THE ROLE AND FUNCTIONS OF INFORMATION TECHNOLOGIES FOR HUMAN BENEFIT IN ONCOLOGY: ADVANCES IN EARLY DETECTION, PRECISION TREATMENT, AND PATIENT-CENTERED CARE

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Abstract. Malignant neoplasms remain among the leading causes of global morbidity and mortality, imposing formidable clinical and socioeconomic burdens on societies worldwide. In the modern era of medicine, information technologies (IT)—encompassing artificial intelligence (AI), computer vision, clinical decision support systems (CDSS), electronic health records, and tele-oncology—have emerged as indispensable instruments serving human welfare across the entire continuum of cancer care. This study provides an extensive empirical evaluation of the functional roles and measurable human benefits of IT in oncology, with particular focus on early tumor detection, automated radiotherapeutic planning, genomic profiling for precision pharmacotherapy, and remote patient monitoring (RPM). Analyzing data across 2,850 oncology patients, deep learning algorithms achieved 94.6% diagnostic sensitivity in identifying early-stage pulmonary and mammary malignancies, while automated contouring systems compressed radiation therapy contouring workflows from 2.5 hours to 14 minutes. Furthermore, mobile tele-oncology symptom monitoring reduced acute emergency department visits by 36.4% and enhanced patient quality of life (QoL) by 28.5%. Integrating human-centric digital technologies into oncology infrastructures democratizes specialized cancer care, mitigates human diagnostic error, and fosters equitable, personalized survival outcomes.

Keywords: oncology, information technologies, artificial intelligence, cancer detection, precision medicine, tele-oncology, radiation therapy planning, patient quality of life, clinical decision support systems.

1. INTRODUCTION AND BACKGROUND

Cancer represents one of the most formidable public health crises of the modern era. According to the World Health Organization (WHO) and the International Agency for Research on Cancer (IARC), approximately 20 million new cancer cases and 9.7 million cancer-related deaths occur annually across the globe. In the Republic of Uzbekistan, the prevalence of malignant neoplasms

continues to present substantial challenges to healthcare infrastructure, with breast, cervical, gastric, and lung cancers constituting the predominant clinical diagnoses. The fundamental determinant of oncological survival is stage-at-diagnosis; identifying malignancies at localized, pre-metastatic stages dramatically improves five-year overall survival rates from below 15% to above 90%.

Despite significant advances in surgical oncology, chemotherapy, and immunotherapy, conventional oncological workflows face systemic limitations. Diagnostic radiological screening (mammography, computed tomography, MRI) and histopathological slide reviews generate colossal visual datasets that must be interpreted by a severely overburdened workforce of specialized oncologists and pathologists. Diagnostic fatigue, inter-observer subjectivity, and regional shortages of oncology experts—particularly in rural and district-level healthcare outposts—frequently lead to delayed diagnoses and staging discrepancies. Furthermore, cancer therapies entail severe toxicities, requiring continuous, personalized post-treatment monitoring that traditional episodic clinic visits cannot adequately deliver.

In this context, the rapid evolution of information technologies (IT) has transitioned computational systems from administrative record-keeping tools into active, cognitive clinical partners designed fundamentally for human benefit. Information technologies in oncology encompass advanced machine learning algorithms, deep convolutional networks for medical image analysis, natural language processing (NLP) for electronic health records, automated radiation dosimetry, cloud-based multidisciplinary tumor boards, and mobile tele-oncology platforms. By democratizing access to expert-level diagnostic knowledge, accelerating therapeutic design, and providing continuous home monitoring for cancer patients, IT serves as the primary engine for human-centered, precision oncology.

2. AIM OF THE STUDY

The objective of this research is to systematically evaluate the functional roles, clinical efficacy, and quantifiable human benefits of modern information technologies across the oncological care continuum (early screening, precision diagnosis, automated therapeutic planning, and remote patient monitoring), and to formulate practical recommendations for integrating digital oncology solutions into regional healthcare networks.

3. MATERIALS AND METHODS

This empirical investigation utilized multi-center benchmark clinical datasets alongside retrospective records from the Samarkand Regional Branch of the Republican Specialized Scientific and Practical Medical Center of Oncology and Radiology and Samarkand State Medical University clinics collected across the 2022–2024 period. The total evaluated cohort comprised 2,850 verified cancer patient records across breast, lung, colorectal, and prostate cancer cohorts.

The study evaluated four functional dimensions of information technology deployment:

1. Computer-Aided Diagnostic (CAD) Systems: Testing deep convolutional neural networks (ResNet-101 and YOLOv8 architectures) on 4,200 digital mammograms and chest CT scans to evaluate automated lesion detection, segmentation, and malignant nodule classification;

2. Automated Radiotherapy Planning Systems (TPS): Quantifying time expenditure and organ-at-risk (OAR) sparing efficacy using AI-driven volumetric auto-segmentation in 350 patients undergoing intensity-modulated radiation therapy (IMRT);

3. Clinical Decision Support Systems (CDSS): Assessing therapeutic concordance between multidisciplinary molecular tumor boards and algorithmic precision oncology recommendation engines (IBM Watson for Oncology / Navify platforms) across 500 complex metastatic cases;

4. Mobile Tele-Oncology and Remote Patient Monitoring (RPM): A prospective observational arm tracking 240 outpatient chemotherapy patients utilizing a specialized mobile symptom-reporting application compared against 240 control patients receiving standard episodic outpatient check-ups.

Outcome metrics included diagnostic Sensitivity, Specificity, Area Under the ROC Curve (AUC-ROC), planning workflow time (minutes), rate of avoidable emergency department visits, and patient Quality of Life (QoL) assessed via the standardized EORTC QLQ-C30 questionnaire. Statistical analysis was performed using SPSS Statistics v26.0 ($p < 0.01$).

4. RESULTS AND EMPIRICAL FINDINGS

The integration of information technologies demonstrated profound clinical and human-centered benefits across all evaluated oncological domains. In early screening, computer-assisted image analysis achieved an overall diagnostic sensitivity of 94.6% and specificity of 91.8% in detecting occult malignant nodules on low-dose chest CT and digital mammograms, successfully identifying microcalcification clusters and ground-glass opacities that were initially overlooked in 11.2% of routine human double-readings.

In radiation oncology, automated deep-learning segmentation drastically compressed the time required to delineate tumor volumes and critical organs at risk (OARs, such as heart, spinal cord, and lungs). Mean planning contouring time plummeted from 148 ± 16 minutes under manual delineation to 14.2 ± 2.1 minutes with AI assistance (a 10.4-fold time savings), while maintaining a high Dice Similarity Coefficient of 0.88–0.93 across anatomical boundaries.

Table 1. Clinical efficacy and operational impact of IT solutions across oncology care domains

Functional Oncology Domain	Conventional Workflow	IT / AI-Enabled Workflow	Quantitative Improvement	Direct Human Benefit
Early Radiological Screening	Manual review (Sens: 84.2%)	AI-assisted CAD (Sens: 94.6%)	+10.4% sensitivity gain	11.2% reduction in missed cancers
Digital Histopathology (WSI)	Manual light microscopy	Deep CNN slide segmentation	4.2x faster slide review	Accurate micro-metastasis detection
Radiation Target Contouring	148 ± 16 min / patient	14.2 ± 2.1 min / patient	10.4-fold workflow acceleration	Shorter treatment initiation delay
Therapy Selection (CDSS)	Empirical guideline lookup	Genomic molecular matching	92.4% treatment concordance	Personalized targeted therapy

Table 2 presents the humanistic outcomes of mobile tele-oncology monitoring among chemotherapy outpatients. Real-time digital toxicity tracking enabled proactive clinical interventions, yielding significant reductions in severe grade 3/4 adverse events and emergency hospitalizations.

Table 2. Patient-centered outcomes of digital remote monitoring during active cancer therapy

Clinical & Humanistic Indicator	Standard Care Cohort (n=240)	Tele-Oncology Cohort (n=240)	Outcome Variance	Significance (p)
Unplanned ER Admissions (per 100 pts)	38.2 ± 3.4	24.3 ± 2.1	-36.4% emergency visits	$p < 0.001$
Severe Chemotherapy Toxicity (Grade 3/4)	31.5%	18.6%	-40.9% severe toxic episodes	$p < 0.001$
Overall Quality of Life (QLQ-C30 score)	58.4 ± 4.6	75.1 ± 3.8	+28.5% quality of life gain	$p < 0.001$
Patient-Reported Treatment Confidence	64.2%	91.8%	+43.0% satisfaction elevation	$p < 0.001$

5. DISCUSSION AND HUMAN-CENTERED IMPLICATIONS

The findings of this investigation demonstrate that information technologies in oncology are fundamentally tools of human empowerment and patient advocacy. In low- and middle-income healthcare systems, specialized oncology resources are intensely centralized in capital and major urban institutes. Deploying digital tele-oncology platforms and cloud-based tumor boards bridges this geographic disparity, enabling rural patients in remote districts of Samarkand region to receive expert consensus treatment plans without enduring burdensome travel and associated lodging costs.

Moreover, the integration of real-time digital symptom monitoring addresses one of the most perilous aspects of outpatient chemotherapy: unmonitored neutropenic fever, severe dehydration, and chemotherapy-induced nausea. Enabling patients to report symptoms via simplified mobile interfaces allows oncology triage teams to intercept toxicities early through supportive medication adjustments, directly preventing life-threatening septic shock and ICU admissions. Crucially, digital tools relieve oncologists from routine clerical data entry, permitting clinicians to dedicate higher cognitive and emotional presence to empathetic patient counseling. AI should never replace human empathy, but rather safeguard the humanistic core of oncology.

6. CONCLUSIONS

1. Information technologies and deep learning algorithms significantly enhance early cancer detection, improving diagnostic sensitivity by 10.4% and eliminating over 11% of false-negative radiological screening errors.

2. AI-driven radiotherapy contouring systems accelerate treatment planning workflows by over 10-fold, shortening critical delays between diagnosis and therapy initiation while protecting healthy tissue.

3. Mobile tele-oncology monitoring reduces acute emergency hospitalizations by 36.4% and elevates overall patient quality of life by 28.5%, establishing an effective digital safety net for chemotherapy outpatients.

4. National healthcare programs should prioritize the digital interconnection of regional oncological dispensaries with central institutes to ensure equitable, timely, and high-technology cancer care for all citizens.

7. REFERENCES

1. World Health Organization. Global Cancer Observatory (GLOBOCAN): Cancer incident and mortality statistics. Geneva: WHO, 2024.

2. Topol E.J. High-performance medicine: the convergence of human and artificial intelligence // Nature Medicine. – 2019. – Vol. 25, No. 1. – P. 44–56.

3. McKinney S.M., Sieniek M., Godbole V., et al. International evaluation of an AI system for breast cancer screening // Nature. – 2020. – Vol. 577, No. 7788. – P. 89–94.

4. Toxirova F.O., Rizaev J.A. Modern digital technologies and innovative management in oncology // Bulletin of Samarkand State Medical University. – 2023. – No. 3. – P. 60–66.

5. Buronov S.M., Hazratqulov I.O., Xudoyqulov Sh.N., Teshayev N.Q. The role of artificial intelligence in radiation oncology and patient monitoring // Scientific Youth Forum of SamSMU. – 2024. – P. 102–106.

6. Basch E., Deal A.M., Dueck A.C., et al. Overall survival results of a randomized trial assessing patient-reported outcomes for symptom monitoring during routine cancer treatment // JAMA. – 2017. – Vol. 318, No. 2. – P. 197–198.

7. Cahan A., Cimino J.J. A learning health care system using computer-aided clinical decision support // New England Journal of Medicine. – 2017. – Vol. 376, No. 13. – P. 1294–1296.

8. Lustberg M.B., Klemmling J. Telemedicine and digital health solutions in modern cancer care // The Lancet Oncology. – 2021. – Vol. 22, No. 8. – P. 1056–1058.

9. World Health Organization. Global strategy on digital health 2020–2025. Geneva: WHO, 2021.

10. Esteva A., Kuprel B., Novoa R.A., et al. Dermatologist-level classification of skin cancer with deep neural networks // Nature. – 2017. – Vol. 542, No. 7639. – P. 115–118.

11. Rizaev J.A., Toxirova F.O. Development of digital medicine and information technologies in healthcare of Uzbekistan // Medical Journal of Uzbekistan. – 2023. – No. 4. – P. 14–19.