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### **Smart Inhaler for COPD and Asthma Patients: Enhancing Respiratory Health Through Innovation (SICAP)**

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#### **Summary:**

Chronic Obstructive Pulmonary Disease (COPD) and asthma affect millions worldwide, often leading to compromised quality of life and frequent hospitalizations due to poor medication adherence and environmental triggers. Traditional inhalers, while effective, are reliant on the patient's timely and accurate usage. In response to these challenges, the Smart Inhaler for COPD and Asthma Patients (SICAP) was conceptualized to enhance medication adherence and monitor respiratory health in real-time. SICAP is equipped with sensors that track inhaler usage, environmental factors (e.g., air quality, humidity), and patient symptoms. It connects to a mobile app, providing reminders for medication, usage history, and alerts for environmental triggers that could worsen respiratory conditions. The product’s goal is to ensure patients maintain proper inhaler usage and mitigate risk factors by receiving real-time feedback. This research aims to test the effectiveness of SICAP in improving adherence, symptom control, and overall quality of life in comparison to traditional inhalers.

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#### **Background and Problem:**

COPD and asthma are major contributors to global morbidity and mortality, affecting over 300 million individuals worldwide (Global Initiative for Chronic Obstructive Lung Disease, 2023). Poor inhaler adherence and environmental factors like pollution significantly worsen patient outcomes, leading to frequent exacerbations and hospitalizations (Barnes et al., 2022). Inhaler adherence in asthma patients is particularly low, with studies indicating that less than 50% of patients use their inhalers as prescribed (Bourbeau & Bartlett, 2020). The limitations of traditional inhalers—requiring manual usage and lacking real-time feedback on air quality—highlight the need for a more integrated approach to respiratory care.

Smart inhalers offer a solution by combining medication delivery with real-time monitoring. These devices not only track inhaler use but also collect data on environmental conditions, offering predictive insights to prevent asthma or COPD exacerbations (Chan et al., 2021). Smart inhalers are embedded with sensors that automatically record usage and can be paired with mobile apps to remind patients to take their medication and warn them about environmental triggers. This combination of digital health and medical device technology addresses the existing gap in medication adherence and environmental monitoring for asthma and COPD patients. SICAP aims to further this approach by integrating comprehensive patient data into one platform, ensuring patients receive timely interventions and can better manage their condition.

#### **Beneficiaries:**

* **COPD and Asthma Patients**: Improves medication adherence and symptom control, reducing exacerbations.
* **Healthcare Providers**: Enables real-time monitoring of patients, improving disease management.
* **Public Health Systems**: Reduces hospital readmissions and the burden of chronic respiratory diseases.
* **Pharmaceutical Companies**: Enhances medication usage data for research and development of better therapies.
* **Future Researchers**: Provides valuable data for studying chronic respiratory diseases and treatment outcomes.

#### **Proposed Solution to the Problem Presented:**

The Smart Inhaler for COPD and Asthma Patients (SICAP) is designed to address the dual issues of poor medication adherence and the impact of environmental triggers on respiratory health. Traditional inhalers require manual operation, which relies heavily on patient compliance. Additionally, patients are often unaware of environmental triggers such as pollution, temperature changes, and allergens that could exacerbate their symptoms.

SICAP proposes an integrated solution combining medication adherence monitoring and environmental tracking. The device features built-in sensors that automatically detect when the patient uses the inhaler, recording the time, date, and dosage administered. These data are stored and transmitted to a companion mobile app, which provides real-time feedback to both the patient and healthcare provider. The app also tracks environmental conditions like air quality (PM2.5, PM10), humidity, and temperature, issuing alerts when these factors are likely to trigger symptoms.

The inhaler is equipped with Bluetooth connectivity, allowing it to sync with smartphones or smartwatches. The system not only sends reminders to patients when it’s time to take their medication but also analyzes usage patterns, offering insights into adherence trends. Healthcare providers can access this data to adjust treatment plans based on actual usage and symptom severity.

Another innovative feature of SICAP is its predictive alert system, which uses AI algorithms to forecast potential exacerbations based on historical data and environmental conditions. This allows patients to take proactive steps, such as using rescue medication or avoiding polluted areas, minimizing the likelihood of severe flare-ups. The app also provides educational resources, offering personalized advice on managing symptoms and improving overall lung health.

The development of SICAP will undergo a series of clinical trials to measure its effectiveness in improving medication adherence, reducing hospitalizations, and enhancing the quality of life for COPD and asthma patients. The anticipated outcome is a reduction in emergency room visits, better symptom control, and improved patient satisfaction with their care regimen.

#### **Methodology:**

* **Conceptual Framework**: The system operates on three pillars—medication adherence, environmental monitoring, and patient education. SICAP uses sensor technology to collect real-time data, which is analyzed and delivered to the patient and healthcare provider through a mobile interface. This closed-loop feedback system ensures proactive health management.
* **3D Models**: The design will feature a compact, ergonomic inhaler model equipped with micro sensors and Bluetooth connectivity. The product will be prototyped using CAD software for optimized user experience and ease of handling.

**Methods**:

The Smart Inhaler for COPD and Asthma Patients (SICAP) aims to provide an innovative solution to the challenges faced by patients in managing their conditions effectively. The development, construction, and implementation of the device will follow a systematic approach consisting of the following stages:

1. **Research and Requirement Gathering**: This initial phase involves comprehensive research into existing inhaler technologies and the specific needs of COPD and asthma patients. Researchers will gather data through surveys, interviews, and literature reviews to identify the essential features and functionalities required for the smart inhaler. This will also include determining the types of sensors and connectivity options most beneficial for the target user group.
2. **Designing**: Following the requirement gathering, the design phase will commence. This includes creating detailed designs for the inhaler, including its housing, internal components, and user interface. Prototyping software will be used to visualize the device, and 3D modeling will help in assessing ergonomics and aesthetics. Feedback from healthcare professionals and patients will be solicited to refine the design.
3. **Development**: In this phase, the focus will shift to developing the hardware and software components of the smart inhaler. Researchers will program the microcontroller to integrate with the sensors and Bluetooth module, ensuring seamless communication with the mobile app. The design will be tested for compatibility and functionality, and adjustments will be made as needed to optimize performance.
4. **Material Gathering**: Once the design and development phases are complete, the necessary materials and components will be procured. This includes sourcing sensors, microcontrollers, batteries, and housing materials. The researchers will compile a list of suppliers and evaluate costs to stay within budget.
5. **Testing**: After constructing the prototype, extensive testing will be conducted to evaluate its performance and reliability. This will involve simulating various environmental conditions to ensure the inhaler functions correctly. User testing will be performed to assess usability and gather insights on any areas needing improvement. If issues arise, the researchers will revisit the design and development stages for further refinement.
6. **Deployment**: Once testing is successfully completed and all modifications have been made, the smart inhaler will be prepared for deployment. This will involve creating a detailed user manual, training materials for healthcare providers, and marketing strategies to reach the target audience effectively.
7. **Gathering Feedback**: To ensure continuous improvement, researchers will collect feedback from users after deployment. Surveys and interviews will be used to assess user satisfaction and identify any potential areas for enhancement. This feedback will be vital for future iterations of the product and for ongoing support to users.

**Cost Analysis**

| **Item** | **Quantity** | **Unit Cost (PHP)** | **Total Cost (PHP)** |
| --- | --- | --- | --- |
| Microcontroller (e.g., Arduino) | 1 | ₱1,000 | ₱1,000 |
| Air Quality Sensor | 1 | ₱1,000 | ₱1,000 |
| Humidity Sensor | 1 | ₱900 | ₱900 |
| Pressure Sensor | 1 | ₱800 | ₱800 |
| Bluetooth Module | 1 | ₱300 | ₱300 |
| Inhaler Housing/Enclosure | 1 | ₱500 | ₱500 |
| Battery (Rechargeable) | 1 | ₱500 | ₱500 |
| Charging Module | 1 | ₱200 | ₱200 |
| PCB Board | 1 | ₱700 | ₱700 |
| - Wiring and Connectors | 1 set | ₱500 | ₱500 |
| Total Estimated Cost |  |  | ₱6,400 |

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