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ANALYSIS OF MEDICAL GAS DISTRIBUTION MANAGEMENT AT PROF. DR. H. ALOEI SABOE REGIONAL HOSPITAL GORONTALO

Wandalika Mooduto[1], Andi Kurniaty[2], Juliko Suleman[3]
[1,2,3]Universitas Bina Mandiri Gorontalo
Email : wandalikamooduto2002@gmail.com,andinaue36@gmail.com,desinovi3@gmail.com

ABSTRACT

Medical oxygen is a critical component of hospital infrastructure, and its effective distribution is essential for maintaining continuity of patient care and safety. This study aimed to analyze medical gas distribution management at Prof. Dr. H. Aloei Saboe Regional Hospital, Gorontalo, focusing on facilities and infrastructure, human resources, and the utilization of the Hospital Management Information System (SIMRS). A descriptive qualitative design was employed from August to October 2024. Data were collected through observation, in-depth interviews, and documentation involving three informants consisting of the Head of the Hospital Facilities and Infrastructure Maintenance Unit (IPSRS), an IPSRS officer, and the Head of the Isolation Room. Data were analyzed through data organization, reduction, coding, categorization, cross-source comparison, and descriptive interpretation. The findings showed that oxygen distribution was supported by a centralized oxygen installation, reserve cylinders, routine external supply, and demand-based distribution. However, centralized and manual distribution systems operated simultaneously, requiring direct stock monitoring and manual reporting. IPSRS staffing was considered adequate for current operations, although afternoon and night shifts had fewer personnel and staff had not received specific medical oxygen management training. SIMRS utilization was also limited, with oxygen monitoring, recording, and reporting at the IPSRS level remaining predominantly manual. The study concludes that medical oxygen distribution management is operationally functional but requires strengthening through standardized procedures, competency-based training, improved contingency mechanisms, and greater integration of oxygen inventory and distribution monitoring into SIMRS to enhance efficiency, responsiveness, and patient safety.

Keywords: medical oxygen; distribution management; hospital infrastructure; human resources; SIMRS

INTRODUCTION

Medical gas is an essential component of hospital infrastructure because it supports a wide range of clinical services, particularly oxygen therapy, anesthesia, respiratory support, emergency care, and intensive care. Unlike conventional hospital supplies, medical gases require specialized storage, distribution, pressure regulation, and monitoring systems because interruptions or errors in supply may directly affect patient safety and continuity of care. The management of medical gas therefore encompasses not only the availability of gas supplies but also the reliability of distribution systems, adequacy of pressure, appropriate storage, equipment safety, monitoring mechanisms, and the competence of personnel responsible for their use and distribution [1][2][3].

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The delivery of medical gases in hospitals can be supported through different supply arrangements, including cylinders, bulk storage systems, and centralized pipeline systems. Centralized medical gas pipeline systems are particularly important because they enable gases to be delivered directly to points of use within clinical areas, reducing the need for frequent movement of cylinders and supporting continuous clinical operations. However, the reliability of such systems depends on appropriate system design, pressure regulation, monitoring, maintenance, and contingency arrangements. Medical gas systems must be designed to maintain the identity, continuity, adequacy, and quality of the gas supplied to the point of use, while also providing safeguards against system failures [1][4].

Safety is a fundamental consideration in medical gas distribution management. Medical gas systems operate continuously and must be capable of maintaining supply even when individual components experience failure. Consequently, hospitals require appropriate backup systems, pressure monitoring, maintenance procedures, and emergency response mechanisms to minimize the risk of service interruption. Sarangi et al. [4], emphasized that the safety of medical gas pipeline systems is closely associated with appropriate installation, operation, maintenance, and monitoring. Similarly, Highley [2], and Westwood and Rieley [5], highlighted the importance of appropriate storage and delivery arrangements to ensure that medical gases are supplied safely and reliably throughout healthcare facilities.

In addition to technical reliability, the management of medical gas distribution involves operational and economic considerations. Hospitals need to maintain adequate supplies while controlling the costs associated with gas procurement, storage, transportation, and distribution. The selection of an appropriate medical gas supply system can influence the total cost of ownership and the operational efficiency of healthcare facilities [6]. Therefore, medical gas management requires an integrated approach that considers infrastructure, supply availability, operational procedures, human resources, monitoring systems, and resource efficiency rather than focusing solely on the availability of oxygen or other gases.

Human resources are another important component of safe medical gas management. Medical gas systems involve multiple personnel and units, including technical staff, nurses, clinical personnel, and hospital infrastructure or maintenance units. Inadequate knowledge or awareness regarding medical gases may increase the possibility of errors in gas identification, equipment use, connection, and distribution. Amor-García et al. [7], demonstrated the importance of multidisciplinary strategies in reducing errors associated with medical gas use. Training and awareness are consequently necessary to ensure that personnel understand the characteristics of medical gases, the operation of supply systems, and appropriate responses to potential failures. Ruyter [3], likewise emphasizes the importance of understanding medical gas supply systems as part of safe anesthetic and clinical practice.

Monitoring is also critical because the availability of medical gas cannot be assessed solely from the physical presence of cylinders or storage tanks. Accurate monitoring of pressure and supply conditions is necessary to identify potential interruptions and ensure continuity of service. Wijaya et al. [8], discussed the importance of centralized monitoring of medical gas pressure as a mechanism for improving the ability to monitor supply conditions. In hospital environments, effective monitoring may therefore support timely identification of declining supply levels or pressure abnormalities and facilitate appropriate responses before the condition affects patient care.

The increasing complexity of hospital services further highlights the importance of effective information management in medical gas distribution. Medical gas requests, stock monitoring, distribution records, and reporting require accurate and timely information to support operational decision-making. Where these processes remain predominantly manual, the availability of real-time information may be limited, potentially making stock monitoring, distribution tracking, and documentation more difficult. Accordingly, the integration of medical gas management with hospital information systems may provide opportunities to improve information availability and operational coordination. However, the effectiveness of such integration depends on the availability and implementation of appropriate information-system functions within the relevant hospital units.

The importance of these aspects can also be observed at Prof. Dr. H. Aloei Saboe Regional Hospital Gorontalo. Based on preliminary observations conducted by the researchers, the hospital has a centralized medical gas installation and maintains a reserve of oxygen cylinders. However, the new and VIP buildings reportedly do not have the same automatic monitoring arrangement as other areas. When the oxygen supply in these rooms is depleted, an alarm is activated and the nurse contacts the Installation of Maintenance and Hospital Facilities (Instalasi Pemeliharaan Sarana Rumah Sakit/IPSRS) to request further assistance. The distribution of oxygen cylinders to hospital rooms is conducted manually based on requests from the respective units. When oxygen is required outside the planned distribution schedule, IPSRS personnel provide the cylinders immediately because the availability of oxygen is directly related to the continuity of patient care.

These preliminary observations indicate that the hospital has established important infrastructure for medical gas supply, including a centralized gas installation and reserve oxygen cylinders, but aspects of distribution, monitoring, and response still involve manual operational processes. The coexistence of centralized infrastructure and manual distribution mechanisms raises an important management issue concerning how medical gas availability, distribution responsiveness, human resources, and information systems are coordinated in daily hospital operations. The issue becomes particularly relevant in clinical environments where delays in oxygen availability may have immediate implications for patient care.

Previous literature has primarily discussed the technical characteristics, safety requirements, supply systems, monitoring mechanisms, economic considerations, and risks associated with medical gases [1][2][6][4][5]. However, the available literature provided for this study does not specifically describe how medical gas distribution management is implemented at Prof. Dr. H. Aloei Saboe Regional Hospital Gorontalo, particularly from the perspectives of infrastructure, human resources, operational distribution procedures, and hospital information systems. This creates a practical gap between the established principles of medical gas management and their implementation within a specific regional hospital context.

Therefore, an empirical assessment of medical gas distribution management at Prof. Dr. H. Aloei Saboe Regional Hospital Gorontalo is important to understand how the existing infrastructure and operational processes support the availability and continuity of medical oxygen services. This study aims to analyze medical gas distribution management at Prof. Dr. H. Aloei Saboe Regional Hospital Gorontalo by examining three main aspects: facilities and infrastructure, human resources, and the utilization of the Hospital Management Information System (Sistem Informasi Manajemen Rumah Sakit/SIMRS). The findings are expected to provide practical information for strengthening the safety, responsiveness, efficiency, and continuity of medical gas distribution within the hospital.

RESEARCH METHODS

Research Approach and Type

Research Approach

This study employed a qualitative research approach to obtain an in-depth understanding of medical oxygen distribution management at Prof. Dr. H. Aloei Saboe Regional Hospital, Gorontalo. A qualitative approach was considered appropriate because the study focused on exploring processes, experiences, practices, and contextual conditions related to oxygen distribution rather than measuring relationships among variables statistically [9]. In this study, the researchers served as the primary research instruments and were directly involved in collecting and interpreting data in the field. The approach enabled the researchers to examine the perspectives and experiences of personnel involved in oxygen distribution management, particularly Hospital Facilities and Infrastructure Maintenance (*Instalasi Pemeliharaan Sarana Rumah Sakit/IPSRS*) personnel and clinical staff. Data were collected through observation, in-depth interviews, and documentation to obtain information from different sources and to facilitate triangulation. The combination of these techniques was intended to strengthen the credibility of the findings by comparing information obtained from interviews with actual practices and available hospital documents.

Type of Research

This study used a descriptive qualitative research design. Descriptive qualitative research aims to provide a systematic and factual description of phenomena based on information obtained directly from participants and the research setting. The design was selected because the study sought to describe and understand how medical oxygen distribution was implemented at Prof. Dr. H. Aloei Saboe

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Regional Hospital, including the availability of facilities and infrastructure, human resources involved in distribution activities, and the utilization of the Hospital Management Information System (*Sistem Informasi Manajemen Rumah Sakit/SIMRS*). Rather than testing hypotheses, the study focused on describing existing practices, procedures, coordination mechanisms, and operational challenges as they occurred in the hospital setting. This design also allowed the researchers to examine how infrastructure, personnel, distribution procedures, and information management interacted in supporting the continuity of oxygen services. The resulting description was expected to provide an empirical basis for identifying strengths, operational challenges, and areas requiring improvement in medical oxygen distribution management.

Time and Location of Research

The study was conducted at Prof. Dr. H. Aloei Saboe Regional Hospital, Gorontalo, from August to October 2024. The research period covered the stages of preliminary observation, data collection, and data analysis. Field activities focused on observing the management and distribution of medical oxygen, including the availability of oxygen supplies, storage arrangements, distribution procedures, personnel involved in distribution activities, and the recording and reporting processes. Direct observations were complemented by interviews with selected informants and examination of relevant documents to obtain a comprehensive understanding of the implementation of oxygen distribution management within the hospital.

Types and Sources of Data

The study used qualitative data obtained from primary and supporting sources. Primary data were collected directly from informants who were involved in or had relevant knowledge of medical oxygen distribution management at the hospital, including IPSRS personnel and clinical personnel responsible for patient care. The primary data consisted of informants' experiences, perceptions, explanations, and descriptions of oxygen procurement, storage, distribution, monitoring, and reporting practices. Supporting data were obtained through direct observation of oxygen distribution activities and examination of relevant hospital documents. The combination of interview, observation, and documentary data enabled the researchers to compare information across different sources and develop a contextual understanding of the implementation of medical oxygen distribution management.

Data Collection Techniques

Data were collected using three complementary techniques: observation, in-depth interviews, and documentation. Observation was conducted to examine the actual conditions and practices associated with medical oxygen distribution, including oxygen storage, cylinder handling, distribution to hospital rooms, and coordination between units. In-depth interviews were conducted with selected informants to explore their experiences, responsibilities, procedures, challenges, and perceptions concerning oxygen distribution management. Documentation was used to obtain supporting information relevant to oxygen availability, distribution, recording, and reporting. The three techniques were applied in combination to facilitate source and technique triangulation, allowing the researchers to compare information obtained from different methods and strengthen the credibility and completeness of the findings.

Data Management and Analysis

Qualitative data analysis was conducted systematically and continuously throughout the research process, beginning during data collection and continuing through the preparation of the final report. Data obtained from interviews, observations, and documentation were first organized and reviewed to identify information relevant to the research objectives. The researchers then reduced the data by selecting, grouping, and coding information according to the main areas of analysis, namely facilities and infrastructure, human resources, and SIMRS utilization in medical oxygen distribution. The categorized data were subsequently presented descriptively to identify patterns, similarities, differences, and operational issues emerging from the field. The researchers then interpreted the findings by comparing information across informants and data sources and by relating the empirical findings to relevant concepts and previous studies. Conclusions were drawn after the researchers had verified the consistency of the findings across the available data sources.

Characteristics of Informants

The study involved three informants selected based on their direct involvement in or relevant knowledge of medical oxygen management and hospital service operations. The informants consisted of the Head of the IPSRS Unit, an IPSRS officer, and the Head of the Isolation Room. To protect participant confidentiality, initials were used to identify each informant. The characteristics of the informants are presented in Table 1.

Table 1. Characteristics of Research Informants

No.	Initials	Position	Age	Gender
1	YD	Head of the IPSRS Unit	43 years	Male
2	NA	IPSRS Officer	30 years	Male
3	SM	Head of the Isolation Room	41 years	Female

The three informants were considered relevant sources of information because they represented both the technical and clinical perspectives required to understand medical oxygen distribution management. The Head of the IPSRS Unit and the IPSRS officer provided information regarding infrastructure, oxygen storage, distribution procedures, and technical management, while the Head of the Isolation Room provided information concerning oxygen requirements and distribution from the clinical service perspective.

RESEARCH RESULTS

Medical Oxygen Supply and Distribution Infrastructure

The findings indicate that Prof. Dr. H. Aloei Saboe Regional Hospital has an established medical oxygen supply system supported by an external supplier, a centralized oxygen installation, and reserve oxygen cylinders. Oxygen supplies are obtained from PT Samator in Limboto, while cylinder refilling is performed by the external supplier on a daily basis. YD, the Head of the IPSRS Unit, explained:

> *"The oxygen supply is purchased from an external*

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supplier, namely PT Samator in Limboto." (YD, 2024)

Regarding the refilling process, YD stated:

> *"Everything is handled by a third party every day."* (YD, 2024)

The hospital therefore does not perform oxygen cylinder refilling independently but relies on a third-party supplier to maintain the availability of oxygen supplies. The daily supply is arranged according to an established schedule and may be increased when oxygen consumption rises. YD explained:

> *"The oxygen cylinders are refilled every day. It is already scheduled and contracted; the daily supply is usually more if needed."* (YD, 2024)

The hospital also has a centralized oxygen installation in addition to manually handled cylinders. The centralized system is used by several rooms, while oxygen cylinders remain available for areas that require an alternative or additional supply. As described by YD:

> *"The hospital also has a large tank in front, which still belongs to the third party. It is connected directly to the installation, but there are also manual cylinders because several rooms still use the central installation."* (YD, 2024)

The routine oxygen supply was reported to be approximately 80 cylinders per day, although the actual requirement depends on hospital consumption. YD stated:

> *"It depends on oxygen usage, but the standard is approximately 80 per day."* (YD, 2024)

These findings show that oxygen availability is maintained through a combination of routine external supply, centralized oxygen infrastructure, and reserve cylinders. The supply mechanism is also designed to accommodate increases in demand through additional requests to the supplier.

Oxygen Stock Monitoring and Unit-Based Distribution

Oxygen distribution to clinical units is primarily based on requests from the respective rooms. The distribution mechanism differs depending on whether a unit is connected to the centralized oxygen installation or requires individual oxygen cylinders. YD explained:

> *"The request comes from the rooms according to their needs. Some already use the installation, so it follows the existing installation, while requests for cylinders are based on actual needs."* (YD, 2024)

The findings further indicate that monitoring of oxygen availability at the point of use is conducted through the pressure regulator attached to the oxygen cylinder. Nurses are responsible for checking the oxygen level and reporting depleted cylinders to IPSRS. YD explained:

> *"The oxygen has a regulator, which is the connection from the oxygen source to the patient. The regulator has a pressure and liter measurement. When it is full, it is 2,000, and when the oxygen is empty, it returns to zero. The nurses check it and report*

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to IPSRS when the oxygen is empty." (YD, 2024)

This process places an important operational role on clinical staff in identifying when oxygen cylinders need to be replaced. Once a request is received, IPSRS personnel distribute the cylinder to the requesting unit.

Daily stock monitoring is also conducted by IPSRS personnel. Stock information is communicated between shifts and reported to hospital management and the external supplier. YD described the process:

> *"Every day we check the amount of oxygen or oxygen stock. The morning shift reports to the afternoon shift and so on. There is a report of the available stock, including filled cylinders and cylinder stock."* (YD, 2024)

The hospital also communicates its oxygen consumption and stock conditions through a management communication group involving the supplier. YD further explained:

> *"In the morning, we report it to the management group, which also includes Samator. They see the standard usage, and they usually deliver 80 cylinders per day. If there are many users at that time, we call them for additional supplies."* (YD, 2024)

The findings demonstrate that stock monitoring is performed routinely and involves communication across shifts. However, the process remains dependent on direct checking, manual reporting, and interpersonal communication between hospital personnel and the external supplier.

Distribution Equipment and Mixed Distribution System

The hospital uses dedicated equipment to support the physical distribution of oxygen cylinders from storage areas to clinical units. Four trolleys are available for this purpose and were considered sufficient by the Head of IPSRS. YD stated:

> *"The equipment used is trolleys. There are four, and they are sufficient."* (YD, 2024)

The distribution system combines centralized oxygen delivery and manual cylinder distribution. Some areas, including the pavilion, use a centralized oxygen system, whereas oxygen cylinders remain necessary for certain patients and rooms. YD explained:

> *"It is carried out manually and partly automatically. For example, the pavilion uses a central system, meaning there is also a place for manual cylinders. Some patients still use ventilators, and the limitation is that they do not yet have a separate connector to the central system."* (YD, 2024)

The findings therefore indicate that the centralized installation has not completely eliminated the need for manual oxygen cylinder distribution. The two systems operate simultaneously according to the infrastructure and clinical requirements of each service area.

In terms of oxygen availability, the hospital's current stock was considered adequate by IPSRS. YD stated:

> *"It is sufficient, but if the oxygen cylinders at IPSRS are running low, we immediately*

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contact the third party." (YD, 2024)

This indicates that the hospital uses a replenishment mechanism in which declining stock levels trigger communication with the external supplier for additional oxygen supplies.

Human Resource Availability and Distribution Responsibilities

The findings indicate that IPSRS has 16 personnel who support hospital facilities and infrastructure operations, including oxygen distribution. Staffing is organized according to work shifts, with seven personnel during the morning shift and two personnel during both the afternoon and night shifts. YD explained:

"The IPSRS personnel number 16 people, but during the afternoon and night shifts there are only two people." (YD, 2024)

He further stated:

"For the morning shift, there are seven people, while in the afternoon and at night there are two people." (YD, 2024)

The number of personnel assigned to the respective shifts does not routinely change according to fluctuations in patient demand. YD explained:

"No, it does not change; it follows the schedule." (YD, 2024)

When oxygen demand increases or an emergency situation occurs, personnel from other shifts may provide additional assistance. YD stated:

"Usually, the morning-shift personnel will help the afternoon and night-shift personnel, who only number two people." (YD, 2024)

Despite the limited number of personnel during the afternoon and night shifts, the Head of IPSRS considered the existing workforce adequate for current operational requirements:

"For now, it is sufficient and can be handled properly." (YD, 2024)

The findings also show that oxygen distribution is part of the responsibilities of personnel assigned to the relevant shifts. NA, an IPSRS officer, stated:

"The afternoon and night-shift personnel." (NA, 2024)

The reported response time for oxygen cylinder distribution after a request is received was approximately 30 minutes. NA stated:

"Thirty minutes." (NA, 2024)

This finding indicates that oxygen requests are handled directly by on-duty IPSRS personnel, with an estimated distribution response time of approximately half an hour.

Human Resource Training and Readiness

Although the number of personnel was considered adequate for current operational requirements, the findings reveal a limitation concerning specialized training in medical oxygen distribution management. The Head of IPSRS stated:

"There has not been any training." (YD, 2024)

This finding was also confirmed by the IPSRS officer:

"I have not attended any training." (NA, 2024)

The statements from both informants indicate that formal specialized training related specifically to medical oxygen distribution management had not been provided or attended by the IPSRS personnel at the time of the study. Consequently, oxygen distribution activities were being performed based primarily on existing work procedures and practical experience.

Hospital Information System and Oxygen Distribution Monitoring

The findings indicate that the implementation of the Hospital Management Information System (SIMRS) in oxygen management is limited and has not yet been fully integrated into the IPSRS distribution process. One clinical informant indicated that information regarding oxygen use could be viewed through SIMRS. SM stated:

> *"The use of oxygen cylinders can be seen in SIMRS."* (SM, 2024)

However, this finding differs from the operational perspective provided by IPSRS. According to YD, IPSRS does not yet use SIMRS as the primary system for managing oxygen distribution. He explained:

> *"Here, we are not yet using SIMRS; it is still manual. Only the pharmacy uses SIMRS to request oxygen cylinders from the third party."* (YD, 2024)

Thus, SIMRS is reportedly used in a limited part of the oxygen supply process, particularly for pharmacy requests to the external supplier, while the operational management conducted by IPSRS remains predominantly manual.

Manual Monitoring, Recording, and Reporting

The findings further demonstrate that oxygen stock monitoring, distribution recording, and reporting within IPSRS are conducted through manual procedures. When asked about the system used to monitor oxygen distribution in the absence of an integrated SIMRS function, YD stated:

> *"A manual system, direct checking, and manual recording and reporting."* (YD, 2024)

The manual mechanism involves direct physical checking of oxygen stocks, communication between personnel across shifts, and manual recording of distribution activities. When oxygen stocks decline, IPSRS personnel contact the external supplier to request additional supplies. Similarly, when a clinical unit reports that its oxygen supply has been depleted, IPSRS personnel respond by delivering a replacement cylinder.

Overall, the findings show that medical oxygen distribution at Prof. Dr. H. Aloei Saboe Regional Hospital is supported by centralized infrastructure, routine external supply, reserve cylinders, and IPSRS personnel who respond directly to unit requests. Nevertheless, several operational components, particularly monitoring, recording, reporting, and IPSRS-level information management, continue to rely on manual procedures. The findings also identify the absence of specific oxygen distribution training as an important aspect of human resource readiness.

DISCUSSION

Medical Oxygen Supply and Distribution Infrastructure

The findings indicate that medical oxygen distribution at Prof. Dr. H. Aloei Saboe Regional Hospital is supported by a combination of centralized oxygen infrastructure and manually managed

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oxygen cylinders. Oxygen is supplied through an external third-party provider, while the hospital also maintains reserve cylinders to respond to fluctuations in demand. This arrangement demonstrates that the continuity of oxygen availability depends not only on the physical infrastructure but also on the reliability of the external supply chain and the hospital's internal distribution processes.

This finding is consistent with Shaban et al. [10], who emphasized that oxygen supply and medical gas pipeline systems constitute safety-critical infrastructure in healthcare facilities. Failures in the supply, distribution, or control of medical gases can directly affect clinical services and may create significant safety risks. Similarly, Ruyter [3], described medical gas supply as an essential component of hospital operations that requires appropriate storage, distribution, monitoring, and contingency arrangements. The presence of reserve cylinders in the hospital can therefore be interpreted as an important operational mechanism for maintaining service continuity when the centralized supply is insufficient or when additional oxygen is urgently required.

However, the findings also demonstrate that the hospital's distribution system is not fully centralized. Some rooms continue to depend on individual cylinders, while other areas are connected to the central installation. The coexistence of centralized and manual distribution creates additional operational requirements because staff must monitor different distribution mechanisms simultaneously. Alassafi et al. [11], highlighted that medical gas systems are associated with maintainability risks that need to be considered during facility design and operation. In this context, the hospital's mixed distribution arrangement requires clear procedures for monitoring, replenishment, equipment handling, and emergency response to prevent interruptions in oxygen availability.

Oxygen Stock Monitoring and Distribution Processes

The study further shows that oxygen distribution is largely demand-driven. Units request cylinders according to their clinical needs, while IPSRS personnel distribute the cylinders using available trolleys. Oxygen levels are monitored through regulators, and nursing personnel are responsible for identifying when oxygen is depleted and reporting the condition to IPSRS. This mechanism reflects a decentralized monitoring process in which clinical units play an important role in initiating replenishment.

From a management perspective, this arrangement provides flexibility because oxygen can be distributed according to actual consumption rather than solely according to a fixed distribution schedule. Carnero and Gómez [12], emphasized the importance of optimizing decision-making in the supply of medicinal gases by considering demand and resource availability. Likewise, Gómez-Chaparro et al. [13], demonstrated that monitoring medical gas consumption is important for improving resource management and hospital sustainability. Therefore, the demand-based distribution observed in this study represents a potentially efficient approach, particularly when oxygen requirements vary among hospital units.

Nevertheless, dependence on manual reporting may create vulnerabilities. The identification of depleted cylinders depends on nurses checking the regulator and subsequently contacting IPSRS. Such a process may be effective under normal conditions, but it remains dependent on human vigilance and timely communication. Amor-García et al. [7], emphasized that human factors are important contributors to errors involving medical gases and that multidisciplinary strategies are necessary to reduce such risks. Consequently, manual monitoring should be supported by standardized procedures, clear responsibilities, and rapid escalation mechanisms, particularly for units providing critical care.

Mixed Distribution Systems and Operational Safety

The existence of both centralized and manual oxygen distribution systems represents an important operational characteristic of the hospital. The centralized system provides oxygen through fixed infrastructure, while manual cylinders remain necessary for areas or situations where centralized connections are unavailable. The study also identified a limitation involving the absence of dedicated connectors for some equipment, including ventilator use. This suggests that infrastructure development has not yet completely eliminated dependence on portable cylinders.

Sarangi et al. [4], emphasized that medical gas pipeline systems require careful attention to installation, monitoring, maintenance, and safety procedures because failures can have serious consequences for patients. Similarly, Dillow [14], stressed the importance of clearly defined responsibilities in the management of pipeline systems. The present findings extend these observations by demonstrating that infrastructure configuration directly influences day-to-day distribution responsibilities. Where centralized infrastructure is incomplete, hospital personnel must compensate through additional manual distribution and monitoring activities.

From a patient safety perspective, the mixed system should therefore not be viewed merely as an infrastructure issue. It also represents an organizational and process-management issue. The effectiveness of the system depends on whether staff can identify oxygen shortages promptly, whether replacement cylinders are immediately available, and whether communication between clinical units, IPSRS, pharmacy, and external suppliers is sufficiently coordinated. A robust contingency plan is particularly important because oxygen interruption may directly affect patients who depend on oxygen therapy or ventilatory support.

Human Resources and Staff Readiness

The findings indicate that IPSRS has personnel assigned according to work shifts, with a smaller number of personnel available during the afternoon and night shifts. Morning-shift personnel may provide additional support when required. Although the informants considered the current staffing level sufficient to manage oxygen distribution, the limited number of personnel during certain shifts indicates a potential operational vulnerability, particularly during unexpected increases in demand or simultaneous emergencies.

The issue becomes more significant because the study found that IPSRS personnel had not received specific training related to medical gas management. This finding represents an important gap between perceived operational adequacy and formal competency development. Staff may be able to perform routine tasks based on experience and existing procedures, but the absence of structured training may increase dependence on individual knowledge and practical experience.

Amor-García et al. [7], demonstrated the importance of multidisciplinary strategies in reducing errors associated with medical gases, while Shaban et al. [10], emphasized the interaction between technical systems and human factors in safety-critical medical gas infrastructure. These findings suggest that staffing adequacy should not be evaluated solely in terms of the number of personnel available. Competence, training, role clarity, and emergency preparedness are equally important components of effective medical gas management.

The absence of formal training is therefore one of the most significant findings of this study. Regular training should address cylinder handling, regulator and pressure monitoring, storage, transportation, identification of abnormal conditions, emergency response, and coordination between IPSRS and clinical personnel. Such training could strengthen staff readiness and reduce the risk of errors resulting from inadequate knowledge or inconsistent procedures.

SIMRS Utilization and Manual Information Management

The study identified an important limitation in the use of the Hospital Management Information System (SIMRS). The findings indicate that medical oxygen management is not yet fully integrated into SIMRS at the IPSRS level. Monitoring, checking, recording, and reporting remain largely manual, while SIMRS is reportedly used in the pharmacy for oxygen requests to the external supplier. The different perceptions among informants regarding the extent to which oxygen utilization can be viewed through SIMRS also indicate that system utilization may be partial or uneven across units.

This finding is relevant because information availability is an important component of effective resource management. Setiorini et al. [15], through an evaluation of SIMRS implementation, demonstrated that the effectiveness of hospital information systems depends on the interaction between technology, organizational factors, and users. In the context of medical oxygen management, a system that only supports selected administrative processes may provide limited benefits if operational monitoring and stock information remain outside the integrated information system.

The continued reliance on manual recording may also limit the hospital's ability to obtain timely information about oxygen consumption, stock levels, distribution patterns, and replenishment requirements. Carnero and Gómez [12], emphasized the importance of information for optimizing decisions concerning medical gas supply. Therefore, integrating oxygen inventory, consumption, distribution, and replenishment data into SIMRS could support more proactive decision-making.

However, digital integration should not simply replace existing manual procedures without considering system reliability and user readiness. The implementation of an integrated oxygen management module would require standardized data entry, clear responsibilities, staff training, and mechanisms for verifying data accuracy. The hospital should also maintain appropriate contingency procedures in case of system disruption.

Implications for Hospital Management and Patient Safety

Overall, the findings demonstrate that medical oxygen distribution management is influenced by the interaction between infrastructure, human resources, supply-chain arrangements, and information systems. The hospital already has several supporting mechanisms, including a centralized oxygen installation, reserve cylinders, scheduled external supply, manual monitoring, and IPSRS personnel responsible for distribution. However, the coexistence of centralized and manual systems, limited training, and incomplete SIMRS integration indicate areas requiring further improvement.

For hospital management, strengthening medical oxygen governance should involve the development of standardized procedures covering procurement, storage, monitoring, distribution, emergency response, and documentation. The hospital should also establish clear coordination mechanisms among IPSRS, nursing units, pharmacy, management, and external suppliers. This is particularly important because medical oxygen is a safety-critical resource rather than merely a routine logistical commodity [10][3].

From a patient safety perspective, the most important priority is ensuring uninterrupted oxygen availability and minimizing dependence on individual staff vigilance. Regular competency-based training, preventive maintenance, adequate reserve capacity, and clear emergency procedures can strengthen the resilience of the oxygen distribution system. The findings also suggest that future development should prioritize the integration of oxygen stock and consumption monitoring into SIMRS so that hospital management can obtain more timely and accurate information for planning and decision-making.

Thus, the management of medical oxygen at Prof. Dr. H. Aloei Saboe Regional Hospital should be approached as an integrated hospital-safety and resource-management issue. Improvements in infrastructure alone may not be sufficient if human-resource competencies and information systems remain underdeveloped. Conversely, digitalization will provide limited benefits without reliable infrastructure, trained personnel, and clearly defined operational procedures. An integrated approach involving technical infrastructure, human resources, organizational processes, and information technology is therefore essential for improving the continuity, efficiency, and safety of medical oxygen distribution.

CONCLUSION

Medical oxygen distribution management at Prof. Dr. H. Aloei Saboe Regional Hospital, Gorontalo, is supported by centralized oxygen infrastructure, reserve cylinders, routine external supply, demand-based distribution, and IPSRS personnel responsible for monitoring and responding to oxygen requests. However,

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the coexistence of centralized and manual distribution systems, limited personnel during afternoon and night shifts, the absence of specific medical oxygen management training, and predominantly manual monitoring, recording, and reporting indicate areas requiring improvement. Although the existing system is considered adequate for current operational needs, strengthening medical oxygen management is necessary to reduce operational and patient-safety risks. The hospital is therefore recommended to establish standardized medical oxygen management and emergency-response procedures, provide regular competency-based training for technical and clinical personnel, strengthen coordination among IPSRS, nursing units, pharmacy, management, and external suppliers, and progressively integrate oxygen stock, consumption, distribution, and replenishment monitoring into SIMRS to support timely decision-making, operational efficiency, continuity of supply, and patient safety.

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