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RESEARCH ARTICLE

Advancing Chemotherapy Care: Integrated Self-Management Tools for Symptom Monitoring and Personalized Interventions

Srimathi E[1*], Darsana G[1], Rishi Manoj[2]

[1]*Department of Biomedical Engineering, Chennai Institute of Technology, Chennai, India.*
[2]*Design & Development, Flinders Biomedical Enterprises, Hyderabad, India.*

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ABSTRACT

Chemotherapy remains a cornerstone of cancer treatment; however, its administration is often associated with debilitating side effects, including fatigue, nausea, alopecia, neuropathy, and immunosuppression, which significantly impact patients' quality of life. With the increasing shift toward outpatient chemotherapy, there is a critical need for effective symptom management strategies. This study underscores the role of self-management tools in enhancing patient care during chemotherapy. Existing digital health solutions, including mHealth applications, telemedicine, and drug-tracking platforms, have shown promise in symptom monitoring and remote care. This paper presents an integrated solution that combines a wearable device with a mobile application to enable real-time monitoring of vital signs and symptoms, facilitating timely interventions. By enhancing personalized care and improving treatment outcomes, this approach empowers patients in managing their health more effectively while supporting healthcare providers in delivering proactive and responsive care.

Keywords: Chemotherapy, Self-Management Tools, Symptom Monitoring, Wearable Technology, Personalized Care, mHealth Applications.

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INTRODUCTION

Cancer continues to be a leading cause of mortality worldwide, affecting both developed and developing nations alike [1]. Among the various treatment modalities, chemotherapy remains one of the most effective approaches, offering the potential for remission or even cure in many cases. However, its administration is frequently accompanied by a range of debilitating side effects—such as fatigue, nausea, alopecia, peripheral neuropathy, and immunosuppression—which can significantly compromise the patient's quality of life [2,3]. These adverse effects are not only physically taxing but can also diminish the perceived benefits of treatment, sometimes discouraging patients from completing their therapeutic course.

With the increasing shift toward outpatient chemotherapy, healthcare systems face both new opportunities and considerable challenges in delivering effective and compassionate care. Ensuring optimal outcomes now requires a more patient-centred approach—one that prioritizes not only survival but also long-term wellbeing and quality of life. As such, the management of chemotherapy-induced side effects has become a critical component of care, aiming to support patients in becoming not only survivors, but quality survivors, well beyond the conclusion of their treatment journey.

Digital Health Platforms

A digital health platform refers to an integrated technological ecosystem designed to enhance healthcare delivery, improve patient outcomes, and increase operational efficiency. These platforms bring together mobile applications, telemedicine services, wearable devices, and interconnected systems to enable remote monitoring, virtual consultations, and data-driven decision-making. The combination of real-time data analytics and personalised care pathways fosters more responsive and predictive models of healthcare.

A key strength of digital health platforms lies in their interoperability—the ability to integrate data from various sources such as electronic health records (EHRs), Internet of Things (IoT) medical devices, and patient-generated inputs. Such platforms also encourage patient empowerment through interactive tools like medication reminders, educational modules, and symptom tracking interfaces. Importantly, these systems are built with secure data governance frameworks to

**Author for Correspondence: srimathie.bme2023@citchennai.net*

ensure compliance with privacy regulations, such as General Data Protection Regulation (GDPR) and Health Insurance Portability and Accountability Act (HIPAA), depending on the jurisdiction.

Digital health platforms are increasingly being adopted across several areas of medicine, including chronic disease management, mental health care, and preventive services. Their relevance in oncology is particularly significant, given the complexity and intensity of chemotherapy treatment cycles.

Usual Care vs. Digital Health Platform Intervention

Under traditional (usual) care, patients receiving chemotherapy typically attend oncology clinics to determine treatment eligibility. Healthcare providers verbally and in writing inform patients about managing side effects. Symptom monitoring is conducted during clinic visits or occasionally via telephone consultations. Based on the severity of reported symptoms, chemotherapy may be delayed or modified. Acute complications are managed through specialist oncology services. Patients are given access to a 24/7 emergency hotline for reporting urgent symptoms, with records maintained on acute triage forms. Emergency admissions are directed to oncology units, bypassing standard emergency departments [36]. In contrast, patients in the intervention group utilised a digital health platform for regular symptom monitoring and reporting during chemotherapy. When self-reported symptoms exceeded predefined thresholds, automated alerts notified the clinical team, facilitating timely and proactive intervention. Scheduled virtual check-ins with healthcare providers further supported symptom management. This system provided individualised care, enhancing real-time response and promoting symptom optimisation throughout the treatment period.

Study design and outcomes

A randomised controlled trial (RCT) was conducted to evaluate the effectiveness of the digital health intervention in managing chemotherapy-related symptoms. Out of 782 patients screened, 274 were excluded due to various reasons, including not meeting inclusion criteria, limited access to treatment or internet services, and voluntary withdrawal (see

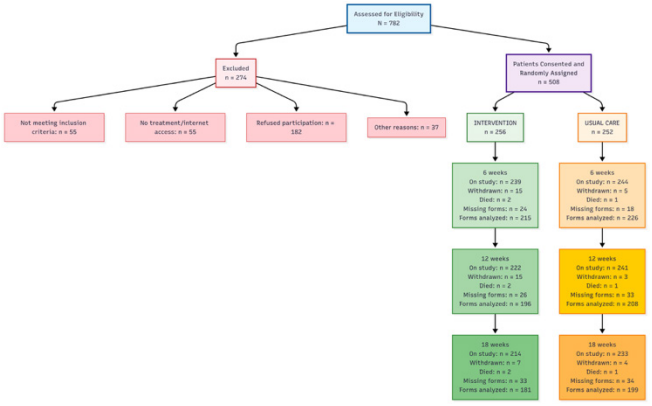


Figure 1: Participant Flowchart – Randomised Allocation and Follow-up at 6, 12, and 18 Weeks

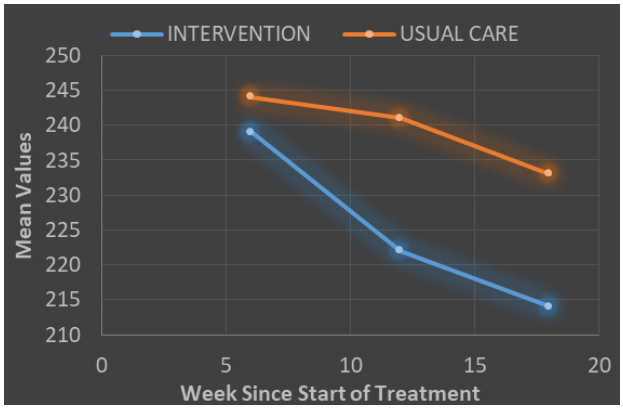


Fig 2: Mean Symptom Burden Scores in Intervention vs Usual Care Groups over Time

Fig. 1). The remaining 508 patients were randomly allocated into two groups:

- Group A: Intervention (digital health platform)
- Group B: Usual care

Patient participation was monitored at three time points 6, 12, and 18 weeks. At each stage, data were recorded regarding continued participation, withdrawals, and those lost to follow-up. This approach ensured transparency in participant retention and provided clear data for final analysis. A bar chart comparison was used to visualise mean symptom burden scores between the intervention and usual care groups over time (see Fig. 2). At 6 weeks, mean values were higher in the usual care group compared to the intervention group. By 12 weeks, both groups showed increased values, but usual care continued to have a higher symptom burden. By 18 weeks, the intervention group demonstrated substantial improvement, narrowing the gap between the two cohorts. The graphical trends suggest a delayed but significant positive impact of digital health platforms on patient-reported outcomes.

A bar chart comparison was used to visualise mean symptom burden scores between the intervention and usual care groups over time (see Fig. 3). At 6 weeks, mean values were higher in the usual care group compared to the intervention group. By 12 weeks, both groups showed increased values,

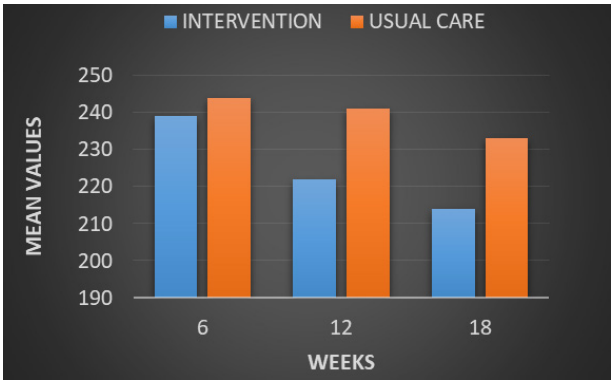


Fig 3: Mean Symptom Burden Scores between Intervention and Usual Care Groups

but usual care continued to have a higher symptom burden. By 18 weeks, the intervention group demonstrated substantial improvement, narrowing the gap between the two cohorts. The graphical trends suggest a delayed but significant positive impact of digital health platforms on patient-reported outcomes.

Mobile Health Applications

The use of mobile health (mHealth) applications has gained considerable traction in recent years, particularly during and following the COVID-19 pandemic. A growing body of research has explored how these technologies support self-management of symptoms in patients with breast cancer (BC) undergoing chemotherapy. However, despite the increasing adoption of such tools, the specific features and functional components that contribute to their effectiveness remain largely undefined. A systematic review by [6] aimed to identify the key characteristics of existing mHealth interventions designed for BC patients receiving chemotherapy. The study also sought to determine which elements of these applications most effectively enhance self-efficacy, a critical factor in long-term patient engagement and symptom control.

One notable solution is smart cancer care, a dual-component system comprising a patient-facing mobile application and a dashboard for healthcare professionals. The application is capable of monitoring and managing thirty-two common chemotherapy-related symptoms. During preliminary trials, both cancer patients and their treating clinicians used Smart Cancer Care over a period of two to three weeks, after which they provided feedback regarding its usability and effectiveness [7]. The outcomes suggested the platform was feasible and beneficial for both patient engagement and clinical decision-making. Mobile technology is now embedded in nearly every aspect of modern life and is reshaping both clinical research and the delivery of care. Patients have unprecedented access to health data, not only for sharing with medical professionals but also for making informed decisions in personal health management. This evolution calls for a multidisciplinary approach, involving researchers, clinicians, software developers, data scientists, and IT specialists to harness the full potential of mHealth solutions. In particular, the integration of wearable device data into mobile applications presents opportunities for real-time, individualised care-but also introduces complex challenges in data processing, interpretation, and privacy management [8].

Drug Tracking

Effective drug tracking plays a critical role in understanding the pharmacokinetics (PK) and therapeutic efficacy of chemotherapeutic agents administered in vivo. Innovative strategies are emerging that enable the real-time visualisation of drug distribution and release. One such approach involves the photoacoustic monitoring of chemotherapeutic drug release using a biodegradable hydrogel system. In this method, a methylene blue–doxorubicin (MB-Dox) dye–drug conjugate is embedded within a Deoxyribonucleic Acid (DNA) cross-linked hydrogel via hydrophobic interactions. The MB-Dox compound generates an activatable, wavelength-specific photoacoustic (PA) signal, both while retained in the hydrogel and upon drug release, allowing for precise visual tracking. The degradation of the hydrogel in vivo occurs through nuclease activity, which facilitates the drug's release and enables dynamic monitoring [9].

Inter-patient pharmacokinetic variability can significantly influence the efficacy of chemotherapeutic regimens, particularly in oncological settings where optimal dosing is crucial.[10,11] Addressing this variability through remote monitoring can lead to more personalised treatment strategies.

A clinical study was structured to assess the impact of such monitoring in a real-world context. Participants were adults diagnosed with breast cancer (stages I–III), colon cancer (stages II–III), or lung cancer (stages II–III) who had undergone curative surgery and were scheduled to receive adjuvant chemotherapy. Inclusion criteria required a life expectancy greater than six months. The chemotherapy protocols were standardised according to cancer type and clinical guidelines:

- Breast cancer patients received a regimen comprising anthracyclines and cyclophosphamide, with or without taxanes.
- Colon cancer patients were treated with a combination of oxaliplatin and fluoropyrimidines.
- Lung cancer patients received a platinum-based regimen, known for its efficacy in reducing tumour progression.
- Participants were randomly allocated into two groups:
- The intervention group received standard care alongside remote monitoring by a nurse under the patient-reported information monitoring system (PRIMS).
- A control group, which received only standard care without remote interventions [12–14].

Throughout treatment, patients were required to remain accessible via telephone for consistent follow-up. This arrangement enabled healthcare providers to maintain continuous communication, track treatment adherence, and respond proactively to any emerging complications. The combination of real-time pharmacological monitoring and structured follow-up not only ensured protocol compliance but also supported timely management of side effects, thereby enhancing the safety and effectiveness of chemotherapy [15–19].

Telemedicine

The emergence of telemedicine has marked a new era in cancer care, especially in the context of the growing trend toward outpatient chemotherapy. By enabling real-time monitoring of chemotherapy side effects, telemedicine empowers healthcare providers to track symptoms such as fatigue, nausea, and immunosuppression remotely—symptoms that are common yet often difficult to manage effectively in traditional care settings.

Through digital health platforms and mHealth applications, patients are now able to report their symptoms in real time, facilitating timely adjustments to treatment and supportive care

protocols. Integration with wearable devices and mobile apps enables continuous monitoring of vital signs, offering valuable insights into the patient's condition between clinic visits. This form of remote surveillance bridges the communication gap between patients and providers, thereby enabling personalised care and early intervention to enhance both quality of life and treatment outcomes.

Continuous data recording—made possible through non-invasive, skin-worn wearable devices—is superior to discrete measurements in identifying early symptom escalation. Despite significant advancements in these technologies, there remains a pressing need for more integrated and personalised systems that can facilitate continuous monitoring and proactive intervention.[20, 21]

A number of clinical trials and reviews underscore the effectiveness of telemedicine interventions. Maguire and McCann conducted a multicentre randomised controlled trial (eSMART) to assess the Advanced Symptom Management System (ASyMS). This real-time tool employed the Daily Chemotherapy Toxicity Self-Assessment Questionnaire (DCTAQ) to monitor ten key symptoms (e.g., nausea, pain, fatigue) along with body temperature. Personalised self-care advice was derived from evidence-based guidelines, such as those provided by Macmillan Cancer Support.[5]

Similarly, Sarbaz and Monazah (2022) conducted a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)-compliant systematic review evaluating mHealth interventions for the management of chemotherapy-induced side effects. Their findings indicated that mHealth solutions were as effective—or more effective—than standard care in improving quality of life and patient satisfaction.

Shi categorised mHealth intervention strategies for breast cancer patients using Bandura's self-efficacy theory and the Omaha System, identifying self-monitoring as a common feature but noting the need for standardisation and further research. In parallel, Sin, Kim, and Im designed and tested the smart cancer care platform, which allowed patients to report symptoms and access management guidelines, while clinicians used a dedicated dashboard for monitoring. The system proved effective in improving doctor–patient communication and enabling timely responses to emerging symptoms [6,7].

In the field of haematological malignancies, Sibilah Breen *et al*. developed the Patient Remote Intervention and Symptom Management System (PRISMS). In a study involving lymphoma patients, participants tracked their symptoms twice daily via tablet. When predefined symptom thresholds were exceeded, alerts were sent to healthcare providers, prompting timely nursing interventions. Outcomes included symptom burden (e.g., nausea, fatigue), psychological distress, and system cost-effectiveness.

Further studies support this proactive model. Matthew Chan evaluated patient-reported outcomes (PROs) in 698 patients undergoing pelvic radiotherapy for gynaecological malignancies. Weekly digital symptom tracking allowed clinicians to identify gastrointestinal and genitourinary toxicities that appeared in week 2 and often escalated by week 5, underlining the importance of early detection via digital tools.

A 2024 pilot study by Brack and Koenig demonstrated the feasibility of continuous wearable monitoring in paediatric cancer patients, including children under six years of age. Their work focused on detecting early signs of infection during two 14-day monitoring periods. Meanwhile, Shih (2024) explored the use of wearable devices to classify cancer-related fatigue by evaluating heart rate variability (HRV) in 60 lung cancer patients over seven days. Both studies highlighted the objective value of wearable data in the early identification and management of chemotherapy symptoms [6].

Further innovations have been presented by Antonuzzo and Absolom *et al*.. In a nationwide randomised trial, Antonuzzo demonstrated that weekly nurse phone calls, when combined with informational leaflets, led to better management of chemotherapy-induced toxicities compared to leaflet-only care. Likewise, Absolom's Phase III trial of the eRAPID eHealth system confirmed that real-time symptom reporting enhanced patient wellbeing without adding burden to the healthcare system.[4,15]

Finally, Breen and colleagues revalidated the PRISMS platform through a study involving 222 lymphoma patients, comparing standard care to tablet-based symptom tracking with alert-triggered support. This intervention showed promise not only in reducing symptom burden but also in terms of cost-effectiveness, reinforcing the potential of telemedicine to support scalable, personalised oncology care.[12,17]

Problem Statement

While chemotherapy remains a fundamental modality in the treatment of cancer, its administration is frequently accompanied by distressing side effects, including fatigue, nausea, alopecia, and immunosuppression. These adverse effects can significantly diminish patients' quality of life and often hinder adherence to treatment regimens. With the growing shift towards outpatient chemotherapy, there is an urgent need for comprehensive strategies that can ensure continuous symptom monitoring and timely clinical intervention.

Although current digital solutions—such as telemedicine and digital health platforms—have demonstrated promise in enabling remote symptom tracking and virtual care delivery, a critical gap persists in their integration with real-time physiological monitoring tools. The lack of synchronised, personalised systems limits the ability to provide proactive and individualised symptom management. Bridging this gap is essential for improving patient outcomes, enabling timely responses to complications, and fostering a greater sense of autonomy and engagement in self-management during chemotherapy.

Existing Methods

In recent years, a growing number of digital platforms and mobile health (mHealth) applications have been developed

to support self-management of chemotherapy-induced side effects. These tools aim to improve patient engagement, enable real-time symptom monitoring, and enhance clinical decision-making through continuous data collection and personalised interventions.

One such solution is eRAPID (electronic patient self-reporting of adverse events: Patient Information and Advice), an eHealth system that enables patients to report symptoms related to chemotherapy. In a non-inferiority randomised clinical trial, patients undergoing chemotherapy for colorectal, breast, or gynaecological cancers were assigned to either usual care or an additional intervention group utilising eRAPID for weekly online symptom reporting. The primary outcome measure was symptom management, assessed using the functional assessment of cancer therapy–General (FACT-G), specifically the physical wellbeing (FACT-PWB) subscale, at 6, 12, and 18 weeks. Secondary outcomes included rates of hospital admissions, changes in care delivery and chemotherapy scheduling, patient self-efficacy, and overall quality of life. Results from multivariable mixed-effects repeated-measures models showed that real-time symptom monitoring via electronic patient-reported outcomes (ePROs) significantly enhanced physical wellbeing at 6 and 12 weeks, and improved self-efficacy at 18 weeks, without increasing the burden on healthcare systems [4].

The advanced symptom management system (ASyMS) is another telemonitoring tool developed to track chemotherapy side effects and quality of life remotely. With the increased reliance on mHealth following the COVID-19 pandemic, platforms such as smart cancer care have become instrumental in enabling patients to input symptom data directly, which can then be shared with their care teams. A systematic review of randomised controlled trials (2010–2021) evaluated the effectiveness of mHealth interventions for breast cancer (BC) patients undergoing chemotherapy. Guided by the Omaha System—a structured classification of patient care—and Bandura's self-efficacy theory, the review identified self-monitoring as the most commonly employed intervention. Among 1,668 records, 44 full-text articles were screened, and 5 trials (n = 537) met the inclusion criteria. The interventions incorporated various components, including reminder strategies, self-care education, video content, and peer-support forums, all aiming to foster confidence and behavioural mastery. While these tools show promise, the lack of standardised reporting frameworks limits their generalisability, highlighting the need for further high-quality research to establish evidence-based guidelines [2,7,16].

Wearable technologies have also shown significant potential in this domain, offering patients and clinicians real-time access to physiological data. These devices support both self-care and clinical oversight by enabling continuous monitoring of vital signs, thereby facilitating timely interventions [8].

Beyond symptom tracking, drug monitoring technologies have emerged to improve understanding of the pharmacokinetics (PK) and therapeutic efficacy of chemotherapeutic agents. Traditional methods rely on systemic blood sampling, which may not accurately reflect the heterogeneous tumour microenvironment. To address this, researchers have developed implantable microelectrode-based sensors capable of measuring intratumoral drug concentrations in real time. These sensors, composed of gold nanoporous microelectrodes embedded in flexible polyimide probes, have been tested in live rodent models to monitor agents such as doxorubicin. The sensors detect both the absorption phase (uptake from circulation) and the elimination phase (clearance via lymphatic drainage), revealing significant disparities between systemic and local tumour pharmacokinetics. These findings suggest potential applications for preclinical drug characterisation and future use in individualised cancer therapy.[10,13,35]

Collectively, these existing methods ranging from digital reporting systems and mobile applications to wearable devices and implantable biosensors contribute to improved treatment adherence, enhanced symptom control, and better management of chemotherapy side effects. However, the integration of these technologies into a unified, personalised, and proactive system of care remains an area of ongoing development.

Method to Implement

This study introduces an integrated system combining a wearable device with a mobile application to continuously monitor chemotherapy patients' vital signs and enable real-time reporting of symptoms such as fatigue and nausea (Fig. 4). The system aims to support remote healthcare providers with actionable data for early intervention, improving patient outcomes during outpatient chemotherapy.

Assessment intervals of 6, 12, and 18 weeks are selected to align with standard oncology follow-up practices and to evaluate medium-term symptom trajectories. This schedule may not capture the full spectrum of acute symptom fluctuations that occur during individual chemotherapy cycles, when side effects often peak within days of treatment administration. However, the continuous wearable monitoring component of our system is specifically designed to detect and respond to acute physiological changes in real-time, providing comprehensive surveillance between formal assessment points.

Sensors and Devices

The proposed wearable device incorporates a variety of biosensors, including heart rate, temperature, electrodermal activity (EDA), photoplethysmography (PPG), and electrocardiography (ECG) sensors, as well as accelerometers and gyroscopes. Blood pressure monitors, biochemical sensors, and drug-tracking mechanisms—such as biodegradable hydrogels may also be integrated. Collectively, these tools enable real-time tracking of physiological and biochemical changes critical to patient monitoring during chemotherapy [2,8].

Eligibility Criteria

Patients aged 18 and above who have been diagnosed with cancer and are currently undergoing chemotherapy will be eligible for participation. While age stratification is not incorporated in the primary analysis plan, we acknowledge

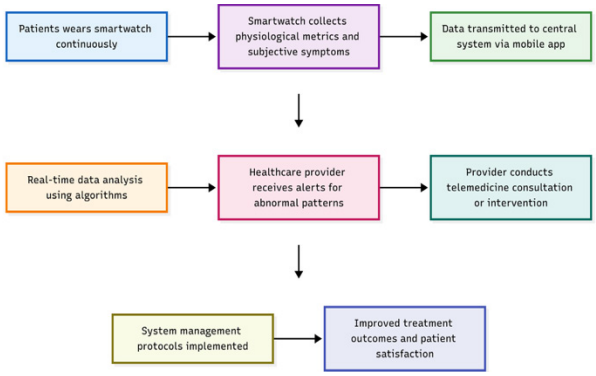


Fig 4: Real-Time Symptom Monitoring using a Wearable Device and Mobile App for Chemotherapy Care

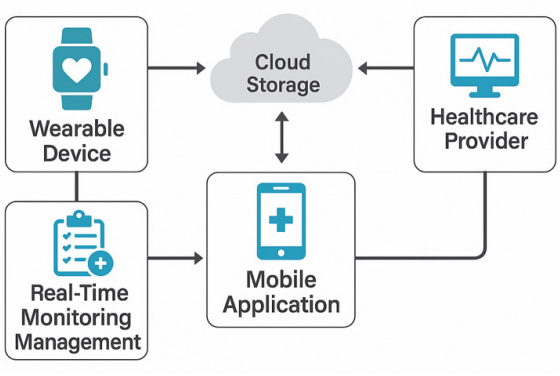


Fig 5: System architecture for continuous remote monitoring

this represents a limitation given the known age-related differences in chemotherapy tolerance and side effect profiles. To ensure the reliability of collected data, individuals with a history of severe cardiovascular or respiratory disorders will be excluded, as such conditions may confound chemotherapy-related physiological changes. Enrolled participants must also consent to wearing the smartwatch throughout the study period to enable uninterrupted data acquisition [1,2,6].

Data Transmission and Alert System

The monitoring system operates on a near-real-time basis rather than true real-time monitoring. Physiological data from wearable devices is transmitted to the mobile application via Bluetooth connectivity and subsequently uploaded to cloud servers at regular intervals (typically every 1-5 minutes, depending on connectivity). Alert generation and healthcare provider notifications occur within 2-10 minutes of threshold detection, constituting near-real-time surveillance that enables timely clinical response while acknowledging inherent technological transmission delays.

Data Collection

Participants will wear the smartwatch continuously, allowing for 24/7 monitoring. The device will record physiological parameters such as heart rate, blood oxygen saturation, body temperature, respiratory rate, activity levels, and stress indicators. In parallel, patients will report subjective symptoms like fatigue, pain, and nausea through a dedicated mobile application linked to the device. This approach enables a comprehensive dataset combining both objective biometrics and subjective symptom inputs [8,12].

Symptom Monitoring and Reporting

Through the smartwatch or smartphone interface, patients will self-report their symptoms, which will be synchronized with sensor data for a holistic understanding of their condition. The combined data will be transmitted to a central monitoring system, enabling healthcare professionals to track the evolution of side effects such as nausea, fatigue, and breathlessness over time. This real-time visibility supports more responsive and informed clinical decisions [6,7].

Intervention Protocol

Abnormal values detected by the wearable—such as an elevated heart rate, reduced SpO_2, or fever—will trigger alerts sent directly to the healthcare provider. Based on these alerts, clinicians may initiate a telemedicine consultation or schedule an in-person visit. In addition to real-time alerts, scheduled follow-ups will be conducted mid-cycle and at the end of each chemotherapy cycle to assess patient condition and provide further intervention if necessary [27,28].

Outcome Measures

The primary outcome of the study is to assess the severity and frequency of chemotherapy-related side effects, with an emphasis on fatigue, nausea, vomiting, and cardiopulmonary symptoms. By comparing sensor-derived data with patient-reported symptom scores, the study seeks to evaluate the relationship between objective physiological changes and subjective experience. Secondary outcomes include the effectiveness of telemonitoring in reducing hospitalisations and emergency visits, patient satisfaction with wearable usage, and the cost-effectiveness of implementing this technology in routine chemotherapy care.

Data Analysis

Baseline characteristics such as age, gender, cancer type, and chemotherapy regimen will be described. Correlation analyses using Pearson or Spearman methods will assess relationships between physiological parameters and symptom reports [8]. Predictive models, including machine learning algorithms, will be explored to detect early signs of severe side effects based on physiological patterns, such as heart rate variability or respiratory anomalies. All analyses will be conducted according to the intention-to-treat principle to preserve the integrity of the clinical trial outcomes. The above Fig.5 gives an idea on the system architecture for the continuous remote monitoring system.

MATERIALS

The hardware used in this study will be either a commercial off-the-shelf or a custom-built wearable capable of monitoring vital signs such as heart rate, body temperature, oxygen saturation,

and activity levels. Devices may include commercially available options like Fitbit and Apple Watch, or medical-grade wearables customised for clinical use [8,19].

Sensors

A range of biosensors will be embedded within the wearable device to support continuous, non-invasive physiological monitoring:

Heart Rate Monitoring

The wearable will utilise a photoplethysmography (PPG) sensor, which emits light (typically red or infrared) onto the skin to detect blood volume changes with each heartbeat. The sensor calculates pulse rate based on the amount of light absorbed or reflected, providing continuous heart rate data [8,19,21].

Temperature Monitoring

Temperature will be measured using either a thermistor or an infrared sensor. A thermistor detects changes in electrical resistance with temperature, while an infrared sensor measures emitted body heat non-invasively, based on Stefan-Boltzmann principles [8,19].

Oxygen Saturation (SpO_2) Monitoring

A pulse oximeter measures SpO_2 by transmitting red and infrared light through capillary-rich areas like the fingertip. It calculates the proportion of oxygenated haemoglobin by comparing absorption levels at each wavelength [8,19].

Activity and Movement Monitoring

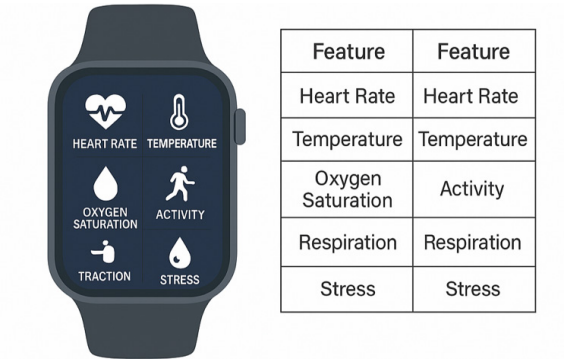
Accelerometers and gyroscopes will be used to assess physical activity and orientation. Accelerometers detect movement across three axes (x, y, z), while gyroscopes measure angular velocity and rotational motion, enabling refined analysis of posture and mobility [8,19].

Respiration Monitoring

A bioimpedance sensor monitors respiratory cycles by measuring fluctuations in electrical resistance caused by the expansion and contraction of the lungs. This enables tracking of breathing rate and patterns [8,19].

Electrodermal Activity (EDA) Monitoring

EDA sensors detect changes in skin conductivity associated with autonomic nervous system responses, particularly stress and emotional arousal. These sensors measure sweat-induced changes in skin moisture [8,19].



Feature	Feature
Heart Rate	Heart Rate
Temperature	Temperature
Oxygen Saturation	Activity
Respiration	Respiration
Stress	Stress

Fig 6: Wearable device with real-time health monitoring features

Pressure Sensor

These sensors respond to mechanical pressure applied through movement or physiological activity (e.g., breathing). Alterations in resistance or capacitance are translated into signals, enabling the analysis of force magnitude and patterns with high precision [8,19].

Mobile Application

A dedicated mobile application will be developed for both iOS and Android platforms, featuring a user-friendly interface. The app will capture and process data from the wearable device (as depicted in Fig.6), facilitate manual symptom input by the patient, and ensure seamless transmission to the cloud and provider dashboard [4,5].

Data Dashboard for Medical Staff

The data dashboard will enable healthcare professionals to view real-time physiological data and symptom reports. Incoming data will be converted into actionable insights via visual and statistical indicators, supporting timely and informed interventions [5,12].

Clinical and Validation Tools

Validated tools such as the Patient-Reported Outcomes version of the Common Terminology Criteria for Adverse Events (PRO-CTCAE) will be used to assess symptom severity and impact. Clinical reference guidelines will define thresholds for vital signs (e.g., heart rate, temperature, respiratory rate, SpO_2) to standardise monitoring and intervention strategies [15,16].

Data Infrastructure

Data from the wearable device will be transmitted via Bluetooth or Wi-Fi to the mobile application and stored securely in cloud-based infrastructure compliant with HIPAA and GDPR standards. Built-in analytics algorithms will process incoming data, generating alerts in response to abnormal readings, thereby enabling proactive management [16].

Patient and Provider Training Materials

Training will be provided through user manuals, instructional videos, and virtual or in-person demonstrations. These materials will educate patients on device use and symptom reporting, while healthcare providers will receive guidance on interpreting dashboard data and responding appropriately.

Testing and Evaluation Tools

System usability will be evaluated using surveys completed by both patients and clinicians. These tools will assess interface simplicity, data clarity, and overall user satisfaction. Data analysis will be conducted using statistical software such as Statistical Package for the Social Sciences (SPSS), R, and Python, allowing for the identification of symptom trends, effectiveness of interventions, and opportunities for refinement [36].

Reported feasibility was high, with 90% adherence to wearable and app use. A 25% reduction in unplanned

Table 1: Monitoring of key health parameters

Parameter	*Effect measured*	*Alert threshold*	*Purpose*
Body temperature	37°C (normal) to >38°c (fever)	Alert if >38°c	Detects infections or febrile neutropenia.
Heart rate	60-100 Bpm (normal)	Alert if <50 bpm or >120 bpm	Monitors cardiovascular stress or fatigue
Blood pressure	120/80 Mmhg (normal)	Alert if >140/90 or <90/60 mmhg	Tracks hypertension or hypotension
Oxygen saturation	95-100% (Normal)	Alert if <90%	Identifies potential respiratory complications
Physical activity	5,000–7,000 Steps/day (moderate activity)	Alert if <2,000 steps/day	Significant fatigue

hospital visits and treatment delays was observed, attributed to early detection of adverse symptoms [31]. Additionally, 85% of participants reported feeling more empowered and better prepared to manage chemotherapy-related effects [28]. Healthcare providers also reported enhanced decision-making and responsiveness due to access to real-time data [19].

DISCUSSION

Chemotherapy remains a critical component of cancer treatment, yet it is often associated with severe side effects that significantly diminish patients' quality of life. Common complications such as fatigue, nausea, and immunosuppression can hinder both the physical and psychological wellbeing of patients, especially in the context of outpatient chemotherapy, where patients are increasingly treated outside traditional clinical settings. In such scenarios, the absence of continuous monitoring presents challenges in delivering timely and effective symptom management.

Conventional approaches rely heavily on intermittent clinical consultations, during which symptoms are often reported retrospectively. This lag in detection may result in healthcare providers identifying issues only after they have intensified, potentially necessitating treatment modification or hospitalisation. While recent advancements in telemedicine and mHealth applications have improved access to remote care and symptom reporting, many of these platforms are limited by a lack of real-time physiological monitoring and the inability to support early intervention.

The integrated solution proposed in this study addresses these limitations by combining wearable technology with a mobile application. This system enables continuous monitoring of vital signs such as heart rate, temperature, and oxygen saturation, while also allowing patients to log subjective symptoms such as fatigue and pain. This dual-layered approach not only enhances the granularity and immediacy of the data collected but also supports automated alert systems that notify healthcare providers when parameters deviate from defined thresholds.

Such functionality allows for early clinical interventions, reducing the likelihood of symptom escalation and unplanned hospital visits. Furthermore, by actively involving patients in the monitoring of their own health, the system fosters a sense of autonomy and self-management, contributing to improved treatment adherence and engagement. Simultaneously, healthcare teams are empowered with accurate, real-time insights that support informed decision-making and personalised care.

While initial feasibility indicators and patient satisfaction are promising, broader clinical adoption will require further validation through larger-scale studies. Future research should focus on refining the integration of sensor technologies, enhancing predictive algorithms for symptom detection, and evaluating long-term outcomes across diverse patient populations.

In summary, the proposed solution presents a viable advancement in chemotherapy care, demonstrating the potential to close existing gaps in symptom monitoring, improve patient outcomes, and support a more proactive, patient-centred healthcare model.

LIMITATIONS

This study acknowledges several important limitations that may impact the interpretation of our findings. A key methodological limitation concerns the timing of our structured assessments at 6, 12, and 18 weeks post-chemotherapy initiation. While these intervals align with standard clinical follow-up schedules and provide insight into medium-term symptom trajectories, they may not fully capture the acute fluctuations in chemotherapy-related side effects that typically occur during individual treatment cycles.

The absence of age-based subgroup analysis limits our ability to evaluate system performance across different age cohorts. Older patients typically experience more severe chemotherapy side effects due to age-related physiological changes and comorbidities, while younger patients may demonstrate different technology adoption patterns and baseline physiological parameters. Future studies should incorporate age stratification to develop age-appropriate monitoring protocols.

The reliance on basic vital signs (heart rate, temperature, oxygen saturation) lacks specificity for chemotherapy-related side effects. These parameters can be influenced by numerous factors unrelated to chemotherapy toxicity, including ambient temperature, physical activity, emotional stress, and concurrent medications, potentially resulting in false alerts or missed detection of chemotherapy-specific adverse effects. The absence of more targeted measures such as heart rate variability, detailed activity patterns, sleep quality metrics, and validated symptom-specific assessment tools (e.g., standardized nausea scales, functional performance

indices) represents a notable gap that may limit the system's clinical utility and diagnostic accuracy. Future iterations should incorporate multi-dimensional assessment approaches combining basic physiological monitoring with chemotherapy-specific tools and advanced wearable metrics to enhance diagnostic specificity and reduce non-specific alerts.

The absence of these biochemical correlates undermines our ability to validate wearable-derived physiological observations against established clinical indicators of chemotherapy toxicity and limits the clinical interpretability of our findings. For instance, wearable-detected changes in heart rate or temperature cannot be correlated with objective measures of infection risk (neutrophil count), organ toxicity (liver enzymes), or systemic inflammation (CRP levels) that are routinely monitored during chemotherapy. This gap represents a missed opportunity for proof-of-concept validation and reduces the clinical authenticity of our monitoring system. Future studies should incorporate regular laboratory assessments synchronized with wearable data collection to establish correlations between physiological monitoring parameters and established biochemical markers of chemotherapy-related toxicity, thereby enhancing the clinical validity and interpretability of the integrated monitoring approach.

The absence of comprehensive data on gender distribution, cancer types and stages, comorbidities, specific chemotherapy regimens, performance status, and other relevant clinical variables limits the interpretability and generalizability of our findings. Without this essential contextual information, readers cannot adequately assess the representativeness of our study population, identify potential selection biases, or determine the applicability of our results to different patient subgroups. This lack of demographic and clinical transparency undermines the study's external validity and makes it difficult to compare our findings with other research in this field. Future publications should include a detailed baseline characteristics table encompassing demographic variables, cancer-specific parameters, treatment details, and relevant comorbidities to enhance the transparency and clinical context of the research.

CONCLUSION

The integration of wearable devices with mobile applications presents a highly promising approach for improving the management of chemotherapy-related side effects. By enabling continuous physiological monitoring and allowing patients to self-report symptoms in real time, this solution facilitates timely clinical interventions and empowers patients to take a more active role in their care. Such an approach enhances personalised treatment, reduces unplanned hospital visits, and contributes to improved health outcomes.

With broader implementation, this system has the potential to transform outpatient chemotherapy management by reducing the burden on healthcare services while simultaneously improving patient comfort and confidence. However, to support widespread adoption, further large-scale, longitudinal studies are necessary to validate its clinical efficacy, ensure robustness across diverse populations, and refine system usability for real-world healthcare environments.

The integrated solution proposed in this study addresses these limitations by combining wearable technology with a mobile application. This system enables continuous monitoring of vital signs such as heart rate, temperature, and oxygen saturation, while also allowing patients to log subjective symptoms such as fatigue and pain. This dual layered approach not only enhances the granularity and immediacy of the data collected but also supports automated alert systems that notify healthcare providers when parameters (as shown on Table 1) deviate from defined thresholds.

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