Design and Application of a Medical Oxygen Supply Timer

Duan Wei, Bai Qing
Department of Medical, People's Hospital of Ningxia Hui Autonomous Region, Ningxia Medical University, Yinchuan, Ningxia, China

Abstract: This study designs an automated, dedicated timer device to standardize and improve the accuracy of oxygen supply duration monitoring.a medical oxygen supply timer was developed, which of The main working principle is that the external laser sensor senses the accumulation time of the float of the oxygen flow meter. The operations include starting timing, stopping timing, and continuing timing. *During operation,* oxygen delivery begins when the flow control valve is opened: the timer detects the float displacement and starts timing. Meanwhile, power is supplied to the electromagnet, which pulls the ferrous plunger downward. This extends the reset spring and actuates the coupling slider rod to move the sealed sliding column, thus enabling oxygen supply. timing — and billing — cease automatically when the flow valve is closed. The developed timer demonstrated high chronological accuracy (error < 0.05%) and stable operation in controlled tests. In the clinical pilot, the device effectively eliminated timing inaccuracies associated with manual methods. The dedicated medical oxygen supply timer presents compact, lightweight, and user - friendly. Clinically, it resolves billing disputes arising from inaccurate oxygen timing, fosters harmonious patient -provider relationships, enables evidence - based monitoring of therapeutic oxygen duration, promotes patient - centered nursing excellence, reduces nursing workload.

Keywords: Medical Oxygen Supply Timer; Timing Accuracy; Clinical Application; Patient Safety; Nursing Workflow Optimization

1. Introduction

Oxygen is fundamental to human survival. Hypoxia impairs cellular oxygen delivery, triggering diverse pathological conditions and diseases [1,2]. Among current clinical interventions, oxygen therapy is indispensable for alleviating hypoxia in vital organs such as the heart, brain, and kidneys [3-5]. Moreover, medical oxygen incurs service charges. Particularly under China's healthcare reform, intermittent oxygen therapy is strictly capped at ≤4 hours per day; any excess is billed as a self - pay item. Yet, existing clinical oxygen delivery devices only measure flow rate, not duration. Therefore, hospitals rely on manual timing and cumulative recording, raising concerns about billing accuracy and fairness [6-7].Manual timing suffers from critical limitations (1) Clinicians must initiate timing only after confirming proper oxygen tubing connection, introducing inevitable delays and compromising temporal precision. (2) When managing multiple patients undergoing oxygen therapy, nurses must manually record the start and end times. This increases their workload, introduces recording errors, and reduces efficiency. (3) During oxygen therapy, patients may temporarily discontinue its use for toileting, examinations, or other reasons. However, centralized oxygen supply systems deliver a continuous flow, which prevents timing with the ability to pause and causes oxygen wastage. This discrepancy between the actual oxygen duration and volume used and those recorded by the system risks billing inaccuracies and potential disputes between patients and providers. To address these clinical challenges, we developed a medical oxygen timer device which of The main working principle is that the external laser sensor senses the accumulation time of the float of the oxygen flow meter.

2. Materials and Methods

2.1 Materials

The operations include starting timing, stopping timing, and continuing timing. Moreover, the operation interface is simple and easy to use. Medical Oxygen Supply Timer components: 1. Oxygen flow timer; 2. Oxygen pressure sensor; 3.

Insulated enclosure; 4. Connector sleeve; 5. Electromagnet; 6. Ferrous plunger; 7. Coupling slider rod; 8. Reset spring; 9. Alarm indicator light; 10. Conductive terminal; 11. Sealed sliding column; 12. Sliding groove; 13. Sealing plug; 14. Inlet gas conduit; 15. Exhaust conduit; 16. Copper conductive strip. During operation, oxygen delivery begins when the flow control valve is opened: the timer detects the float displacement and starts timing. Meanwhile, power is supplied to the electromagnet, which pulls the ferrous plunger downward. This extends the reset spring and actuates the coupling slider rod to move the sealed sliding column, thus enabling oxygen supply. Timing—and billing—cease automatically when the flow valve is closed. Key components are illustrated in Figures 1.

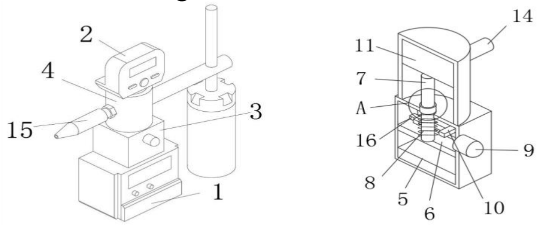

Figure 1. Overall 3D Diagram of Medical Oxygen Delivery Timing Device

2.2 General Information

A convenience sample of 98 adult inpatients (47 males, 51 females) was admitted to the Department of Internal Medicine, Ningxia Hui Autonomous Region People's Hospital, from November 2025 to February 2026. They required intermittent oxygen therapy for ≥8 days according to clinical indications and physician orders.

2.3 Research Methods

A standardized checklist was developed and administered by trained personnel over an 8 - day observation period. Data collected included: demographic and clinical characteristics (name, sex, hospital ID, diagnosis); oxygen therapy prescription start/end times; cumulative oxygen exposure (manually timed for Days 1–4; meter - recorded for Days 5–8); frequency of patient/family inquiries regarding oxygen therapy; and number of formal complaints.

3. Results

After 8 days of data collection, the collected data were statistically processed using SPSS 21.0, and the results are as follows. The comparison of the two oxygen metering and billing methods revealed a statistically significant difference ($P < 0.05$), as shown in Table 1.

Table 1. Comparison of Two Oxygen Therapy Timing and Billing Methods

Project	Time (min)	Inquiry (per session)	Complaints (Count)
Manual billing	524	96	30
Oxygen Timer Device	276	30	0
t	22.576	13.368	7.002
p	<0.01	<0.01	<0.01

t and p-values are the statistical analysis results of the Manual billing group in comparison with the Oxygen Timer Device group.

4. Discussion

In the era of rapid advancement in medical science and continuous improvement of healthcare systems, the refinement, scientification, and humanization of nursing practices have become critical dimensions for enhancing medical quality and fostering harmonious physician-patient relationships. Among these, basic oxygen therapy (BO2), as a vital intervention in respiratory medicine and supportive treatment for various acute and chronic diseases, relies on management processes characterized by accuracy, transparency, and efficiency, which directly impact medical safety, resource utilization, and patient experience[8,9]. For decades, the manual recording of oxygen administration durations by nursing staff has revealed multiple limitations in clinical practice: not only does it involve cumbersome procedures prone to errors due to human error or delayed documentation, but it also risks patient skepticism and potential disputes caused by opaque billing practices, inadvertently increasing psychological burdens on caregivers and management costs. These shortcomings diverge from the patient-centered philosophy of high-quality nursing services and the requirements of modern hospital management systems. Consequently, developing an objective, precise, and automated method for measuring oxygen administration duration has emerged as an urgent clinical challenge. The medical oxygen timing device introduced and validated in this study represents a proactive and effective solution to this need. This paper aims to further explore its core value in safeguarding public health, objectively analyze current limitations and deficiencies, and provide conclusive recommendations for future development based on the study findings. The empirical data from this study clearly demonstrate that the application of medical oxygen timing devices has producted positive and profound impacts across multiple dimensions—including clinical practice, management, humanistic considerations, and economic aspects. Its significance extends far beyond mere "timing" functionality, as it is integrated into a systematic framework for maintaining and promoting population health.

4.1 Precision Medicine and Safe Healthcare

Enhancing medical precision and treatment safety to solidify the foundation of health protection. Precision medicine represents a pivotal direction in contemporary medical advancement, with precise oxygen therapy serving as a fundamental component [10]. The results of this study demonstrate that the cumulative oxygen administration time recorded by the oxygen meter device is significantly more accurate than manual recording ($P < 0.05$). This improvement in accuracy holds critical implications for health maintenance. Firstly, it ensures the scientific validity of therapeutic dosages. The efficacy of oxygen therapy is closely correlated with oxygen concentration and duration, particularly in long-term home oxygen therapy or precision hospitalization treatments for patients with chronic obstructive pulmonary disease (COPD) or respiratory failure. Accurate recording of cumulative time serves as a key objective basis for evaluating therapeutic outcomes and adjusting treatment regimens. The device utilizes an external laser sensor to non-contact detect the elevation of the oxygen flow meter float, enabling automatic, continuous, and second-by-second cumulative timing. This eliminates potential errors such as forgetfulness, delays, or estimation errors associated with manual recording during necessary activities like meals, bathroom visits, or outpatient examinations, allowing healthcare providers to scientifically and accurately determine the patient's "effective oxygen therapy duration." This provides reliable data support for optimizing treatment plans, indirectly improving therapeutic outcomes and patient prognosis, thereby representing the most direct and fundamental safeguard for patient health.

4.2 Equity and Sustainability of Medical Resources

Optimizing the allocation of medical resources to promote equity and sustainability in healthcare economics. Medical oxygen is a critical medical resource, and its rational utilization is pivotal for controlling healthcare costs and ensuring equitable resource distribution. The inaccuracies inherent in traditional manual timing often result in either "overcharging" or "undercharging." The former imposes unnecessary financial burdens on patients, compromising their interests, while the latter fails to reflect the true value of hospital resources, leading to hidden waste. This device achieves precise synchronized timing — eliminating idle consumption of oxygen resources at the technical level and ensuring that each minute of oxygen usage aligns with actual therapeutic needs. This not only enhances the precision of hospital oxygen management and reduces resource waste but, more importantly, establishes a transparent and fair billing foundation. As shown in Table 1, none of the 98 patients raised any objections or complaints regarding their oxygen costs post-use. This sense of fairness constitutes a vital component of physician-patient trust, which serves as the intrinsic motivation for patients to comply with treatment and promote health. From a broader health economics perspective, the adoption of such technologies improves the operational efficiency and cost-effectiveness of the entire healthcare system, enabling limited public medical resources to more accurately address genuine health needs, thereby yielding significant social benefits.

4.3 Improve Health Levels and Satisfaction

Deepening the "patient-centered" nursing philosophy to enhance health attainment and satisfaction. Modern health concepts emphasize holistic well-being encompassing physical, mental, social, and spiritual dimensions. Patients 'healthcare experiences, psychological perceptions, and sense of control over medical processes constitute essential components of health. The application of this device represents a technical advancement in translating the "patient-centered" philosophy from slogan to practice. Firstly, it empowers patients with rights to informed consent and supervision. The display screen clearly shows cumulative treatment duration, enabling patients and families to monitor progress and cost structures in real-time. This transforms "black-box operations" into "transparent billing," eliminating anxiety and suspicion caused by information asymmetry while strengthening patients' agency and sense of security during medical care. Secondly, it liberates nursing staff from repetitive mechanical documentation tasks. Nurses no longer need to repeatedly check, record, or calculate time metrics, significantly reducing workload intensity and minimizing work-related burnout and potential errors due to tedious procedures. The saved time and energy allow greater focus on patient condition monitoring, health education, psychological counseling, and specialized nursing care, shifting nursing practices from "transactional" to "professional and humanistic" approaches. This shift in care focus directly enhances the depth and warmth of nursing services, meeting patients 'higher-level psychological and social needs while significantly improving satisfaction. Consequently, it not only treats diseases but also safeguards patients' mental health and social adaptation, representing a more comprehensive dimension of health maintenance.

4.4 Reduce Iatrogenic Infections

Strengthening Hospital Infection Control Barriers to Safeguard Basic Medical Safety. Nosocomial infections pose a significant threat to patient health outcomes, and infection control must be the primary consideration for any medical device introduction. This device features an ingenious design where oxygen flow is not directly transmitted through the timing mechanism but instead undergoes contactless laser sensor-based sensing and timing. This physical isolation design completely eliminates the risk of secondary oxygen contamination caused by internal equipment contamination, thereby preventing it from becoming a new source of infection. This characteristic enables seamless integration into existing stringent hospital infection control systems, enhancing management efficiency without compromising basic medical safety. It provides patients with a cleaner and safer treatment environment, which inherently constitutes fundamental protection for public health.

4.5 Scientific Hospital Operation Management

Supporting hospitals in scientific management and integrity building to foster a harmonious and healthy ecosystem. The scientific and intelligent management of hospitals serves as a guarantee for continuous improvement in medical quality. The objective and tamper-proof time data provided by this device serves as a foundational dataset for hospital quality management, performance evaluation, and process optimization. It promotes standardization and transparency in oxygen therapy service workflows, enhancing the precision of hospital operations. Additionally, the resulting transparent billing practices and zero-complaint outcomes directly strengthen the hospital's public credibility and integrity image. In an era where physician-patient relationships are of paramount concern, this technology-driven integrity and transparency act as a "lubricant" and "reinforcer" for building harmonious and trustworthy physician-patient relationships. Such harmonious relationships help mitigate stress responses caused by disputes, facilitate patients' physical and mental recovery, and create a more favorable psychosocial environment for medical practices, thereby fostering a broader societal ecosystem conducive to public health.

5. Limitations

Although this study has preliminarily demonstrated the application advantages of this medical oxygen supply timing device, any new technology may face challenges and room for improvement during its widespread adoption and further refinement. A clear understanding of its limitations is essential for future development.

5.1 The Scope and Depth of the Study Require Further Expansion.

The sample size and observation period of this study were relatively limited, primarily focusing on short-term efficacy evaluation within a single medical unit. The long-term stability of usage, device durability, and generalizability and compatibility across different hospital levels (e.g., primary community hospitals versus large tertiary hospitals), departments (e.g., ICU, emergency department, postoperative resuscitation unit), and oxygen therapy modalities (e.g., nasal cannula, mask, high-flow oxygen therapy) have not been adequately validated. Additionally, the study primarily focused on direct indicators such as timing accuracy and satisfaction, lacking long-term follow-up studies on how these metrics could be more deeply integrated with clinical decision support systems (e.g., using precise timing data to alert for oxygen therapy dependence or assess off-line timing) or their indirect impacts on long-term patient health outcomes (e.g., readmission rates, quality of life improvement).

5.2 There is Room for Improvement in Technological Integration and Intelligentization Levels.

Current devices primarily focus on precise timing and display functions, representing relatively standalone "single-point" technologies. In the era of medical informatization, the Internet of Things (IoT), and big data, their potential as data acquisition terminals remains underutilized. For instance, challenges include seamless integration with hospital information systems (HIS), nursing information systems (NIS), or electronic medical records (EMR) to achieve automated timing data entry, automatic cost correlation, and generation of oxygen therapy analysis reports; incorporating wireless transmission modules for remote data monitoring and alarm alerts for abnormal conditions (e.g., prolonged power-off without network connectivity); and compatibility with additional sensors. Future potential includes integrating blood oxygen saturation monitoring to preliminarily assess oxygen therapy efficacy, thereby providing more parameters to support the transition from "precision timing" to "precision oxygen therapy." Current "convenience" is predominantly reflected in physical operational aspects, while interoperability in information systems requires further enhancement.

5.3 The Dimensions of Cost-Benefit Analysis Require Broader Coverage.

While this study emphasizes the managerial and social benefits generated by the device, a comprehensive cost-benefit analysis—including equipment procurement costs, installation and maintenance expenses, lifecycle costs, savings in nursing labor costs, reduced oxygen waste, decreased dispute resolution costs, and potential gains from enhanced hospital reputation—requires more detailed data support. This is particularly crucial for institutions with limited medical resources, where clear long-term economic evaluations serve as essential decision-making foundations for policy implementation.

5.4 The Adaptability of Extreme Clinical Scenarios Remains to Be Tested.

In environments with extremely high oxygen flow rates (e.g., during resuscitation), frequent and rapid movement of oxygen equipment (e.g., during hospital transfers or ambulances), or strong electromagnetic interference in specialized medical settings (e.g., near magnetic resonance imaging (MRI) examination rooms), the reliability, interference resistance, and safety of this device (particularly its sensors and electronic components) require further rigorous testing and scenario-based validation.

6. Summary and Recommendations on Future Development Prospects

In conclusion, the medical oxygen supply timing device represents an inevitable trend in the development of oxygen therapy management towards automation, precision, and transparency. Its initial application has demonstrated significant value in improving medical quality, optimizing resource utilization, enhancing patient experience, and promoting doctor-patient harmony, serving as a successful practice of nursing tool innovation in advancing high-quality nursing services.

6.1 Strengthen Multicenter, Multi-Level, and Long-Term Empirical Research.

Future studies are recommended to expand sample sizes, conduct multicenter studies covering different regions, levels, and types of medical institutions, and extend follow-up periods. Research design should shift from simple efficacy verification to more complex mechanism exploration and benefit analysis, such as: performing rigorous cost-effectiveness/benefit analyses; investigating its profound impact on the restructuring of nursing work models; and exploring how data can be utilized for clinical quality indicator monitoring (e.g., oxygen therapy compliance rates).

6.2 Promote Technological Iteration and Deep Integration of Intelligence and Informatization.

Encourage collaboration between research institutions and medical institutions to drive product upgrades. Short-term objectives should focus on achieving standardized data interfaces for the device, enabling seamless integration with mainstream hospital information platforms to eliminate "information silos." Medium-term efforts may explore functionalities such as wireless transmission integration, battery life optimization, and mobile alerts (push notifications to nurses' handheld terminals). Long-term vision involves leveraging artificial intelligence algorithms to correlate oxygen therapy duration, flow rates, and patient vital signs data, aiming to develop simple oxygen therapy efficacy prediction or anomaly alert models. This evolution will transform the device from a mere "timer" into an "intelligent oxygen therapy auxiliary terminal."

6.3 Establish and Refine Relevant Standards and Specifications.

Relevant industry authorities and academic organizations may consider taking the lead in developing technical standards for medical oxygen therapy timing devices, data interface specifications, and clinical usage and maintenance guidelines based on sufficient practical evidence. Standardization serves as a prerequisite for promoting large-scale and standardized application of technologies, which helps ensure product quality, clarify data responsibilities, and guarantee safe, effective, and compliant operation in any medical institution.

6.4 Exploring Diversified Application Scenarios and Business Models.

Beyond inpatient wards, this technology can be extended to outpatient oxygen therapy areas, long-term oxygen therapy (LTO) management for home settings, rehabilitation medical institutions, and nursing homes. In home settings, connected smart timing devices may assist community healthcare professionals in remotely monitoring patients' oxygen therapy adherence. Regarding business models, exploration of equipment service-based leasing models or value-added service models based on IoT data can be pursued to reduce initial investment thresholds for primary healthcare institutions.

6.5 Strengthen Systematic Training with Humanistic Care as Its Core.

The ultimate value of any technology is reflected through people. While promoting the device, comprehensive training should be provided for nursing staff and all medical personnel, with emphasis not only on equipment operation but also on guiding them to understand the profound meaning of "patient-centered care" behind the technology: how to utilize time saved to provide higher-quality communication, how to interpret timing data to enhance trust with patients, and how to employ more accurate data for individualized health guidance. Ensure that technology truly becomes a powerful tool for extending nursing humanistic care and strengthening physician-patient collaboration, rather than a cold machine.

In summary, the medical oxygen delivery timing device validated in this study serves as an exemplary integration of information technology with clinical nursing needs. While addressing the specific pain point of "imprecise timing," its impact extends like ripples across multiple dimensions including healthcare quality, resource efficiency, patient experience, and hospital management, profoundly reflecting the precision, efficiency, fairness, and compassion essential for maintaining public health. Although further refinements remain necessary, this initiative demonstrates promising directions. Through sustained research, iterative intelligent upgrades, standardized protocols, and humanistic guidance, such innovations will undoubtedly play an increasingly vital role in building safer, more efficient, warmer, and more trustworthy modern healthcare systems, ultimately benefiting the health well-being of the general population.

Acknowledgments

This paper is supported by Ningxia Natural Science Foundation Project (No. 2025AAC030328).

References

[1] Wang J, Li MJ, Xia Q, Wang NY, et al. Problems and counter measures in communication between nurses and patients ininternal medicine nursing. Nurs Rehabil Res,2025,4(2):70-72.

[2] Chinese Society of Neurosurgery, Chinese Neurocritical Care Collaboration Group. Expert Consensus on Airway Management for Neurocritical Care Patients in China (2023). Natl Med J China. 2023;96(21):1639–1642.

[3] Yang T, Cai BQ, Cao B, et al.. Ex acerbation in patients with stable COPD in China: analysis of a prospective, 52-week, nationwide, observational cohort study (REAL). Ther Adv Respir Dis, 2023, 17:175-179.

[4] Liu ZB, Chen H. Zhao Hongmei's

respiratory rehabilitation enables critically ill patients to return to a quality of life .Physic Rep, 2023-07-27(A06).
[5] Peng FX, Pan MQ, Liang JY, et al. Research on the new of health popularization in public hospitals from the all-media perspective: take the First Affiliated Hospital of Sun Yat-Sen University as an example. Mod Hosp,2024,24(6):944-948.
[6] Wang YX, Liu MW. Ethical challenges and countermeasures of doctor-patient relationship in the context of artificial intelligence medical treatment. Chin Med Ethics,2024,35(7):764-768,789.
[7] Song FY, Ding KX, Qi W, et al. Effects of Baduanjin Exercise on lung function and 6 min walk in COPD patients: a systematic review and meta-analysis. Sci Rep2024,14 (1):17788
[8] Siraj RA. Comorbid cognitive impairment in chronic obstructive pulmonary disease (COPD) current understanding, risk factors, implications for clinical practice, and suggested interventions. Medicine,2023,59(4):732.
[9] Yang L, Ren MT, Yao JQ, et al. Study on healthy fitness and sleep status of the elderly with regular exercise over 65years old. Chin J Gen Pract,2024,22(4):578-581,621.
[10]Zong XY, Zhu LZ, Wang XF, et al. Application of a home based exercise program in elderly patients with osteoporosis *and frailty. Chin J Nurs,2024,59(10):1171-1179.*

