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Improving Health and Managing Illness through Wearables: The Importance of Terminology

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ABSTRACT:

This study explores the integration of digital wearables with clinical terminology such as SNOMED CT and LOINC codes, aiming to enhance physical assessments through health data standardization. Employing a mixed-methods design, it combines quantitative analysis—like mapping wearable-collected health metrics to Electronic Health Record (EHR) standards and clinical terminologies for interoperability—and qualitative insights from literature to underscore the potential benefits in diagnostics and treatment. Results indicate that this integration facilitates seamless data exchange between wearables and healthcare systems, promoting real-time patient data analysis for timely lifestyle and non-communicable disease (NCD) management. The use of standardized clinical terminology ensures accurate coding, documentation, and analysis, improving clinical decision-making and personalized care. This approach not only empowers individuals in managing NCDs but also supports healthcare professionals in delivering optimal care, highlighting the significant potential of digital health technologies in tackling chronic and lifestyle-related diseases.

Keywords: Clinical Terminology, SNOMED CT, LOINC, digital wearables, Interoperability

1. Introduction

Chronic diseases are conditions that develop over an extended period because of a combination of genetic, physiological, environmental, and behavioral variables. The four primary categories of NCD are diabetes, cancer, chronic respiratory diseases (such as chronic obstructive pulmonary disease and asthma), and cardiovascular disorders (including heart attacks and stroke). More than three-quarters of all NCD fatalities worldwide (31.4 million) occur in low- and middle-income nations, which are disproportionately affected by NCDs.(*Noncommunicable Diseases*, n.d.)

The statistics reveal the extent to which the pandemic has been affecting health systems worldwide, in some cases severely curtailing access to vital services. These disruptions are likely to set back global progress in both life expectancy and healthy life expectancy made in the first 20 years of the century. Global life expectancy at birth had increased from 66.8 years in 2000 to 73.3 years in 2019, and healthy life expectancy increased from 58.3 years to 63.7 years(*World Health Statistics 2022*, n.d.). This was largely due to gains in maternal and child health, and to major investments and improvements in communicable disease programmes, such as HIV, tuberculosis, and malaria. However, the 2020 data shows how service disruptions contributed to an increase in deaths from tuberculosis and malaria between 2019 and 2020(*World Health Statistics 2022*, n.d.)

Tiase et al. (2020) conducted a scoping review on patient-generated health data (PGHD) and electronic health record (EHR) integration. Nineteen studies met inclusion criteria from 9463 abstracts screened. Most were pilots (2013-2019). PGHD types included biometric and patient activity (57.9%), questionnaires and surveys (36.8%), and health history (5.3%). Diabetes was the most common patient condition (42.1%) for PGHD collection. Active integration (57.9%) slightly outweighed passive integration (31.6%). Themes emerged on PGHD flow's 3 steps: resource requirements, data delivery to EHR, and review preferences.(Tiase et al., 2021)

Even before the impact of COVID-19, many health systems had significant limitations in reaching those with unmet medical needs.(González-Touya et al., 2021) The pandemic has revealed and exacerbated such pre-existing weaknesses and demonstrated the urgent need to build more resilient health systems worldwide(*Health System Resilience*, n.d.)

Digital health technologies offer new opportunities for assisting prevention, and early identification of life-threatening diseases, and management of chronic ailments outside of traditional healthcare settings.(Fan & Zhao, 2022) They can also enable consumers to make better-informed decisions about their health. Digital health technologies are being used by providers and other stakeholders to Reduce inefficiencies, improve access, reduce costs, increase quality, and make medicine more personalized for patients.(*What Is Digital Health? | FDA*, n.d.)

The use of digital technologies has become universal, and there has never been a time when the global population was more connected. Innovation is occurring on a scale that has never been seen before, especially in the digital arena. The potential for using digital health solutions is enormous, but its use to improve population health is yet relatively untouched. To speed up the attainment of global health and well-being, WHO is leveraging the potential of digital technology and health innovation.(*Digital Health*, n.d.-a)

The World Health Assembly adopted the WHO Global Strategy on Digital Health in 2020. It provides a path for tying the most recent innovations in innovation and digital health together and putting these tools to use to enhance health outcomes. Digital health is intended to enhance equal and universal access to high-quality healthcare as part of WHO's strategic vision. For health systems to provide high-quality, reasonably priced, and equally distributed treatment, digital health can help them become more sustainable and efficient.(*Digital Health*, n.d.-b)

These lofty goals are difficult to fulfill, especially in low-and middle-income countries. The Global Strategy on Digital Health of the WHO aims to assist nations in enhancing their healthcare systems via the use of digital health technology and to realize the goal of universal health coverage. All Member States, including those with restricted access to digital technology, commodities, and services, can implement the plan because it is intended to be effective for that purpose.(*Digital Health*, n.d.-b)

In the past few years, India has launched several initiatives in digital health. Pursuant to the Cabinet decision for full functional autonomy, the National Health Agency was reconstituted as the National Health Authority on 2nd January 2019, under Gazette Notification Registered No. DL –(N) 04/0007/2003-18. NHA has been set up to implement PM-JAY, as it is popularly known, at the national level. NHA is leading the implementation of the Ayushman Bharat Digital Mission (ABDM) in coordination with different ministries/departments of the Government of India, State Governments, and private sector/civil society organizations.(*NHA | Official Website Ayushman Bharat Digital Mission*, n.d.)

The Ayushman Bharat Digital Health Mission (ABHM) stands out, aiming to create a digital health ecosystem with unique health IDs, digitized health records, and a registry of doctors and health facilities. These initiatives represent a commitment to leveraging technology for healthcare transformation.(*Ayushman Bharat Digital Mission (ABDM)| National Portal of India*, n.d.)

Significance of study

The development and implementation of Digital Health Technologies (DHT)(Kim et al., 2023) by the healthcare ecosystem have advanced quickly as a result of this digitization. The word "digital biomarker" has been applied to a wide range of measurements as a result of the widespread use of DHTs.

To improve the assessment of scientific evidence for future digital biomarkers, our aim in this paper is to connect the definition of "digital biomarker" with clinical terminology now used to describe biomarkers and to identify potential use for enabling consistency in evidence development in digital health technology to make interoperable personal health data with Digital Biomarkers such as wearables.

Wearable devices monitor various fitness metrics such as heart rate, heart activity, and oxygen saturation level. These metrics provide valuable insights into an individual's physical activity, which is considered the most dependable indicator of their current health status. For many years, health researchers have been using body-worn sensors to track physical activity. Therefore, if clinical information from wearable devices could be directly transferred to electronic health record (EHR) software, individuals would enjoy numerous benefits in terms of wellness and well-being.

A person with a long-lasting illness often involves various healthcare tasks, such as visiting doctors, regularly checking vital signs, buying medications, undergoing laboratory tests, making dietary changes, and keeping track of their progress using digital biomarkers. Wearable devices equipped with IoT technology also assist doctors in monitoring the patient's real-time health data. The connected applications on these wearables provide doctors with easy access to the patient's medical history, enabling them to manage follow-ups more effectively.

Until now, a significant amount of data has been generated through digital biomarkers, but it has largely remained untapped. However, by consolidating this fragmented data and utilizing interoperability, we can analyze the data to benefit the patient. This information can be used to support decision-making, modify lifestyle and health behaviors, and improve clinical outcomes for patients.

The adherence to standardized protocols and specifications is of paramount importance in the realm of clinical data, as highlighted by the study "Practical Challenges in the Secondary Use of Real-World Data: The Notifiable Condition Detector" by Mustafa Fidahussein et all(2011). This study underscores the significance of adhering to standards such as HL7, LOINC, SNOMED CT, and UCUM in the context of electronic laboratory reporting and health information exchange. The study delves into the evaluation of healthcare transactions within a health information exchange, with a specific focus on supporting the automated detection of public health-notifiable diseases.(Fidahussein et al., 2011)

In the study titled "Personalized wearable systems for real-time ECG classification and healthcare interoperability" by Amit Walinjkar (2017), the focus is on advancing the capabilities of wearable biomedical devices for continuous health monitoring. While wearable health devices are common, the study addresses real-time analysis, prediction, and alert systems for potential health risks. Using ECG monitoring as an example, the research highlights signal processing, arrhythmia detection, and classification. The study leverages machine learning models with the MITDB arrhythmia database, achieving over 97% accuracy using kNN classifiers. The integration of FHIR standards and IoT devices enables real-time data exchange, promoting proactive healthcare interventions in the era of personalized monitoring.(Walinjkar & Woods, 2017)

The study by Po Yang et al. (2019) delves into the emerging field of multimodal wearable intelligence for dementia care within the context of Healthcare 4.0. This innovative approach, stemming from Ubiquitous Computing and IoT, is reshaping healthcare by transitioning from centralized systems to personalized ones, aligning with the Healthcare 4.0 framework. Despite its potential for improved elder care, especially for dementia patients, challenges like affordable sensors, device diversity, and interoperability persist. The research offers a comprehensive overview of advanced multimodal wearable technologies, examining their applications and successful cases in dementia care. The paper proposes a review framework, highlighting key technologies, and outlines future directions and obstacles in the Healthcare 4.0 landscape.(Yang et al., 2021)

In the 2019 study titled "Hapicare: A Healthcare Monitoring System with Self-Adaptive Coaching using Probabilistic Reasoning" by Hossain Kordestani et al., the focus is on addressing the needs of patients with chronic conditions by introducing a novel healthcare monitoring system called Hapicare. Unlike conventional methods, Hapicare employs ontology-based uncertain reasoning, utilizing IoT sensor data and patient self-assessments. While other solutions rely on fixed rules, Hapicare utilizes probabilistic reasoning, incorporating Bayesian and non-monotonic inference. This approach integrates Semantic Sensor Network and SNOMED-CT ontologies for non-monotonic inference. The system effectively manages uncertain contextual information from sensors and patient history, enabling accurate diagnosis and timely responses, even considering symptom overlaps, errors, and hidden information.(Kordestani et al., 2019)

Above reviewed literature underscores the pivotal role of clinical terminology in establishing a robust and resilient healthcare framework tailored to address the challenges posed by chronic and lifestyle diseases, facilitated by wearable technologies. The synthesis of various studies and scholarly contributions highlights the significance of accurate and standardized clinical terminology in ensuring seamless communication, data exchange, and interoperability among wearables and healthcare systems. This synthesis is particularly pertinent as wearables become integral tools for continuous health monitoring and early disease detection.

2. Methodology

The integration of EHRs with medical devices, such as wearable fitness and health trackers, is a novel feature provided by health systems. Although early device integration comprised tracking a small set of basic vital signs, as health systems attempt to meet new standards, adopt new treatment models, and take advantage of technological innovation, the scope of patient data has rapidly grown.(Dinh-Le et al., 2019)

Wearable technology such as wristbands, smartwatches wearable mobile sensors collect a variety of health information including vitals, blood sugar levels, exercise habits, sleep patterns, and mood. Patient data are gathered passively through sensors in apps that communicate with devices through application programming interfaces (APIs), or actively through consumer reporting. These data are then shared through data aggregators like Apple's HealthKit, which compiles data from various health apps.(Vijayan et al., 2021)

The use of clinical terminology in wearables can ensure accurate and standardized interpretation of health-related information. Through this, wearable devices can monitor vital signs, track activity levels, and detect anomalies, translating them into clinically relevant terms. SNOMED CT and LOINC is a comprehensive clinical terminology and wearable devices, on the other hand, refer to technologies worn on the body to collect health data. Combining SNOMED CT and LOINC with wearables can enhance healthcare by facilitating precise data capture and analysis for improved diagnostics and treatment.

Table 1 Health features Measured by Digital wearables and their mapping with SNOMED CT and Loinc

Heath Features in Digital Wearables	SNOMED CT Code	LOINC Code
Temperature	703421000 |Temperature (observable entity) |	8310-5 | Body temperature
Sleep, function	258158006 |Sleep, function (observable entity) |	28343-2 | Sleep And Rest Pattern Status [OMAHA]
ECG	271921002 |Electrocardiogram finding (observable entity) |	71575-5 | ECG NEMSIS
Heart rate	364075005 |Heart rate (observable entity) |	8867-4 | Heart rate
Blood oxygen	103228002 |Hemoglobin saturation with oxygen (observable entity) |	20564-1 | Oxygen saturation in Blood
Physical activity	68130003 |Physical activity (observable entity) |	82287-4 | Physical activity panel
Steps Count	129006008 |Walking (observable entity) |	41950-7 | Number of steps in 24 hour Measured

Source: Apple Watch Series, Garmin Venu, Fitbit Sense, Samsung Galaxy Watch, Fitbit Charge 5, Amazfit GTS 4 Mini, Redmi Smart Band Pro etc.

3. Results

By mapping clinical terminology, wearables can provide meaningful insights to both users and healthcare professionals. It enables the integration of wearable data into electronic health records and clinical decision support systems. This promotes effective communication between patients, caregivers, and healthcare providers, facilitating personalized and informed care in the realm of wearable technology.

Wearables, such as smartwatches and fitness trackers, have emerged as powerful tools in managing non-communicable diseases (NCDs). These compact devices provide continuous health monitoring and data collection, enabling individuals to track vital parameters like heart rate, blood pressure, sleep patterns, and physical activity levels. By syncing with smartphones and dedicated apps, wearables offer real-time feedback and personalized insights. They empower users to make informed decisions about their lifestyle choices, facilitating early detection of NCDs and promoting proactive health management.

Table 2 Lifestyle disease and their significant clinical observations

Life Style or non-communicable diseases	**Clinical Observation**	**Standard Terminology and Codes from SNOMED CT**	**LOINC Code**
Diabetes	Weekly exercise regime	229080003 |Exercise regime (regime/therapy) |	NA
	Blood sugar charts	405176005 |Blood glucose status (observable entity)|	41652-9 | Glucose [Mass/volume] in Venous blood
	Adherence to medication	713116003 |Monitoring adherence to medication regime (regime/therapy) |	
	Stress	405052004 |Level of stress (observable entity) |	93038-8 | Stress level
	vital signs	304495004 |Monitoring of blood pressure, temperature, pulse rate and respiratory rate (regime/therapy)|	74728-7 | Vital signs, weight, height, head circumference, oximetry, BMI, and BSA panel - HL7.CCDAr1.1
Hypertension	Adherence to medication	713116003 |Monitoring adherence to medication regime (regime/therapy) |	NA
	Blood pressure	75367002 |Blood pressure (observable entity)|	96607-7 | Blood pressure panel mean systolic and mean diastolic
	Stress	405052004 |Level of stress (observable entity)|	93038-8 | Stress level
	Sleep	258158006 |Sleep, function (observable entity)|	28343-2 | Sleep And Rest Pattern Status [OMAHA]
	Weekly exercise regime (Physical Activity)	229080003 |Exercise regime (regime/therapy)|	NA
	vital signs	304495004 |Monitoring of blood pressure, temperature, pulse rate and respiratory rate	NA

		(regime/therapy)|	
Cancer Disease	Adherence to medication	713116003 |Monitoring adherence to medication regime (regime/therapy) |	NA
	Stress	405052004 |Level of stress (observable entity)|	93038-8 | Stress level
	vital signs	304495004 |Monitoring of blood pressure, temperature, pulse rate and respiratory rate (regime/therapy)|	74728-7 | Vital signs, weight, height, head circumference, oximetry, BMI, and BSA panel - HL7.CCDAr1.1
Obesity	Calorie Burn	364395008 |Dietary intake (observable entity) |	
	Weekly exercise regime (Physical Activity)	229080003 |Exercise regime (regime/therapy)|	NA
	Stress	405052004 |Level of stress (observable entity)|	93038-8 | Stress level
	Sleep	258158006 |Sleep, function (observable entity)|	28343-2 | Sleep And Rest Pattern Status [OMAHA]

The use of digital wearables in diabetes management has revolutionized the way individuals monitor and control their condition.(Rodriguez-León et al., 2021) These innovative devices, such as smartwatches and glucose monitoring systems, offer real-time data and actionable insights. Digital wearables enable continuous tracking of blood glucose levels, physical activity, and sleep patterns, providing a comprehensive overview of the patient's health. They offer alerts and reminders for medication, exercise, and nutrition, promoting self-care and adherence to treatment plans. Furthermore, these wearables facilitate remote monitoring by healthcare professionals, allowing for timely interventions and personalized care. By empowering individuals with accurate information and improving communication between patients and healthcare providers, digital wearables play a vital role in enhancing diabetes management and overall well-being.(Sugandh et al., 2023)

The use of digital wearables has emerged as a promising approach to managing hypertension, a prevalent cardiovascular condition.(Dhingra et al., 2023) These wearable devices, such as smartwatches and fitness trackers, offer several benefits in monitoring and controlling blood pressure. They provide real-time data on heart rate, activity levels, and sleep patterns, allowing individuals to track their progress and make informed lifestyle choices. Furthermore, some wearables offer personalized feedback, reminders for medication intake, and stress reduction techniques, promoting self-management and adherence to treatment plans. By integrating technology into hypertension management, digital wearables empower individuals to take control of their health and improve their overall well-being.(Hare et al., 2021)

The use of digital wearables in cancer care has emerged as a promising avenue for improving patient outcomes and enhancing treatment management. These innovative devices, such as smartwatches and fitness trackers, offer various functionalities that can be leveraged in cancer management.(*Wireless Devices and Cancer Treatment Advances in Remote Monitoring*, n.d.) Wearables can monitor vital signs, physical activity, and sleep patterns, and provide real-time data to healthcare providers, enabling early detection of symptoms and timely interventions. Moreover, they promote patient engagement and self-care by empowering individuals to track their health and make informed decisions.(*Wireless Devices and Cancer Treatment Advances in Remote Monitoring*, n.d.) The integration of digital wearables in cancer care holds immense potential to enhance personalized treatment approaches and improve the overall quality of life for cancer patients.

Wearables have the potential to revolutionize healthcare by fostering self-awareness, encouraging preventive measures, and supporting remote patient monitoring, ultimately leading to improved outcomes and better quality of life for individuals affected by NCDs.

4. Conclusion

The integration of clinical terminology standard such as SNOMED CT and LOINC in digital wearables for the management of non-communicable diseases (NCDs) may bring numerous benefits. Firstly, it enables seamless interoperability between wearable devices and healthcare systems, allowing real-time exchange of patient data. This integration enhances care coordination and enables timely interventions for NCD management. Secondly, the standardized clinical terminology facilitates accurate and consistent coding of health information, ensuring proper documentation and effective data analysis. This leads to improved clinical decision-making and personalized care delivery. Overall, the integration of LOINC and SNOMED CT clinical terminology in digital wearables empowers individuals in managing NCDs while facilitating healthcare professionals in delivering optimal care.

Declarations

Competing Interests: The authors declare no competing interests.

Disclaimer: Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors.

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