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Point-of-Care Testing (POCT) for Cancer and Chronic Disease Management in the Workplace: Opportunities and Challenges in the Era of Digital Health Passports

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Review

Point-of-Care Testing (POCT) for Cancer and Chronic Disease Management in the Workplace: Opportunities and Challenges in the Era of Digital Health Passports

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Abstract: The rising global burden of chronic diseases and cancer among the workplace has intensified the need for accessible, rapid diagnostic strategies within workplace settings. Point-of-care testing (POCT) offers a decentralized solution, providing timely diagnostic insights without the need for centralized laboratory facilities. In the workplace, POCT offer significant advantages for early detection and management of cancer and chronic diseases, improving employee health outcomes and reducing absenteeism. Concurrently, the development of digital health passports has created secure, dynamic platforms for managing and sharing personal health data. This review explores the technological innovations underpinning POCT, examines its application in workplace health screening and analyzes how integration with Internet of Things (IoT) and digital health passports can enhance early detection and chronic disease management. The discussion extends to the ethical, regulatory and practical challenges associated with implementation. Furthermore, emerging trends such as artificial intelligence-driven diagnostics, blockchain-enabled data security and wearable biosensors are considered as potential future directions. Together, POCT and digital health passports represent a significant evolution towards proactive, personalized workplace healthcare systems.

Keywords: Internet of Things (IoT); Point-of-Care Testing (POCT); chronic disease; cancer screening; workplace health; digital health passports; blockchain technology; data privacy; occupational medicine; mobile diagnostics

1. Introduction

Chronic diseases and cancer continue to exert significant pressure on global health systems, contributing to over 70% of all deaths worldwide according to the World Health Organization (WHO) [1]. The economic and societal costs associated with these conditions extend far beyond healthcare expenses, impacting workforce productivity, absenteeism and organizational resilience. Traditional diagnostic models, heavily reliant on centralized laboratories, often present barriers such as delays in diagnosis, limited accessibility and low participation rates, particularly among working populations who may struggle to prioritize medical appointments amid professional commitments. Since the workplace is the second most significant setting where individuals spend the most time after home, the development of diagnostic tests suitable for workplace-based screening of cancer and chronic diseases is an immediate requirement. Occupational health issues are denominated as 'employers liabilities' in the context of regulatory compliance. Industries are compelled to keep track of employees' health status and lifestyle. In the counterpart of employees though, no framework is available for them to monitor their health status directly without being susceptible to the employers' prejudgement and discrimination. In conjunction with cancer and chronic disease preliminary tests, focusing on the workplace and its intrusiveness and privacy issues, a tracking system neologism 'E-employment' should be introduced to provide on- and post- workplace application, along with the system overview and mechanism in tackling the concerns [2,3].

Point-of-care testing (POCT) has emerged as a transformative approach to decentralized diagnostics, providing rapid and reliable results at or near the site of care [4–7]. By minimizing logistical burdens and enabling immediate clinical decision-making, POCT offers a pragmatic solution for enhancing early detection efforts within occupational health initiatives.

Awareness of health and preventive healthcare management has become a global trend since the outbreak of the COVID-19 pandemic in 2020. Since then, several routine health tests, such as COVID-19 rapid antigen tests, have been performed at an individual level and healthy habits are being promoted by countries across the globe. Health screenings for chronic diseases such as diabetes, cardiovascular disease and cancer are becoming increasingly widespread in workplaces and communities as a part of corporate social responsibility. A variety of point-of-care (POC) and rapid testing technologies have been developed for such tests that have traditionally been performed in hospitals and clinical laboratories [8]. Conventional methodology involves sample collection and transportation to a testing center, a multi-step process to obtain analyzed results that could take anywhere from a few hours to a few weeks. Furthermore, the interpretation of test results is highly reliant on epidemiologists and laboratory technicians, irrespective of the testing platform and well-trained professionals are needed for sample preparation and result analysis. To avoid misinterpretation of the results, secondary confirmation by a reference platform with a different methodology is often required. The emergence of alternative testing approaches, the advancements in testing technologies and the interests of various stakeholders have contributed to the development of rapid tests with higher accessibility and reliability [9]. COVID-19 rapid tests are a prime example of how testing technologies can be developed and deployed in a very short time by several stakeholders and such innovations should be focused on other health and wellness-related issues as well [10–12].

In addition, the COVID-19 pandemic catalyzed the development and widespread adoption of digital health passports—secure, mobile platforms for managing personal health information [13–16]. While initially deployed to document vaccination status and SARS-CoV-2 test results, these technologies possess broader applicability. Digital health passports can serve as comprehensive health records, integrating diagnostic data from POCT and other sources to support longitudinal health monitoring and targeted interventions.

The convergence of POCT and digital health passports within workplace settings represents a promising model for fostering healthier, more resilient workforces. This review examines current technological capabilities, implementation strategies, ethical and regulatory considerations and future perspectives, including artificial intelligence (AI) applications, blockchain integration and wearable continuous monitoring.

2. Technological Advances in Point-of-Care Testing (POCT)

2.1. Principles of POCT

Point-of-care testing encompasses diagnostic modalities conducted at or near the patient, aiming to deliver immediate clinical information that can inform medical decision-making. Traditionally associated with simple assays such as blood glucose measurements, the field has expanded dramatically due to advances in microfluidics, biosensors and miniaturized molecular diagnostics [17,18]. Modern POCT platforms often combine high analytical performance with user-friendly interfaces, permitting their deployment by minimally trained personnel outside traditional laboratory environments.

Critical characteristics of effective POCT devices include rapid turnaround time, portability, minimal sample volume requirements and connectivity features enabling data transmission to electronic health records or personal health applications [19–22]. These attributes align POCT technologies closely with the needs of occupational health programs, where efficiency and accessibility are paramount.

Cancer and chronic diseases contribute significantly to healthcare expenditure, particularly in workplace settings. A major driver of this burden is the delay between early detection and intervention, commonly resulting from the reliance on screening with laboratory tests. Over the years, various cancer and chronic disease markers have been identified, each with distinct testing technologies, including imaging tests (e.g., mammogram), biopsy tests (e.g., cervical biopsy) and biological tests (e.g., PSA blood-based test). A recent, extensive review on this subject is provided by Golfinopoulou and Kintzios [8]. Laboratory pre-analytical, analytical and post-analytical errors and the transportation of biological samples to laboratories have led to significant delays between sampling and receiving test results [23]. These delays are detrimental because they compromise the effectiveness of early detection, aggravate the disease and increase morbidity and extensive healthcare expenditure [24].

POC and rapid testing technologies are emerging that can be deployed in workplace settings (e.g., factories, offices) to screen employees and workers for cancer and chronic diseases uniformly, inexpensively and constantly. For workplace settings, tests should ideally be low-cost, fast (single-use disposables preferred), have high specificity (>99%) and sensitivity (>90%) and provide results in <30 min (preferably 1–10 min). Diagnostic tests should saturate the entire sample size of the worker population pool to ensure that diseases are not missed. Current tests focusing on specific diseases usually overlook co-morbidity or screening for a new unrelated disease, increasing vulnerability [25]. New "pan-catchers" or multiplexed tests are being designed in this regard, screening different diseases in parallel using POC or rapid tests [26]. According to the World Health Organization report on workplace settings, POC testing is a priority area for making care available for all in post-COVID settings [27].

A representative sample of the most common POCT technologies used for cancer and/or chronic disease screening is graphically presented in Figure 1.

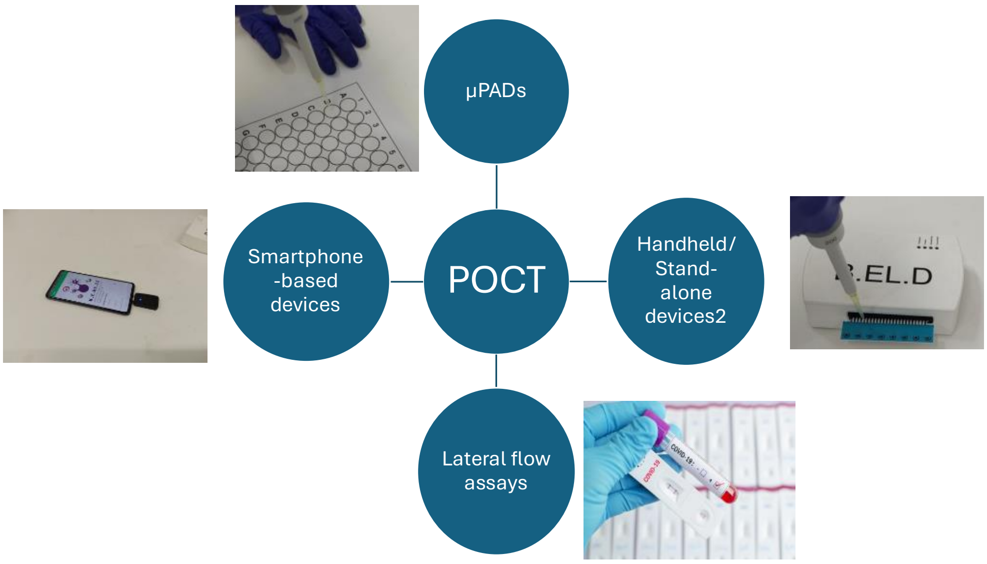

Figure 1. Graphical presentation of representative types of Point-of-Care systems used in the workplace.

2.2. POCT for Cancer Detection

Cancer remains a leading cause of premature mortality and workplace health programs represent an untapped opportunity for systematic early detection initiatives. Several POCT-based screening tools have demonstrated utility in this context.

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Prostate-specific antigen (PSA) tests, adapted into lateral flow or immunochromatographic formats, allow rapid, semi-quantitative assessment of prostate cancer risk within approximately 15 minutes [28,29]. Similarly, fecal immunochemical tests (FITs) for colorectal cancer screening can be conducted conveniently onsite, offering non-invasive detection of occult blood in stool samples with high specificity [30].

In female employees, high-risk human papillomavirus (HPV) infections—a precursor to cervical cancer—can be identified using molecular POCT platforms such as GeneXpert HPV, which provide results within an hour. Emerging technologies targeting circulating tumor DNA (ctDNA) through minimally invasive liquid biopsies, while still largely investigational, promise future expansion of workplace-based cancer screening modalities [31].

Despite these advances, it is crucial to recognize that POCT-based cancer screening must adhere to rigorous clinical validation protocols to ensure sensitivity, specificity and appropriate post-test counseling pathways.

2.3. POCT for Chronic Disease Monitoring

Beyond cancer, POCT have demonstrated substantial utility in chronic disease management—an area of particular relevance to workforce health [8].

For diabetes mellitus, portable HbA1c analyzers such as the Siemens DCA Vantage provide laboratory-comparable results from capillary blood samples in minutes, facilitating both diagnosis and glycemic control monitoring [32]. Cardiovascular risk assessments can be enhanced through onsite lipid profile testing using devices like the CardioChek PA system, offering total cholesterol, HDL, LDL and triglyceride measurements within a rapid timeframe [33].

Early identification of renal dysfunction, a common comorbidity among hypertensive and diabetic populations, is enabled by handheld creatinine analyzers such as the Abbott i-STAT system [34]. The integration of these tests into regular workplace screening programs can drive earlier diagnosis, improved disease management and reduced downstream healthcare costs.

Table 1 summarizes the currently used POCT for chronic disease screening.

Table 1. Currently used POCT systems for chronic disease.

Disease	Biomarker assayed	POCT system	Speed of assay (min)
Diabetes melitus	HbA1c	DCA vantage analyzer	6
Cardiovascular	Lipid panel	CardiCheck PA	2
Kidney	Creatinine	Abbott i-STAT Analyzed	10

3. Integration of POCT into Workplace Health Screening

The workplace presents a unique and underutilized environment for implementing systematic health screening programs. Adult employees represent a relatively stable, accessible population cohort and workplace-based initiatives can leverage convenience and familiarity to overcome barriers traditionally associated with preventive healthcare engagement.

Onsite deployment of POCT devices enables rapid, minimally disruptive health assessments. Employees can complete screenings during working hours without the need to schedule separate medical appointments, significantly increasing participation rates compared to conventional offsite health campaigns [35,36]. Furthermore, the immediacy of POCT results facilitates timely follow-up actions, reducing diagnostic delays that often exacerbate disease progression.

Corporate wellness programs integrating POCT have demonstrated tangible benefits. For instance, Amazon Care's mobile health services offered rapid diagnostic testing and vaccinations to employees onsite, minimizing absenteeism and promoting engagement [37].

A simplified flowchart for applying POC tests at the workplace is presented in Figure 2.

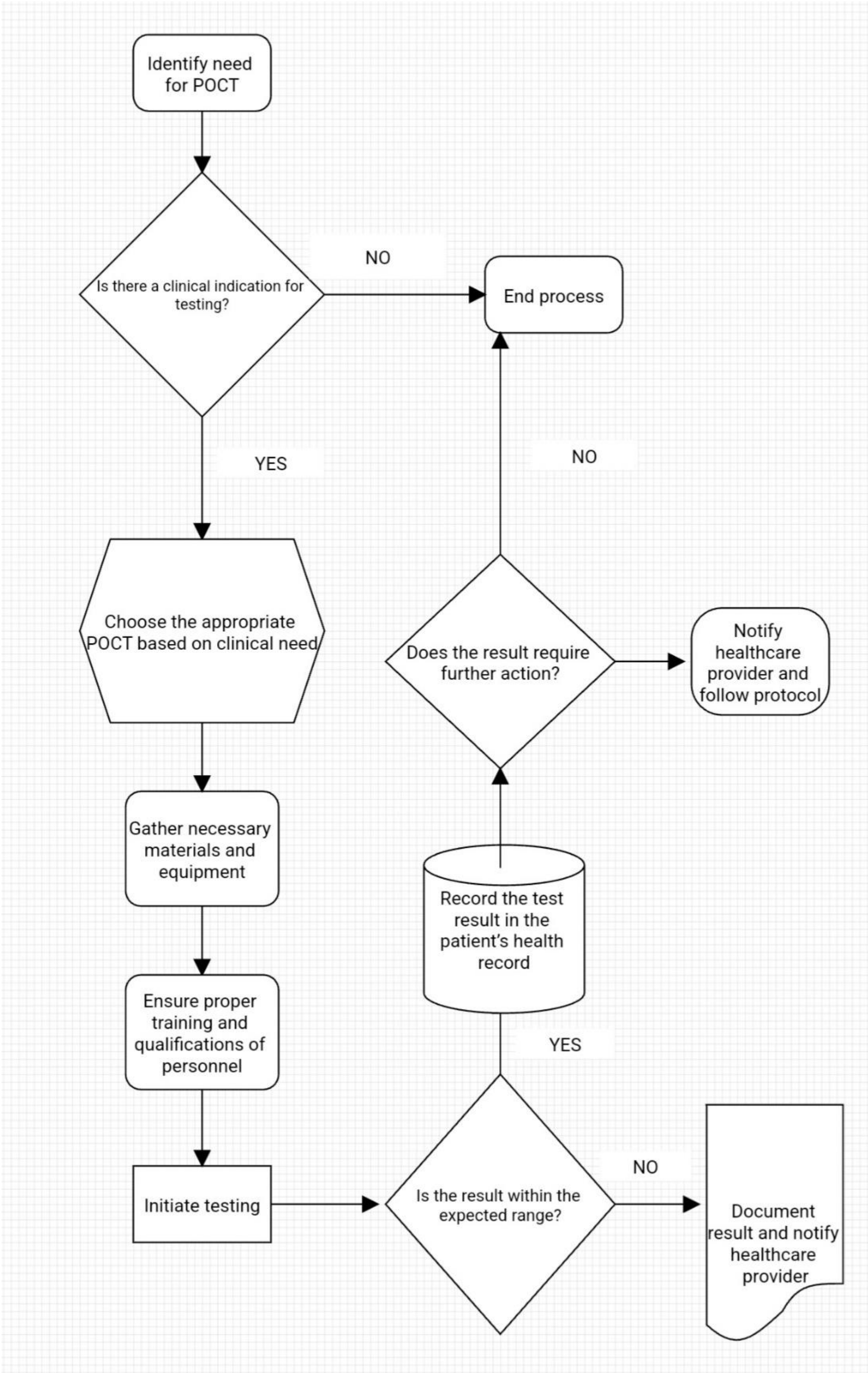

Figure 2. Flowchart for the application process of Point-of-Care tests at the workplace.

4. Internet of Things (IoT) in Healthcare

4.1. Overview of IoT and Its Applications in Healthcare

The Internet of Things (IoT) is a group of interrelated, internet-connected elements that are collecting, recording, exchanging and acting on data in real-time. IoT technology supports end-users in visualizing, determining trends, managing and acting on data through real-time reporting or proactive alerts on smart devices. An initial implementation of the IoT in healthcare can begin with a single department in a nursing home or hospital, health clinics or personal health monitoring and expand into systems to monitor many devices worn by patients. In the health sector, the equipment used for the IoT is commonplace, such as sensors attached to patients, wearable devices, computing hardware and smart devices [38]. Health IoT also provides a platform for various services such as smart medical devices, stress management, nurse call systems and reminders for medication. The integration of the IoT into healthcare will have significant effects on diagnoses, treatments and care.

The application of the IoT platform can use machine learning and data analysis techniques. The IoT health platform can identify and filter huge data sets collected through medical sensing devices and smart devices into events that require monitoring or actuation. Short messages and alerts can be delivered in real-time to organizations and health professionals managing patient care or health-related tasks [39]. During the processing of health data, the IoT technology can predict patient outcomes based on various models derived from historical health data. IoT can significantly promote the quality, accessibility and affordability of health care. It serves as a platform for collecting data using connected sensors and devices to leverage services based on their ability to deliver decision-making access to crucial real-time information [40–43]. The health care sector can effectively use IoT for medical monitoring, smart wearable devices, health care sensors and medication adherence to improve outcomes and reduce costs [44–46].

IoT enables remote monitoring of individuals and chronic disease patients using health sensors, leading to early detection and unanticipated chronic disease prevention. It also facilitates the development of wearable smart devices to generate comprehensive data from various biological and nonbiological sensors, allowing for better decision-making regarding one health, safety and personalized treatment [47]. Connected smart utensils and pillboxes integrated with IoT can unobtrusively track eating habits and medication adherence. Additionally, telemedicine and mobile health create remote interconnectedness and low-cost wearables for continuous monitoring of patients during and after hospital discharge [48,49].

4.2. Integration of IoT with Point-of-Care Testing in the Workplace

In the era of the Internet of Things, every device is likely interconnected. The convergence of IoT with advances in point-of-care testing technology presents an excellent opportunity to develop innovative IoT-connected devices for rapid testing of cancer and chronic diseases in the workplace. There are several benefits to implementing IoT for POCT, especially in the workplace settings. Workplace POCT can facilitate early disease detection and timely treatment and healthcare planning for employees, even when the diseases are early stage non-symptomatic. Such late detection can otherwise result in huge treatment costs and loss of productivity to the workplace [50,51]. With the integration of rapid imaging-based setup, data processing and IoT, emotional health monitoring using facial expression can also be facilitated in the workplace. By tracking and recording the reaction of employees in the workplace, emotional and sanity shifts can be monitored. Predictive analysis based on data analytics can further alert the management for necessary adjustments to avoid workplace that cause emotional discomfort such as an increase in workload. All outcomes of workplace POCT will significantly enhance employees' health, well-being and productivity. For employers, this will be an investment with long-term returns with the benefits of healthier and productive employees [53–55].

There are technological considerations for integrating IoT with POCT in the workplace. The design of an IoT-connected POCT setup may require rapid imaging-based detection platforms, connectivity instrumentations for the cloud server and cloud computing-based data analytics and decision support systems. The data transfer from devices to a cloud server may involve Bluetooth and Wi-Fi and setting up a dashboarding user interface for data interpretation. The cloud computing infrastructure may require Installation of cloud computing software and data storage management and connectivity with the company server for notification. For either rapid test-based devices hygienically disposed of used cards and consumables may be required [56–58]. The devices and the cloud computing infrastructure should also comply with ISO 13485 and the EU's In Vitro Diagnostic Medical Device Directive (98/79/EC) regulations for point-of-care diagnostics setup. Suitable technologies for the workplace may include using devices such as disposable test kits or card-based setups, sample-to-answer devices with an inbuilt microfluidic cartridge-based lateral flow direction and IoT-connected portable electrochemistry-based bio-sensing [59,60].

Factors such as disruptive sensing did not exist during periods of better well-being. There are smart watches providing general well-being information as heart and blood pressure and 10,000 steps. However, such measurements do not put individuals in context of the environment or their co-workers. There is a need for a paradigm shift regarding health and well-being. Instead of a single individual creating awareness of their health and well-being, a platform is needed to foster collaboration between the worker, the workplace and various scientific and technological domains [61,62].

A comprehensive integration of IoT with Point-of-Care Testing requires consideration of four technology-enabling steps across the PoCT value chain. An emerging class of PoCT devices close to the user that meet at least qualitative performance essentials in terms of clinical performance and are mass-manufactured smart devices connecting to the internet will be suitable candidates for the PoCT-IoT fusion [63]. In applying IoT technologies, requirements of these devices must be fully understood in terms of connectivity, health information transmission protocols, transmission robustness and cyber security concerns. Steps to address these issues need extensive collaboration between biomedical engineers, connectivity engineers and users. Cyber security issues in health care require dedicated inputs from specialists in information security.

5. Digital Health Passports: Enablers of Workplace POCT

The integration of digital health passports with workplace POCT represents a powerful evolution in health management strategies. Originally developed in response to the COVID-19 pandemic, digital health passports provide secure, verifiable platforms for individuals to manage and share personal health information, including diagnostic test results, vaccination records and screening outcomes [13–16].

At their core, digital health passports are mobile applications or web-based interfaces linked to encrypted databases, often incorporating blockchain technology to ensure data integrity and tamper resistance [64]. These platforms empower individuals by granting them ownership and control over their health data, while facilitating selective disclosure of information to employers, healthcare providers or public health authorities as needed.

In the context of workplace health programs, the integration of POCT could result into digital health passports allowing real-time, decentralized health monitoring. After a POCT is performed onsite, results can be securely uploaded to an individual's digital health record, immediately accessible via smartphone or other devices. Employees retain the right to manage data sharing permissions, thereby preserving autonomy and confidentiality.

Furthermore, real-time data aggregation at the population level—conducted in a de-identified and compliant manner—can enable organizations to monitor workforce health trends, anticipate healthcare resource needs and design targeted wellness initiatives. Such integration transforms episodic health screening into a dynamic, continuous process aligned with the broader shift toward personalized and predictive healthcare models [65–67].

Technological enablers critical to this integration include blockchain for secure and decentralized data management, artificial intelligence (AI) for predictive analytics and mobile health (mHealth) platforms for user engagement and remote access [68,69].

Advantages and challenges related to POC testing and Digital Health platforms in the workplace are summarized in the following Table 2.

Table 2. Advantages and Challenges in adopting POC and Digital Health platforms in the workplace.

	Employees	Employers
Advantages	Privacy and ownership of personal health data.	Streamlined occupational health recordkeeping.

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	Convenience of carrying verified health records.	Risk mitigation against outbreaks or health emergencies.
	Empowerment through health status awareness and real-time updates.	Reduced absenteeism through proactive health monitoring.
	Onsite testing removes logistical barriers like travel time and scheduling conflicts, particularly beneficial for underserved employee populations	Early disease detection and management reduce healthcare utilization and insurance claims over time
		Aggregate, anonymized POCT data can inform company-wide wellness initiatives, enhancing strategic planning for human resources and occupational health departments.
Challenges	Employees may fear misuse of their health data, discrimination or breaches of confidentiality	Ensuring consistent, reliable POCT results across decentralized settings remains a major challenge
		Navigating legal requirements like HIPAA (USA), GDPR (EU) and local labor laws is complex but critical
		Not all workplaces may have the necessary infrastructure (e.g., internet connectivity, device compatibility) to deploy POCT and digital health passport solutions effectively

6. Regulatory, Ethical and Privacy Considerations

The deployment of POCT and digital health passports within workplace environments raises significant regulatory, ethical and privacy concerns that must be addressed to ensure legal compliance and maintain employee trust.

From a regulatory perspective, compliance with data protection frameworks such as the Health Insurance Portability and Accountability Act (HIPAA) in the United States and the General Data Protection Regulation (GDPR) in the European Union is paramount [70]. These regulations impose stringent requirements on the collection, processing, storage and sharing of personal health information, mandating explicit informed consent and data minimization principles.

Regulatory frameworks related – among others - to digital health monitoring are briefly presented in the following Table 3.

Table 3. Regulatory frameworks related to digital health monitoring acroos different countries and regions.

Framework	**Description**
Health Insurance Portability and Accountability Act (HIPAA)	In the United States, HIPAA establishes standards for the protection of sensitive health information. Employers offering workplace health services must ensure that POCT results and digital passport data are securely managed and not disclosed without employee consent
General Data Protection Regulation (GDPR)	In Europe, the GDPR classifies health data as „special category" personal data, requiring explicit consent for its processing and strict compliance with data minimization and purpose limitation principles
Occupational Safety and Health Administration (OSHA)	Employers must balance the benefits of health surveillance with OSHA regulations, ensuring that health screening programs are voluntary unless mandated by specific workplace hazards
Food and Drug Administration (FDA) Oversight	In the U.S., POCT devices must often be approved under the Clinical Laboratory Improvement Amendments (CLIA) as „waived" devices for simplicity and low risk or meet Emergency Use Authorization (EUA) standards during public health emergencies
International Standards	Global frameworks such as the ISO 15189 (quality and competence for medical laboratories) and WHO guidelines on decentralized diagnostics provide guidance on POCT quality management

In occupational settings, additional considerations arise from labor laws and anti-discrimination statutes, which prohibit adverse employment decisions based on health status. Thus, employers must establish clear boundaries regarding the use of health data, ensuring that screening programs are voluntary, non-coercive and administered equitably across the workforce [71].

Ethical principles of autonomy, beneficence, non-maleficence and justice must guide all aspects of program design and implementation. Employees should be fully informed about the purpose, risks and benefits of POCT-based screening initiatives and must retain the right to refuse participation without fear of reprisal.

Data privacy and cybersecurity represent critical operational domains. Organizations must implement robust technical safeguards, including end-to-end encryption, secure authentication protocols and regular vulnerability assessments, to protect sensitive health information from unauthorized access or breaches [65,72]. Anonymization and aggregation techniques should be employed whenever feasible to protect individual identities in workforce health analytics.

Transparent governance structures, third-party audits and clear communication strategies can further enhance accountability and foster a culture of trust essential for the long-term success of workplace health programs utilizing POCT and digital health passports.

The arrival of POCT and rapid testing for cancer and other chronic diseases in the workplace is likely to evoke strong and polarized opinions and views. Broadly, these may comprise moral, ethical and social concerns [74] and considerations both for and against their application in a workplace context throughout the system identification and requirements elicitation activities. Such views could likewise extend to opinions or concerns about testing and screening for more common and in the main treatable, diseases such as high blood pressure (hypertension), high cholesterol (hyperlipidaemia), diabetes and obesity (collectively known as 'lifestyle' diseases). An examination of the relevant ethical questions, issues and implications surrounding a potential workplace-based system should be undertaken [75]. Proposed workplace-testing regimes and initiatives must have due regard to a number of general ethical principles. The nature and manner of testing within the workplace must be acceptable both to individuals (employees) tested and to employers and other stakeholders (insurers etc.) affected. Testing should only be introduced if a clear and important benefit can be demonstrated. Suggested social, community or group benefits of relative unquantifiable worth should be disregarded. Testing results must be treated in a way that individuals' preferences in privacy and confidentiality are respected. Testing procedures should reflect fairness and impartiality. No individual, group or community in the workplace should be subjected to testing or any form of risk unless the number of persons or population (group or community) concerned is proportional to (optimally less than) the benefit for the workplace population as a whole [76–78].

7. Challenges and Barriers to Implementation

While the integration of POCT and digital health passports into workplace settings offers substantial promise, several challenges must be carefully considered and addressed.

Privacy concerns remain paramount. Despite technological safeguards, employees may harbor fears regarding the potential misuse of their personal health information, whether for employment decisions, insurance discrimination or surveillance purposes. Building trust through transparent policies, voluntary participation and third-party oversight is critical to mitigating these fears [72].

Technological barriers can also impede implementation. Reliable internet connectivity, secure device infrastructure and interoperability between POCT devices and digital health platforms are prerequisites for successful deployment. Organizations operating across multiple sites, including remote or resource-limited environments may face particular challenges in ensuring consistent access and data integration.

Furthermore, the quality and reliability of POCT results must be rigorously managed. Variability in device performance, user error and environmental factors can compromise diagnostic accuracy.

Establishing standardized protocols, training personnel and participating in external quality assessment programs are necessary measures to uphold clinical validity [62].

Regulatory uncertainty poses another barrier. Rapid technological innovation often outpaces legislative frameworks, creating ambiguity regarding the legal status of emerging digital health applications. Proactive engagement with regulators, legal counsel and ethics committees can help navigate this evolving landscape.

Finally, the financial costs associated with purchasing POCT devices, implementing digital health platforms and maintaining cybersecurity infrastructure must be weighed against anticipated benefits. Although preventive health strategies typically offer favorable long-term return on investment, initial resource allocation remains a critical consideration.

Advances in the IoT have expedited healthcare delivery to patients. Slow steady IoT equipment operation is outdated. The telehealth service delivery model was put to the test during the pandemic. In a representative example, 12.6 million individuals were enrolled in employment injury compensation plans by the Employees' State Insurance Corporation, Government of India, exclusive to the organized sector. 52,103 employees were regularly monitoring blood glucose, cholesterol and hypertension at a workplace. It has been determined that the disease burden of non-communicable diseases is exceedingly high among employees. For every three employees screened, one was found to have hypertension and 0.39 had abnormal body mass index (BMI), glucose or high low-density lipoprotein (LDL) cholesterol. A workplace screening strategy was proposed that combines point-of-care testing with telehealth and a deep learning architecture. This proposal anticipates covering 90% of Tamil Nadu's organized workforce by IoT-enabled screening while reducing service delivery costs by 38% [79,80].

The COVID-19 pandemic has compelled academic institutions and industries to come out with portable rapid POC devices for the immediate detection of COVID-19. The current work highlights the development of innovative advancements in chronic disease point-of-care screening and testing devices that can be addressed toward industry-academic collaborations. A paradigm shift in this direction is presented by the recent work by Apostolakis et al. [81], who developed a smartphone app capable of analyzing data regarding anti-S1 antibodies at very low concentrations coupled with an innovative bioelectric biosensor [82]. Patient-specific historical and current data are combined with the results from the customized embedded device and encoded by the app in a widely accepted QR code. Subsequently, the QR code can be used as a digital health passport including useful information constantly updated to match a person's status (Figure 3).

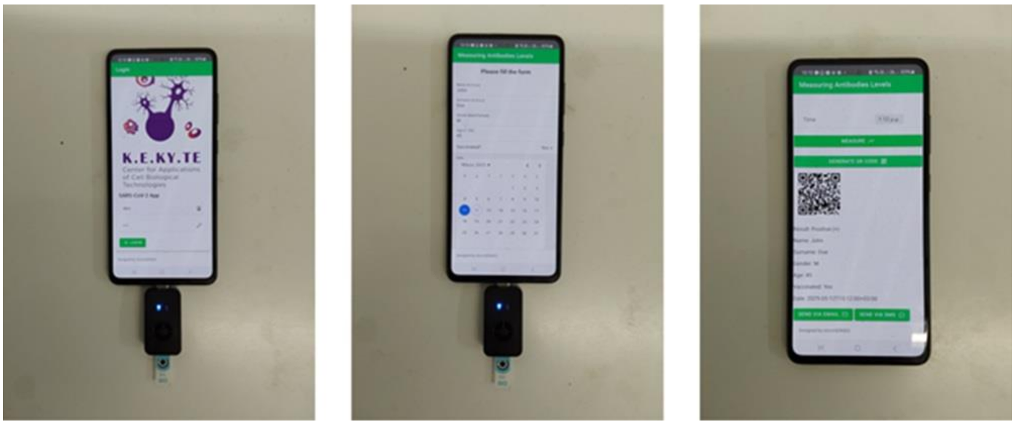

Figure 3. Representation of the user interface of the bespoke app developed by Apostolakis et al. [81]. Prior to the measurement of a saliva sample with the aid of a portable bioelectric biosensor [82] (attached to the smartphone via a USB port) (*left*), the user inputs personal and historical data (e.g. age, gender, status of vaccination against SARS-CoV-2, e.t.c.) (*middle*). After the completion of the three-minute assay, a QR code is generated containing the test results (*right*).

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8. Future Directions and Innovations

Even with the rapidly evolving widespread availability of chronic disease and cancer tests, the continued implementation of workplace point-of-care cancer screening is contingent upon developing testing technologies that are easy to use without specialized medical training and that provide reliable results. There also remains a need for point-of-care tests that are very sensitive (minimally invasive, with little chance of false negative results) and very specific (resulting in few positive tests for individuals who do not have the disease and so low chances of false positive results; no unexpected positive results). Innovations in testing technologies, sample types (biofluids), testing environments (such as using smartphones to read test results) and test formats (mixed tests or multiplex formats that test for multiple conditions simultaneously, executive tests, etc.) are all necessary and important components of addressing this need and relevant future areas for research.

The landscape of workplace health management is poised for further transformation through the integration of emerging technologies that enhance the capabilities of POCT and digital health passports.

Artificial intelligence (AI) represents a particularly promising frontier. Machine learning algorithms can augment the interpretation of POCT results, improving diagnostic accuracy, stratifying disease risk and enabling predictive analytics [73]. For example, AI models trained on large datasets can detect subtle patterns in biomarker profiles indicative of early-stage disease, informing personalized intervention strategies.

Blockchain technology offers further opportunities beyond data security. Smart contracts—self-executing digital agreements—could automate consent management, ensuring that employees retain granular control over the use of their health data. Blockchain can also facilitate cross-border interoperability of digital health passports, supporting multinational workforces and global mobility [64,65].

As shown in Figure 4, the integrated workflow of POCT and Digital Health Passports at the workplace would first necessitate the use of onsite or mobile devices to perform diagnostic tests (e.g., HbA1c, PSA), resulting in real time results which can be digitized and encrypted at the source. Subsequently, the results can be uploaded via API to a secure server or blockchain ledger, while the employee receives a notification through their mobile health app. Through a consent-based sharing, employees can selectively share their health data with occupational health services, insurers or healthcare providers. This integration reduces administrative burden, enhances transparency and empowers employees to manage their health autonomously.

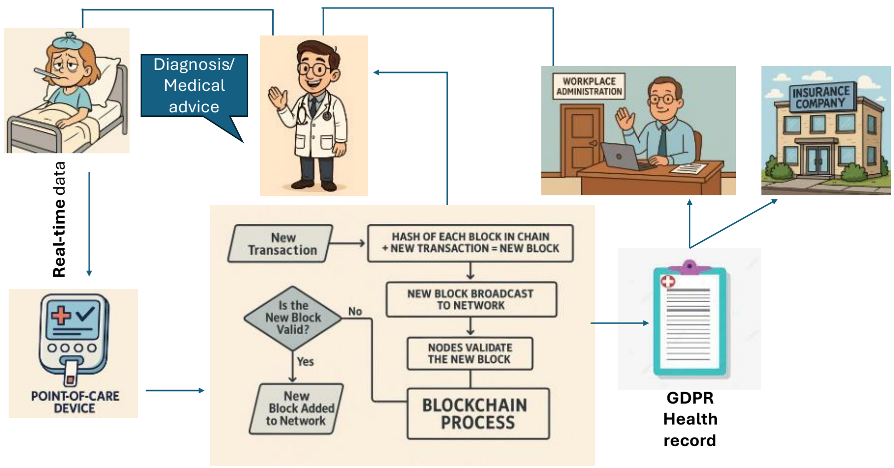

Figure 4. Simplified represengtation of blockchain integration with POC health monitoring in the workplace. Blockchain ensures that once a POCT result is entered, it cannot be modified without network consensus. This

builds trust between employees, employers and health providers by securing sensitive health data against hacking, falsification or unauthorized access.

Wearable biosensors represent another exciting development. Advances in materials science and microelectronics have enabled the creation of wearable devices capable of continuously monitoring physiological parameters such as glucose levels, cardiac rhythms and inflammatory markers [70,74,75]. Integration of wearable data streams into digital health passports can transform periodic workplace screenings into continuous, dynamic health monitoring systems.

Policy development must keep pace with these technological advances. Clear guidelines are needed to govern data ownership, secondary data usage, AI decision-making transparency and equitable access to emerging digital health tools. Interdisciplinary collaboration among technologists, ethicists, policymakers and occupational health experts will be essential to realizing the full potential of these innovations.

Point-of-care testing in regard to the detection of biomarkers in blood or breath samples is already well established. However, the sensitivity is insufficient for the detection of cancer or chronic diseases at an early stage. Current commercial breath test devices cannot detect biomarker levels below the nanomolar concentration range and are therefore insufficient to analyze the breath samples of healthy individuals. For blood assays, current POC approaches either rely on expensive equipment or disposable sensors and consume reagents thereby compromising the sustainability of the testing approaches. For non-invasive breath tests, methods with a broad potential application space in smart and cheap sensors based on polymers, carbon nanomaterials and metallics are proposed. These technologies are close to being ready for market implementation as they have already undergone clinical testing or have been used in pilot studies [83–85].

Furthermore, functionalized materials with novel properties in the THz frequency range can be employed to design wearable technologies for sweat analysis. Implanted devices can sense biomarkers in tissue and fluids and respond to the local environment to release drugs, e.g., anti-cancer drugs. POC detection devices for cancer biomarkers in blood samples based on single neuronal behavior or echolocated waves in nanoplasmonic platforms can be fabricated. These applications and approaches provide a path forward to establishing a healthier and less stressful environment in the modern workplace [86–89].

In conjunction with advancements in testing technologies, future/ongoing research efforts related to chronic disease and cancer testing in the workplace should also focus on addressing factors related to broader workplace testing practices (beyond the test itself). For instance, addressing factors such as company policies and laws affecting workplace testing, as well as employee perceptions and opinions regarding workplace testing, is also paramount for successful implementation. While some company policies (such as access to point-of-care test results) and laws affecting the use of point-of-care tests (such as the FDA approval path for point-of-care tests) may hinder the use of workplace testing, there are current and ongoing research opportunities to influence the development of beneficial policies and laws [90–92].

Recent decades have seen the clustering of POC tests based on respiratory, cardiovascular, cancer, diabetes and urinalysis prospects. Interestingly, novel tests such as the detection of fungal and bacterial infections, venereal diseases and alcohol and drug abuse are on the horizon to make the POC platform comprehensive in all possible disease fronts [93,94].

9. Conclusions

The convergence of point-of-care testing (POCT), digital health passports and advanced analytics heralds a new era in workplace health management. By enabling rapid, decentralized diagnostics and secure, real-time health data management, these technologies offer the potential to shift healthcare models from reactive to preventive, empowering employees and organizations alike.

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Successful implementation, however, requires careful attention to ethical principles, regulatory compliance, data privacy and technological robustness. Transparency, voluntary participation and inclusivity must underpin all workplace health initiatives to ensure trust and equity.

Looking forward, emerging innovations in artificial intelligence, blockchain and wearable biosensors promise to further enhance the scope, efficiency and personalization of workplace health strategies. Organizations that embrace these technologies thoughtfully will not only foster healthier workforces but also strengthen organizational resilience and contribute to broader public health goals.

In this evolving landscape, the workplace is not merely a site of employment but becomes a proactive hub for advancing health, well-being and innovation in the digital era.

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Abbreviations

The following abbreviations are used in this manuscript:

AI	Artificial Intelligence
CDC	Centers for Disease Control and Prevention
COVID-19	Coronavirus Disease 2019
ECDC	European Centre for Disease Prevention and Control
FDA	Food and Drug Administration
GDPR	General Data Protection Regulation
HIPAA	Health Insurance Portability and Accountability Act
IoT	Internet of Things
LMICs	Low- and Middle-Income Countries
mHealth	Mobile Health
POCT	Point-of-Care Testing
WHO	World Health Organization

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