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The Moderating Effect of Finance on the Provision of Universal Health Care in Lusaka Province Public Health Facilities, Zambia

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Abstract

Universal Health Coverage (UHC) requires health systems to provide accessible, affordable, equitable and quality healthcare services without exposing individuals and households to financial hardship. This study examined whether facility-level finance moderates the relationships between drug availability, healthcare personnel, medical equipment, health facility infrastructure and UHC service provision in Lusaka Province, Zambia. The study adopted a positivist philosophy and a quantitative explanatory cross-sectional design. Data were collected from 104 healthcare professionals working in facilities within the public health delivery system in Lusaka Province. A structured questionnaire containing 60 closed-ended items across six constructs was administered using a five-point Likert scale. Hierarchical multiple regression was specified in three steps: the four health-system inputs were entered in Step 1, finance was added in Step 2, and the four input × finance interaction terms were entered in Step 3. Step 1 explained 55.1% of the variance in UHC provision. Step 2 explains 72.9% of the variance and the full interaction model 74.7%. The interaction block therefore contributes a further 1.8 percentage points of explained variance beyond the direct contribution of finance. In the full model, finance remained positively associated with UHC provision ($B = 0.312$, $\beta = 0.298$, $p < 0.001$), and all four interaction terms were positive and statistically significant. The findings indicate that finance has both a direct association with UHC provision and a moderating role in the relationships between health-system inputs and UHC service provision. The study concludes that predictable facility-level financing can support the effective conversion of medicines, personnel, equipment and infrastructure into UHC services.

Keywords

Universal Health Coverage, Drug Availability, Health Financing, Public Health Facilities, Healthcare Personnel, Medical Equipment, Health Facility Infrastructure

1. Introduction

Universal Health Coverage (UHC) has become a central objective of national health systems and international health-development policy. It requires that all people obtain the health services they need, of sufficient quality to be effective, without experiencing financial hardship when accessing care (World Health Organization (WHO), 2010; WHO & World Bank, 2023). UHC is commonly understood through three interconnected dimensions: population coverage, service coverage and financial protection. These dimensions require health systems not only to expand access but also to ensure that available services are safe, equitable, affordable and responsive to the needs of different population groups.

The achievement of UHC depends substantially on the capacity of health facilities to deliver essential services. Public health facilities require medicines, skilled healthcare personnel, functional medical equipment, adequate infrastructure and reliable financing. These resources are interdependent. Medicines cannot be effectively used without competent personnel; medical equipment cannot contribute to diagnosis and treatment when it is unavailable, dysfunctional or lacks trained operators; and infrastructure cannot improve service delivery when facilities do not have adequate staff, equipment or operational funding. Systems Theory therefore suggests that the performance of a health facility is determined not only by the presence of individual components but also by the relationships among those components (von Bertalanffy, 1968).

In Zambia, the provision of UHC is influenced by the availability and distribution of health-system resources, the organisation of public healthcare services and the adequacy of health financing. Although reforms have been introduced to improve access and financial protection, public health facilities continue to experience challenges relating to medicine shortages, human-resource constraints, equipment breakdowns, infrastructure limitations and delays in the release or utilisation of funds. These challenges may affect the capacity of facilities to provide comprehensive, continuous and quality services.

Health financing is particularly important because it supports the acquisition, maintenance and utilisation of other health-system inputs. Financing provides the resources required to procure medicines, recruit and retain healthcare personnel, purchase and maintain equipment, improve infrastructure, pay utilities and support routine operations. The WHO Health Financing Framework emphasises that health financing is not limited to the mobilisation of money; it also includes the collection, pooling and purchasing of resources in ways that promote access, effi-

ciency, equity and financial protection (WHO, 2010). At facility level, therefore, the adequacy and predictability of financing may determine whether available inputs can be translated into effective service delivery.

Most studies examining health-system resources have treated finance as an independent predictor of healthcare delivery. However, finance may also operate as a moderating variable. A moderating variable changes the strength or direction of the relationship between an independent variable and a dependent variable (Baron & Kenny, 1986; Hayes, 2022). In the context of this study, finance may strengthen the contribution of drugs, personnel, equipment and infrastructure to UHC provision. For example, medical equipment may have a stronger relationship with UHC where sufficient funds exist for maintenance, electricity, consumables and staff training. Similarly, adequate staffing may contribute more effectively to UHC where facilities have funds for remuneration, transport, supervision and continuing professional development.

The facility-level moderating role of finance remains insufficiently examined in Zambia. Existing policy and health-sector discussions frequently focus on overall health expenditure, financing reforms and national health-system performance. However, national financing figures may not adequately explain how financial resources affect the day-to-day capacity of individual public health facilities. This study therefore investigated whether facility-level finance strengthens or weakens the relationships between drug availability, healthcare personnel, medical equipment, health facility infrastructure and UHC service provision in public health facilities in Lusaka Province.

1.1. Problem Statement

Despite the recognised importance of health-system inputs and financing, the presence of medicines, healthcare personnel, medical equipment and infrastructure does not necessarily result in effective UHC service provision. Public health facilities may possess these inputs but still experience difficulties in maintaining continuous and quality service delivery when financing is inadequate or unpredictable. Financial constraints can affect medicine procurement, staff recruitment and retention, equipment maintenance, infrastructure development and routine facility operations. Consequently, the effectiveness of one health-system input may depend partly on the financial resources available to utilise and sustain it.

Finance may therefore strengthen or weaken the relationship between health-system inputs and UHC provision. For example, medical equipment is likely to contribute more effectively to healthcare delivery when funds are available for maintenance, repairs, electricity and consumables. Similarly, adequate healthcare personnel may improve service delivery when sufficient funds are available for recruitment, training, supervision and staff motivation. Finance may also support the continuous procurement of medicines and the maintenance of hospital infrastructure. Although health-system resources and health financing are widely recognised as important determinants of healthcare delivery, limited attention has

been given to whether facility-level finance changes the strength of the relationships between these inputs and UHC provision in Lusaka Province.

The study therefore examined the direct relationships between four health-system inputs and UHC provision and assessed whether facility-level finance moderates these relationships in public health facilities in Lusaka Province. This distinction is important because finance may contribute directly to UHC provision while also changing the extent to which available medicines, personnel, equipment and infrastructure are translated into healthcare services.

1.2. Study Objectives

The study was guided by the following objectives:

- To examine the relationship between drug availability and the provision of UHC services.
- To assess the relationship between healthcare personnel and the provision of UHC services.
- To determine the relationship between medical equipment and the provision of UHC services.
- To examine the relationship between health facility infrastructure and the provision of UHC services.
- To assess the moderating effect of finance on the relationships between health-system inputs and UHC service provision.

1.3. Research Hypotheses

The study tested the following hypotheses:

H1: Drug availability is significantly associated with UHC service provision.

H2: Healthcare personnel are significantly associated with UHC service provision.

H3: Medical equipment is significantly associated with UHC service provision.

H4: Health facility infrastructure is significantly associated with UHC service provision.

H5: Finance significantly moderates the relationships between drug availability, healthcare personnel, medical equipment, health facility infrastructure and UHC service provision.

2. Literature Review

2.1. Universal Health Coverage

Universal Health Coverage is concerned with ensuring that individuals and communities receive the health services they need without suffering financial hardship. The WHO identifies access, quality, equity and financial protection as essential elements of UHC (WHO, 2010). The WHO and World Bank (2023) further emphasise that progress towards UHC must be assessed through both service coverage and financial protection. A health system may provide a wide range of services but still fail to achieve UHC if those services are inaccessible, unaffordable

or of poor quality.

At the facility level, UHC provision can be reflected in the availability of essential services, affordability of care, equitable treatment, patient satisfaction, service quality, efficiency and protection from excessive out-of-pocket expenditure. These dimensions depend on the capacity of facilities to maintain adequate resources and organise service-delivery processes effectively.

2.2. Availability of Essential Drugs and Universal Health Coverage Provision

Essential medicines are central to the prevention, diagnosis and treatment of disease (World Health Organization (WHO), 2010). Drug availability involves the consistent presence of required medicines, reliable procurement and supply systems, adequate stock levels and the ability of patients to obtain prescribed medicines. Medicine shortages may lead to delayed treatment, referrals, avoidable complications and increased out-of-pocket expenditure (WHO & World Bank, 2023).

From a systems perspective, medicines are one component of a broader service-delivery system. Their contribution depends on the availability of qualified healthcare personnel, diagnostic capacity, storage facilities, procurement systems and operational financing (von Bertalanffy, 1968). Consequently, drug availability is expected to have a positive relationship with UHC provision. However, the strength of this relationship may depend on finance because funds are needed for procurement, storage, distribution and stock management (WHO, 2010).

2.3. Healthcare Personnel and Universal Health Coverage Provision

Healthcare personnel include doctors, nurses, midwives, clinical officers, pharmacists, laboratory staff, community health workers and other cadres involved in the provision of health services. The availability and adequacy of personnel affect waiting times, continuity of care, quality of treatment, patient communication and the range of services that a facility can provide (WHO, 2019).

Staff shortages may increase workload, reduce morale and compromise the quality of care. Conversely, adequate staffing may improve service availability, responsiveness and patient satisfaction. Healthcare personnel also require financial support through salaries, allowances, training, supervision and appropriate working conditions. Finance may therefore strengthen the relationship between staffing and UHC provision by enabling facilities to retain personnel, provide training and support effective service delivery (WHO, 2010; Ministry of Health, Zambia, 2022).

2.4. Medical Equipment and Universal Health Coverage Provision

Medical equipment supports diagnosis, treatment, monitoring and emergency care. Its contribution to healthcare delivery depends on availability, functionality, reliability, maintenance and the presence of personnel who can operate it (WHO,

2019). Equipment that is unavailable or non-functional may reduce the quality and range of services provided. Medical equipment is also financially demanding. Facilities require funds for procurement, installation, calibration, repairs, replacement parts, electricity and staff training. Thus, the mere presence of equipment does not guarantee improved UHC provision. Finance may strengthen the relationship between equipment and UHC by ensuring that equipment remains functional and integrated into routine service delivery (WHO, 2010).

2.5. Health Facility Infrastructure and Universal Health Coverage Provision

Health facility infrastructure includes buildings, wards, consultation rooms, waiting areas, laboratories, pharmacies, water systems, sanitation, electricity, waste-management facilities and other physical structures supporting healthcare delivery. Adequate infrastructure promotes patient safety, privacy, infection prevention and service accessibility (WHO, 2019). Inadequate infrastructure may result in overcrowding, poor sanitation, long waiting times and reduced patient satisfaction. Infrastructure improvements may also be ineffective when adequate personnel, medicines, equipment and operational funds do not accompany them. Finance is therefore expected to moderate the infrastructure-UHC relationship by supporting construction, rehabilitation, utilities, maintenance and the operationalisation of infrastructure investments (von Bertalanffy, 1968; WHO, 2010).

2.6. Health Financing and Universal Health Coverage

Health financing refers to the mobilisation, allocation, management and utilisation of financial resources for healthcare delivery. It includes government funding, health insurance arrangements, donor resources, internally generated funds and other financing mechanisms. The WHO (2010) argues that health financing should promote access to needed services while protecting households from financial hardship.

Finance can influence UHC through at least three mechanisms. First, it provides resources for purchasing health-system inputs. Second, it supports the operation and maintenance of facilities. Third, it determines whether available inputs can be effectively converted into healthcare services. In this study, finance was therefore conceptualised not only as a direct predictor of UHC but also as a moderator of the relationships between health-system inputs and UHC provision (Baron & Kenny, 1986; Hayes, 2022).

3. Theoretical Framework

3.1. Systems Theory

Systems Theory, associated with von Bertalanffy (1968), views organisations as interconnected systems whose performance emerges from the interaction of their components. A public health facility is an open system that receives inputs from its environment, transforms those inputs through administrative and clinical pro-

cesses, and produces healthcare services and outcomes (Katz & Kahn, 1966). The theory is relevant because medicines, personnel, equipment, infrastructure and finance are not independent resources. A shortage in one component may reduce the effectiveness of the others. For example, healthcare personnel may be unable to provide appropriate treatment when essential medicines are unavailable. Similarly, equipment may remain unused when trained operators or maintenance funds are absent. Systems Theory, therefore, supports the expectation that the four health-system inputs will be positively associated with UHC provision and that finance may influence the strength of these relationships.

3.2. Input-Process-Output Model

The Input-Process-Output model, developed by systems theorists and widely associated with the systems approach to organisational analysis, explains how organisational resources are transformed into outputs through operational processes (von Bertalanffy, 1968; Kast & Rosenzweig, 1972). In the present study, drugs, healthcare personnel, medical equipment and infrastructure represent inputs. Clinical, administrative and public-health activities constitute the transformation processes, while UHC service provision represents the intended output. The model suggests that inputs create the potential for service delivery, but this potential must be realised through effective organisational processes. Finance supports the transformation process by providing resources for procurement, maintenance, staffing, utilities and management (WHO, 2010). The model therefore provides a basis for examining finance as a factor that conditions the relationship between health-system inputs and UHC service provision.

3.3. Donabedian's Structure-Process-Outcome Framework

Donabedian's (1988) framework distinguishes between structure, process and outcome. Structural elements include human resources, equipment, buildings and other organisational resources. Processes refer to the activities involved in providing care, while outcomes refer to the effects of healthcare delivery. The four independent variables in this study are primarily structural conditions. UHC provision represents an outcome-oriented construct incorporating accessibility, affordability, equity, quality, efficiency, service availability, patient satisfaction and financial protection. Finance supports both structure and process by enabling facilities to acquire, maintain and utilise resources.

4. Conceptual Framework

The conceptual framework in **Figure 1** proposes that drug availability, healthcare personnel, medical equipment and health facility infrastructure are positively associated with UHC provision. Finance is included as both a direct predictor of UHC provision and a moderating variable. It is therefore expected to have a direct path to UHC provision and to strengthen or weaken each of the four input-UHC relationships.

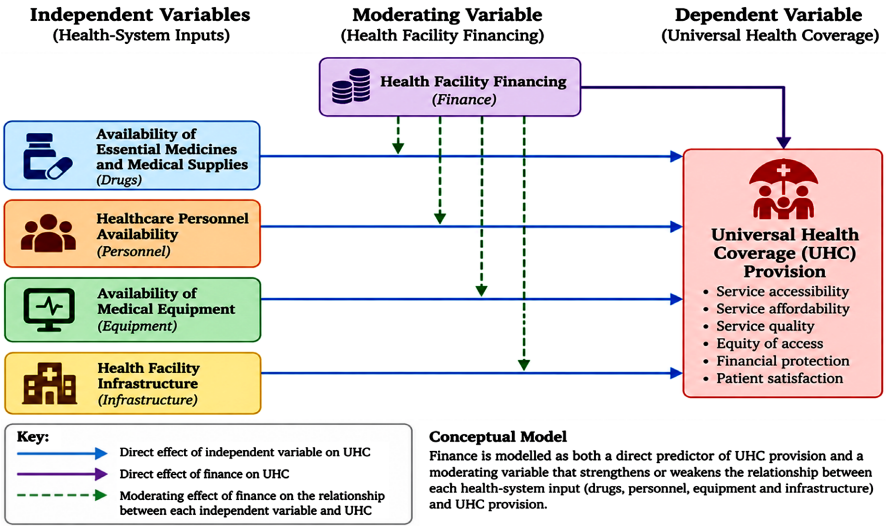


Figure 1. Conceptual framework.

The model can be expressed as:

$$\begin{aligned}\mathrm{UHC} = {} & \beta_0 + \beta_1 D + \beta_2 P + \beta_3 E + \beta_4 I + \beta_5 F + \beta_6 (D \times F) \\ & + \beta_7 (P \times F) + \beta_8 (E \times F) + \beta_9 (I \times F) + \varepsilon\end{aligned} \tag{1}$$

where:

- UHC = provision of Universal Health Coverage services;
- D = availability of drugs;
- P = healthcare personnel;
- E = medical equipment;
- I = health facility infrastructure;
- F = finance;
- $D \times F$ = interaction between drugs and finance;
- $P \times F$ = interaction between personnel and finance;
- $E \times F$ = interaction between equipment and finance;
- $I \times F$ = interaction between health facility infrastructure and finance;
- ε = error term.

5. Methods

5.1. Research Philosophy and Design

The study adopted a positivist research philosophy. Positivism was considered appropriate because the study sought to measure relationships among clearly defined variables and test hypotheses using quantitative statistical techniques. A quantitative explanatory cross-sectional design was employed. The explanatory orientation was appropriate because the study examined the relationships between health-system inputs and UHC provision and assessed whether finance changed the strength of those relationships (Creswell & Creswell, 2023).

The study was conducted in Lusaka Province, Zambia, within facilities forming part of the public health delivery system. The sampling frame comprised 194 pub-

lic health facilities operating at primary/community, intermediate and hospital levels. The analytical unit was the individual healthcare professional. Eligible respondents were healthcare professionals whose roles provided direct knowledge of facility operations, resource availability, financing and service delivery. The frame comprised facilities owned by the Ministry of Health together with mission and faith-based facilities operating under formal Ministry of Health partnership arrangements, reflecting their role in the public health delivery system.

The facility was the sampling unit. Applying Yamane's (1967) formula to the 194 facilities at a 5% margin of error gave a sample of 130 facilities, allocated proportionally across the five facility levels as shown in **Table 1**, with simple random sampling applied within each stratum. At each selected facility, one eligible healthcare professional completed the questionnaire, drawn from the clinical, pharmaceutical, laboratory or administrative functions on the basis of direct knowledge of facility operations, resource availability, financing and service delivery. The study retained 104 completed questionnaires, representing an 80% response rate. Because each facility was represented by a single respondent, the 104 responses correspond to 104 separate facilities.

Table 1. Sampling framework.

Facility level	Sampling-frame population	Target sample	Achieved responses
Primary/community facilities	159	110	93
Intermediate facilities	14	10	4
Level 1 hospitals	12	6	4
Level 2 hospitals	5	3	1
Level 3 hospitals	4	1	2[a]
Total	194	130	104

[a]Two eligible questionnaires were returned from the Level 3 stratum although the proportional target was one; both were retained in the achieved respondent sample.

The achieved sample comprised 104 respondents, representing an 80% response rate. Two eligible questionnaires were returned from the Level 3 stratum although the proportional target was one, and both were retained as fieldwork over-recruitment. The 104 respondents were drawn from 104 separate facilities, one respondent per facility. No respondents were clustered within facilities, responses are therefore independent across facilities, and no clustering or multilevel adjustment was required. The effective sample size for the regression analysis is 104.

Data were collected using a structured self-administered questionnaire adapted from the WHO Health Systems Building Blocks Framework and the WHO—World Bank UHC Monitoring Framework. The questionnaire contained 60 con-

struct items distributed equally across six constructs: 10 items for drug availability, 10 for healthcare personnel, 10 for medical equipment, 10 for health facility infrastructure, 10 for finance and 10 for UHC provision. Items were scored on a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree. Construct scores were obtained by aggregating the corresponding items. Three items were worded so that agreement indicates a resource constraint rather than a favourable condition: one in the drug availability construct, one in the medical equipment construct and one in the finance construct. These items were reverse-scored before aggregation. Higher construct scores therefore indicate more favourable conditions.

Drug availability was measured with 10 items concerning essential medicine availability, stock levels, procurement reliability, access to prescribed medicines and disruption caused by shortages. Healthcare personnel were measured with 10 items covering staffing adequacy, training, professionalism, communication, motivation, workload, commitment and timely service provision. Medical equipment was measured with 10 items covering availability, functionality, diagnostic usefulness, maintenance, reliability and treatment delays. Health facility infrastructure was measured with 10 items covering wards, consultation rooms, waiting areas, sanitation, utilities, physical condition, overcrowding and contribution to service delivery.

Finance was measured with 10 facility-financing items concerning adequacy, availability, predictability, allocation and utilisation of financial resources for procurement, staffing, equipment, infrastructure and routine operations. UHC provision was measured with 10 outcome-oriented items covering access, affordability, equity, quality, efficiency, patient satisfaction, service availability and financial protection. The finance and UHC item sets were distinct: no identical questionnaire item was included in both constructs. Nevertheless, some finance items refer to service access or quality, while UHC items measure those outcomes directly. This conceptual proximity is acknowledged; finance was operationalised as the availability and management of facility-level financial resources, whereas UHC was operationalised as the reported service-delivery outcome. In particular, UHC financial-protection and affordability items were not used as measures of facility finance. Because the finance and UHC constructs were measured through the same respondent and showed a relatively high bivariate correlation ($r = 0.758$), the manuscript treats their conceptual proximity as a measurement limitation rather than assuming complete construct separation.

5.2. Operationalisation of Variables

Drug availability was measured through 10 items concerning essential medicine supplies, stock levels, procurement reliability, access to prescribed medicines and the extent to which medicine shortages disrupted treatment. Healthcare personnel were measured through 10 items covering staffing adequacy, training, professionalism, communication, motivation, workload, commitment and timely service

provision. Medical equipment was measured through 10 items covering availability, functionality, diagnostic usefulness, maintenance, reliability and equipment downtime. Health facility infrastructure was measured through 10 items covering wards, consultation rooms, waiting areas, sanitation, utilities, physical condition, overcrowding and contribution to service delivery. Finance was measured through 10 facility-level financing items concerning adequacy, availability, predictability, allocation and utilisation of financial resources for procurement, staffing, utilities, maintenance and routine operations.

The UHC provision was measured through 10 outcome-oriented items covering accessibility, affordability, equity, quality, efficiency, patient satisfaction, service availability and financial protection. The finance and UHC item sets were distinct: affordability and financial-protection items were used to measure UHC provision, not facility finance. Thus, finance represents the financial resources and financing conditions available to facilities, whereas UHC provision represents the reported service-delivery outcome. The wording of the UHC items was designed to capture service-delivery outcomes rather than the availability of financial resources to facilities; nevertheless, the conceptual proximity between finance and UHC is acknowledged as a limitation.

5.3. Validity and Reliability

A pilot study involving 15 respondents was conducted to assess clarity, relevance, sequencing, completion burden and preliminary internal consistency. Feedback from the pilot informed revisions to wording, sequencing and questionnaire flow before the main survey. The final instrument retained 60 construct items. Cronbach's alpha coefficients were 0.89 for drug availability, 0.91 for healthcare personnel, 0.87 for medical equipment, 0.88 for hospital infrastructure, 0.92 for finance and 0.90 for UHC provision. The overall instrument alpha was 0.90. These coefficients indicate high internal consistency (Taber, 2018).

5.4. Common Method Variance

Since all study constructs were measured using one self-report instrument at one point in time, common method variance (CMV) was considered. The study used Harman's single-factor test together with procedural remedies. The first unrotated factor accounted for less than 50% of total variance. This result reduces, but does not eliminate, concern about common method bias; Harman's test has recognised limitations and is therefore treated as a diagnostic rather than definitive proof that CMV is absent (Harman, 1967; Podsakoff et al., 2003).

5.5. Data Analysis

Data were analysed using SPSS. Descriptive statistics and Pearson's product-moment correlations were used to summarise the constructs and examine bivariate associations. Moderation was tested through hierarchical multiple regression in three explicitly specified steps. All continuous predictors were mean-centred before interaction terms were calculated.

Step 1—Health-system inputs model:

$$\begin{aligned} \mathrm{UHC}_i = {} & \beta_0 + \beta_1 \mathrm{Drugs}_i + \beta_2 \mathrm{Personnel}_i + \beta_3 \mathrm{Equipment}_i \\ & + \beta_4 \mathrm{Infrastructure}_i + \varepsilon_i \end{aligned} \tag{2}$$

Step 2—Health-system inputs plus finance:

$$\begin{aligned} \mathrm{UHC}_i = {} & \beta_0 + \beta_1 \mathrm{Drugs}_i + \beta_2 \mathrm{Personnel}_i + \beta_3 \mathrm{Equipment}_i \\ & + \beta_4 \mathrm{Infrastructure}_i + \beta_5 \mathrm{Finance}_i + \varepsilon_i \end{aligned} \tag{3}$$

Step 3—Full moderation model:

$$\begin{aligned} \mathrm{UHC}_i = {} & \beta_0 + \beta_1 \mathrm{Drugs}_i + \beta_2 \mathrm{Personnel}_i + \beta_3 \mathrm{Equipment}_i \\ & + \beta_4 \mathrm{Infrastructure}_i + \beta_5 \mathrm{Finance}_i + \beta_6 \left(\mathrm{Drugs} \times \mathrm{Finance}\right)_i \\ & + \beta_7 \left(\mathrm{Personnel} \times \mathrm{Finance}\right)_i + \beta_8 \left(\mathrm{Equipment} \times \mathrm{Finance}\right)_i \\ & + \beta_9 \left(\mathrm{Infrastructure} \times \mathrm{Finance}\right)_i + \varepsilon_i \end{aligned} \tag{4}$$

where UHC denotes UHC service provision; Drugs denotes drug availability; Personnel denotes healthcare personnel; Equipment denotes medical equipment; Infrastructure denotes health facility infrastructure; Finance denotes facility-level finance; and ε denotes the error term. Step 1 estimates the contribution of the four health-system inputs. Step 2 estimates the incremental contribution of finance after controlling for those inputs. Step 3 tests whether finance changes the strength of the four input-UHC relationships. Moderation is assessed from the interaction terms and their incremental contribution to explained variance, while the finance main-effect coefficient represents the direct association of finance conditional on the other predictors.

Normality, multicollinearity and residual independence were assessed before regression analysis. The reported diagnostic results indicated no significant departures from normality. The Durbin-Watson statistics were 1.89 for Step 1 and 1.92 for the full model, suggesting no substantial autocorrelation in the residuals.

6. Results

6.1. Correlation Analysis

The correlation analysis (Table 2) indicated positive and statistically significant

Table 2. Pearson correlation coefficient.

Variable	Drugs	Health Personnel	Medical Equipment	Health facility infrastructure	Finance	UHC
Drugs	1					
Personnel	0.612**	1				
Equipment	0.598**	0.645**	1			
Health facility infrastructure	0.574**	0.603**	0.621**	1		
Finance	0.668**	0.702**	0.689**	0.655**	1	
UHC Provision	0.701**	0.734**	0.712**	0.689**	0.758**	1

**Correlation significant at 0.01 level (2-tailed).

relationships between all the predictor variables and UHC provision. Finance had the strongest correlation with UHC provision, followed by healthcare personnel, medical equipment, drug availability and hospital infrastructure. The results suggest that facilities reporting better availability of medicines, personnel, equipment, infrastructure and finance also tended to report stronger UHC provision.

The correlations among the independent variables were moderate to strong but did not indicate a reason to exclude any of the predictors from the regression analysis.

6.2. Model 1: Main-Effects Model

Step 1: Health-system inputs model. The four health-system inputs were entered simultaneously. The model produced R = 0.742 and R^2 = 0.551 (adjusted R^2 = 0.532), indicating that drugs, personnel, equipment and infrastructure jointly explained 55.1% of the variance in UHC provision. The model was statistically significant, F(4, 99) = 27.18, $p < 0.001$. The coefficient results were: drug availability, B = 0.214, β = 0.238, t = 3.01, $p = 0.003$; healthcare personnel, B = 0.268, β = 0.281, t = 3.88, $p < 0.001$; medical equipment, B = 0.192, β = 0.201, t = 2.59, $p = 0.011$; and hospital infrastructure, B = 0.173, β = 0.182, t = 2.40, $p = 0.018$.

6.3. Step 2: Health-System Inputs Plus Finance

Finance was entered after the four health-system inputs, allowing its direct contribution to be distinguished from the interaction effects entered in Step 3. The five-predictor model explains $R^2 = 0.729$ (adjusted $R^2 = 0.715$), compared with $R^2 = 0.551$ in Step 1, an increase of $\Delta R^2 = 0.178$. The corresponding standardised finance coefficient is β = 0.219 in this five-predictor specification. As noted beneath Table 3, the Step 2 fit statistics are derived from the correlation matrix and n = 104.

Table 3. Hierarchical regression model fit.

Step	Predictors entered	R^2	Adjusted R^2	ΔR^2
1	Drugs, personnel, equipment, health facility infrastructure	0.551	0.532	—
2	Step 1 + finance	0.729	0.715	0.178
3	Step 2 + four input × finance interactions	0.747	0.720	0.018

Note: Step 2 fit statistics are derived from the correlation matrix and n = 104.

Step 3: Full moderation model. The four interaction terms were added to the Step 2 model. The full model produced R = 0.864, R^2 = 0.747 and adjusted R^2 = 0.720. Relative to Step 2, the interaction block contributes $\Delta R^2 = 0.018$. Relative to Step 1, finance and the four interaction terms together contribute $\Delta R^2 = 0.196$, $\Delta F(5, 94) = 14.68$, $p < 0.001$. The evidence for moderation is assessed from the individual interaction coefficients and the conditional slopes reported in Section 6.5. The full model was statistically significant, F(9, 94) = 27.67, $p < 0.001$.

6.4. Direct Effect of Finance

In the full nine-predictor model, finance had a positive direct association with UHC provision (B = 0.312, SE = 0.075, β = 0.298, t = 4.16, $p < 0.001$; variance inflation factor (VIF) = 2.40). This coefficient represents the direct finance effect conditional on the four health-system inputs and the interaction terms.

6.5. Interaction Effects

The four interaction terms were positive and individually statistically significant in the full model. Drug availability × Finance: B = 0.118, SE = 0.045, β = 0.142, t = 2.62, $p = 0.010$; Healthcare Personnel × Finance: B = 0.135, SE = 0.048, β = 0.155, t = 2.81, $p = 0.006$; Medical Equipment × Finance: B = 0.109, SE = 0.047, β = 0.128, t = 2.32, $p = 0.022$; and Health Facility Infrastructure × Finance: B = 0.121, SE = 0.046, β = 0.139, t = 2.63, $p = 0.010$. The positive interaction coefficients indicate that the relationships between the four health-system inputs and UHC provision become more positive as finance increases.

At low finance (−1 standard deviation [SD]), mean finance, and high finance (+1 SD), the estimated slopes for drug availability were 0.032, 0.142, and 0.252, respectively; for healthcare personnel, they were 0.069, 0.195, and 0.321, respectively; for medical equipment, they were 0.030, 0.131, and 0.232, respectively; and for health facility infrastructure, they were 0.007, 0.120, and 0.233, respectively. Each slope was computed as the full-model input coefficient ± (interaction coefficient × SD of finance), with SD of finance = 0.93.

Table 4 presents the interaction effects between facility-level finance and the four health-system inputs. The interaction between drugs and finance was positive and statistically significant (B = 0.118, SE = 0.045, β = 0.142, t = 2.62, $p = 0.010$), indicating that higher levels of finance strengthened the positive relationship between drug availability and UHC provision. Similarly, the personnel × finance interaction was positive and statistically significant (B = 0.135, SE = 0.048, β = 0.155, t = 2.81, $p = 0.006$), demonstrating that finance strengthened the relationship between healthcare personnel and UHC provision.

Table 4. Interaction effects.

Term	B	SE	β	t	*p*
Drugs × Finance	0.118	0.045	0.142	2.62	0.010
Personnel × Finance	0.135	0.048	0.155	2.81	0.006
Equipment × Finance	0.109	0.047	0.128	2.32	0.022
Health facility infrastructure × Finance	0.121	0.046	0.139	2.63	0.010

Note: B = unstandardised coefficient; SE = standard error; β = standardised coefficient.

The equipment × finance interaction was also positive and statistically significant (B = 0.109, SE = 0.047, β = 0.128, t = 2.32, $p = 0.022$), indicating that the

contribution of medical equipment to UHC provision increased with higher levels of facility-level finance. Finally, the infrastructure × finance interaction was positive and statistically significant (B = 0.121, SE = 0.046, β = 0.139, t = 2.63, p = 0.010), showing that finance strengthened the relationship between health facility infrastructure and UHC provision.

Overall, all four interaction terms were positive and statistically significant, demonstrating that facility-level finance significantly strengthened the relationships between drugs, healthcare personnel, medical equipment, health facility infrastructure and UHC service provision. The largest standardized interaction coefficient was observed for healthcare personnel × finance (β = 0.155), followed by drugs × finance (β = 0.142), infrastructure × finance (β = 0.139) and equipment × finance (β = 0.128).

The results support the moderating hypothesis at the level of the individual interaction terms: all four input × finance coefficients were positive and statistically significant. The interaction results therefore indicate that the strength of each input-UHC association varies with the level of finance, while the direct finance coefficient indicates a separate positive association with UHC provision.

7. Discussion

The study found that drug availability, healthcare personnel, medical equipment and health facility infrastructure were positively associated with UHC provision. This finding is consistent with Systems Theory, which views healthcare facilities as interconnected systems in which the performance of one component depends partly on the availability and functioning of other components (von Bertalanffy, 1968; Kast & Rosenzweig, 1972).

The positive association between drug availability and UHC provision indicates that consistent access to essential medicines is important for service availability, treatment continuity and patient satisfaction. Medicine shortages can undermine the capacity of healthcare personnel to treat patients and may force patients to purchase medicines outside public facilities. This may weaken financial protection, which is a core dimension of UHC (WHO & World Bank, 2023; WHO, 2019).

Healthcare personnel had the strongest direct association with UHC provision in the main-effects model. This finding reflects the central role of healthcare workers in diagnosis, treatment, counselling, prevention, administration and patient support. Even where medicines and equipment are available, inadequate staffing may limit the number and quality of services that a facility can provide. The result is also consistent with the structure-process-outcome perspective, which identifies human resources as a fundamental structural condition for effective healthcare processes (Donabedian, 1988; WHO, 2019).

Medical equipment was also positively associated with UHC provision. Functional equipment improves diagnostic and treatment capacity and may reduce unnecessary referrals. However, equipment requires regular maintenance, calibra-

tion, electricity, consumables and trained operators. Therefore, equipment acquisition without a corresponding maintenance and operational budget may not produce sustained improvements in healthcare delivery (WHO, 2010; Ministry of Health, Zambia, 2022).

Health facility infrastructure was positively associated with UHC provision, although its relationship was weaker than those of personnel, equipment and drugs. Infrastructure provides the physical environment in which healthcare services are delivered. Adequate wards, consultation rooms, sanitation, water and electricity may improve patient safety, privacy and service efficiency. Nevertheless, infrastructure alone cannot guarantee UHC if other inputs remain inadequate (Donabedian, 1988; WHO, 2019).

The most important finding was that finance significantly moderated all four relationships. This indicates that the contribution of medicines, personnel, equipment and infrastructure to UHC provision depends partly on the availability of financial resources. The result supports the argument that finance is not merely another health-system input but also an enabling condition that determines whether other inputs can be converted into effective services (WHO, 2010; Hayes, 2022).

The positive interaction between drug availability and finance suggests that financial resources strengthen the contribution of medicines to UHC provision. Adequate financing may improve procurement, stock management, storage, distribution and the availability of medicines at the point of care. Similarly, the positive interaction between personnel and finance indicates that staffing contributes more strongly to UHC where facilities have adequate funds for recruitment, retention, training, supervision and staff support (WHO, 2010; Ministry of Health, Zambia, 2022).

The interaction between medical equipment and finance suggests that the value of equipment depends on the availability of funds for maintenance, repairs, consumables and technical support. The interaction between infrastructure and finance indicates that buildings and physical facilities are more likely to support UHC when funds are available for utilities, rehabilitation, sanitation and routine maintenance (WHO, 2010; Ministry of Health, Zambia, 2022).

The three-step analysis clarifies the statistical role of finance. Step 1 explains 55.1% of the variance in UHC provision using the four health-system inputs. Adding finance in Step 2 increases explained variance by 17.8 percentage points. Adding the four interaction terms in Step 3 produces a further increase of 1.8 percentage points. The evidence for moderation comes from the four individual interaction coefficients and the conditional slopes, whereas the larger Step 2 increase represents the direct contribution of finance.

The findings have important implications for health policy. First, resource allocation should not focus exclusively on capital investments or the procurement of inputs. It should also provide adequate operational financing to ensure that inputs remain available and functional. Second, health financing should be predictable. Delays in funding may interrupt procurement, staff support, equipment

maintenance and facility operations. Third, financing arrangements should be coordinated across government allocations, health insurance resources, donor funding and facility-level revenues. Fragmented financing may create gaps between the availability of resources and their actual utilisation (WHO, 2010; Ministry of Health, Zambia, 2022).

8. Conclusion

The study concludes that drug availability, healthcare personnel, medical equipment and health facility infrastructure are positively associated with UHC service provision in the sampled facilities in Lusaka Province. Finance has a significant positive direct association with UHC provision and the four input × finance interactions are positive and statistically significant. Given the cross-sectional design and self-reported measures, these findings should be interpreted as associations and moderation effects rather than evidence of temporal or causal effects. The results indicate that financing conditions are relevant to how health-system inputs are translated into reported UHC service provision.

9. Implications

9.1. Theoretical Implications

The study contributes to Systems Theory by demonstrating that the effectiveness of health-system inputs depends not only on their availability but also on the financial conditions under which they are utilised. Drugs, healthcare personnel, medical equipment and infrastructure may create the potential for service delivery; however, their contribution to UHC provision is strengthened when adequate financial resources support procurement, staffing, maintenance and daily operations. This extends the systems perspective by positioning finance as an enabling and moderating condition within the relationship between health-system inputs and service outcomes (von Bertalanffy, 1968; Kast & Rosenzweig, 1972).

The findings also reinforce the structure-process-outcome perspective of healthcare quality. Although the four resource variables were positively associated with UHC provision, their effects were stronger when supported by finance. This suggests that structural resources do not automatically produce improved outcomes unless appropriate operational processes are adequately funded (Donabedian, 1988). The study therefore provides a basis for integrating financial conditions more explicitly into theoretical explanations of health-service delivery and UHC attainment.

9.2. Practical Implications

The findings imply that health authorities should allocate resources for both the acquisition of health-system inputs and their continued operation. Procurement of medicines and equipment should be accompanied by adequate funding for stock management, maintenance, repairs, consumables and technical support. Similarly, staffing policies should provide sufficient resources for recruitment, re-

tention, training, supervision and staff welfare. Infrastructure investments should also include budgets for utilities, rehabilitation, sanitation and routine maintenance (WHO, 2010; Ministry of Health, Zambia, 2022).

The study further highlights the need for predictable and coordinated health financing. Delayed or fragmented funding may prevent facilities from converting available resources into effective services. Government allocations, health insurance resources, donor support and facility-level revenues should therefore be aligned with facility needs and UHC priorities. Strengthening financial planning, monitoring and accountability at facility level may improve the utilisation of resources and support more equitable access to quality healthcare services (WHO, 2019; WHO & World Bank, 2023).

10. Recommendations

10.1. Improve the Predictability of Facility-Level Financing

The Ministry of Health and relevant financing institutions should improve the predictability and timeliness of funds released to public health facilities. Delayed disbursements may disrupt procurement, utilities, maintenance and routine service delivery.

10.2. Link Capital Investment to Operational Budgets

Capital investments in buildings and medical equipment should be accompanied by realistic budgets for maintenance, utilities, consumables and technical support. This would reduce the risk of infrastructure and equipment becoming underutilised or non-functional.

10.3. Strengthen Financing for Healthcare Personnel

Financing plans should provide for recruitment, retention, professional development, supervision and staff welfare. Adequate personnel financing may improve service continuity, staff motivation and the quality of patient care.

10.4. Improve Medicine Procurement and Stock Management

Financial resources should be allocated to strengthen procurement planning, stock monitoring, storage and distribution systems. Facilities should also be supported to identify and respond quickly to medicine shortages.

10.5. Improve Coordination of Funding Sources

Government, the National Health Insurance Management Authority (NHIMA), cooperating partners and other financing institutions should improve coordination to reduce duplication, funding gaps and uncertainty. Financing mechanisms should be aligned with facility-level service-delivery priorities.

10.6. Strengthen Maintenance Systems

Dedicated maintenance budgets should be established for medical equipment,

buildings, water systems, electricity and sanitation facilities. Maintenance should be treated as a core component of health financing rather than an occasional activity.

10.7. Improve Facility-Level Financial Accountability

Public health facilities should strengthen financial planning, reporting, monitoring and accountability. Transparent financial management may improve the utilisation of available resources and ensure that funding is directed towards essential service-delivery needs.

11. Limitations of the Study

An additional methodological limitation concerns possible clustering of respondents within facilities. The sampling frame was facility-based, whereas the analytical unit was the individual healthcare professional. Each participating facility contributed one respondent, so the 104 observations are independent across facilities and no clustering adjustment was required. Because each facility is represented by a single respondent, facility conditions are described from one professional's perspective and inter-rater agreement within facilities could not be assessed; future studies could survey several professionals per facility.

The study used a cross-sectional design, which limits the ability to establish temporal or causal relationships. The findings are based on self-reported perceptions of healthcare professionals and may therefore be affected by response bias. The study was conducted in Lusaka Province and may not be generalisable to all public health facilities in Zambia. In addition, the study did not incorporate detailed objective data on facility budgets, medicine stock records, equipment functionality or patient-level health outcomes. Future studies should use longitudinal designs and combine survey responses with administrative, financial and clinical data. Further research could also compare provinces, facility levels and different financing arrangements to determine whether the moderating role of finance varies across contexts. A further limitation is that the principal sampling frame was facility-based while the analytical unit was the individual healthcare professional; the manuscript therefore does not assume that multiple respondents from the same facility are statistically independent beyond the regression specification used. In addition, the relatively high correlation between finance and UHC provision ($r = 0.758$) indicates conceptual proximity between the constructs, which may contribute to shared-method or construct-overlap effects. Future studies should use facility-level administrative financial and service data, establish the number of respondents per facility, and where appropriate account for clustering.

Ethical Approval

The study received ethical approval from the University of Lusaka Research Ethics Committee (Ref: FWA00033228-27202/26, 15 April 2026) and research authority approval from the National Health Research Authority (Ref: NHRA-3505/20/04/2026,

28 April 2026). Participation was voluntary and respondents were informed of the purpose of the study and the confidentiality of their responses.

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Author Contributions

Doreen Chanda Mwansa: conceptualisation, methodology, data collection, formal analysis and writing—original draft; Mike Goma: supervision and writing—review and editing. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest regarding the publication of this paper.

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