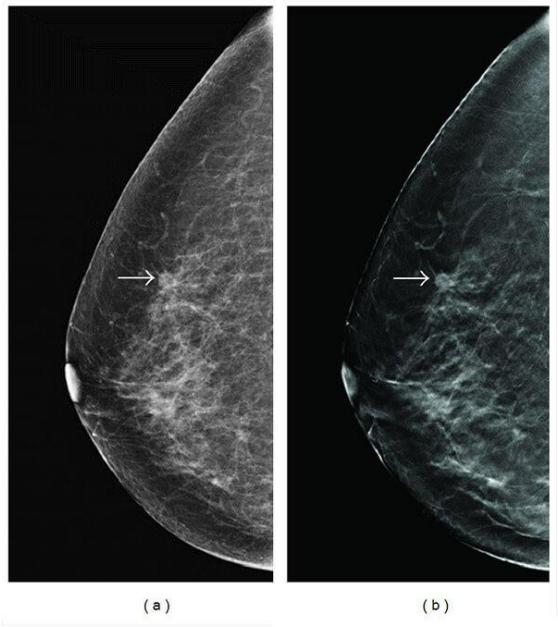

Figure 1: This image presents a side-by-side comparison of a mammogram that has a suspicious nodule/lesion on the breast with arrows

New hope of earlier cancer detection is provided by the advent of novel molecular biomarkers. A very promising type of test is circulating tumor DNA (ctDNA) - pieces of DNA that the tumors release into the blood. Even in the absence of a visible disease, ctDNA has the ability to transport tumor-related genetic and epigenetic changes. New studies have proposed that sensitive assays can identify ctDNA long before the appearance of tumors by imaging. Indicatively, Slavin et al. observe ctDNA is released into the blood with apoptosis and necrosis of tumors, and it can be detected even at the initial stages of malignancy. In cancers that have no good screening (ovarian, pancreatic, gastric), ctDNA may make possible a new, minimally invasive liquid biopsy-based method of detecting disease at an early stage. Multi-cancer early detection tests based on ctDNA are currently being developed by many companies, which use ctDNA with other biomarkers (e.g. CA-125, methylation patterns, exosomal RNA) to enhance their performance.[8] Another category of epigenetic marks with high potential is DNA methylation. Cancer progression frequently is accompanied by extensive alterations in DNA methylation (e.g. hypermethylation of tumor suppressor gene promoters) which can be identified in cell-free DNA. Importantly, the aberrant methylation events are commonly early during tumorigenesis. According to Yang and Li, epigenetic changes are not only observed at the later stages of cancer development, but they can also be observed at the early stages of its formation, which is why DNA methylation patterns can be viewed as a great biomarker to identify cancer at an early stage. In fact, cancer-specific methylation signature-detecting assays in blood (or other fluids) have been promising in the detection of cancers at an early stage. Even small amounts of methylated ctDNA can be measured with advanced sequencing or digital PCR techniques, which provide a highly specific way of indicating occult malignancy.[9]

RNA biomarkers, particularly microRNAs (miRNAs), are also becoming new promising early cancer indicators. Small regulatory RNAs (miRNAs) that can be released into the circulation are often dysregulated in cancer. Recent reviews point out that miRNAs may be extraordinarily stable in blood and other biofluids and that certain miRNA expression panels can be linked to early-stage cancers. To illustrate this, Metcalf et al. point out that even though miRNAs have been facing difficulties, recent advances indicate that miRNAs have the potential to be sensitive and specific biomarkers in early cancer diagnosis. The recent breakthroughs in high-throughput sequencing and machine learning have made it possible to identify miRNA signatures unique to cancer

patients compared to controls in blood or urine. Should they be verified, miRNA panels may offer cheap, non-invasive screening assays of otherwise clinically silent cancers at an early stage.[10]

Other active fields of research are proteomics-based biomarkers or measuring panels of proteins or peptides. Protein expression is an indication of cell behavior as compared to genomics, which determines the mutations of unknown functional worth. New developments in mass spectrometry, microarray technology and affinity assays can now enable the simultaneous measurement of hundreds of proteins with small clinical samples. Proteomic technologies are revolutionizing the discovery of cancer biomarkers, as Conrad et al. refer to it. An example is the circulating protein panels (e.g. autoantibodies, cytokines, metabolic enzymes) that have been investigated to provide an early detection of lung, liver, colorectal and other cancers. Genomic methods are complemented by proteomic methods that are able to capture dynamic changes in tumor-secreted proteins. Finally, multi-protein biomarkers have the potential to be more sensitive in early-stage disease.[11]

The topic of extracellular vesicles (EVs), such as exosomes and microvesicles, has been of interest as a biomarker carrier. EVs are nano sized lipid vesicles released by all cells - tumor cells and they carry DNA, RNA, protein and lipid cargo that is reminiscent of their cell of origin.. Notably, tumor-derived EVs are circulated in blood and other fluids even at small cancer. Recent work highlights EVs' "potential as noninvasive biomarkers" of cancer. In fact, EVs that are secreted by malignant cells contain oncogenic proteins, mRNAs and miRNAs that can be profiled to act as evidence of the presence of a tumor. EV isolation (ultracentrifugation, immunocapture, microfluidics) is becoming increasingly technologically accessible to enrich and analyse tumor EVs using patient blood samples. Researchers expect to make breakthroughs in cancer diagnosis and monitoring at an early stage through the combination of EV analysis with liquid biopsy techniques.[12]

These improvements are supported by new potent technologies. Liquid biopsy systems (digital PCR, NGS) allow the detection of rare molecules such as ctDNA and miRNA in blood with great sensitivity. Next-generation sequencing enables the examination of cell-free DNA (whole-genome or targeted mutation/methylation) and machine learning can be used to detect complexities in multi-omic data. Protein microarrays, mass-spectrometry, nucleic acid panels and highly multiplexed assays (which can simultaneously measure dozens of markers) can be used to measure dozens of markers. As an illustration, Xiao et al. explain the ways in which liquid biopsies, nanobiosensors, artificial intelligence and NGS are revolutionizing biomarker discovery and use by enhancing sensitivity and automating the analysis process. Equally, microfluidic lab-on-a-chip systems are being designed to automate and downsize biomarker tests, which one day would allow the tests to be performed at the point-of-care to screen cancer. Simply put, biological markers are converging with cutting-edge technology and are turning early detection more and more attainable.[13]

A few of these new biomarkers are in clinical trials. Multi-cancer early detection (MCED) ctDNA methylation based tests (including the Galleri test) have gone into large trials. As an example, the studies conducted by GRAIL will involve more than 300,000 individuals to confirm its blood-based MCED assay. Cell-free DNA panels, proteomic signature and EV profiles are under test in prospective cohorts by other companies and academic consortia. Similar initiatives are validating assays of cfDNA methylation (e.g. Epi proColon of colon cancer), microRNA panels (of lung and liver cancer), autoantibody signatures, and urine-based biomarkers. The new tests are in any case compared to imaging or biopsy results to determine their sensitivity to early cancers. Finally, clinical validation is aimed at making sure that these biomarkers are able to detect the disease at the stage when it can be cured and can lead to better patient outcomes.[14]

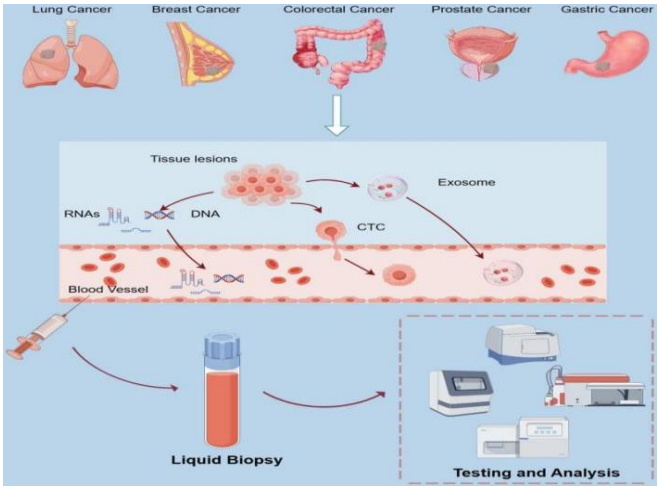

Figure 2 : As the image indicates, various cancers shed biomarkers like DNA, RNA, CTCs and exosomes into the blood that can be detected by the liquid biopsy to diagnose and analyse early cancer.

The fact that the mortality rate with late cancer diagnosis is high and is persistent means that it is rational and urgent to concentrate on new cancer markers to detect cancer at its early stage. At least one-third of cancer deaths can be avoided by earlier diagnosis and treatment, as the WHO stresses. However, the existing tests such as CA-125 and PSA do not suffice to screen the population- their shortcomings highlight the necessity to have superior biomarkers. The review will identify new diagnostic strategies by reviewing the latest studies on ctDNA, methylation markers, miRNAs, proteomic signatures, EVs and others. These developments are important to understand to inform future studies and clinical translation. Overall, the changing landscape of biomarkers is promising to enable the identification of cancer at an earlier stage, when it can be most effectively treated, and the overall burden of cancer in the world will decrease.

AIMS AND OBJECTIVES

- To critically assess the existing evidence on the diagnostic biomarkers CA-125 and PSA to early detect cancer.
- To evaluate their clinical usefulness, determine what limitations they already have, and point to the areas that need to be explored further.

METHODOLOGY

Based on the topics of PSA (prostate cancer) and CA-125 (ovarian cancer), the research was done systematically to determine the possible markers in early diagnosis. Such design is important because it allows for collecting data and giving a theoretical base for early cancer diagnosis. Databases including PubMed, Scopus, ScienceDirect, and Google Scholar were utilized in order to find necessary information in the academic environment. The period of time for the literature review was four months following the approval of the synopsis. 120 papers published within 2010 and 2025 were screened and relevant sources were selected for analysis. Publications in English related to the use of CA-125 and PSA in the context of early cancer diagnosis with specified patients were included. Exclusion criteria include advanced stages of cancer, not peer-reviewed papers, incomplete studies, in vitro and animal researches.

DISCUSSION

The thesis of the current review was done to assess the efficiency of new diagnostic marks to detect cancer at an early stage with special focus on the efficiency of CA-125 and PSA as conventional biomarks. Overall results of the thesis indicate that early diagnosis is one of the essential factors of cancer outcome, since the diagnosis with localized disease is always followed by increased survival chances, reduced disease burden, and increased treatment opportunities. The thesis also demonstrates that even though the conventional markers are still clinically helpful, they cannot be used as independent screening methods to detect the population in terms of early detection. More recent molecular methods such as ctDNA and

DNA methylation-based methods, seem more promising since they are biologically more relevant to the tumor process and can be measured using minimally invasive liquid biopsy methods.[15]

The key strength of this thesis is that it contextualizes the debate of biomarkers in the broader context of the subject of public health in cancer load and at the time of diagnosis. The literature reviewed suggests that the problem of delayed diagnosis remains a major cause of cancer mortality, and such circumstances necessitate the discovery of more effective screening methods in a timely manner. The thesis results are consistent with those of Siegel et al. who stressed that cancers diagnosed at localized stages have significantly improved five-year survival as compared to those diagnosed after regional or distant metastasis. This can be used to substantiate the main point of the current review that the development of biomarkers needs to be evaluated not simply in terms of the ability to be detected by the analytical methods, but based on its ability to push diagnosis further to the more treatable stages of disease progression.[16]

The CA-125 discussion in this thesis paper sheds light on the historical significance of the tumor markers as well as the significant limitations of the conventional ones. CA-125 can also be used to monitor and identify recurrence in ovarian cancer, as its level can be used to indicate the tumor load. Nonetheless, the thesis is correct in demonstrating that CA-125 can only be useful in the early stages of the disease with only half of the stage I patients showing a presence of high level of the CA-125. The other issue is its low specificity as benign gynecologic and non-gynecologic conditions can also elevate serum CA-125, causing false-positive results. The reviewed literature and the results of the PLCO study as well as the results of the analysis of Chark chi and Duffy presented in the thesis substantiate the idea that CA-125 in its pure form will not be a useful population screening biomarker. Instead, it has the highest value of follow-up of known disease or as a part of multimodal diagnostic strategies as opposed to being a single test.[17]

It can be similarly interpreted in the case of PSA. This thesis rightfully recognizes that PSA has revolutionized the assessment of prostate cancer since it is easy, cheap and can be applied in the treatment follow-up and recurrence. However, the use of PSA screening is a controversial issue given that benign prostatic hyperplasia, prostatitis, age related changes and prostate volume could all have an effect on the PSA levels. This poses a threat of over diagnosis, unnecessary biopsies and over treatment. The results of the thesis are aligned with the evidence of ERSPC and guideline-based evidence that indicate that PSA can decrease the prostate cancer-specific mortality in specific population groups, however, the gains will have to be offset by the substantial harms. Thus, the current review is right in its conclusion that PSA cannot be considered an optimal screening marker without risk-adapted interventions, meaning that it is more appropriate to include clinical opinions, MRI screening, and other molecular devices.[18]

Compared to any other biomarkers mentioned within the thesis, ctDNA will be the most attractive candidate to use in early detection of cancer in the future. This makes perfect sense since ctDNA is a direct reflection of the genetic changes occurring in tumors, and can be obtained in a noninvasive manner via blood. Wan, Heitzer, Bardelli, Forshew, Murtaza, and Dawson have provided support in the thesis analysis that ctDNA has already proven to have significant value in treatment monitoring, detection of relapse and tumor heterogeneity. It is particularly relevant to precision oncology because of its capacity to facilitate dynamic genomic alterations, prior to radiologic deterioration. It is, however, also revealed in the discussion that the most challenging task of ctDNA is screening of population that is asymptomatic or in the early-stage where the fractions of tumor DNA are usually very low. Here, the analytical sensitivity, pre-analytical standardization and the prevention of false positives due to non-tumor causes like clonal hematopoiesis are significant impediments. In this way, the thesis approves of a reasonable interpretation of ctDNA being potentially the most promising, but still not quite ready to conduct a large-scale screening on a routine basis.[19]

Although DNA methylation biomarkers are not

as warranted by the thesis, they can be even more applicable than mutation-based assays in the early detection. Among these the most critical is that the changes in epigenetics tend to be early in tumorigenesis, in some cases, the changes in epigenetics may actually be preclinical findings. This renders the use of methylation-based methods especially appealing towards screening. The results of the thesis are consistent with those of Liu et al. and Yang and Li who demonstrated that methylation profiling could be very specific and could be used to predict the tissue of origin as well. The latter feature is particularly useful in multi-cancer detection since, in order to perform downstream clinical workup, it is crucial to determine the origin of the signal of the cancer. The discussion thus underlines that, with the application of high-throughput sequencing and machine-learning classification models, the application of methylation assays could prove to be a central platform on which multi-cancer early detection can be performed.[20]

The other significant contribution of this thesis is that future of cancer diagnostics is not likely to be based on one marker. The evidence review unitarily indicates that a combination of biomarkers models is very likely to be superior to individual tests. This can be observed in multi-analyte methods, like CancerSEEK, where protein biomarkers and cfDNA mutation signals are combined in order to enhance sensitivity and specificity. This in practical sense translates to the fact that the weaknesses of one biomarker could be offset by the strengths of another biomarker. The results table of the thesis indicates this change with ctDNA, methylation markers, miRNAs, extracellular vesicles, proteomics, and advanced analytics demonstrating a shift towards integrated, minimally invasive, multi-omic screening platforms. This is a significant interpretation since the biology of cancer is not uniform and no single biomarker circulating in the blood is likely to represent all the pertinent signals of tumor types and stages.[21]

The chapters about microRNAs, extracellular vesicles and proteomics further enrich the discussion of the thesis. The MicroRNAs have the appeal of being comparatively stable in circulation and possibly indicative of early dysregulation of oncogenic pathways. Extracellular vesicles are also promising since they shield tumor-derived cargo, such as DNA, RNA and proteins and thus, offer information of biologically rich information. Proteomics, in its turn, provides a functional approach, which supplements the nucleic acid-based assays. Nonetheless, the thesis is just right not to overstate these technologies. It demonstrates that although these biomarker classes have significant theoretical and experimental potential, all of them continue to have significant translational challenges, most notably, reproducibility, normalization, methods of isolation, inter-platform consistency. So, they can now be taken as complementary technologies that will become supporting of the future multi-marker panels, but not the means of substituting the proven techniques alone.[22,23]

One of the most important themes of this review is the use of technology to decide on the ability of a biomarker to traverse the research-to-practice gap. The thesis has emphasized the fact that the discovery and interpretation of biomarkers are revolutionizing with the modern liquid biopsy platforms, digital PCR, next-generation sequencing, multiplex assays, as well as machine-learning tools. This is significant in that the biological relevance is not the sole determinant of the usefulness of a biomarker because it must also be able to be measured with accuracy, reproducibly, rapidly and at a lower cost. The thesis goes further than just a mere comparison between old and new markers, but rather states that early detection is a systems-level problem that entails biology, computing, assay design, and clinical workflow integration. This meaning is especially powerful and it is indicative of the present-day translational oncology.[24]

The thesis may have some flaws, although it is not without its strengths, which should also be used to steer the interpretation of the discussion. The conclusions rely on the quality and diversity of existing literature since it is not an original clinical study. The studies included have significant differences in terms of cancer type, population of patients, methodology used to conduct the assay and clinical endpoints, hence making it hard to compare them directly.

Moreover, most of the most promising biomarkers mentioned are still prospectively being validated, and have not yet demonstrated cost-effectiveness, feasibility, and scale clinical utility. To that end, the current review rightly concludes that even though ctDNA and methylation-based assays are at the forefront today, further standardization of these techniques, larger cohorts of validation, and more defined clinical pathways to cope with positive test outcomes have to be in place before these techniques are rolled out into routine use in population screening.[25,26,27]

Overall, this thesis presents a reasonable and justified discourse on the shift of the single-marker testing to integrated molecular diagnostics in the early cancer detection. CA-125 and PSA are still significant examples of biomarkers that are clinically useful, but not ideal; they can be used to monitor and risk stratify, but cannot be used to reliably provide stand-alone screening. The new biomarkers, particularly ctDNA and methylation signatures, have significantly higher potential since they are much more direct in their capture of tumor biology, and can be implemented using minimally invasive liquid biopsy systems. Nevertheless, it is also obvious that promise is not enough as the evidence was reviewed in this thesis. The success in the future will be through enhancement of assay sensitivity in the early disease, technical standardization, multi-marker model integration and validation of these tools in large populations. In general, the results indicate that the future of cancer diagnosis at early stages is most likely to be based on multi-omic and technology-based approaches based on the bloodstream, as opposed to single traditional serum markers.[28,29]

CONCLUSION

The enhancement of the early detection of cancer by using more valid diagnostic biomarkers is emphasized in this review. Traditional tumor markers e.g. CA-125 and PSA have still gained some usefulness in clinical practice but are not particularly effective as a screening tool, since they lack sufficient sensitivity and specificity and are increased in various benign conditions. The literature suggests that new biomarkers such as circulating tumor DNA, patterns of DNA-based DNA methylation, microRNAs, proteomic, and extracellular vesicles have potential to enable the detection of cancer earlier and more accurately. The innovation of technologies, including liquid biopsy and next-generation sequencing, also contribute to the multi-biomarker diagnostic approaches. In general, the future of cancer screening will probably be based on combined biomarker methods and not on the individual markers. Nevertheless, these novel biomarkers need to be further validated, standardized in terms of methods and large-scale clinical trials before they can be broadly adopted in clinical practice.

Limitation:

This was literature research and lacked primary clinical or laboratory information. The results are based on the quality and heterogeneity of the published studies that existed before, which varied in terms of cancer type, biomarker type, methodology and study population. English-language articles were also used and therefore all the non-English studies that are relevant might have been overlooked. Besides that, no original meta-analysis or pooled statistical validation was carried out. Numerous of these new biomarkers are in the preclinical phase of development and have not been completely standardized to be used routinely. International data is also a major basis of the findings which might reduce their immediate applicability to local contexts. Moreover, the particular aspects of original clinical studies are occasionally present in the thesis, which can establish the lack of a methodological consistency.

Recommendations:

It is suggested that the development and clinical integration of the emerging diagnostic biomarkers should be a priority at the healthcare institutions and research organizations with the aim of enhancing early detection of cancer. The latest technologies, including liquid biopsy, next-generation sequencing, and multi-omics strategies, need to be implemented more often in the sphere of diagnostic research and clinical practice. Laboratory professional and clinical training programs need to be reinforced to enhance the skill of molecular diagnostics and

biomarker interpretation. They should also work towards the minimization of the cost and enhancing access to these technologies and come up with standardized protocols and regulatory guidelines to provide reliable and consistent testing. Moreover, extensive validation experiments and further research, such as the incorporation of artificial intelligence, would be required to make biomarker discovery and diagnostic accuracy better, as well as, awareness campaigns to inform healthcare professionals and the general population about new approaches to diagnosing cancer.

REFERENCES

Elbarazi I, Ahmed LA. Alleviating the Global Burden of Cancer Through Prevention and Early Detection. *Cancer Control*. 2025;32:10732748251378666.

Siegel RL, Miller KD, Fuchs HE, Jemal A. Cancer Statistics, 2024. *CA: A Cancer Journal for Clinicians*. 2024;74(1):7–33.

Duffy MJ. Clinical uses and limitations of CA-125 in ovarian cancer. *International Journal of Biological Markers*. 2006;21(3):215–223.

Buys SS, Partridge E, Black A, et al. Effect of screening on ovarian cancer mortality: the PLCO trial. *JAMA*. 2011;305(22):2295–2303.

Mottet N, et al. EAU-ESTRO-SIOG guidelines on prostate cancer. *European Urology*. 2021;79(2):223–241.

Schröder FH, Hugosson J, Roobol MJ, et al. Screening and prostate cancer mortality: the ERSPC trial results. *European Urology*. 2014;65(5):E1–E12.

Wan JCM, Massie C, Garcia-Corbacho J, et al. Liquid biopsies come of age: towards implementation of circulating tumour DNA. *Nature Reviews Cancer*. 2017;17(4):223–238.

Klein EA, Richards D, Isaacs WB, et al. Clinical validation of a multi-cancer early detection test using cell-free DNA methylation profiling. *Annals of Oncology*. 2020;31(6):745–759.

Yang Q, Li X. DNA methylation as an early diagnostic marker of cancer. *Oncology Letters*. 2014;7(5):1343–1348.

Calin GA, Croce CM. MicroRNA signatures in human cancers. *Nature Reviews Cancer*. 2006;6(11):857–866.

Conrad DH, Goyette J, Thomas PS. Proteomics and cancer screening: development and applications. *Journal of Proteome Research*. 2007;6(11):4329–4345.

Théry C, Zitvogel L, Amigorena S. Exosomes: composition, biogenesis and function. *Nature Reviews Immunology*. 2002;2(8):569–579.

Bardelli A, Pantel K. Liquid biopsies, what we do not know (yet). *Cancer Cell*. 2017;31(2):172–179.

Cohen JD, Li L, Wang Y, et al. Detection and localization of surgically resectable cancers with a multi-analyte blood test. *Science*. 2018;359(6378):926–930.

Elbarazi I, Ahmed LA. Alleviating the Global Burden of Cancer Through Prevention and Early Detection. Cancer Control. 2025;32:10732748251378666.

Siegel RL, Miller KD, Fuchs HE, Jemal A. Cancer Statistics, 2024. CA Cancer J Clin. 2024;74(1):7-33.

Duffy MJ. Clinical uses and limitations of CA-125 in ovarian cancer. Int J Biol Markers. 2006;21(3):215-23.

Buys SS, Partridge E, Black A, et al. Effect of screening on ovarian cancer mortality: the PLCO trial. JAMA. 2011;305(22):2295-303.

Charkhchi P, Cybulska P, Gronwald J, et al. CA125 and Ovarian Cancer: A Comprehensive Review. Diagnostics (Basel). 2020;10(7):487.

Schröder FH, Hugosson J, Roobol MJ, et al. Screening and prostate cancer mortality: results of the European Randomized Study of Screening for Prostate Cancer (ERSPC) at 13 years of follow-up. Lancet. 2014;384(9959):2027-35.

Mottet N, van den Bergh RCN, Briers E, et al. EAU-ESTRO-SIOG Guidelines on Prostate Cancer. Eur Urol. 2021;79(2):223-41.

Wan JCM, Massie C, Garcia-Corbacho J, et al. Liquid biopsies come of age: towards implementation of circulating tumour DNA. Nat Rev Cancer. 2017;17(4):223-38.

Yang Q, Li X. DNA methylation as an early diagnostic marker of cancer. Oncol Lett. 2014;7(5):1343-8.

Calin GA, Croce CM. MicroRNA signatures in human cancers. Nat Rev Cancer. 2006;6(11):857-66.

Théry C, Zitvogel L, Amigorena S. Exosomes: composition, biogenesis and function. Nat Rev Immunol. 2002;2(8):569-79.

Conrad DH, Goyette J, Thomas PS. Proteomics as a method for early detection of cancer: review and applications. J Gen Intern Med. 2008;23 Suppl 1:78-84.

Bardelli A, Pantel K. Liquid biopsies, what we do not know (yet). Cancer Cell. 2017;31(2):172-9.

Cohen JD, Li L, Wang Y, et al. Detection and localization of surgically resectable cancers with a multi-analyte blood test. Science. 2018;359(6378):926-30.

Liu MC, Oxnard GR, Klein EA, et al.; CCGA Consortium. Sensitive and specific multi-cancer detection and localization using methylation signatures in cell-free DNA. Ann Oncol. 2020;31(6):745-59