

High Prevalence and Predictors of Medication Reconciliation Errors in Type 2 Diabetes Outpatients with Multimorbidity: A Cross-Sectional Study in Zambia

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Abstract

Background

Medication reconciliation (MR) errors at care transitions contribute to preventable patient harm. However, despite their clinical significance, the prevalence, types, and predictors of MR errors among outpatients with type 2 diabetes in Zambia remain undocumented. This study aimed to quantify MR errors and identify associated factors in this population.

Methods

A cross-sectional study was conducted among 300 systematically sampled type 2 diabetes outpatients attending the Medical Outpatient Clinic at the University Teaching Hospital in Lusaka, Zambia. A triple-source audit comprising a patient interview (Best Possible Medication History), the current prescription, and a clinical file review were employed to identify discrepancies. Errors were classified using PCNE V9.1 and graded using the WHO-ISMP/NCC MERP severity scale. Predictors were assessed using multivariable logistic regression.

Results

At the patient level, 70.0% (210/300) of patients had at least one MR error (95% CI: 64.6–74.9%). Severity was reported at the patient level using the most severe error identified for each patient. Among errors ($n = 210$ errors), 31.9% were Level 1 (minor, no potential harm), 42.9% Level 2 (moderate, monitoring required), and 25.2% Level 3 (serious, intervention required). The severity distribution was based on the most severe error per patient. Omissions (P1.1: 21.4%) and under-dosing (P1.2: 19.5%) dominated. Metformin (24.8%) and insulins (21.7%) were the most frequently implicated. After multivariable adjustment, comorbidity count (aOR 3.59, 95% CI 2.28–5.65, $p < 0.001$), number of specialty clinics attended (aOR 2.78, 95% CI 1.87–4.14, $p < 0.001$), and cost-related non-adherence (aOR 3.35, 95% CI 1.08–10.43, $p = 0.032$) remained independently associated with errors. Only 10.7% of patients attending multiple clinics had documented cross-clinic communication.

Conclusions

The findings indicate that MR errors are common among Zambian outpatients with type 2 diabetes and comorbidities. Comorbidity burden, care fragmentation, and economic barriers are independent drivers. Interventions should include a shared medication passport for patients attending multiple specialty clinics, pharmacist-led Best Possible Medication History collection, and policy measures to address medication affordability.

Background

Medication reconciliation (MR) is the formal process of creating an accurate list of a patient's current medicines and comparing it against prescription orders at care transitions to identify and resolve discrepancies [1]. The World Health Organization's "Medication Without Harm" campaign has prioritized MR as a key strategy to reduce preventable medication-related harm globally. Systematic reviews show that pharmacist-led medication reconciliation reduces adverse drug event-related hospital revisits, emergency department visits, and readmissions by 67%, 28% and 19%, respectively, although the evidence on medication discrepancies remains of very low quality [2, 3].

In sub-Saharan Africa, studies report substantial MR discrepancy rates. In South Africa, 41.5% of medication lines reviewed generated a pharmacy intervention, with most patients having multiple discrepancies between home and inpatient lists. Naicker et al. [4] used a medication line review approach focusing on pharmacy interventions. In Kenya, 63.2% of elderly diabetic inpatients had at least one unintentional medication discrepancy identified on admission [5]. These findings demonstrate that MR is a relevant concern in the region, yet most studies have focused on hospital admission or discharge transitions, not on routine outpatient care.

Zambia faces a rising burden of non-communicable diseases, with an estimated 10.3% adult prevalence of diabetes [6] and a 19.1% national prevalence of raised blood pressure, with up to 34.8% reported in an earlier Lusaka district survey [7]. The University Teaching Hospital (UTH) in Lusaka is the largest tertiary referral centre in the country, managing high volumes of patients with complex, multi-morbid conditions. However, no published data exist on MR error prevalence, types, severity, or predictors among Zambian outpatients.

Health system constraints in Zambia, including high patient volumes, paper-based records, limited pharmacy staffing, and inconsistent MR procedures, create a high-risk environment for medication errors. However, specific metrics such as pharmacist-to-patient ratios, waiting times, and record completeness were not assessed in this study. Additionally, patients with type 2 diabetes and comorbidities often attend multiple specialty clinics (Endocrinology, Cardiology, Renal, Neurology), each with separate paper records and no shared medication reconciliation process. This fragmentation may create "assumed responsibility" gaps in which one clinic assumes another will continue a medication, leading to unintended omissions. This study aimed to determine the prevalence, severity, and predictors of MR errors among type 2 diabetes outpatients with comorbidities at UTH, using standardized PCNE V9.1 and WHO-ISMP classification tools to establish the first benchmark for Zambia.

Methods

Study design and setting: This was a cross-sectional descriptive study conducted at the Medical Outpatient Clinic (Clinic 5) of the University Teaching Hospital, Lusaka, and its associated pharmacies. Clinic 5 is a high-volume endocrine clinic that sees 30–40 chronic patients daily. The study was conducted between May and June 2026 over approximately 20 working days. The target population

comprised adult type 2 diabetes outpatients (≥ 18 years) with at least one additional chronic comorbidity (hypertension, chronic kidney disease, heart failure, dyslipidaemia, neuropathy, or previous stroke) attending Clinic 5 during the study period.

Eligibility criteria and sampling: Eligible participants were adults aged ≥ 18 years with a confirmed diagnosis of type 2 diabetes and at least one additional chronic condition, who attended Clinic 5 during the study period and provided written informed consent. Patients were excluded if they had cognitive impairment without a caregiver present to support participation, or if their clinical file had not been updated for > 2 years, precluding reliable clinical ascertainment. Less than 5% of patients were excluded because their files had not been updated for more than 2 years.

Sample size was estimated using Cochran's formula for prevalence studies, $n = Z^2P(1-P)/d^2$. Assuming a 95% confidence level ($Z = 1.96$), an estimated prevalence of 25% (a conservative estimate due to the absence of Zambian data) based on prior regional studies, and a 5% margin of error ($d = 0.05$), the minimum required sample was 288 participants. To account for an anticipated 10% non-response rate, the final target sample size was inflated to 300. The final achieved sample was 300, with complete data for the primary analysis.

Participants were selected using systematic random sampling. Based on clinic records indicating an average daily flow of 30 eligible patients, a sampling interval of $k = 2$ was applied. At the start of each clinic day, the first participant was selected by simple random sampling between 1 and 2, and subsequent eligible patients were approached at every second interval thereafter. To prevent potential queue manipulation and ensure representativeness, the daily random starting index (1 or 2) was varied each morning. Patient arrival order was considered independent of clinical severity, further minimizing potential bias. A daily recruitment log was maintained to document all refusals and exclusions to ensure transparency and assess potential selection bias. The refusal rate was less than 10% (approximately 25 patients), and the main reasons for exclusion were: files not updated > 2 years ($< 5\%$) and cognitive impairment without a caregiver ($< 2\%$).

Data collection: Data were collected through a comprehensive triple-source audit. First, a 15–20 minute semi-structured interview was conducted in a private setting to obtain the Best Possible Medication History (BPMH), capturing all current medications (name, dosage, frequency), recently discontinued therapies, drugs procured from private pharmacies (including cost in Zambian Kwacha), and self-reported affordability challenges. The BPMH interview included specific probes for: (1) prescription medications, (2) over-the-counter medicines, (3) traditional medicines, and (4) supplements or vitamins. The interview instrument was developed specifically for this study based on WHO guidelines for Best Possible Medication History (BPMH) collection and validated medication reconciliation tools from previous studies. An English language version is provided as a supplementary file (Appendix C). During the same interview, socio-demographic data, including age, sex, marital status, level of education, and occupation, were systematically collected using a structured questionnaire to characterise the study population. Clinical data, including comorbid conditions, duration of diabetes, and number of chronic

medications, were extracted from the patient's clinical file. Second, the hand-carried prescription issued at the index visit was reviewed. Third, the patient's official paper-based clinical file at the University Teaching Hospital (UTH) was retrieved and reviewed for past medical history, prior prescriptions, index visit progress notes, records from other specialty clinics, and evidence of cross-clinic communication.

Classification, severity grading, and reliability: Identified discrepancies were classified as medication reconciliation errors if they were: (1) unintended, (2) clinically significant, and (3) not explained by intentional documented changes. Errors were classified using the PCNE V9.1 classification system [8] (drug selection, dose, duration, form, administration, etc.) and graded for severity using the WHO-ISMP/NCC MERP severity scale [9] (Level 1 minor/no harm; Level 2 moderate/monitoring required; Level 3 serious/intervention required; Level 4 critical/permanent harm or death). The WHO-ISMP/NCC MERP index was adapted to categorize potential harm (potential adverse drug events) rather than actual harm, aligning with standard medication reconciliation research methodology (Feldman et al., [10]; NCC MERP, [9]). Standardization was maintained through formal PI training prior to data collection, predefined classification criteria, and manual verification of all automated outputs. Immediate safety intervention was performed for all Level 3 and Level 4 errors and all were successfully implemented before the patient left the facility (100% acceptance rate).

Intra-rater reliability was assessed using a local, quantized DeepSeek 1.5B large language model (LLM) as an exploratory tool to evaluate prompt consistency. Quantization is a technique that reduces the size of a large language model by approximating its weights with lower precision, allowing it to run on local hardware without cloud connectivity. This approach was chosen because (1) it has no persistent memory, ensuring true blinding across sessions, (2) it is open-source and reproducible, and (3) it could be run locally without sending patient data to external servers. Twenty pilot cases were presented to the model for PCNE and severity classification, then re-presented after a 7-day washout period, blinded to previous decisions. The 20-case pilot was chosen as a practical sample size for testing reliability; while no formal power calculation was performed, the high agreement (kappa 0.91) suggests the sample was sufficient. Raw PCNE agreement was 95% (19/20) with Cohen's kappa of 0.91 (almost perfect agreement); severity agreement was 100% (20/20). Crucially, all primary clinical data extraction, PCNE categorizations, and WHO-ISMP severity ratings were 100% manually assigned and verified by the principal investigator (a licensed clinical pharmacist) to ensure clinical accuracy. Additionally, the researcher performed intra-rater checks on a 10% sample (n = 30) after a 7-day washout to minimise recall bias, achieving 94% agreement on PCNE codes and 91% on severity.

Variables and statistical analysis

The primary dependent variable was the occurrence of a MR error, coded as a binary outcome (yes/no) defined as the presence of at least one clinically significant MR error, regardless of severity. Independent variables were selected a priority based on existing literature and clinical relevance and included: age as a continuous variable, gender as a categorical variable, polypharmacy defined as the concomitant use of five or more chronic medications (binary), comorbidity count as a continuous variable, number of

specialty clinics attended as a continuous variable (range 1–4), documented cross-clinic communication (binary: present/absent), documented cost-related non-adherence (binary: present/absent), and prescription of a high-risk medication flagged as any medication on the Institute for Safe Medication Practices (ISMP) high-alert list (binary: present/absent).

Data were analyzed using IBM SPSS Statistics for Windows, Version 27.0. Prevalence was calculated with 95% confidence intervals using the Wilson score method. Univariable and multivariable logistic regression were performed to identify predictors of MR errors. A conservative $p < 0.20$ was used for entry into the multivariable model to avoid excluding potentially important variables that might become significant after adjustment. Variables with $p < 0.20$ in univariable analysis were entered into the multivariable model. Multicollinearity was assessed using Variance Inflation Factors (VIF); VIF values were: comorbidity count (2.8), polypharmacy (2.3), and specialty clinics (2.1), all below the threshold of 10, indicating no significant collinearity. Adjusted odds ratios (aOR) with 95% confidence intervals were reported. Internal model validation was performed using 1,000 bootstrap resamples to assess the stability and potential overfitting of the multivariable logistic regression model. Statistical significance was set at $p < 0.05$. Model fit was assessed using Nagelkerke R^2 , the Hosmer-Lemeshow goodness-of-fit test, and classification accuracy.

Results

Participant characteristics

A total of 300 patients were enrolled (Table 1). The mean age was 55.8 years (SD 12.3); 54.7% were female. The mean comorbidity count was 2.64 (range 1–6); the mean chronic medications were 2.1 (SD 1.4, range 1–8). Polypharmacy (≥ 5 drugs) was present in 7.0% ($n = 21$), and high-risk medications in 43.7% ($n = 131$). Over one-third (37.3%, $n = 112$) attended two or more specialty clinics; only 10.7% ($n = 12$) had documented cross-clinic communication.

Table 1
Socio-demographic and Clinical Characteristics of Participants (*n* = 300)

Variable	Characteristic	Frequency, n	Percentage, %	<i>p</i> value
Sex	Male	134	44.7	0.950
Sex	Female	166	55.3	0.950
Age, years old	Mean (SD)	55.8 (12.3)†	N/A	0.347‡
Age, years old	18 to 30	8	2.1	0.560
Age, years old	31 to 40	35	11.9	0.560
Age, years old	41 to 50	62	21.0	0.560
Age, years old	51 to 60	85	28.8	0.560
Age, years old	> 60	105	35.6	0.560
Marital Status	Married	198	69.5§	0.410
Marital Status	Unmarried	87	30.5§	0.410
Polypharmacy	≥ 5 drugs	21	7.0	0.107
Polypharmacy	< 5 drugs	279	93.0	0.107
Comorbidity	1–2	136	45.3	< 0.001
Comorbidity	3–4	112	37.3	< 0.001
Comorbidity	5–6	52	17.3	< 0.001
Cross clinic Documentation¶	Present	12	10.7	0.008
Cross clinic Documentation¶	Absent	100	89.3	0.008
Cost related nonadherence	Present	8	2.7	0.032
Cost related nonadherence	Absent	292	97.3	0.032
High risk medication	Present	131	43.7	0.038
High risk medication	Absent	169	56.3	0.038

Footnotes: Participants were type 2 diabetes outpatients with multimorbidity attending the University Teaching Hospital in Lusaka, Zambia. *p* values are from χ^2 tests (or Fisher's exact test where appropriate). † Age was missing for five participants (1.7%); mean age is based on 295 participants. ‡ *p* value for age (continuous) is from *t* test; *p* values for age categories are from χ^2 test. § Marital status was missing for 15 participants (5.0%); percentages are based on 285 participants. ¶ Percentages for cross-clinic documentation are based on the 112 patients who attended two or more specialty clinics (37.3% of the total cohort).

Variable	Characteristic	Frequency, n	Percentage, %	<i>p</i> value
Chronic medication	1–2	150	50.0	0.140
Chronic medication	3–5	105	35.0	0.140
Chronic medication	6–8	45	15.0	0.140
Specialty clinics attended	1–2	248	82.7	< 0.001
Specialty clinics attended	3–4	52	17.3	< 0.001

Footnotes: Participants were type 2 diabetes outpatients with multimorbidity attending the University Teaching Hospital in Lusaka, Zambia. *p* values are from χ^2 tests (or Fisher's exact test where appropriate). † Age was missing for five participants (1.7%); mean age is based on 295 participants. ‡ *p* value for age (continuous) is from *t* test; *p* values for age categories are from χ^2 test. § Marital status was missing for 15 participants (5.0%); percentages are based on 285 participants. ¶ Percentages for cross-clinic documentation are based on the 112 patients who attended two or more specialty clinics (37.3% of the total cohort).

Error characteristics—prevalence, severity, error types, and medication classes

Overall, 70.0% (210/300) of patients had at least one MR error (95% CI: 64.6–74.9%). Among the 210 errors identified, the severity distribution was: Level 1 (minor, no potential harm): 31.9% (*n* = 67); Level 2 (moderate, monitoring required): 42.9% (*n* = 90); Level 3 (serious, intervention required): 25.2% (*n* = 53); Level 4 (critical/permanent harm): 0%.

Using PCNE V9.1, the distribution of error types is presented in Table 2. Omissions (P1.1: 21.4%) and under-dosing (P1.2: 19.5%) dominated, accounting for 60.1% of classified errors. The 67 cases labeled as 'PCNE code not recorded' represented minor administrative or documentation discrepancies (e.g., missing signature, incorrect date format) that did not match discrete PCNE sub-categories for drug-related problems. These were clinically assessed as having no potential for patient harm and were thus recoded as WHO-ISMP Level 1 (minor) errors.

Assumed responsibility omissions: An exploratory finding was that 22.4% (47/210) of error patients had medications omitted because Clinic 5 assumed another specialty clinic (Cardiology, Renal, Neurology) would continue them. Of these, 41 cases (19.5%) had undocumented assumptions, and 6 cases (2.9%) had documented assumptions but no cross-clinic coordination. This was operationalized using the following definition: (1) a medication was prescribed by a specialty clinic according to the clinical file, (2) the medication was omitted from the Clinic 5 prescription, (3) there was no documented cross-clinic communication explaining the omission, and (4) the patient reported taking the medication as prescribed by the other clinic.

Medication classes: Metformin (24.8%, *n* = 40) and insulins (21.7%, *n* = 35) accounted for 46.5% of drug-specific errors. Other classes included: calcium channel blockers 16.1% (*n* = 26), statins 9.9% (*n* = 16),

diuretics 9.9% ($n = 16$), ACE inhibitors 5.6% ($n = 9$), beta-blockers 5.0% ($n = 8$), antiplatelet agents 4.3% ($n = 7$), anticoagulants 1.2% ($n = 2$), and NSAIDs 1.2% ($n = 2$).

Cost-related non-adherence (economic barriers): Another exploratory novel finding was that 2.7% (8/300) of patients had statins intentionally omitted due to out-of-pocket cost (ZMW 450). These omissions were documented in clinical files as intentional (PCNE cause C3.2) and represent therapeutic gaps requiring policy intervention. Cost-related non-adherence was assessed through self-report and cross-verified with clinical file documentation.

Table 2
Error Characteristics: Prevalence, Severity, Error Types, and Medication Classes

Characteristic	Category	n	%
Prevalence	MR error present	210	70.0
Prevalence	MR error absent	90	30.0
WHO-ISMP Severity	Level 1 (Minor)	67	31.9
WHO-ISMP Severity	Level 2 (Moderate)	90	42.9
WHO-ISMP Severity	Level 3 (Serious)	53	25.2
WHO-ISMP Severity	Level 4 (Critical)	0	0.0
PCNE Error Types	P1.1 – Omission	45	21.4
PCNE Error Types	P1.2 – Dose too low	41	19.5
PCNE Error Types	P2.2 – Dose too high	20	9.5
PCNE Error Types	Other classified	37	17.7
PCNE Error Types	PCNE code not recorded (but recoded as WHO-ISMP Level 1)	67	31.9
Medication Classes	Metformin	40	24.8
Medication Classes	Insulins	35	21.7
Medication Classes	Calcium Channel Blockers	26	16.1
Medication Classes	Statins	16	9.9
Medication Classes	Diuretics	16	9.9
Medication Classes	ACE Inhibitors	9	5.6
Medication Classes	Beta-blockers	8	5.0
Medication Classes	Antiplatelet agents	7	4.3
Medication Classes	Anticoagulants	2	1.2
Medication Classes	NSAIDs	2	1.2
Footnotes: Severity percentages are based on 210 errors at the patient level using the most severe error per patient. PCNE percentages are based on total errors ($n = 210$). Medication class percentages are based on 162 drug-specific errors.			

Predictors

Multivariable logistic regression identified three independent predictors of MR errors (Table 3). Comorbidity count was the strongest predictor (aOR 3.59, 95% CI 2.28–5.65, $p < 0.001$), indicating that each additional comorbidity was associated with 3.6-fold higher odds of errors. The number of specialty clinics attended was also a strong predictor (aOR 2.78, 95% CI 1.87–4.14, $p < 0.001$), with each additional clinic nearly tripling error odds. Documented cost-related non-adherence was independently associated (aOR 3.35, 95% CI 1.08–10.43, $p = 0.032$). Polypharmacy showed an elevated but non-significant effect after adjustment (aOR 2.05, $p = 0.142$); this is likely due to the small number of patients with polypharmacy ($n = 21$, 7%), which limited statistical power. Age was not predictive (aOR 1.06 per 10-year increase, $p = 0.412$). High-risk medications showed a protective effect (aOR 0.49, $p = 0.038$), possibly reflecting increased clinician vigilance. The model demonstrated good fit with a Nagelkerke R^2 of 0.362, a Hosmer-Lemeshow p -value of 0.447, and an overall classification accuracy of 79.1%.

Table 3
Multivariable Logistic Regression – Predictors of MR Errors

Predictor	aOR	95% CI	<i>P</i> -value
Comorbidity count (per condition)	3.59	2.28–5.65	< 0.001
Number of specialty clinics (per clinic)	2.78	1.87–4.14	< 0.001
Cost-related non-adherence	3.35	1.08–10.43	0.032
Polypharmacy (≥ 5 drugs)	2.05	0.55–7.68	0.142
Age (per 10 years)	1.06	0.84–1.34	0.412
High-risk medications	0.49	0.28–0.86	0.038

Model fit: Nagelkerke $R^2 = 0.362$; Hosmer-Lemeshow $\chi^2 = 7.84$, $df = 8$, $p = 0.447$; classification accuracy = 79.1%.

Discussion

This is the first study to systematically quantify MR errors among type 2 diabetes outpatients with comorbidities in Zambia. The 70.0% prevalence is substantially higher than the 20–41% reported in other African settings [4, 5]. This disparity likely reflects several factors: our cohort consisted exclusively of T2DM patients with comorbidities (mean 2.64), a high-risk population with multiple medications, multiple specialists, and fragmented care; our outpatient setting differs from hospital admission/discharge studies, where reconciliation is more structured; and our triple-source audit captured discrepancies, particularly silent omissions and out-of-pocket purchases, that would have been missed by file-only or prescription-only reviews.

The finding that 25.2% of errors were serious (Level 3), requiring immediate intervention, is clinically concerning. These included omissions of warfarin in atrial fibrillation, insulin in type 2 diabetes patients requiring insulin therapy, and metformin in chronic kidney disease – errors that could have caused

permanent harm. All 53 Level 3 errors were corrected before the patient left the facility, with a 100% acceptance rate by clinicians.

The predominance of omission and under-dosing errors (60.1% of classified errors) aligns with other African studies [4, 5] and is consistent with the findings of Gleason et al. [11]. Metformin and insulin accounted for nearly half of drug-specific errors, reflecting both their high prescribing frequency and the clinical complexity of dose adjustment, particularly in patients with renal impairment. Cost-related omissions (economic barriers) affecting 2.7% of patients highlight the intersection of medication safety and economic barriers, consistent with previous Zambian research, in which 48% of hypertensive patients were nonadherent and 55.8% of those cited cost as the reason [12]. The lower rate in our study may reflect under-documentation or different patient populations.

Our finding that each additional comorbidity increased error odds by 3.6-fold (aOR 3.59) is consistent with literature showing comorbidity burden as a key driver of medication discrepancies [11, 13], though the magnitude is larger in our study, possibly due to amplified fragmentation in a paper-based, multi-specialty system.

The novel exploratory finding of “assumed responsibility” omissions (22.4% of error patients) represents a previously undocumented system-level coordination failure. Only 10.7% of patients attending multiple clinics had documented cross-clinic communication, meaning 89.3% had no documented coordination between their specialty clinics. This fragmentation directly leads to medication omissions, where one clinic assumes another will continue medications, but without communication, the medications are lost. Even when assumptions were documented (6 cases), omissions still occurred, suggesting that documentation alone is insufficient without active cross-clinic communication.

The number of specialty clinics attended was a strong independent predictor (aOR 2.78 per additional clinic), providing the first quantitative evidence linking care fragmentation to MR errors in Zambia.

Another novel exploratory finding was the identification of economic barriers as an independent predictor of medication reconciliation errors. Cost-related nonadherence was documented in 2.7% of patients, with statins omitted due to out-of-pocket costs of ZMW 450. This highlights the intersection of medication safety and economic constraints. While cost-related nonadherence has been previously documented in Zambia [12], our study is the first to demonstrate its independent association with reconciliation errors (aOR 3.35, $p = 0.032$). This finding suggests that affordability is not just an adherence issue but a patient safety issue that requires systemic policy responses, including ensuring the continuous availability of essential NCD medications and expanding NHIMA coverage.

The protective effect of high-risk medications (aOR 0.49) may reflect increased clinician vigilance rather than a true biological effect. Clinicians are generally more careful when prescribing insulin, warfarin, and other high-alert medications; they may double-check doses, document more thoroughly, and ensure patient understanding.

Implications for Practice and policy

Our findings have immediate implications for clinical practice and health policy at the University Teaching Hospitals and more broadly in Zambia. The observed 70% prevalence of medication discrepancies, with 25% classified as serious and potentially harmful, underscores an urgent need for system-level intervention to improve medication safety among patients with type 2 diabetes and multimorbidity. First, we recommend implementing a unified, patient-held Medication Passport, which is a standardized paper-based record that travels across specialty clinics to document active medications and explicit prescriber accountability. A pilot phase is recommended to test feasibility in the UTH setting before full implementation, with considerations including: (1) a simple, pictorial design for low-literacy patients, (2) integration with existing clinic workflows, and (3) training for staff on use of the passport.

Second, establishing a pharmacist-led best possible medication history (BPMH) service at Clinic 5, with BPMH collected prior to clinician consultation, could substantially reduce omissions and dosing errors. A feasibility study of pharmacist-led BPMH at UTH is recommended, including cost analysis and evaluation of patient outcomes.

Third, mandatory pharmacist verification prior to dispensing high-alert medications, including insulin and warfarin, should be institutionalized. Given staffing constraints, we recommend a phased approach: (1) start with a pilot in one clinic, (2) evaluate feasibility and cost, and (3) expand based on evidence.

Fourth, policy action is needed to address economic barriers to adherence by ensuring the continuous availability of essential NCD medicines and expanding coverage under the National Health Insurance Management Authority (NHIMA). NHIMA coverage was not assessed in this study; future studies should evaluate the impact of health insurance coverage on MR errors.

Finally, medication reconciliation should be formally integrated as a core competency in undergraduate and postgraduate pharmacy curricula to build sustainable capacity for medication safety.

Limitations

This study has several limitations. The single-site design limits generalizability to other Zambian settings, particularly rural or private clinics with different patient volumes and staffing. The cross-sectional design cannot establish causality. The absence of inter-rater reliability with a second human rater is acknowledged; therefore, we used an LLM for intra-rater reliability instead as a feasible alternative. The 31.9% PCNE code unclassified rate was a data collection limitation; however, these errors were recoded as Level 1 minor errors and do not affect the primary prevalence finding. The novel exploratory findings on assumed responsibility and economic barriers require confirmation in future prospective studies. Additionally, the quality of cross-clinic communication was not assessed beyond presence/absence, and private pharmacy purchases were not independently verified.

Specific limitations identified:

The quality of cross-clinic communication was not assessed beyond presence/absence, a pragmatic limitation given the paper-based record system.

Private pharmacy purchases were not independently verified, relying on patient self-report due to the lack of a centralized electronic pharmacy record system.

NHIMA coverage was not assessed, which could influence medication affordability and adherence.

Registrar rotations may have influenced prescribing practices, introducing variability not captured in this study.

Cost-coping strategies (tablet splitting, reducing visits) were not assessed, which could provide further insight into economic barriers.

The small number of patients with polypharmacy ($n = 21$, 7%) limited power to detect an independent effect.

Conclusions

Medication reconciliation errors are highly prevalent and clinically significant among outpatients with type 2 diabetes and multimorbidity in Zambia. Comorbidity burden, fragmentation of care across multiple specialty clinics, and economic barriers were independent predictors of these errors. The predominance of omissions stemming from assumed responsibility across clinics points to a fundamental failure in care coordination. This study provides the first benchmark for medication reconciliation errors in the Zambian outpatient setting and highlights urgent, system-level opportunities to improve medication safety in resource-constrained health systems.

Abbreviations

Abbreviation

Full Form

aOR

Adjusted Odds Ratio

BPMH

Best Possible Medication History

CI

Confidence Interval

MR

Medication Reconciliation

NHRA

National Health Research Authority

PCNE

Pharmaceutical Care Network Europe

SD

Standard Deviation

T2DM

Type 2 Diabetes Mellitus

UTH

University Teaching Hospital

WHO-ISMP

World Health Organization – Institute for Safe Medication Practices

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the ERES Converge Institutional Review Board (Ref. No. 2026-Feb-009), and the study was conducted in accordance with the Declaration of Helsinki. Permission to conduct the study was granted by the Senior Medical Superintendent of the University Teaching Hospital and the National Health Research Authority of Zambia. Written informed consent was obtained from all participants in English, Nyanja, or Bemba. Data were de-identified and stored on password-protected devices. Participants were informed of their right to withdraw from the study at any time without penalty.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

LKM conceptualised the study, designed the methodology, collected and analysed the data, and drafted the manuscript. DM and BK supervised the research, provided critical revisions, and approved the final manuscript. All authors read and approved the final manuscript.

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