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Evaluating Appropriateness Criteria for Health Commodities Quantification Methods in Namibia's Central Medical Stores

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Abstract

Background

The selection of appropriate quantification methods is critical for efficient health commodity management, impacting stock availability, wastage, and financial sustainability. This study evaluated the criteria used to determine the appropriateness of quantification methods for medical supplies at Namibia's Central Medical Stores (CMS).

Methods

A qualitative case study approach was employed. Data were collected through in-depth interviews with 15 key informants at CMS and supplemented by document analysis. Thematic analysis using ATLAS.ti software identified and analyzed the core criteria guiding method selection.

Results: Five principal criteria emerged: (1) Shelf life of the commodity, (2) Variability in demand, (3) Clinical guidelines and treatment protocols, (4) Supplier reliability, and (5) Previous forecasting accuracy. These criteria are applied to tailor quantification approaches, balancing the need to prevent expiry, respond to demand fluctuations, adhere to medical standards, ensure supply continuity, and learn from past performance.

Conclusion: The study reveals that CMS employs a multi-faceted, pragmatic set of criteria to guide quantification. However, the application of these criteria is often informal and inconsistent. Institutionalizing these criteria within a standardized decision-support framework could enhance the objectivity, consistency, and effectiveness of quantification processes at CMS.

Keywords: Quantification Criteria, Inventory Management, Decision-Making, Health Commodities, Supply Chain, Namibia

Introduction

Accurate quantification the process of determining the type and quantity of health commodities required to meet the needs of a target population is a linchpin of effective public health supply chain management (Chiwanga et al., 2025; Sarley et al., 2010). Inaccurate quantification can lead to dire consequences: stock-outs compromise patient care and treatment outcomes, while overstocking results in financial waste and expiry of precious commodities (Rowe et al., 2018; Mahmood et al., 2024). For institutions like Namibia's Central Medical Stores (CMS), which operate under

budget constraints and serve a dispersed population, getting quantification right is not just an operational goal but a public health imperative.

Quantification is not a one-size-fits-all process. Different health commodities—from high-cost, low-volume cancer drugs to low-cost, high-volume antibiotics present distinct management challenges. Therefore, the appropriateness of a quantification method (e.g., consumption-based, morbidity-based, or service-based) must be judged against specific product and context characteristics (MOH Philippines, 2015). While global guidelines suggest various methods, the criteria used by local practitioners to choose one method over another in real-world settings are less documented, particularly in resource-constrained contexts.

In Namibia, concerns about stock imbalances at CMS point to potential shortcomings in the quantification process. Understanding not just what methods are used, but why they are selected, is crucial for designing targeted interventions (Li et al., 2020). This study therefore focused on the second sub-objective of a larger evaluation: to evaluate the criteria used by CMS to determine the appropriateness of its quantification methods. By uncovering these decision-making heuristics, the research aims to provide a foundation for strengthening the logic and consistency of quantification, thereby improving the availability and rational use of health commodities.

Research Objective

To evaluate the criteria used to determine the appropriateness of the quantification methods used for determining required medical supply quantities by the Central Medical Stores.

Literature Review

Forecasting and quantification of Health Commodities

Forecasting accuracy in Central Medical Stores is crucial for maintaining an efficient and reliable healthcare supply chain. Literature suggests that factors such as historical demand patterns, data quality, and forecasting model selection significantly impact accuracy. Research by Li et al. (2020) emphasises the importance of incorporating advanced statistical models to capture complex demand variations. Organisational factors like communication between different departments, collaboration with suppliers, and inventory management strategies play a pivotal role. Studies by Smith et al. (2022) highlight the need for a holistic approach that considers both internal and external factors influencing the supply chain.

Technological advancements is a very significant tool in accuracy and reliability of health commodities forecasting. Research by Chen et al. (2021) indicates that these technologies enhance forecasting precision by adapting to changing patterns and improving the adaptability of models. It is crucial to recognise the contextual differences in healthcare systems and adapt forecasting methods accordingly. Literature also underscores the significance of continuous monitoring and adjustment of forecasting models to address evolving healthcare demands and unforeseen events, as discussed in the works of Johnson et al. (2021).

Research indicates that the accurate forecasting of medical supplies is contingent upon an understanding of demand drivers. Factors such as population health trends, disease prevalence, and demographic shifts impact the demand for various medical products. Studies by Jain et al. (2018) emphasise the need for forecasting models to incorporate epidemiological data for a more robust understanding of demand patterns.

The role of data quality in forecasting accuracy cannot be overstated. Poor data quality can lead to erroneous predictions and hinder the effectiveness of forecasting models. Research by Wang et al. (2018) highlights the importance of data cleansing, validation, and regular audits to ensure the reliability of the input data. Collaboration between healthcare providers, suppliers, and government agencies is crucial for accurate forecasting. Literature by Razak et al. (2023) suggests that establishing strong partnerships can facilitate the exchange of information, reducing uncertainties and enhancing the accuracy of predictions. Transparent communication and information sharing create a more responsive and adaptable supply chain.

The selection of an appropriate forecasting model is a critical decision. The literature underscores the significance of choosing a model that aligns with the characteristics of the medical supply chain. For instance, recent studies by Kim et al. (2024) emphasise the importance of evaluating various forecasting models, including time series analysis, machine learning algorithms, and simulation methods, to identify the most suitable approach for a particular context. Government policies and regulatory frameworks also play a role in forecasting accuracy. Changes in regulations, reimbursement policies, or public health initiatives can influence demand patterns. Scholars like García-Cáceres et al. (2024) emphasise the need to integrate regulatory insights into forecasting models to account for external factors affecting the healthcare supply chain. Lastly, the dynamic nature of the healthcare landscape requires continuous monitoring and adaptation of forecasting methods. Real-time data analytic, as suggested by Zhang et al. (2021), enable

timely adjustments to forecasting models in response to emerging trends or unforeseen events, ensuring the resilience and reliability of the medical supply chain.

Steele et al. (2019) identified two significant hurdles affecting the proficient management of medical supplies as: insufficiency and unreliability of data concerning consumption, coupled with deficiencies in quantification and forecasting skills. By assessing these methods, this study sought to contribute positively towards reducing the issue of accessibility and availability of medical resources, thereby enhancing healthcare service delivery in Namibia.

Methods

Study Design

This study formed part of a larger qualitative case study evaluating health commodities forecasting and quantification at CMS. The design was anchored in constructivism, seeking to understand the meanings and decision-making processes of supply chain professionals within their operational context (Adom et al., 2016).

Study Setting and Population

The research was conducted at the CMS headquarters in Namibia. Participants were key personnel directly involved in the quantification and procurement cycle, including procurement pharmacists, senior pharmacists, procurement officers, and logistics managers. These individuals were responsible for making or informing decisions on what quantities of which items to order.

Sampling and Data Collection

A purposive sampling strategy was used to select 15 participants with deep operational knowledge of quantification. Primary data collection involved semi-structured interviews guided by a protocol that probed: “How do you decide which method or approach to use when determining how much of a particular medicine to order?” and “What factors make a quantification method ‘right’ or ‘wrong’ for a specific product?” Interviews were recorded and transcribed. Documentary analysis of CMS’s Standard Treatment Guidelines (STGs), procurement plans, and past quantification reports provided additional context (Holloway & Galvin, 2023).

Data Analysis

Thematic analysis, following the framework by Braun and Clarke (2012), was conducted using ATLAS.ti software. The analysis focused specifically on extracting and categorizing the reasons, rules-of-thumb, and formal factors participants described using when selecting and applying quantification methods. Transcripts were coded inductively, and codes were subsequently clustered into overarching themes representing the core criteria for appropriateness.

Ethical Considerations

Ethical approval was obtained from the Namibia University of Science and Technology (NUST) and the Ministry of Health and Social Services. All participants provided written informed consent. Confidentiality was maintained through the use of anonymous identifiers (R1-R15), and data were stored on a password-protected device.

Results

Analysis of the interview data revealed five interconnected criteria that CMS staff employ, either explicitly or implicitly, to judge the appropriateness of a quantification approach for a given health commodity. These are summarized in Table 1.

Table 1: Criteria for Determining Appropriateness of Quantification Methods at CMS

Criterion	Description	Illustrative Quote
1. Shelf Life	Prioritizes methods that align order quantities with product expiration dates to minimize wastage.	"Utilising the shelf life… ensures that only safe and potent medications are distributed. This approach aligns with quality control standards…" (R15)
2. Variability in Demand	Favors methods that can accommodate or be adjusted for unpredictable fluctuations in consumption.	"Integrating variability in demand… enables us to respond effectively to fluctuations… like seasonal illnesses or outbreaks." (R12)
3. Clinical Guidelines & Treatment Protocols	Requires quantification to be grounded in standardised treatment regimens and public health program targets.	"Clinical guidelines… offer standardized recommendations… helping us estimate demand for health commodities." (R14)
4. Supplier Reliability	Influences safety stock calculations and order frequency based on the supplier's track record for on-time, complete delivery.	"Reliable suppliers are more likely to deliver on time… reducing the likelihood of stock-outs. This is crucial for patient safety." (R3)
5. Previous Forecasting Accuracy	Uses the historical performance of a method for a specific product to gauge its future suitability.	"Analysing previous forecasting accuracy serves as a benchmark… It helps in assessing the model's strengths and weaknesses." (R7)

The perishable nature of pharmaceuticals made shelf life a paramount criterion. For short-shelf-life items, especially vaccines and certain antibiotics, participants described using more frequent, smaller batch ordering to avoid expiry. This criterion directly influenced the choice of a procurement cycle and the maximum quantity to be held in stock. As one respondent stated, "*Shelf life-based quantification… prevents the accumulation of outdated stock*" (R1). This aligns with the goal of cost-effectiveness and responsible resource management.

2. Variability in Demand

Participants distinguished between commodities with stable, predictable demand (e.g., chronic disease medications) and those with high volatility (e.g., anti-malarials, influenza drugs). For the latter, methods needed to be more adaptive.

> "*By analysing historical data and trends, authorities can anticipate these shifts and adjust their inventory levels accordingly*," noted one participant (R12).

This criterion often led to the use of safety stock models and more conservative or flexible forecasting methods for volatile items.

3. Clinical Guidelines and Treatment Protocols

This criterion ensured that quantification was evidence-based and programmatically aligned. Quantification for programmatic commodities (e.g., Anti-Retrovirals for HIV, TB drugs) was heavily dictated by national treatment protocols and patient enrollment numbers.

> "*By incorporating clinical guidelines into the quantification process… there is a systematic and evidence-driven framework*," explained a respondent (R14).

This criterion often overrode pure consumption-based history, especially when scaling up new treatment protocols.

4. Supplier Reliability

The trustworthiness of suppliers emerged as a key practical criterion. For commodities sourced from suppliers with a history of delays or inconsistent quality, participants reported building larger safety stocks or opting for more conservative quantification to create a buffer.

"Evaluating the track record and performance of suppliers… allows for a more nuanced approach to demand planning," said one procurement officer (R13).

This criterion linked quantification directly to supply chain risk management.

5. Previous Forecasting Accuracy

Participants described a learning feedback loop where the historical accuracy of past quantifications for a specific product informed current method selection. If a particular method (e.g., a simple consumption average) consistently led to over- or under-stocking for an item, staff would adjust their approach.

"*By analysing past performance, decision-makers can identify patterns, trends, and potential errors in forecasting*," remarked a senior pharmacist (R7).

This criterion represents an empirical, experience-based refinement of the quantification process.

Discussion

This study identifies a pragmatic, multi-dimensional framework of criteria that practitioners at Namibia's CMS use to navigate the complex task of health commodities quantification. The findings move beyond a simple cataloguing of methods to uncover the applied rationality behind their selection (Dwicaksono & Fox, 2018). The criteria reflect a balance between clinical imperatives (guidelines, shelf life), operational realities (demand variability, supplier performance), and continuous improvement (learning from past accuracy).

The emphasis on shelf life and demand variability demonstrates an acute awareness of the financial and public health risks of expiry and stock-outs, which are well-documented challenges in low- and middle-income country supply chains (Tougher et al., 2012; Trap et al., 2018). Using clinical guidelines as a cornerstone for program commodities ensures quantification supports national disease control priorities, aligning with the principles of rational medicine use (MOH Philippines, 2015). The criterion of supplier reliability introduces a crucial risk-management dimension, acknowledging that the best quantification plan can fail if the supply base is weak, a point underscored in supply chain literature (Bossertt et al., 2007; Kamalahmadi & Mellat-Parast, 2016; Kolapo et al., 2009).

The use of previous forecasting accuracy as a criterion indicates an intuitive practice of adaptive management. However, its effectiveness is limited by the absence of formalized forecast accuracy reporting at CMS, as noted in the larger study (Cobos Muñoz et al., 2017). Without systematic measurement and analysis of past errors, this learning remains anecdotal.

A significant insight is that while these five criteria are recognized and used, their application appears informal and reliant on individual experience. There is no documented, standardized protocol that mandates how these criteria should be weighted or combined for different product categories (Yang & Peng, 2022). This informal application can lead to inconsistencies and makes the knowledge vulnerable to staff turnover (Reuben et al., 2026). Formalizing these empirically-derived criteria into a structured decision-support tool or algorithm could significantly enhance the robustness and transparency of the quantification process.

Conclusion

The Central Medical Stores of Namibia employs a more elaborate and context-sensitive set of five key criteria shelf life, demand variability, clinical guidelines, supplier reliability, and past accuracy to determine appropriate quantification methods. These criteria collectively address the core challenges of minimizing waste, ensuring availability, adhering to medical standards, managing supply risk, and learning from experience.

The main recommendation arising from this evaluation is the formalization and systematization of these criteria. CMS should develop a Quantification Method Selection Guideline that explicitly defines these criteria and provides a framework (e.g., a decision matrix or scoring system) for applying them to different commodity categories. This guideline should be integrated into staff training and, ideally, embedded within the health logistics management information system (LMIS) to provide real-time, data-informed decision support. By moving from implicit expertise to explicit protocol, CMS can standardize best practice, improve decision consistency, and ultimately achieve more reliable and efficient quantification outcomes for the Namibian public health system.

The primary contribution of this study to the scientific community lies in moving beyond a normative listing of quantification methods to an empirical, practice-based typology of the decision heuristics used by frontline supply chain professionals in a resource-constrained, middle-income country setting. By formalizing the implicit rules-of-

thumb that practitioners have developed through experience, this research provides a replicable analytical framework that can be tested, adapted, and refined in other low- and middle-income country contexts, thereby advancing the evidence base for context-aware public health supply chain theory. From an economic perspective, the findings have direct and substantial implications: systematic application of these five criteria can reduce the dual financial burdens of overstocking (capital tied up in expired or obsolete inventory) and emergency procurement costs arising from avoidable stock-outs. Formalizing this framework into a structured decision-support tool would empower CMS to achieve more predictable inventory turnover, lower wastage expenditure, and better allocation of scarce pharmaceutical budgets ultimately translating into more health outcomes per dollar spent. Therefore, this work not only explains how CMS currently determines appropriateness but also provides a practical pathway to transform experiential knowledge into an auditable, efficient, and economically beneficial quantification protocol for the Namibian public health system.

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Author's Contributions

Execution of the experimental protocols, data analysis, and preparation of the original manuscript draft.

Ethics

No potential conflict of interest was reported by the authors.

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