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FROM DETECTION TO DETOX: A HYBRID MODEL OF MACHINE LEARNING AND BIBLIOTHERAPY IN DIGITAL DEMENTIA CARE

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Abstract

The increasing prevalence of digital dementia among Generation Z underscores the need for hybrid frameworks that combine technological innovation with humanities-based interventions. This paper proposes a two-step model: *Detection* through machine learning algorithms analysing digital behavior patterns such as smartphone usage logs, app-switching, and typing speed; and *Detox* through bibliotherapy interventions designed to improve memory, reflective thinking, and mindful screen use. By situating this model within the bio-psycho-socio approachand aligning it with theAttitude, Ethics, and Communication (AETCOM) module in medical education, the study illustrates a multidisciplinary pathway for early detection, prevention, and management of digital dementia. The hybrid model bridges the gap between computational detection tools and therapeutic, non-pharmacological interventions, contributing to the global discourse on digital health and medical humanities.

Keywords: Generation Z, Detection, Detox, AETCOM, medical humanities

Introduction

The rapid proliferation of digital technologies in the twenty-first century has reshaped human cognition, behaviour, and social interaction. While smartphones, tablets, and constant internet connectivity have enhanced efficiency and global connectedness, they have also introduced new cognitive vulnerabilities. Among these is the emerging condition termed “digital dementia” a form of cognitive decline associated with excessive reliance on digital devices for memory, attention, and information processing [1]. Unlike classical dementia, which is typically linked with aging and neuropathological changes, digital dementia manifests primarily among younger populations, especially Generation Z (Gen Z), who are immersed in digital environments from early adolescence. Symptoms include reduced attention span, impaired memory consolidation, and diminished reflective capacity, all of which mirror traditional dementia-like deficits but are rooted in behavioral and environmental overexposure to screens rather than irreversible neurological degeneration [2].

While tech enabled devices enable rapid information access, it also diminishes the cognitive depth associated with learning and long-term retention [3]. This shift has prompted scholars to describe a transition from internal memory consolidation to cognitive outsourcing

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[4]. When individuals become overly reliant on digital devices, it may impair the hippocampus, an area of the brain critical for learning and memory formation [5]. Adolescents and young adults, whose brains are still developing, are especially susceptible to the long-term effects of such habits.

Generation Z typically identified as those born between the mid-1990s and early 2010s, has come of age in a digital environment where internet access, smartphones, and social media are natural companions [6, 7]. Often referred to as "digital natives," members of this generation have had constant exposure to technology, which has significantly influenced their habits, thought processes, and modes of communication. While digital fluency offers advantages, it also poses distinct risks to their cognitive and emotional well-being.

Studies have shown that Gen Z tends to engage in constant multitasking and values immediacy in communication [8]. Although these patterns support efficiency in a fast-paced digital world, they also encourage superficial engagement with information and weaken the ability to concentrate for extended periods [9]. Many students now prioritize scanning over in-depth reading, which has implications for literacy development and memory retention [10].Economic Survey 2023-2024 released by the Ministry of Finance,Government of India, highlights the increase in mental health issuesamong children and adolescents due to doomscrolling [11].

Scholarly discourse has so far approached digital dementia from two distinct yet complementary directions: technological detection and therapeutic intervention. On the one hand, advances in machine learning (ML) provide sophisticated tools for detecting early signs of cognitive decline through digital behavioural data. Smartphone usage logs, app-switching patterns, keystroke dynamics, and IoT-based monitoring can serve as digital biomarkers of memory deficits and attention disorders [12]. ML classifiers and deep learning architectures have already been employed in the detection of Alzheimer's disease and mild cognitive impairment, suggesting their potential in identifying analogous patterns in digital dementia [13]. On the other hand, the humanities offer non-pharmacological interventions**,** most notably bibliotherapy**,** which employs curated reading, narrative engagement, and reflective activities to enhance cognitive function and emotional well-being. Bibliotherapy aligns with the principles of the bio-psycho-socio model of health, emphasizing the interplay between biological, psychological, and social dimensions in maintaining well-being [14].

Literature Review

Machine Learning and Deep Learning

Machine learning (ML) has revolutionized the detection and diagnosis of cognitive impairments by leveraging large-scale data analysis and predictive modeling. Traditionally, neurocognitive assessments relied on clinical tests such as the Mini-Mental State Examination (MMSE) or Montreal Cognitive Assessment (MoCA). However, these are limited by subjectivity, time constraints, and inability to capture real-world cognitive behavior. ML overcomes these limitations by analyzingdigital biomarkerspatterns in

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everyday digital interactions that reveal underlying cognitive health. Several studies have demonstrated the feasibility of using deep learning (DL) and machine learning (ML) for early detection of "digital dementia"-like conditions, focusing not just on classic dementia, but also on cognitive impairment detected using digital biomarkers, virtual assessments, and technology-enabled tools[15,16,17,18,19].

Data can harnessed from smartphones and wearables to develop digital biomarkers and cross-domain datasets, creating scalable infrastructure for privacy-protected early detectionincluding digital forms of cognitive impairment [15]. Systematic review (PMC/Frontiers) covering 108 studies, including algorithms validates feasibility of digital platforms for virtual early detection and screening of dementia and other neurocognitive disorders, emphasizing the impact of integrating digital health solutions into medical practice in [19]. The study [16] developed and validated a scalable ML-based digital neurocognitive testing panel for MCI and dementia in large cohorts, showing how digital tools can supplement or replace traditional cognitive evaluations for early detection. Further studies including a survey [20] of classification, segmentation, and feature extraction using DL for early Alzheimer's detection, analyzing digital and neuroimaging channels including open-access datasets and the value of digital endpoints in clinical prediction. Maji et al. [18] proposes a novel deep learning-powered gamified platform for virtual dementia screening. The 2D-CNN model reached nearly 96% accuracy using face-based digital image data, demonstrating strong feasibility for virtual/digital detection. Jahan et al., [17] explores natural language processing methods using digital speech samples for early dementia prediction, leveraging text data in virtual environments and validating with clinical and non-clinical datasets.

Bibliotherapy, Humanities, and AETCOM

While technology enables precision in detection, addressing digital dementia requires interventions that cultivate reflection, empathy, and behavioral transformation. At its core, bibliotherapy works by enabling readers to identify with fictional characters, experience emotional catharsis, and gain insight into personal challenges [21]. The therapeutic power of literature lies in its ability to foster identification, catharsis, and insight, allowing readers to reframe personal challenges and internalize healthier behaviors [22] In the context of digital dementia, bibliotherapy can help Gen Z learners rebuild attention span, memory capacity, and reflective depth through curated narratives and structured reading activities.

Empirical research supports bibliotherapy’s efficacy. Studies suggest that bibliotherapy helps reduce harmful habits by promoting mindfulness, emotional regulation, and meaningful social interaction [23]. For adolescents, bibliotherapy has been shown to encourage emotional expression, improve self-concept, and promote coping strategies [24]. In medical education, bibliotherapy aligns with the broader field of Medical Humanities, which integrates literature, philosophy, ethics, and the arts into health professional training. The introduction of the AETCOM (Attitude, Ethics, and Communication) module into Indian medical education marks a significant shift toward competency-based learning. This

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framework recognizes that strong clinical skills must be supported by ethical awareness, empathy, and communication abilities. The National Medical Commission officially embedded AETCOM into the Competency-Based Medical Education (CBME) curriculum in 2018 [25], acknowledging that technical knowledge alone is no longer enough in modern healthcare.

By integrating bibliotherapy into digital dementia care, the intervention phase of this study offers a humanistic balance to excessive technological addiction. It ensures that individuals identified as at-risk by ML algorithms are not reduced to data points but are instead engaged in meaningful narrative processes that encourage cognitive resilience and mindful screen use. When positioned within the bio-psycho-socio model of health, bibliotherapy addresses the psychological and social dimensions of digital dementia, complementing the biological precision of ML detection.

Synthesis

The literature demonstrates that while digital dementia is a growing concern among Gen Z, existing approaches remain fragmented. ML offers promising tools for early detection through digital biomarkers, yet these methods alone cannot effect behavioral change. Conversely, bibliotherapy provides a non-pharmacological pathway for cognitive rehabilitation, however the diagnostic precision of data-driven detection is diminished. Integrating these approaches within a hybrid model, supported by medical humanities principles and embedded in educational modules such as AETCOM offers a comprehensive strategy for detection, prevention, and intervention.

Methodology

Research Design

This study adopts a hybrid methodological framework combining computational approaches with humanistic interventions. The design is grounded in **the** bio-psycho-socio model of health [26] which emphasizes the interrelatedness of biological, psychological, and social determinants of well-being. The research unfolds in two sequential yet interconnected phases:

1. **Detection Phase** – employing machine learning (ML) models to identify digital behavior patterns associated with cognitive decline.

2. **Detox Phase** – implementing bibliotherapy interventions to restore memory, reflective capacity, and mindful digital engagement.

The research suggests using a mixed-methods approach, integrating quantitative data from digital biomarkers and cognitive scales with qualitative insights from bibliotherapeutic reflections and usability studies.

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Phase 1: Detection through Machine Learning

Data Collection

Digital behavior data will be collected from consenting Gen Z participants (aged 18–25). Sources include:

- **Smartphone usage logs**: total screen time, app-switching frequency, session duration.
- **Keystroke dynamics**: typing speed, error frequency, hesitation times.
- **IoT and sensor data**: accelerometer-based activity logs, optional EEG/eye-tracking during multitasking tasks.
- **Cognitive assessments**: validated tools such as the *Smartphone Addiction Scale–Short Version (SAS-SV)*, and memory recall tasks for comparative analysis.

All data will be anonymized and securely stored in compliance with ethical guidelines [27].

Algorithms

- **Classification models**: Support Vector Machines (SVM) and Random Forests to distinguish between high-, moderate-, and low-risk individuals.
- **Sequence models**: Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM) architectures to analyse app-switching and multitasking sequences.
- **Anomaly detection**: Isolation Forest and Autoencoder models to identify outliers indicative of abnormal attention or memory patterns.

The models will be trained on a combination of supervised and unsupervised datasets, with accuracy evaluated against cognitive test results.

Evaluation Metrics

- **Accuracy and F1 score** for classification models.
- **Area Under the ROC Curve (AUC)** to assess detection reliability.
- **Correlation analysis** between ML-identified patterns and neurocognitive test scores.
- **Usability studies** to ensure detection tools are user-friendly and ethically acceptable.

Phase 2: Detox through Bibliotherapy

Intervention Design

Following detection, participants identified as at-risk will undergo bibliotherapy-based interventions. The intervention draws upon curated texts promoting reflection and cognitive engagement, supplemented by the workbook (*Digital Dementia to Digital Detox*). The design includes:

1. **Prescriptive reading**: Narratives addressing attention, memory, and mindfulness.
2. **Interactive activities**: Guided journaling, reflective writing, and group discussions.

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3. **Narrative reconstruction**: Encouraging students to reinterpret their digital habits through metaphor and storytelling.

Delivery

- **Format**: Weekly sessions (60–90 minutes) over 8–10 weeks.
- **Mode**: Small-group workshops facilitated by trained moderators; hybrid online/offline delivery for flexibility.
- **Tools**: Printed reading material, and reflective journals for recording responses.

Evaluation

- **Pre- and post-intervention assessments**:
  - *SAS-SV scores* for smartphone addiction.
  - *Memory recall and attention span tasks*.
  - *Self-reported reflective capacity* measured through qualitative surveys.
- **Comparative analysis**: Statistical tests (paired *t*-tests, ANOVA) to evaluate cognitive improvement.
- **Qualitative analysis**: Thematic coding of reflective journals to capture behavioral transformation.
- Integration of Detection and Detox
- The novelty of this methodology lies in its feedback loop. The ML detection phase identifies at-risk individuals and establishes baseline digital biomarkers. The bibliotherapy intervention phase then provides non-pharmacological intervention tailored to these risk profiles. Finally, follow-up data is fed back into the ML system, allowing adaptive refinement of detection models and bibliotherapy modules.
- This iterative cycle ensures that detection is not merely diagnostic but is directly tied to intervention, creating a sustainable model for digital dementia care.

Ethical Considerations

- **Informed consent**: Participants will be briefed about data collection methods, privacy, and the scope of bibliotherapy.
- **Data protection**: All digital logs anonymized; sensitive data encrypted.
- **Non-stigmatization**: Participants identified as “at risk” will be supported through constructive interventions, avoiding negative labeling.
- **Human-centered balance**: Ensures ML detection is complemented by bibliotherapy, avoiding reduction of individuals to mere data points.

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Justification for Hybrid Approach

Existing studies often prioritize either detection or intervention. However, detection without intervention risks pathologising behaviours without solutions, while intervention without precise detection may lack specificity. The hybrid methodology combines the precision of ML with the transformative depth of bibliotherapy, offering a holistic framework consistent with the AETCOM moduleandMedical Humanities**.**

Proposed Hybrid Framework

Conceptual Overview

The hybrid framework, titled "From Detection to Detox," seeks to integrate computational precision with humanistic care in addressing digital dementia. It is designed as a two-stage process with a continuous feedback loop, ensuring that early detection of cognitive risks leads directly to personalized interventions, and that outcomes from those interventions refine detection algorithms.

The framework rests on three pillars:

1. **Detection (Machine Learning)** – Identification of at-risk individuals based on digital biomarkers.

2. **Detox (Bibliotherapy)** – Humanistic intervention to restore memory, attention, and reflective capacity.

3. **Integration (Feedback Loop)** – Continuous adaptation of detection and intervention tools through iterative evaluation.

Stage 1: Detection

- **Input**: Digital behaviour logs, keystroke dynamics, app-switching patterns, sensor data, and cognitive test scores.
- **Process**: Machine learning classifiers and sequence models analyse these data streams to identify anomalies indicative of cognitive overload, attention fragmentation, or memory lapses.
- **Output**: Categorization of individuals into high-, moderate-, and low-risk profiles for digital dementia.

The detection stage ensures early recognition of cognitive vulnerabilities, enabling timely intervention before impairments become severe.

Stage 2: Detox

- **Input**: At-risk individuals identified through detection.
- **Process**: Bibliotherapy interventions are administered through curated readings, reflective exercises, and group discussions, guided by principles of therapeutic storytelling and narrative medicine.

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- **Output**: Enhanced attention span, improved memory consolidation, and greater awareness of digital habits.

The detox stage shifts focus from diagnosis to transformation, empowering participants to reframe their relationship with digital technology through literature and reflective practice.

Stage 3: Integration (Feedback Loop)

A defining feature of the model is the feedback loop connecting detection and detox. Post-intervention data such as reduced SAS-SV scores, improved recall tasks, and enhanced reflective capacity are fed back into the ML system. This achieves the following two:

- Model Refinement: The ML algorithms adjust based on intervention results, increasing their predictive accuracy for future cohorts.
- Adaptive Bibliotherapy: Bibliotherapy modules are dynamically modified in response to participant outcomes, ensuring personalization and relevance. The feedback mechanism ensures that the framework is self-correcting and scalable, suitable for broader application in academic, clinical, and community contexts

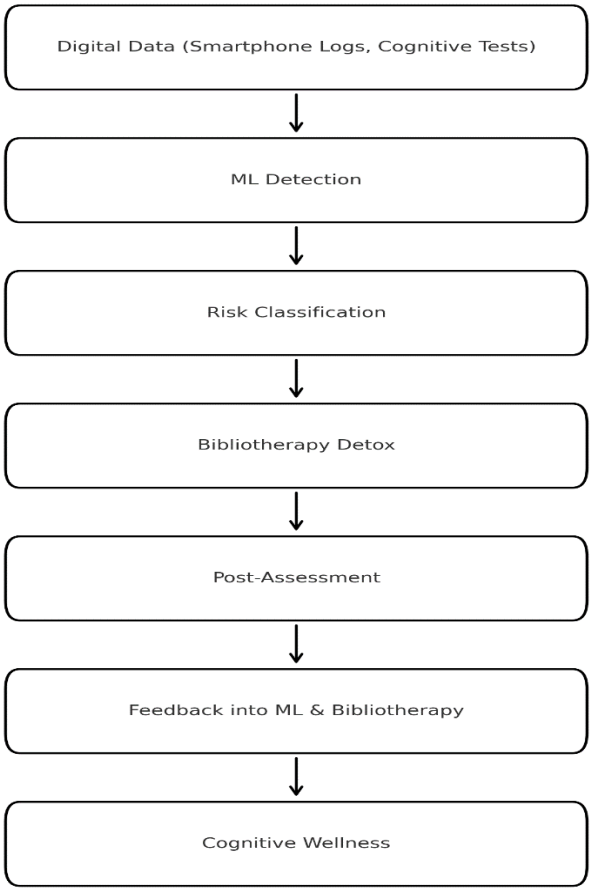

Fig 1. Flowchart of the framework

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The Fig 1 visually demonstrates how the system moves from data-driven diagnosis to narrative-driven healing, with each cycle strengthening both detection and intervention.

Alignment with Medical Humanities and AETCOM

The proposed hybrid framework is not merely a technical intervention but an educational and ethical model. By embedding bibliotherapy within the AETCOM module, the framework situates digital dementia care within medical humanities training. Students and health professionals learn not only to detect but also to humanize treatment, ensuring that technology and literature work in tandem to address cognitive decline in the digital age.

Anticipated Advantages

The following are the anticipated advantages of this conceptual framework.

- Holistic Care: Balances biological detection with psychosocial intervention.
- Personalization: Adaptive interventions ensure that no two individuals receive identical bibliotherapy prescriptions.
- Scalability: Applicable in educational institutions, clinical practice, and public health policy.
- Sustainability: Continuous feedback loop enables long-term refinement of both ML algorithms and bibliotherapy approaches.

Strengths of the Hybrid Model

One of the principal strengths of this model is its complementarity. Machine learning offers precision and scalability, capable of analysing vast amounts of digital behaviour data to identify subtle markers of cognitive decline. Bibliotherapy, by contrast, provides depth and personal meaning, engaging individuals in reflective processes that foster behavioural change. Together, they form a closed loop of detection and intervention that is greater than the sum of its parts.

Another strength lies in the model's preventive orientation. By detecting early signs of cognitive overload, the framework moves beyond reactive treatment to proactive prevention. This anticipatory stance is crucial for Gen Z populations, who are at heightened risk due to their immersive engagement with digital technologies. Moreover, bibliotherapy provides a low-cost, non-pharmacological intervention that can be widely implemented in schools, universities, and community health programs.

The alignment of this model with the AETCOM module in medical education further strengthens its relevance. Embedding bibliotherapy into curricula not only equips medical students with tools to manage their own digital health but also cultivates empathy and communication skills necessary for patient-centered care.

Ethical Considerations

The dual nature of the model raises ethical tensions between data-driven surveillance and human-centered care. Ensuring that detection does not stigmatize participants is crucial.

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The risk of labeling individuals as "digitally impaired" could exacerbate anxiety or reinforce stereotypes about youth dependence on technology. Mitigation strategies include framing detection results as opportunities for growth rather than deficiencies, and positioning bibliotherapy as a supportive, empowering practice rather than corrective punishment.

Conclusion

The phenomenon of digital dementia underscores the cognitive and behavioral challenges emerging in an age dominated by technology. Gen Z, as the first generation of digital natives, is particularly vulnerable to memory decline, attention deficits, and behavioral addictions linked to excessive screen use. Traditional approaches that focus solely on detection or intervention fail to capture the complexity of this issue. This paper has proposed a hybrid model 'From Detection to Detox' that integrates machine learning (ML) and bibliotherapy as complementary strategies for both identifying and addressing digital dementia.

The detection phase capitalizes on advances in machine learning to analyse digital biomarkers such as smartphone logs, keystroke dynamics, and app-switching patterns. These computational tools provide precision and scalability, enabling the early identification of at-risk individuals. The detox phase, rooted in bibliotherapy and medical humanities, offers a human-cantered intervention that restores reflective capacity, strengthens memory, and delivers mindful digital practices. Together, these phases form a continuous feedback loop in which detection informs intervention and intervention outcomes refine detection algorithms.

This hybrid approach has significant implications for education, healthcare, and policy. By aligning bibliotherapy with the AETCOM module mandated by the National Medical Commission (NMC) in India, the model embeds humanistic care within medical education, equipping future physicians with both technological literacy and empathetic skills. At the community level, bibliotherapy provides a low-cost, scalable intervention that can be adapted across cultural contexts, while ML-based detection ensures precision in identifying vulnerable populations.

The study also emphasises the importance of ethical safeguards. As ML tools become increasingly integrated into digital health, issues of privacy, consent, and stigmatization must be addressed proactively. Likewise, bibliotherapy must be culturally contextualized to ensure inclusivity and relevance. Future research should focus on validating digital biomarkers, conducting empirical trials of bibliotherapy in digital dementia care, and developing adaptive systems that personalize interventions based on detection outcomes. Ultimately, the 'From Detection to Detox' framework represents a paradigm shift in how digital dementia is understood and managed. By bridging the gap between technology and the humanities, it demonstrates that effective solutions must be both precise and humane, data-driven and narrative-centered. Such integration not only addresses the immediate risks of digital overuse but also contributes to a broader vision of cognitive wellness in the digital age. In doing so,

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the model exemplifies the bio-psycho-socio approach to health, ensuring that digital dementia is tackled not as a narrow clinical issue but as a multidimensional challenge of our time.

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