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WanderWatch: A Market-Ready Wearable Alert System Enhancing Safety and Reducing Costs in Dementia Care Industry

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Abstract

Dementia affects millions worldwide and poses a growing global health challenge, with a new diagnosis occurring every three seconds. Symptoms typically begin around age 65, often starting with memory loss that interferes with daily activities such as navigation—raising serious safety concerns. This study aims to enhance patient safety and reduce caregiver burden by providing timely alerts when a patient leaves the home, minimizing the need for constant supervision.

To address this, the project introduces WanderWatch, a wearable alert device specifically designed for individuals with dementia. Testing showed that WanderWatch significantly reduced response times, achieving a substantial improvement over baseline methods and enhancing the effectiveness of caregiver notifications. In addition to its performance, WanderWatch is notably more affordable than comparable technologies, offering a cost-effective solution for families and care providers.

The device's initial detection range of 20 meters was optimized to three feet to improve precision and reduce false alarms. This refinement ensures more accurate detection and timely alerts, making WanderWatch a reliable and practical tool for improving dementia patient monitoring and supporting caregiver efforts.

Keywords: Dementia; Wearable technology; Wanderwatch; Patient safety

1. Introduction

Dementia is a growing global health issue, affecting nearly every country worldwide. According to Alzheimer's Disease International, someone develops dementia every three seconds, and as of 2024, more than 55 million people are living with the condition globally (1). Symptoms typically begin around the age of 65, with affected individuals experiencing difficulties in routine tasks such as navigation and memory recall.

One particularly dangerous symptom is wandering, where patients may leave their homes unsupervised. This behavior puts them at significant risk of becoming lost, confused, injured, or fatally exposed to environmental hazards. Studies indicate that approximately six in ten dementia patients are likely to wander when disoriented (2). In Japan alone, there were around 16,000 reported dementia-related wandering cases as of 2020 (3).

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The Philippines is not exempt from this issue. The country reports an incidence rate of 16 dementia cases per 1,000 individuals, and with a growing elderly population, the urgency to address dementia-related wandering increases (4).

Although the exact cause of wandering is not fully understood, a likely contributor is sundowning syndrome—a phenomenon characterized by increased agitation and restlessness in the late afternoon or evening (5). Since wandering can occur unpredictably, caregivers face challenges in maintaining constant supervision, particularly during nighttime.

Previous interventions have attempted to address this problem. Automated doors in care facilities have been used to restrict movement, but they may also cause agitation in patients who feel confined (6). This emphasizes the need for a more sophisticated, technology-driven solution that can balance patient freedom with safety.

Devices such as the Safe-Life Medical Alarm 4G and the Safe-Life Watch Alarm 4G use GPS to track patients in real-time (7). Smart home solutions like bed mats and floor sensors have also been implemented to notify caregivers when a patient moves (8). However, these tools often depend on reliable internet connectivity and may suffer from false alarms, reducing their overall effectiveness.

In response to these challenges, this study introduces a wearable, door-activated alert system specifically designed for individuals with dementia. The system aims to automate alerts when a patient exits a designated area, thereby reducing the need for constant direct supervision and improving both patient safety and caregiver peace of mind.

This research highlights how technology can offer a safer, more reliable, and practical solution for monitoring dementia patients, thus minimizing the risks of wandering-related accidents. It represents a significant step toward improving care outcomes and ensuring a secure environment for individuals living with dementia.

2. Review of related literature

Wandering is a frequent behavior among individuals with dementia. Once this behavior emerges, the risk of serious harm—such as falls, dehydration, exhaustion, traffic accidents, and getting lost—increases significantly (9). Historically, caregivers have relied on manual supervision to manage this risk, but modern technologies have been developed to support caregiver efforts and improve patient safety.

Globally, 46.8 million people were affected by dementia in 2015, a number expected to rise substantially by 2050. In Indonesia, cases are projected to reach 4 million due to increased life expectancy (10). Although local data is limited, known risk factors include age, genetics, diabetes, hypertension, and lifestyle-related causes.

Dementia is strongly associated with aging and neurodegeneration. By 2030, global dementia cases are expected to reach 66 million, with 71% occurring in low- and middle-income countries by 2050 (11). Up to 35% of cases may be preventable by addressing midlife health risks such as hypertension, diabetes, and depression (12).

Approximately 60% of dementia patients exhibit wandering behavior, and nearly half of those who go missing for more than 24 hours suffer severe injury or death (13). Technological solutions like GPS trackers and fingernail barcodes help caregivers quickly locate missing individuals. Elopement management systems (EMS), for example, notify caregivers when patients leave specific areas and can automatically lock doors or sound alarms. However, these systems often require a stable internet connection, which may not be universally available (14). Locking exits entirely may reduce risk but can lead to distress or aggressive behavior in patients due to cognitive limitations (15).

Preventive strategies have evolved from symptom-focused care to lifestyle-based approaches that emphasize physical activity, mental stimulation, and nutrition. However, critics argue this model places excessive responsibility on individuals and overlooks social and systemic influences (16). Personalized care plans now integrate medical, psychological, and social support, but health disparities still challenge widespread implementation. Up to 40% of dementia cases could be prevented by addressing 12 modifiable risk factors (17).

Castro et al. found that two-thirds of interventions combining diet, physical activity, and cognitive stimulation improved cognitive outcomes in older adults, though results varied and some studies reported no significant benefits (18). Dietary recommendations include increased intake of fruits, vegetables, and whole grains, and reduced sugar consumption.

Gopalkumar et al. support a holistic prevention model that emphasizes community-based programs, early intervention, and policy reform to make care accessible and effective (19).

Wigg compared environments with locked versus unlocked doors and found that while locked doors reduce wandering, they also increase aggression. Unlocked doors provide autonomy but raise the risk of patients going missing, suggesting that safety protocols must strike a balance between physical security and emotional well-being (20).

Studies estimate that 40% of dementia patients will become lost at some point, with about 5% doing so repeatedly, sometimes with fatal consequences. Caregivers often resort to confinement, but this can be dangerous during emergencies such as fires. GPS tracking devices offer a safer alternative by allowing mobility while reassuring caregivers (21).

Smart home technologies are also effective in mitigating nighttime wandering, a high-risk period. Movement-monitoring devices improve both safety and caregiver well-being (8). Populations in low- and middle-income countries, and disadvantaged groups in wealthy nations, remain most at risk. Around 30–40% of cases link to modifiable factors such as smoking and inactivity. Mobile health technologies, such as smartphone apps, may help extend preventive care to underserved populations (22).

Miskelly proposed a bracelet system adapted from prison monitoring devices that alerts caregivers when a patient leaves a designated area (23). While effective, it relies on outdated pager systems, raising concerns about responsiveness and compatibility with modern technologies.

Safe-Life's GPS-enabled pendant offers real-time tracking and has undergone multiple revisions to enhance reliability (7). Another solution includes floor mat sensors that activate alarms and play calming pre-recorded messages when a patient steps out of bed. After 12 weeks of use, these systems demonstrated potential to reduce caregiver stress and improve safety (24).

Wearable technologies now play a significant role in dementia care. Their lightweight, hands-free design ensures continuous comfort and usability, enhancing both safety and caregiver peace of mind (25).

3. Methodology

3.1. Research Design

This study will use the developmental-experimental research design to systematically design, develop, and evaluate the effectiveness of the WanderWatch system in enhancing patient safety and caregiver responsiveness for individuals with dementia. This approach combines elements of both developmental research, which focuses on understanding changes over time, and experimental research, which tests the effectiveness of interventions.

3.2. Research Instrument

The study will utilize Incident Report Logs to meticulously document any incidents of wandering. These logs will capture critical information, including the timing of alerts received from the WanderWatch, caregiver response times, accuracy, and implementation cost. This structured approach will facilitate a comprehensive understanding of the system's effectiveness in real-world scenarios, and statistical Analysis Tools will be developed to analyze the quantitative data gathered from both the questionnaires and incident logs.

3.3. Sampling

The researcher will apply purposive sampling. Respondents in the survey will be chosen specifically by the researcher. In this method, the researchers can select cases that will best contribute to the data collection.

3.4. Locale

This study was conducted in a private establishment where the study could be conducted properly and effectively. The location of the establishment is on Purok 3, Cambanogoy, Asuncion, Davao del Norte.

3.5. Data Gathering Procedure / Evaluation of the Project

These procedures will be carried out by the researcher to obtain the needed data that determined the level of functionality and efficiency of the Door-Activated wearable alert system

- Sent a letter request to private establishments/locations to conduct the study.

- Provided orientation session to the respondents for them to know the details and intension of the study to be conducted.
- Gathered the data needed for the study by providing the incident report logs.
- Retrieved the fill-out incident report logs.
- Provided statistical treatment of the gathered data.

3.6. Statistical Treatment and Analysis of Data

Upon gathering the data, the mean of the result will be assessed and analyzed.

Median / Wilcoxon Signed Ranks Test The median will be calculated, and the Wilcoxon Signed Ranks Test will be interpreted to compare two populations using two matched samples. This computation is relevant to determine how effective and consistent the device is working in terms of Response time.

3.7. Development and evaluation of the project

Figure 1 illustrates the complete concept design of WanderWatch, a door-activated wearable alert system for patients with dementia during the development phase.

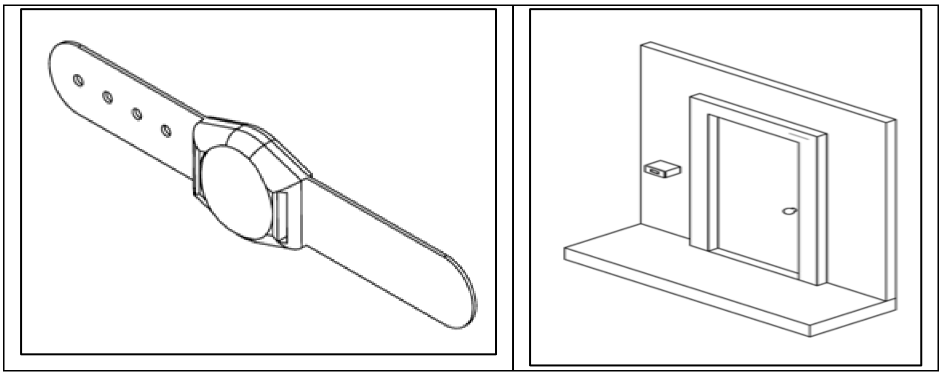

Figure 1 Isometric view

Figure 2 illustrates the assembling parts of the device of the WanderWatch, Door Sensor and description table of assembling parts.

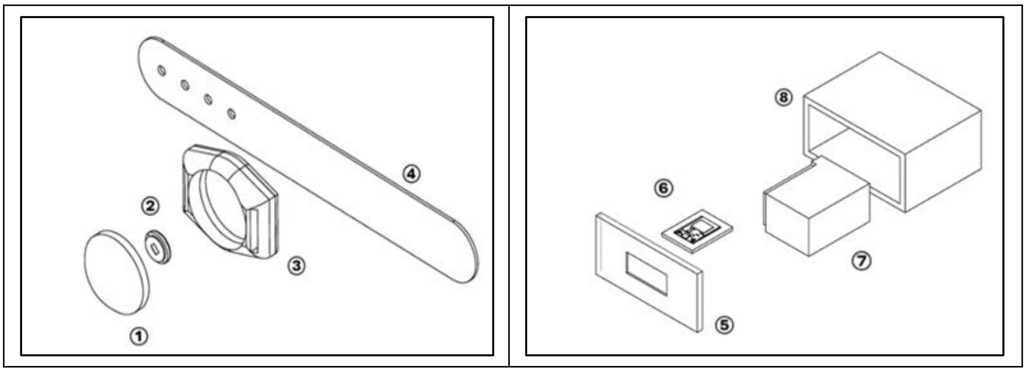

Figure 2 Exploded view

Figure 3 illustrates the top view, front view and right view of the wanderwatch.

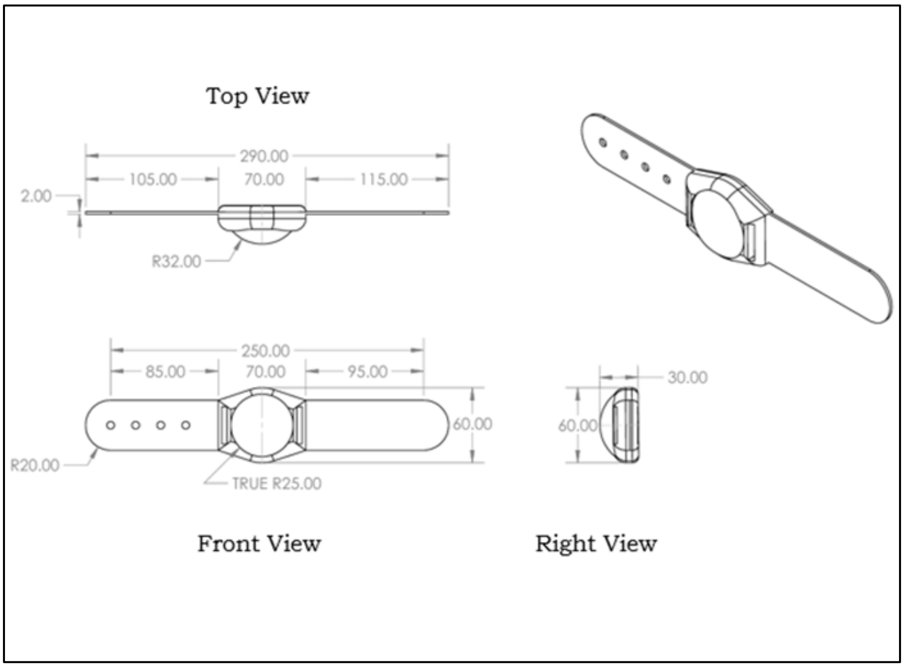

Figure 3 Top view, front view, right view

Figure 4 illustrates each orthographic projection of the WanderWatch

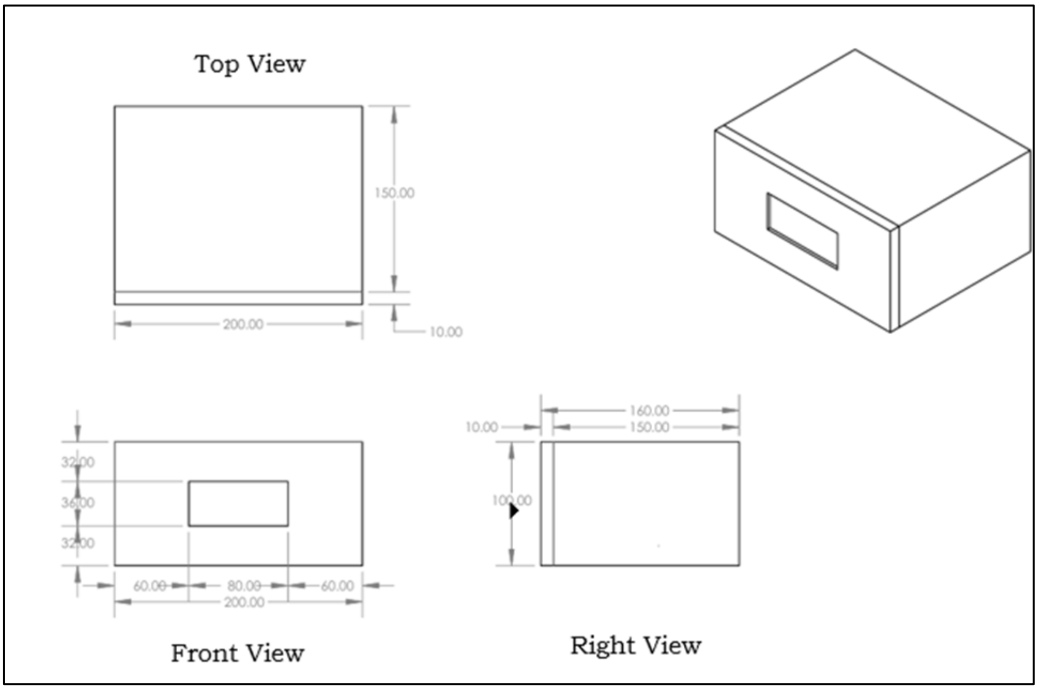

Figure 4 Wanderwatch Orthographic Projection

Figure 5 is the project's new process flow and technical advancements are geared towards optimizing the efficiency of detection and notification, positioning the device as an exceptionally effective tool for this purpose. Central to this development is an intuitive detecting mechanism by the ESP32 which acts as a sensor that attentively detects Bluetooth devices emitted by the BLE device. The device is further equipped with a wearable device, allowing the sensor to detect the patient. The design of the device prioritizes user comfort and precision, featuring a system that attentively detects and immediately notifies. Collectively, these features establish the door-activated wearable alert system as a timesaving, productivity-boosting, and safety-conscious solution, making it an optimal choice for professionals, family members, and caregivers seeking an efficient tool for monitoring.

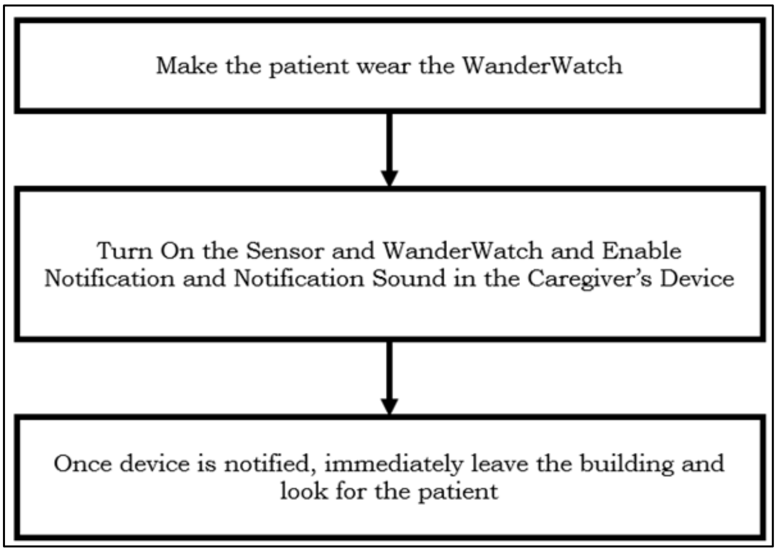

Figure 5 Process flow

3.8. General Dimensions

3.8.1. Dimensions

- Height : 1 cm
- Length : 13 cm
- Width : 4 cm
- Material : Carbon Fiber & Aluminum

Table 1 List of Supplies and Materials

Quantity	Unit	Name & Description
1	pc	BLE Beacon
1	pc	ESP32 Microcontroller
1	pc	Lithium Battery
1	pc	Battery Holder

Table 2 Tools and Instruments

Tools and Instruments	Function
Laptop	Laptop can be used to code the ESP32 microcontroller
Screwdrivers	In the construction of the system, screwdrivers can be employed to secure different parts together.
Drill and Drill Bits	In the context of making the system, the drill can be used to create openings for attaching components or adjusting the device's length, contributing to its functionality and ease of use.
Wrench	When constructing the system, a wrench can be utilized to secure critical components, ensuring the structural integrity of the device, and preventing any loosening during use.
3d Printer	The 3d printer would be used to create the Watch's Strap

3.8.2. Construction, Assembly and Fabrication Procedure

- Design WanderWatch: A Door-Activated Wearable Alert System for Patients with Dementia
  - Plan the design of WanderWatch: A Door-Activated Wearable Alert System for Patients with Dementia

- Illustrate the design figure in different views using AutoCAD.
- Decide on the structure and the type of materials to be used.
- Measure the design to get the correct dimension.

- Develop a Wearable Alert System
  - Gather the materials needed.
  - Print the different parts of the WanderWatch: A Door-Activated Wearable Alert System for Patients with Dementia.
  - Code the system for WanderWatch
  - Assemble the parts of the device.
- Test the functional parts of the of WanderWatch: A Door-Activated Wearable Alert System for Patients with Dementia
  - Examine and check the parts of the of WanderWatch: A Door-Activated Wearable Alert System for Patients with Dementia
  - Test the response time and accuracy of WanderWatch
  - Test the distance of Activation
- Revise every malfunctioning part of the WanderWatch: A Door-Activated Wearable Alert System for Patients with Dementia
  - Repair its faulty parts.
  - Test the response time and accuracy of WanderWatch
  - Test Distance activation

4. Results and discussion

4.1. Presentation of Data

Table 3 shows Wanderwatch response times. The time as the cellphone received SMS notification as the patient within the premise of the door activated sensor. Figure 6 is the existing versus new process flow analysis of wanderwatch.

Table 3 Wander Watch response times

Method	Median (s)	SD
Existing Process Flow	120 s	69 s
New Process Flow	7.74 s	0.64 s

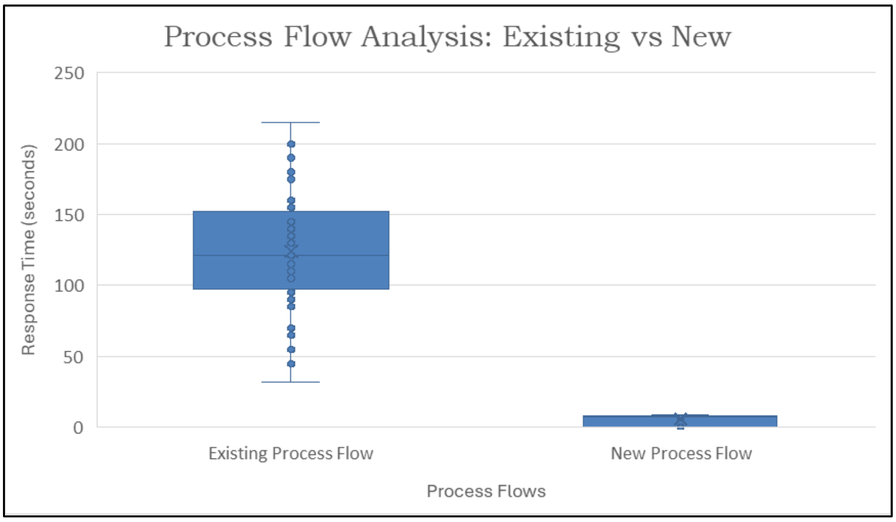

Figure 6 Process Flow Analysis

The data presented in the Table 4 reveals that WanderWatch demonstrates a significant improvement in the median time for caregivers to notice when a patient has wandered off, along with a lower standard deviation, which indicates a more reliable response time. Moreover, when comparing New Process flow to Existing process flow, all trials show better performance, with shorter median times and reduced variability. As WanderWatch was introduced during the trial, the system performed 93.55% of efficacy. This means that by implementing the Wander watch system, caregivers can detect when a patient with dementia is at risk of wandering off much more quickly.

Table 4 Descriptive and Test Statistics

Assumption	N Value	Z Value	P<0.05	Rejected/Accepted
The time response has no significant difference	29	-4.703	0.001	Rejected

The data suggests that the WanderWatch system significantly reduced response times compared to the Existing Process. Since all 29 Trials had a faster response time with WanderWatch and the p-value is very low, it indicates a highly significant improvement in response time using the WanderWatch.

Table 5 Shows Wander Watch detection range. The distance where the ESP32 could detect the Wander Watch as well as its corresponding signal strength per distance.

Table 5 Detection range

	Mean	Minimum	Maximum	SD
Distance 1 (0-2m)	-60.5 dBm	-68 dBm	-50 dBm	5.48
Distance 2 (2-4m)	-68.7 dBm	-71 dBm	-65 dBm	2.00
Distance 3 (4-6m)	-76.7 dBm	-81 dBm	73.0 dBm -	2.75

The data presented in the Table 5 indicates that the device is capable of detecting signals up to 6 m from the door, with a mean signal strength as weak as -76.7 dBm. The signal strengths, measured as Received Signal Strength

Indicator (RSSI), tend to be significantly stronger when the device is positioned within 0 to 2 m of the door. To improve the system's overall effectiveness and reduce the chances of false alarms, the programming established a minimum threshold of -50 dBm for the Received Signal Strength Indicator (RSSI) value. This means that the system is designed to detect Bluetooth signals only when they are within an optimal range of 0-2 meter from the door.

Table 6 shows a comparison of the prices of some of the developed technology and the introduced project, WanderWatch.

Table 6 Price comparison

Developed Technology	WanderWatch: A Door-Activated Wearable Alert System for Patients with Dementia	SUREFIRE PERSONAL ALARM	WIRELESS CAREGIVER PAGER
Price	P 1,500	P 2,236	P 24,028
Difference	--	P 7,36	P 22,528

WanderWatch solely focuses on the wandering behavior of the patients and aims to aid the caregivers in these situations. Unlike other technologies, such as the smart watch, the surefire elderly personal alarm, and the wireless caregiver pager, our WanderWatch is much more low-priced. With it only costing us Php 1,500 pesos to create, with the other technologies costing Php 2,236 at base level and Php 24,028 at most.

In conclusion, the testing of WanderWatch demonstrated a significant improvement in response time and accuracy. With WanderWatch, there was an impressive 93.55% reduction in median response time compared to the baseline, substantially enhancing the system's efficiency in alerting caregivers. Moreover, compared to the developed technologies being sold in the market, WanderWatch is 15.02 times cheaper. Additionally, WanderWatch's detection range was initially capable of reaching distances of up to 20 feet. However, for optimal accuracy and to minimize false alarms, this range was fine-tuned to a more precise 3 feet. This adjustment ensures more reliable detection and timely alerts, making WanderWatch a highly effective tool for caregiver support and monitoring.

5. Summary, conclusions, and recommendations

5.1. Summary of Findings

With WanderWatch, the study discovered a dramatic 93.55 percent reduction in median response time versus baseline, making the system much more efficient in alerting caregivers. In addition, WanderWatch is 15.02 times more affordable than the available developed technologies available for sale today in the market. Further, its detection range at startup, in the case of WanderWatch, went up to 20 feet away. The extent of this device was later fine-tuned to 3 ft, thus ensuring full accuracy with minimum false alarms and cleaner detections and quicker alerts, which makes it a great device for any caregiver.

5.2. Conclusions

Based on the study's findings, the following conclusions are drawn:

- WanderWatch proved superior in response time and accuracy than the basic version. The findings indicate that this device could effectively notify the caregiver 93.55 times faster than previous practices.
- The sensor could detect signals up to 20 feet, however for a more reliable outco me and inaccuracies, the system was limited to detect up to only three feet.
- WanderWatch presents itself as a much more cost-effective project and is easily accessible to people who are financially troubled yet still maintain its quality. With it being 15.02 times cheaper than other technologies in the market.
- WanderWatch stands out in the market with its novelty and innovation. Having qualities such as door activated detection, SMS/Data private notification, and premise detection through Bluetooth that may be in other technologies but not combined like WanderWatch.
- With the features of the WanderWatch, patients with dementia are in safe hands as the watch immediately sends a signal to the caregivers chosen gadget, ensuring their safety and well-being.

Recommendations

Based on the findings of the study, the following recommendations are presented to enhance the functionality and efficiency of the developed system:

- Turn the caregiver’s phone notification to the maximum volume, for much better outcomes
- Set up the sensor in a dry place, to protect the microcontroller from being wet and damaged
- Make the Watch’ design smaller for a much more comfortable feel.
- Replace the currently used lithium battery with a much more reliable and long-lasting power source.
- Adjust the range of the sensor based on the size of the building to prevent false alarms as much as possible.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

The present research work does not contain any studies performed on animals/humans subjects by any of the authors.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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