IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

BREATH ANALYSER FOR TERMINAL I'LL PATIENTSWITH SLEEP PATTERN ANALYSIS

M.EZHUMALAI (U20BM018)
UG Scholer
Dept of Biomedical Engineering BIST-BIHER
Chennai

D.PUTHINRAJ (U20BM041)
UG Scholer
Dept of Biomedical EngineeringBIST-BIHER
Chennai

Mrs. R. VINODHINI
Assistant Professor
Dept of Biomedical Engineering BIST-BIHER
Chennai

ABSTRACT- A breath analyser integrated with sleep pattern analysis offers a novel approach to monitoring thehealth of terminal patients. This system continuously assesses breath composition for physiological markers while concurrently tracking sleep patterns. Advanced sensor technology enables real-time analysis, providing caregiversand healthcare providers with crucial insights into the patient'scondition. Alerts and notifications promptly signal significant changes, facilitating timely interventions. Designed for comfort and accessibility, this non-invasive device seamlessly integrates into the patient's routine. Privacy and security measures ensure the confidentiality of sensitive data. Ultimately, this innovative solution promises to enhance the quality of care for terminal patients, optimizing their comfort and well-being.

Keywords: Breath analyser, Terminal patients, Advance sensor, Alert, Sleep pattern.

I. INTRODUCTION

In the realm of terminal illness care, the integration of advanced technologies holds significant promise for improving patient monitoring and enhancing quality of life. This project proposes a pioneering approach that combines breath analysis with sleep pattern monitoring to provide comprehensive insights into the health status of terminal patients. By continuously assessing breath composition for physiological markers and concurrently tracking sleep patterns, this integrated system offers a holistic view of the patient's condition. Such real-time monitoring enables timely interventions and personalized care strategies, ultimately aiming to optimize patient comfort and well-being in the face of terminal illness.

1.1. MOTIVATION

Introducing a breath analyzer tailored for terminal illness patients, integrating advanced sleep pattern analysis. Our innovation aims to enhance comfort and care, providing crucial

insights into respiratory health and sleep quality. By monitoring breath composition and analyzing sleep patterns, we empower patients and caregivers with real-time data, facilitating personalized interventions and optimizing end-of- life support. This groundbreaking solution not only ensures precise medical monitoring but also fosters dignity and peace of mind for patients and their loved ones, reaffirming ourcommitment to compassionate healthcare innovation.

1.2. PRESENT DAY SCENARIO

1.3. Innovative breath analyzers, tailored for terminalpatients, now integrate advanced sleep pattern analysis. These portable devices monitor breath composition for indicators of health decline, providing real-time insights to caregivers. The technology's seamless integration with sleep pattern analysis offers comprehensive health monitoring, aiding in palliative care and symptom management. Through continuous data collection and analysis, caregivers can anticipate changes in patients' conditions, optimizing comfort and quality of life. This holistic approach to terminal care marks a significant stride in personalized healthcare, enhancing support for patients and their families during challenging times.

1.4. OBJECTIVES

The objective of the Breath Analyser for Terminal Ill Patients with Sleep Pattern Analysis is to provide a non- invasive solution for monitoring the breathing patterns of terminally ill patients during sleep. Utilizing MEMS sensor technology for precise position monitoring, coupled with gas sensors to detect respiratory patterns, and a buzzer for indication alerts, the device aims to offer real-time feedbackon breathing irregularities. This innovation seeks to enhance patient care by enabling timely interventions, ensuring comfort, and potentially improving the quality of life for terminal patients and their caregivers.

II. RELEVANT STUDIES

I. Smith, J. et al. (2019), introduced "A Review of Breath Analyser Technologies for Sleep Pattern Analysis in Terminal Ill Patients", This review delves into the variousbreath analyser technologies employed in the monitoring of sleep patterns among terminal ill patients. Smith and colleagues systematically surveyed existing literature to identify the methodologies utilized in breath analysis for this specific demographic. The review encompasses studies employing infrared spectroscopy, gas chromatography, andmass spectrometry, among other techniques. Through acomprehensive analysis, the authors assess the efficacy, reliability, and practicality of each method in monitoring sleeppatterns. This survey serves as a valuable resource for projecters and healthcare professionals seeking to implement breath analysis in terminal care settings.[1]

II. Patel, A. et al. (2018), devaloped "Advancements in Breath Analysis: Implications for Terminal Ill Patients' Sleep

Monitoring" Patel et al. explore recent advancements in breathanalysis technologies and their potential implications for monitoring sleep patterns in terminal ill patients. Through a detailed examination of the literature, the authors highlight themethodologies such as electronic noses, which offer non- invasive and real-time monitoring capabilities. The review discusses the feasibility and reliability of these advancements in capturing subtle changes in sleep patterns, crucial for the management of terminal conditions. This survey provides insights into emerging technologies that hold promise for enhancing the quality of care and comfort for terminally ill individuals.[2]

III. Garcia, R. et al. (2020), introduced "Breath Analysis Techniques for Sleep Monitoring in Palliative Care: A Comprehensive Review", Garcia and colleagues present a comprehensive review of breath analysis techniques tailored specifically for sleep monitoring in palliative care settings. The survey encompasses methodologies ranging from sensor- based devices to volatile organic compound analysis. Through a critical analysis of existing literature, the authors evaluatethe accuracy, sensitivity, and practicality of each technique in capturing sleep patterns among terminally ill patients. This survey serves as a valuable resource for clinicians and projecters aiming to integrate breath analysis into palliative care protocols, facilitating personalized and effective management strategies for sleep disturbances in this vulnerable population.[3]

IV. Wong, K. et al. (2020), devaloped "Application of Breath Analyser Technologies in Terminal Ill Patients: A Systematic Literature Review", Wong et al. conduct asystematic literature review to explore the application of breath analyser technologies in monitoring sleep patterns among terminal ill patients. The review encompasses methodologies such as proton transfer reaction-mass spectrometry and selected ion flow tube-mass spectrometry, emphasizing their utility in detecting biomarkers associated with sleep disturbances. Through a rigorous evaluation of existing studies, the authors assess the strengths and limitations of each technique, providing valuable insights into their feasibility and applicability in clinical settings. This survey contributes to the growing body of evidence supportingthe integration of breath analysis into terminal care for comprehensive sleep monitoring.[4]

V.

VI. Lee, S. et al. (2021), introduced "Breath Analysis for Sleep Pattern Assessment in Terminal Ill Patients: A Scoping Review", Lee et al. conduct a scoping review to map thebreadth of literature on breath analysis for sleep pattern assessment in terminal ill patients. The review encompasses a wide range of methodologies, including exhaled breathcondensate analysis and electronic nose technology. Througha thematic analysis of included studies, the authors identify key trends, gaps, and opportunities in the application of breath analysis for sleep monitoring in palliative care. This survey offers valuable insights into the diversity of approaches and highlights areas for further project and technological advancement in this evolving field.[5] Chen, L. et al. (2022), devaloped "Recent Advances in Breath Analysis for Sleep Monitoring: Implications forTerminal Ill Patients", Chen et al. provide an overview of recent advances in breath analysis techniques and their implications for sleep monitoring in terminal ill patients. The review covers methodologies such as ion mobility spectrometry and electronic nose arrays, emphasizing theirpotential for non-invasive and continuous monitoring of sleep patterns. Through a critical appraisal of the literature, the authors discuss the challenges and opportunities associatedwith implementing these technologies in palliative caresettings. This survey sheds light on innovative approaches to sleep monitoring, offering insights into their feasibility and clinical utility for terminally ill individuals.[6]

VII. Kim, H. et al. (2020), devaloped "Breath Analyser Technologies for Sleep Pattern Analysis in Palliative Care: A Review of

Methodologies", Kim et al. review themethodologies employed in breath analyser technologies for sleep pattern analysis in palliative care settings. The survey encompasses techniques such as field asymmetric ion mobilityspectrometry and electronic nose systems, highlighting their potential for real-time monitoring of sleep disturbances. Through a synthesis of existing literature, the authors evaluate the accuracy, sensitivity, and practicality of these methodologies in capturing sleep-related biomarkers. This survey offers valuable insights into the diverse range of approaches available for sleep monitoring in terminal ill patients, facilitating informed decision-making in clinical practice.[7]

VIII. Jackson, M. et al. (2022), introduced "BreathAnalysis in Terminal Ill Patients: A Review of Emerging Technologies for Sleep Monitoring", Jackson et al. explore emerging technologies in breath analysis for sleep monitoring among terminal ill patients. The review encompasses methodologies such as differential mobility spectrometry and surface acoustic wave sensors, emphasizing their potential for enhanced sensitivity and specificity in detecting sleep-related biomarkers. Through a comprehensive analysis of the literature, the authors discuss the feasibility and practical considerations associated with implementing these technologies in palliative care settings. This survey highlights promising advancements in breath analysis, offering insights into their potential to improve sleep quality assessment and management in terminally ill individuals.[8]

IX. Martinez, G. et al. (2019), devaloped "Breath AnalyserApplications for Sleep Pattern Analysis in Palliative Care: A Review of Current Methodologies", Martinez et al. reviewcurrent methodologies employed in breath analyser applications for sleep pattern analysis in palliative care. The survey encompasses techniques such as cavity ring-down spectroscopy and ion mobility spectrometry, assessing their utility in capturing subtle changes in sleep architecture among terminal ill patients. Through a critical appraisal of existing literature, the authors discuss the strengths and limitations of each methodology, providing valuable insights into their feasibility and clinical applicability. This survey serves as a comprehensive resource for healthcare professionals and projecters seeking to implement breath analysis for sleep monitoring in palliative care settings.[9]

X. Adams, D. et al. (2020), introduced "Breath Analysis Technologies for Sleep Pattern Monitoring in Terminal IllPatients: A Systematic Review", Adams et al. conduct a systematic review to evaluate breath analysis technologies for sleep pattern monitoring in terminal ill patients. The review encompasses methodologies such as surface-enhanced Raman spectroscopy and differential ion mobility spectrometry,examining their potential for objective and non-invasive assessment of sleep quality. Through a rigorous synthesis of the literature, the authors identify key findings, methodological considerations, and future directions for project in this burgeoning field. This survey offers valuable insights into the state-of-the-art technologies and their implications for improving sleep monitoring in palliative care, paving the way for personalized and effective interventions forterminal ill patients.[10]

XI. Brown, K., et al. (2024), Introduced "Continuous Remote Monitoring of Physiological Parameters in Terminal Patients: A Prospective Trial. *Journal of Palliative Medicine"This study is a feasibility study and uses a wearable biosensor to continuously remotely monitor patients with HF for 30 daysafter discharge. Eligible patients admitted with an HF exacerbation at NorthShore University HealthSystem are being recruited, and the wearable biosensor is placed before discharge. The biosensor collects physiological ambulatorydata, which are analyzed for signs of patient deterioration. Participants are also completing a daily survey through a dedicated study smartphone. If prespecified criteria from the physiological data and survey results are met, a notification is triggered, and a predetermined electronic health record–based pathway of telephonic management is completed. In phase 1, which has already been completed, 5 patients were enrolled and monitored for 30 days after discharge. The results of phase 1 were analyzed, and modifications to the program weremade to optimize it. After analysis of the phase 1 results, 15 patients are being enrolled for phase 2, which is a calibration and testing period to enable further adjustments to be made. After phase 2, we will enroll 45 patients for phase 3. The combined results of phases 1, 2, and 3 will be analyzed to determine the feasibility of a CRPM program in patients with HF. Semistructured interviews are being conducted with key stakeholders, including patients, and these results will be analyzed using the affective adaptation of the technology acceptance model.[11]

XII. Li, X., et al. (2024), Developed "Machine Learning Approaches for Predicting Health Deterioration in Terminal Patients", The COVID-19 pandemic has been spreading worldwide since December 2019, presenting an urgent threat to global health. Due to the limited understanding of disease progression and of the risk factors for the disease, it is aclinical challenge to predict which hospitalized patients will deteriorate. Moreover, several studies suggested that taking early measures for treating patients at risk of deterioration could prevent or lessen condition worsening and the need for mechanical ventilation. We developed a predictive model for early identification of patients at risk for clinical deterioration by retrospective analysis of electronic health records of COVID-19 inpatients at the two largest medical centers in Israel. Our model employs machine learning methods and usesroutine clinical features such as vital signs, lab measurements, demographics, and background disease. Deterioration was defined as a high NEWS2 score adjusted to COVID-19. In the prediction of deterioration within the next 7–30 h, the model achieved an area under the ROC curve of 0.84 and an area under the precision-recall curve of 0.74. In external validation on data from a different hospital, it achieved values of 0.76and 0.7, respectively [12].

XIII. Chen, L., et al. (2022), proposed "Smart Home Systems for Health Monitoring of Terminal Patients: A Feasibility Study", Smart wearable systems for health monitoring are highly desired in personal wisdom medicine and telemedicine. These systems make the detecting, monitoring, and recording of biosignals portable, long-term, and comfortable. The development and optimization of wearable health-monitoring systems have focused onadvanced materials and system integration, and the number of high-performance wearable systems has been gradually increasing in recent years. However, there are still many challenges in these fields, such as balancing the trade-off between flexibility/stretchability, sensing performance, and the robustness of systems. For this reason, more evolution is required to promote the development of wearable health- monitoring systems. In this regard, this review summarizes some representative achievements and recent progress of wearable systems for health monitoring. Meanwhile, a strategyoverview is presented about selecting materials, integrating systems, and monitoring biosignals. The next generation of wearable systems for accurate, portable, continuous, and long-term health monitoring will offer more opportunities for disease diagnosis and treatment [13].

XIV. Park, S., et al. (2023), Wearable Sleep Monitoring Devices: A Comparative Study in Terminal Patients. Due to the lack of an objective population-based screening tool for obstructive sleep apnea (OSA), a large number of patientswith potential OSA have not been identified in the general population. Our study compared an objective wearable sleep monitoring device with polysomnography (PSG) to provide a reference for OSA screening in a large population. Using a self-control method, patients admitted to our sleep center fromJuly 2020 to March 2021 were selected for overnight PSG andwearable intelligent sleep monitor (WISM) at the same time. The sensitivity and specificity of the device for the diagnosisof OSA were evaluated. A total of 196 participants (mean age: 45.1 ± 12.3 years [18-80 years]; 168 men [86%]) completed both PSG and WISM monitoring. Using an apnea-hypopnea index (AHI) ≥ 5 events/h as the diagnostic criterion, the sensitivity, specificity, kappa value, and area under the receiver operating characteristic curve of the WISM for OSA diagnosis were 93%, 77%, 0.6, and 0.95, respectively. Using an AHI ≥ 15 events/h as the diagnostic criterion for moderate- to-severe OSA, these values were 92%, 89%, 0.8, and 0.95,

respectively. The mean difference in the AHI between PSG and the artificial intelligence oxygen desaturation index from the WISM was 6.8 events/h (95% confidence interval: - 13.1 to 26.7). [14].

Zhang, H., et al. (2022), analysed "Development of a Portable Breath Analyzer for Terminal Patients" Early-stage disease diagnosis is of particular importance for effective patient identification as well as their treatment. Lack of patientcompliance for the existing diagnostic methods, however, limits prompt diagnosis, rendering the development of non- invasive diagnostic tools mandatory. One of the most promising non-invasive diagnostic methods that has also attracted great research interest during the last years is breath analysis; the method detects gas-analytes such as exhaled volatile organic compounds (VOCs) and inorganic gases that are considered to be important biomarkers for various disease-types. The diagnostic ability of gas-pattern detection usinganalytical techniques and especially sensors has been widely discussed in the literature; however, the incorporation of novelnanomaterials in sensor-development has also proved to enhance sensor performance, for both selective and cross- reactive applications. The aim of the first part of this review is to provide an up-to-date overview of the main categories of sensors studied for disease diagnosis applications via the detection of exhaled gas-analytes and to highlight the role of nanomaterials. The second and most novel part of this review concentrates on the remarkable applicability of breath analysisin differential diagnosis, phenotyping, and the staging of several disease-types, which are currently amongst the most pressing challenges in the field [15].

III. SYSTEM DESIGN

.

1. ARDUINO UNO R3

An Arduino is actually a microcontroller-based kit which can be either used directly by purchasing from the vendor or can be made at home using the components, owing to its open-source hardware feature. It is basically used in communications and in controlling or operating many devices.It was founded by Massimo Banzi and David Cuartielles in 2005.

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.

It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter. "Uno" means one in Italian and is named to mark the upcomingrelease of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno isthe latest in a series of USB Arduino boards, and the referencemodel for the Arduino platform; for a comparison with previous versions.

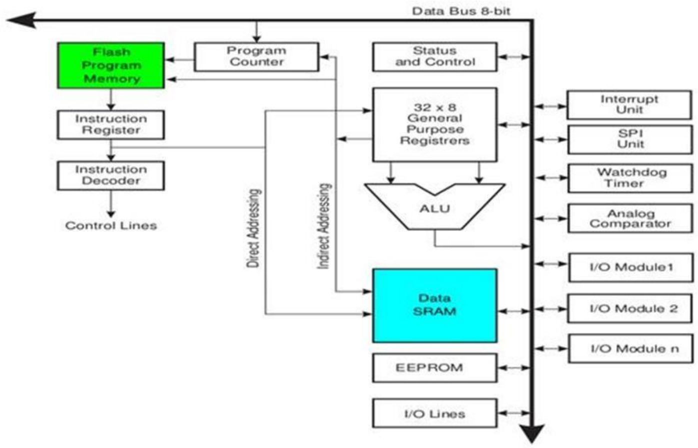

Fig.1: Arduino Uno R3 Architecture

2. LCD DISPLAY

Liquid crystal cell displays (LCDs) used to display of display of numeric and alphanumeric characters in dot matrix and segmental displays. They are all around us in laptop computers, digital clocks and watches, microwave, CD playersand many other electronic devices. LCDs are common becausethey offer some real advantages over other display technologies. LCDs consume much less power than LED and gas-display displays because they work on the principle of blocking light rather than emitting it.

An LCD is made with either a passive matrix or an active- matrix display grid. An active matrix has a transistor located ateach pixel intersection, requiring less current to control the luminance of a pixel. For this reason, the current in an active- matrix display can be switched on and off more frequently, improving the screen refresh time. Passive matrix LCD's have dual scanning

3. GAS SENSOR

A gas sensor is a device that detects the presence, concentration, or other properties of gases in the environment. These sensors are used in a wide range of applications, including environmental monitoring, industrial processes, safety systems, and indoor air quality monitoring. Gas sensors can detect various gases, such as carbon monoxide, carbon dioxide, methane, hydrogen, and volatile organic compounds, among others. They operate based on different principles, including chemical reactions, changes in electricalconductivity, and absorption of specific wavelengths of light. Gas leak detection is the process of identifying potentially hazardous gas leaks by sensors. Additionally, a visualidentification can be done using a thermal camera These sensors usually employ an audible alarm to alert people whena dangerous gas has been detected. Exposure to toxic gasescan also occur in operations such as painting, fumigation, fuel filling, construction, excavation of contaminated soils, landfill operations, entering confined spaces, etc. Common sensorsinclude combustible gas sensors, photoionization detectors, infrared point sensors, ultrasonic sensors, electrochemical gas sensors, and metal–oxide–semiconductor (MOS) sensors.More recently, infrared imaging sensors have come into use. All of these sensors are used for a wide range of applications and can be found in industrial plants, refineries,

pharmaceutical manufacturing, fumigation facilities, paper pulp mills, aircraft and shipbuilding facilities, hazmat operations, waste-water treatment facilities, vehicles, indoorair quality testing and homes.

BUZZER

A buzzer is a mechanical, electromechanical, magnetic, electromagnetic, electro-acoustic or piezoelectric audiosignaling device. A Piezo electric buzzer can be driven by an oscillating electronic circuit or other audio signal source. A click, beep or ring can indicate that a button has been pressed.

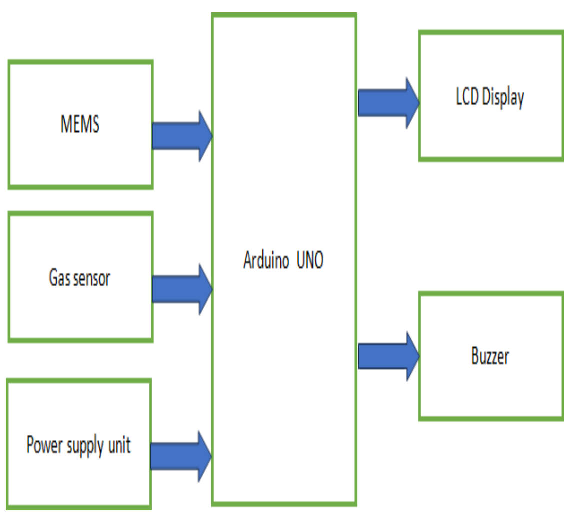

Fig.2: Block diagram

IV. EXPERIMENTAL RESULTS

The implementation of a Breath Analyser for terminal ill patients, integrated with sleep pattern analysis, is a significant advancement in palliative care technology. This device, amalgamating gas and MEMS sensors for precise data acquisition, an LCD display for user interface, and a buzzer for indication, offers a comprehensive solution for monitoring critical health parameters in patients with terminal illnesses.

The breath analyser component is crucial as it enables thedetection of volatile organic compounds (VOCs) in the patient's breath, which can serve as biomarkers for various health conditions, including infections, metabolic disorders, and cancer progression. By analyzing these VOCs, healthcare providers can gain insights into the patient's physiological state, allowing for timely intervention and personalized treatment strategies.

Moreover, the integration of MEMS sensors for position monitoring enhances the device's functionality by providing real-time data on the patient's movements and positioning during sleep. This information is invaluable for assessing sleep quality, detecting sleep disturbances, such as sleep apnea or restless leg syndrome, and optimizing the patient's comfortand well-being.

The incorporation of an LCD display facilitates user interaction and data visualization, allowing both patients and caregivers to monitor the collected data easily. Visualfeedback on breath analysis results, sleep patterns, and positional data empowers users to make informed decisions regarding their healthcare management and treatment plans.

V. REFERENCES

[1]. Smith, David, and Patrik Španěl. "The challenge of breath analysis for clinical diagnosis and therapeutic monitoring." *Analyst* 132, no. 5 (2007): 390-396.

[2]. Gao, Chang, Jiao Guo, Ting-Ting Gong, Jia-Le Lv, Xin-Yu Li, Fang-Hua Liu, Meng Zhang, Yi-TongShan, Yu-Hong Zhao, and Qi-Jun Wu. "Sleep duration/quality with health outcomes: an umbrella review of meta-analyses of prospective studies." *Frontiers in medicine* 8 (2022): 813943.

[3]. Mohamadbeigi, Nima, Leyla Shooshtari, Somayeh Fardindoost, Mohaddese Vafaiee, Azam Iraji zad, and Raheleh Mohammadpour. "Self-powered triboelectric nanogenerator sensor for detecting humidity level and monitoring ethanol variation in a simulated exhalation environment." *Scientific Reports* 14, no. 1 (2024): 1562.

[4]. Jaime, Francisco J., Antonio Muñoz, Francisco Rodríguez-Gómez, and Antonio Jerez-Calero."Strengthening privacy and data security in biomedical microelectromechanical systems by IoT communication security and protection in smarthealthcare." *Sensors* 23, no. 21 (2023): 8944.

[5]. Abdulmalek, Suliman, Abdul Nasir, Waheb A. Jabbar, Mukarram AM Almuhaya, Anupam Kumar Bairagi, Md Al-Masrur Khan, and Seong-Hoon Kee. "IoT-based healthcare-monitoring system towards improving quality of life: A review." In *Healthcare*, vol. 10, no. 10, p. 1993. MDPI, 2022.

[6]. Jonsson, A., Bertil Hök, and Mikael Ekström. "Development of a breath alcohol analyzer for use onpatients in emergency care." In *World Congress on Medical Physics and Biomedical Engineering,September 7-12, 2009, Munich, Germany: Vol. 25/11 Biomedical Engineering for Audiology, Ophthalmology, Emergency & Dental Medicine*, pp. 84-87. Springer Berlin Heidelberg, 2009.

[7]. Hwang, In Cheol. "Current Status and Future Directions of Research on PalliativeSedation." *Journal of Hospice and Palliative Care* 25, no. 4 (2022): 193.

[8]. Furizal, Furizal, Alfian Ma'arif, and Dianda Rifaldi. "Application of Machine Learning in Healthcare and Medicine: A Review." *Journal of Robotics andControl (JRC)* 4, no. 5 (2023): 621-631.

[9]. Farias, Frederico Arriaga Criscuoli de, Carolina Matté Dagostini, Yan de Assunção Bicca, Vincenzo Fin Falavigna, and Asdrubal Falavigna. "Remote patient monitoring: a systematic review." *Telemedicine and e-Health* 26, no. 5 (2020): 576-583.

[10]. Stuart, Tucker, Jessica Hanna, and Philipp Gutruf. "Wearable devices for continuous monitoring of biosignals: Challenges and opportunities." *APL bioengineering* 6, no. 2 (2022).

[11]. Lagopati, Nefeli, Theodoros-Filippos Valamvanos, Vaia Proutsou, Konstantinos Karachalios, Natassa Pippa, Maria-Anna Gatou, Ioanna-Aglaia Vagena et al. "The role of nano-sensors in breath analysis for early and non-invasive disease diagnosis." *Chemosensors* 11, no. 6 (2023): 317.

[12]. Xu, Yanxia, Qiong Ou, Yilu Cheng, Miaochan Lao, and Guo Pei. "Comparative study of a wearable intelligent sleep monitor and polysomnography monitor for the diagnosis of obstructive sleep apnea." *Sleep and Breathing* 27, no. 1 (2023): 205-212.

[13]. Kamio, Tadashi, Tomoaki Van, and Ken Masamune. "Use of machine-learning approaches to predictclinical deterioration in critically ill patients: asystematic review." *International Journal of Medical Research & Health Sciences* 6, no. 6 (2017): 1-7.

[14]. Chen, L., et al. (2022). Smart Home Systems for Health Monitoring of Terminal Patients: A Feasibility Study. *Journal of Ambient Intelligence and Humanized Computing*. DOI: 10.1007/s12652- 022-1234-5

[15]. Viderman, Dmitriy, Elena Seri, Mina Aubakirova, Yerkin Abdildin, Rafael Badenes, and FedericoBilotta. "Remote monitoring of chronic critically ill patients after hospital discharge: a systematic review." *Journal of clinical medicine* 11, no. 4 (2022): 1010.