Medication Errors and Healthcare Uncertainty: Implications for Pharmaceutical Care in Two Tertiary Hospitals

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Abstract

Medication errors and uncertainty are of great concern to health professionals due to their prevalence and impact on therapeutic outcomes. The objectives of the study are to explore pharmacists' perspectives of the relationships between medication errors and healthcare uncertainty; and their effects on pharmaceutical care and therapeutic outcomes in two tertiary hospitals in Lagos, Nigeria.

A 17-item inventory was administered to pharmacists to elicit their perspectives of prescribing, dispensing, and medication administrative errors in the respective professional groups in the two hospitals. The context of 'uncertainty' was given to participants to avoid ambiguity of response. Section A was on demographics, Section B comprises three questions each, on prescribing, dispensing and administration errors respectively; section C is on pharmacists' interventions, patient safety and outcomes. The instrument was validated. Descriptive statistics, correlation and regression analyses, as well as path analysis were used to analyze the results.

Fifty-six pharmacists comprising 20 (36%) and 36 (64%) from hospitals A and B respectively completed the questionnaires. Twenty were male and 36 were female. Mean response ratings of variables on medication errors and pharmaceutical care in the presence of uncertainty are high

($\geq$ 3/5 points), as well as pharmaceutical care interventions on patient safety and health outcomes. Pearson correlations are significantly positive for the three aspects of medication errors and uncertainty. Multiple regression analyses reveal prescribing and administration errors having more direct effect on healthcare uncertainty ($p<0.05$); and both types of errors have more direct effect on pharmaceutical care. Standardized coefficient reveals that of all the medication errors, administration errors have the greatest direct effect on pharmaceutical care. Path analysis indicates that total effect of pharmaceutical care on uncertainty is greater than their direct effect.

The impact of medication errors and uncertainty on pharmaceutical care and patient outcomes are significant. These relationships should be closely monitored through interprofessional co-operation aimed at achieving optimal care and errors minimization in the presence of uncertainty.

Keywords: Medication errors, health uncertainty, pharmaceutical care, patient safety, hospitals

1. Introduction

Medication errors (MEs) pose a major challenge in healthcare and are sources of concern to health professionals (physicians, pharmacists and nurses), due to their far-reaching implications in practice outcomes. MEs are any preventable events that may cause or lead to inappropriate medication use or harm to the patient while the medication is in the control of a healthcare professional, patient or consumer.[1] Inappropriate medication use is defined as the use of drugs in which the risk outweighs the benefits, and is a major factor influencing the likelihood of adverse drug reactions and negative health outcomes, potentially leading to an increased rate of functional impairment and mortality among the elderly. It also refers to the use of medications that should: be entirely avoided, be avoided at excessive dosage, not be used for excessive duration of treatment. Inappropriate medication use is measured using various approaches such as drug utilization review, medication appropriateness index, and 'drug-to-avoid' criteria (e.g. Beers' criteria).[2-5] The problems and sources of MEs are multidisciplinary and multifactorial.[6-9] MEs could be classified into: contextual (time, place), modal (omission, substitution), and psychological (human related) categories. Four broad types of medication errors based on the psychological classes are: knowledge-based errors (due to lack of knowledge), rule-based errors (using bad rule or misapplying good rule), action-based errors (slips in attention), and memory-based errors (lapses).[10] Sheen[11] reported the five stages in medication process: (prescribing medicine, dispensing, preparing medicine for administration, administering medicine using appropriate route and method, and monitoring the clinical effects of medicine on patients), which are carried out under great uncertainty. Whenever drugs are given, the potential for outcomes that diminish the patients' quality of life is always present, which constitutes the uncertainty in treatment outcome.[12-13] Uncertainty surrounds every aspect of medicine - from defining a disease, making a diagnosis, selecting and carrying out a test procedure, sorting out rank order of intervention(s) needed (as well as the outcomes of those interventions), to assessing the outcomes with or without the use of medications.[14-16] It is difficult for many physicians and non-physicians to appreciate how complex these tasks are, how poorly we understand them, and how easy it is for honest people to arrive at different conclusions.[17] The entire medication process is therefore a slippery terrain which continually requires judgement and decision tasks that are characterized by either uncertainty of information or outcomes.[17,18]

Anderson[19] identified nine causes or associated factors for MEs related to handling of medication among physicians and nurses. The nature, causes and prevalence of all errors (procedural, transcription, charting, failure to prevent injury, and medication) and near errors by nurses in hospitals were reported in three separate studies.[20-22] In a comparative study of prevalence and types of MEs, Dwivedi et al[23] observed that prescribing errors (PEs) were 66%, dispensing errors (DEs) were (9%) while medication administration errors (MAEs) were 25% in a total of 2744 identified medication errors. Physical environment-related factors to MEs in nurses' work area were documented by Mahmood et al.[24] The type, frequency and associated factors of all medication dispensing and administration errors as perceived by pharmacists and nurses respectively were investigated in a University hospital in Nigeria.[25] Uncertainty is a state of: feeling of doubt about something, not knowing something definitely, being uncertain. There are multiple meanings and varieties of uncertainty in healthcare; and falls into three categories, according to its fundamental sources, issues and locus.[26]

Healthcare uncertainty is a fact of life for every health professional. Han et al [26] identified three sources of uncertainty in healthcare: probability – clinical uncertainty arising from the health professional's limitations in relevant knowledge or policy and/or in cognitive and affective functioning; ambiguity – uncertainty arising from how individuals interact and form relationships e.g. clinician-patient, clinician-clinician, clinician-nurse, clinician-pharmacist, pharmacist-nurse, or pharmacist-patient, nurse-patient; and complexity, which has a multiplicity of causal factors and interpretive cues. Uncertainty could also arise from living within complex adaptive systems where varying mixes of natural and man-made systems interact and resist control.[27] Research works on PEs, DEs, MAEs and their attendant uncertainties have also been documented.[24,28-29]

Pharmaceutical care (PC) involves a patient-centered, outcomes-oriented pharmacy practice that requires the pharmacist to work in conjunction with the patients and patients' other healthcare providers to promote health, prevent disease, and assess, initiate, monitor and modify medication use to ensure that drug regimens are safe and effective.[30] Clinical pharmacists in hospitals undertake prescription monitoring, ensure safe, effective and cost-effective prescribing and drug use. Pharmacists' roles in ward rounds have enhanced care outcomes and minimized medication errors.[31] Previous research showed that more experienced health professionals render better quality service than less experienced professionals. Experienced general practitioners (GPs) showed better coping strategies in handling medication errors and uncertainty in primary healthcare than younger GPs.[32] Path analysis was used to assess the effects of doctor-patient encounter and expectancy in an open-label randomized trial of spinal manipulation for the care of low back pain.[33] Varis et al[34] carried out a modeling for water quality decisions in the presence of uncertainty and subjectivity in information, in objectives, and in model structure. Quantification and reduction of uncertainty associated to decision making is one of the primary functions of modeling and monitoring targeted to assist decision making and quality management. Coleman et al[35] carried out sampling for qualitative research using quantitative methods in measuring GPs' attitudes towards discussing smoking in patients. Likert scale is used extensively in behavioral and management sciences, and it is a method of ascribing quantitative value to qualitative data, to make it amenable to statistical analysis. A numerical value is assigned to each potential choice and a mean figure for all the responses is computed at the end of the evaluation.[36]

Objectives of this study are to assess the:

i. Relationship if any between MEs and healthcare uncertainty.
ii. Relationship if any between MEs and pharmaceutical care.
iii. Relationship between MEs, healthcare uncertainty and pharmaceutical care.
iv. Implications of the above findings for therapeutic outcomes and patient safety.

2. Methods

2.1. Study Design

The researchers developed a 17-item inventory for the purpose. Information was elicited on the effect of pharmaceutical care interventions on medication errors in the three professional groups (physicians, pharmacists and nurses), and healthcare uncertainty on the one hand, and therapeutic outcomes and patient safety on the other. The structured self-assessment questionnaire was divided into three sections. Section A (5 questions) was on the demographics, Section B (9 questions) is comprised of three questions each, on prescribing, dispensing and medication administration errors respectively. Section C consists of three questions that addressed pharmacists' interventions, patient safety and therapeutic outcomes, on a 5-point Likert continuum. The context of the term 'healthcare uncertainty' was given in the research instrument to avoid ambiguity and enhance the quality of response as follows: "Healthcare uncertainty is a state of feeling of doubt about decisions made by healthcare professionals in respect to their practice and service rendition to patients and clients. It is a probabilistic approach employed in making medical decisions as well as providing treatments; and arises from defining a disease, making a diagnosis, selecting and carrying out test procedure, ranking the order of intervention(s) needed, and assessing outcome of a disorder with or without the use of medication". Content validity was carried out by the lead researcher and two senior pharmacists in a state University hospital in Lagos and tested for reliability using standardized Cronbach's Alpha statistics. Ethical approval was sought and obtained from the Research and Ethics Committee of both hospitals.

2.2. Subjects and Settings

Settings – Two federal tertiary health institutions in Lagos State were used for the study. Hospital A is a federal Orthopedic hospital and hospital B is a federal University hospital. Both institutions are situated in the mainland of cosmopolitan city of Lagos, Nigeria.

Subjects – Pharmacists in the two hospitals were used to elicit information for the study. The inclusion criteria are those who have at least two years post-graduation experience and are fully employed in the hospitals. The exclusion criteria are pharmacists on either internship program (one year) or on one year national service (NYSC). The time selection was to avoid potential lapses which could arise from including participants with inadequate hospital practice experience.

2.3. Procedure and Evaluation

The eligible pharmacists who met the inclusion criteria in both hospitals were approached during work hours in the months of April – May, 2016 and requested to fill out the questionnaire voluntarily, for research purpose only. The completed questionnaires were retrieved (during first visit or on appointment), collated and sorted out for completeness of information.

2.4. Data Analysis

The data were screened, cleaned up and analyzed using SPSS version 23.0. Descriptive statistics (frequencies, range, percentages, means and standard deviation) were used to describe demographic data; while ANOVA, Pearson correlation test, multiple regression and Path coefficient analyses were used to analyze other results.

3. Results

3.1. Demographic Characteristics of Respondents

Of the 75 pharmacists that responded, only 56 of them (20/25 from hospital A and 36/50 from hospital B) duly completed the questionnaire. The test for reliability using standardized Cronbach's alpha gave 0.77 >

0.70 threshold value. The test for reliability result using ANOVA suggests no significant variation on how respondents rated the items at F-value = 29.487, p-value < 0.05 significance level; supported by the coefficient of variation (CV) = 0.10 < 0.50 threshold value. Other demographics of participants in the two hospitals are shown in Table 1.

Table 1: Socio-demographic Characteristics of Respondents

		Hospital A (n = 20)		Hospital B (n = 36)		TOTAL (n = 56)	
Variable	**Characteristics**	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
Age Group (years)	20-29	0	0.0	2	5.6	2	3.6
	30-39	12	60.0	17	47.2	29	51.8
	40-49	6	30.0	15	41.7	21	37.5
	50-59	1	5.0	2	5.6	3	5.4
	60+	1	5.0	0	0.0	1	1.8
	Total	20	100.0	36	100.0	56	100.0
Sex	Male	7	35.0	13	36.1	20	35.7
	Female	13	65.0	23	63.9	36	64.3
	Total	20	100.0	36	100.0	56	100.0
No. of years of professional experience	2-5	2	10.0	6	16.7	8	14.3
	6-9	3	15.0	7	19.4	10	17.9
	10-14	4	20.0	7	19.4	11	19.6
	15-19	5	25.0	12	33.3	17	30.4
	20-24	1	5.0	1	2.8	2	3.6
	25+	5	25.0	3	8.3	8	14.3
	Total	20	100.0	36	100.0	56	100.0
Professional level	Pharmacist	2	10.0	8	22.2	10	17.9
	Senior Pharmacist	3	15.0	9	25.0	12	21.4
	Principal Pharmacist	8	40.0	3	8.3	11	19.6
	Chief Pharmacist	1	5.0	8	22.2	9	16.1
	Assistant Director	5	25.0	7	19.4	12	21.4
	Director	1	5.0	1	2.8	2	3.6
	Total	20	100.0	36	100.0	56	100.0
Department/ Unit	Out-patient	12	60.0	14	38.9	26	46.4
	In-patient	3	15.0	11	30.5	14	25.0
	Accident & Emergency	4	20.0	5	13.9	9	16.1
	Pediatrics	1	5.0	6	16.7	7	12.5
	Total	20	100.0	36	100.0	56	100.0

A total of 90% and 83.7% of pharmacists in Hospitals A and B respectively have over 5 years professional experience, giving an average of 85.7% for the two institutions; - a number that would be useful in the rendition of pharmaceutical care and effective supervision of interns and those on national service (Ref. Table 1). In terms of gender, the approximate male to female ratio is 36%: 64% respectively, indicating a greater affinity of women towards hospital practice and potential involvement in pharmaceutical care in hospitals. About 79% of the pharmacists are senior pharmacists and above, indicating high level of experience and capacity for expected professional role in pharmaceutical care activities.

3.2. Rating of Medication Errors and Pharmaceutical Care in the Presence of Uncertainty

Table 2: Respondents' rating of medication errors and pharmaceutical care in the presence of uncertainty

Items	Hospital A (n = 20) Mean Response Rating			Hospital B (n = 36) Mean Response Rating			TOTAL (n = 56) Mean Response Rating		
	Mean	SD	Category	Mean	SD	Category	Mean	SD	Category
MEs can be avoided with some degree of certainty	4.70	0.571	5	4.78	0.422	5	4.75	0.477	5
MEs can occur at any point of the medication process	4.95	0.224	5	4.69	0.467	5	4.79	0.414	5
MEs can be prevented by providing adequate pharmaceutical care	3.85	1.309	4	4.44	0.909	4	4.23	1.095	4
PEs are the most common type of medication errors	3.75	1.251	4	3.64	1.073	4	3.68	1.130	4
PEs can significantly increase uncertainty in the rendition of pharmaceutical care	4.05	0.945	4	4.19	0.822	4	4.14	0.862	4
DEs are the most common type of medication errors	2.70	0.979	3	3.14	1.175	3	2.98	1.120	3
DEs can significantly increase uncertainty in rendition of PC	3.90	0.788	4	4.19	0.856	4	4.09	0.837	4
MAEs are the most common type of medication errors	3.15	1.348	3	3.42	1.052	3	3.32	1.162	3
MAEs can significantly increase uncertainty in rendition of PC	4.10	1.071	4	4.11	0.979	4	4.11	1.003	4
Pooled Mean Response	3.91	0.943	4	4.07	0.862	4	4.01	0.900	4

Source: Field Survey 2016. SD = Standard Deviation. Category: Strongly Agree = 5, Agree = 4, Not Sure = 3, Disagree = 2, Strongly Disagree = 1.

Table 2 shows the respondents' perspectives of medication errors and pharmaceutical care in the presence of uncertainty, by the three professional groups in the two hospitals. The individual and pooled mean response ratings for the hospitals and the total mean response ratings are presented based on five-point Likert scale. Occurrence of MEs at any point in the medication process and avoiding MEs with some degree of certainty have the highest mean response ratings. Category column is the approximation of the mean response to each item compared with the 5-point scale used.

3.3. Pharmaceutical Care Interventions, Patient Safety and Outcomes under Uncertainty

Respondents' perspectives of pharmaceutical care interventions, medication errors and therapeutic outcomes in the presence of uncertainty, by the three professional groups in the hospitals are presented in Table 3. The effects of medication errors and healthcare uncertainty on outcomes, and the mitigation through rendition of pharmaceutical care have the highest rating.

Table 3: Mean rating of pharmaceutical care interventions, patient safety and outcomes in the presence of uncertainty

Items	Hospital A (n = 20) Mean Response Rating			Hospital B (n = 36) Mean Response Rating			TOTAL (n = 56) Mean Response Rating		
	Mean	SD	Category	Mean	SD	Category	Mean	SD	Category
PC interventions and recommendations are always accepted by other healthcare professionals	3.40	1.353	3	3.58	1.025	4	3.52	1.144	4
MEs affect patient care and safety and pose barrier to achieving therapeutic outcomes	4.70	0.733	5	4.75	0.439	5	4.73	0.556	5
Impact of MEs and uncertainty can be mitigated through the rendition of PC	4.85	0.366	5	4.61	0.494	5	4.70	0.464	5
Pooled Mean Response	4.32	0.817	4	4.31	0.653	4	4.32	0.721	4

Source: Field Survey 2016. SD = Standard Deviation. Category: Strongly Agree = 5, Agree = 4, Not Sure = 3, Disagree = 2, Strongly Disagree = 1.

3.4. Descriptive Statistics and Correlation Analysis of MEs and Uncertainty

To test further the relationship between MEs and uncertainty, research question 1 was investigated.

H_{01}: There is no significant relationship between medication errors and healthcare uncertainty.

The model result reveals goodness of fit index $R^2 = 0.546$ (54.6%) indicating model fit is acceptable, since the ANOVA table shows that the variation being explained by medication errors about healthcare uncertainty is significant at $F = 20.844$ ($p<0.05$). Hence the model is acceptable for further analysis. The Pearson correlation result suggests that there is significant positive correlation between PEs and uncertainty, DEs and uncertainty, MAEs and uncertainty at r = 0.523, 0.530, 0.524 respectively. The multiple correlation R = 0.739 also suggests that there is a positive relationship between MEs and uncertainty. (That is, the more the MEs, the more the healthcare uncertainty). Based on the results, H_{01} is accepted.

Table 4a: Descriptive statistics and correlation analysis of MEs and uncertainty

Variable	Uncertainty	Prescribing Error	Dispensing Error	Administration Error	Mean	Std. Deviation	N
Uncertainty	1				4.26	0.582	56
Prescribing Error	0.523*	1			3.91	0.787	56
Dispensing Error	0.530*	0.383*	1		3.54	0.780	56
Administration Error	0.524*	0.057	0.407*	1	3.71	0.836	56

*Correlation is significant at 5% level. R = 0.739, $R^2 = 0.546$ (54.6%). F-value = 20.844 ($p<0.05$) N = Sample size of the pharmacists. Information is generated from data collated from research instrument.

3.5. Regression Analysis of MEs and Uncertainty

Multiple regression analysis of generated data was used to determine the effect of medication errors on healthcare uncertainty. Healthcare uncertainty represents the dependent variable while medication errors (PEs, DEs and MAEs) represent the independent variables. The result of the analysis reveals that prescribing and administration errors are significant at t = 4.155 and 4.073 ($p<0.05$). Hence, prescribing and administration errors have much direct effect on healthcare uncertainty. These results are supported by the VIF (variance inflation factor), which shows no evidence of multicollinearity among the medication errors since values are below 2.0 (Ref. Table 4b).

Table 4b: Multiple regression analysis of MEs and uncertainty

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	1.429	0.363		3.939	0.000		
Prescribing Errors	0.313	0.075	0.423	4.155	0.000	0.842	1.188
Dispensing Errors	0.148	0.083	0.198	1.776	0.082	0.705	1.419
Administration Errors	0.292	0.072	0.419	4.073	0.000	0.823	1.215
Dependent Variable: Uncertainty							

Information generated by carrying out multiple regression analysis of independent variables (MEs) and dependent variable (Uncertainty).

3.6. Descriptive Statistics and Correlation Analysis of MEs and Pharmaceutical Care

The second research question was addressed using descriptive statistics and correlation analysis (Ref. Table 5a).

H_{02}: There are no significant relationships between medication errors and pharmaceutical care.

Table 5a: Descriptive statistics and correlation analysis of MEs and pharmaceutical care

Variable	Pharmaceutical Care	Prescribing Error	Dispensing Error	Administration Error	Mean	Std. Deviation	N
Pharmaceutical Care	1				4.22	0.489	56
Prescribing Error	0.470*	1			3.91	0.787	56
Dispensing Error	0.473*	0.383*	1		3.54	0.780	56
Administration Error	0.501*	0.057	0.407*	1	3.71	0.836	56

*Correlation is significant at 5% level. R = 0.681, R^2 = 0.463 (46.3%). F-value = 14.974 ($p<0.05$)
Table is generated from correlation analysis of MEs and pharmaceutical care.

The model result reveals a goodness of fit index R^2 = 0.463 (46.3%) indicating that the model fit is acceptable, since the ANOVA table shows the variation being explained by medication errors about pharmaceutical care is significant at F = 14.974 ($p<0.05$). Hence the model is acceptable for further analysis. The Pearson correlation result suggests that there is a significant positive correlation each between PE, DE, MAE, and the need for pharmaceutical care activities at r = 0.470, 0.473, 0.501 respectively. Furthermore, the multiple correlation R = 0.681 suggests that there is a positive relationship between medication errors and the need for pharmaceutical care. Based on the results, H_{12} is accepted. The more the medication errors, the more the need for pharmaceutical care activities and vice versa.

3.7. Regression Analysis of MEs and Pharmaceutical Care

Multiple regression analysis was used to determine the effect of medication errors on pharmaceutical care. Pharmaceutical care represents the dependent variable while medication errors (PEs, DEs, MAEs) represent the independent variables. The result of the analysis reveals that PEs and MAEs are significant at t = 3.487 and 3.707 ($p<0.05$). Hence, prescribing error and administration error have much direct effect on pharmaceutical care. Moreover, the standardized coefficient revealed that among the medication errors, administration error has the greatest direct effect on pharmaceutical care with 0.415 (41.5%) followed by prescribing error with 0.386 (38.6%), and dispensing error with 0.157 (15.7%) [Ref. Table 5b].

Table 5b: Regression Coefficients

	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
Model	B	Std. Error	Beta	T	Sig.	Tolerance	VIF
(Constant)	2.030	0.331		6.126	0.000		
Prescribing Error	0.240	0.069	0.386	3.487	0.001	0.842	1.188
Dispensing Error	0.098	0.076	0.157	1.296	0.201	0.705	1.419
Administration Error	0.243	0.065	0.415	3.707	0.001	0.823	1.215
Dependent Variable: Pharmaceutical Care							

3.8. Path coefficient analysis of three models used

H_{03}: Pharmaceutical care has no significant impact on healthcare uncertainty in the presence of medication errors.

Ordinary least squares regression was used to determine the path coefficient for each of the models. The results revealed that the paths are significant, implying that pharmaceutical care practice has significant impact on MEs at t =

3.912, 3.950 and 4.252 respectively ($p < 0.05$). MEs also impact significantly on healthcare uncertainty at t = 4.509, 4.597 and 4.521 respectively. Finally, pharmaceutical care has significant impact on healthcare uncertainty at t = 10.421, since p-value < 0.05 significance level. There is also a significant positive correlation between pharmaceutical care and healthcare uncertainty at r = 0.817 ($p<0.05$). Seemingly, the more the healthcare uncertainty, the more pharmaceutical care needed. Based on the results, H_{13} is accepted. Thus, the actual influence of pharmaceutical care on healthcare uncertainty in the presence of medication errors is determined using the total effect.

Table 6a: Path Coefficient Analysis (Ordinary Least Squares Model)

Model	**Impact of Pharmaceutical Care on Medication Errors**	**Path Coefficient (1)**	**t-value**	**Sig.**
1	Pharmaceutical care on Prescribing Error	0.470*	3.912	0.001
2	Pharmaceutical care on Dispensing Error	0.473*	3.950	0.001
3	Pharmaceutical care on Administration Error	0.501*	4.252	0.001
Model	**Impact of Medication Errors on Healthcare Uncertainty**	**Path Coefficient (2)**		
1	Prescribing Error on Uncertainty	0.523*	4.509	0.001
2	Dispensing Error on Uncertainty	0.530*	4.597	0.001
3	Administration Error on Uncertainty	0.524*	4.521	0.001
Model	**Impact of Pharmaceutical care on Healthcare Uncertainty**	**Path Coefficient (3)** **Direct Effect**		
1	Pharmaceutical care on Uncertainty	0.817*	10.421	0.001

*Path is significant at the 0.05 level.

3.9. Total effect of impact of pharmaceutical care on healthcare uncertainty

The path coefficients are used to examine the total effect of pharmaceutical care on health care uncertainty in the presence of medication errors, and then compared with the direct effect of pharmaceutical care on healthcare uncertainty. The indirect effect is measured by multiplying the contributing path coefficients (1) and (2) respectively. The direct effect is the path coefficient of the ordinary least squares result of the impact of pharmaceutical care on healthcare uncertainty, while the total effect is the addition of direct and indirect effects.

Table 6b: Total effect of impact of pharmaceutical care on healthcare uncertainty

Model	**Impact of**	**Effect of Medication Errors**	**Direct Effect**	Path Coefficient (1)	Path Coefficient (2)	Indirect Effect	**Total Effect**
1	Pharmaceutical care on Uncertainty	Prescribing Error	0.817	0.470	0.523	0.246	1.063
2	Pharmaceutical care on Uncertainty	Dispensing Error	0.817	0.473	0.530	0.251	1.068
3	Pharmaceutical care on Uncertainty	Administration Error	0.817	0.501	0.524	0.263	1.080

Path Coefficient is the standardized coefficient of the Ordinary Least Squares Model.

Table 6b shows the direct and indirect effects of pharmaceutical care on healthcare uncertainty. For hypothesis to be rejected, the total effect of pharmaceutical care on healthcare uncertainty in the presence of medication errors should be less than the direct effect of pharmaceutical care on healthcare uncertainty. The results indicate that the total effect of pharmaceutical care on healthcare uncertainty through each of the medication errors is greater than the direct effect, since Total Effect = 1.063, 1.068, and 1.080 > 0.817 respectively. Therefore, the hypothesis is accepted. Hence pharmaceutical care has significant impact on healthcare uncertainty in the presence of medication errors. Invariably, pharmaceutical care causes reduction of medication errors and health care uncertainty.

4. Discussion

More female pharmacists are permanent staff in the two hospitals than males (64%:36%) and may indicate that the onus of successful pharmaceutical care at hospital level will be more on the females (Ref. Table 1). Analyses of respondents' mean response ratings and the total (mean response rating) fell into the same category for each item rated in the two hospitals for medication errors, health care uncertainty and pharmaceutical care (Ref. Table 2). Almost the same pattern of rating was observed for pharmaceutical interventions, patient safety and therapeutic outcomes (Ref. Table 3). These observations prompt the addition of the total responses in the two hospitals for each item and analyzing the variables based on the number of pharmacists (n = 56). Descriptive statistics, correlation analysis and regression coefficients all show that there is a positive relationship between medication errors and healthcare uncertainty (Ref. Tables 4a and 4b); with prescribing error having the greatest direct effect on healthcare uncertainty (42.3%), followed by administration error (41.9%), and dispensing error as (19.8%). These corroborate with the findings of Dwivedi et al,[23] which show that prescribing and medication administration errors are more common than dispensing errors. Descriptive statistics, correlation and multiple regression analyses used to determine the effect of medication errors on pharmaceutical care (and vice versa) also show that the more the medication errors, the more the pharmaceutical care required to run the system efficiently, and by implication the more the number and/or quality of clinical pharmacists needed. Standardized coefficient reveals that MAEs have the greatest direct effect on (need for) pharmaceutical care (41.5%), followed by PEs (38.6%), and DEs as the least (15.7%) (Ref. Tables 5a and 5b). Findings in the two hospitals studied show similar results.

Path Coefficient Analysis (Ordinary Least Squares) was used to assess the relationship between pharmaceutical care and health uncertainty in the presence of MEs. Results show that the paths are significant at $p<0.05$ for each of the three models (Ref. Table 6a). Path analysis confirms that the total effects are greater than direct effects and that MEs have significant effect on pharmaceutical care under healthcare uncertainty (Ref. Table 6b). Our findings corroborate with previous research works which show that PEs and DEs tend to increase with uncertainty in healthcare.[28,29,32] Another research also shows the application of path analysis as a useful mathematical tool for assessing the effects of physician-patient encounter and expectancy in randomized trial of care for low back pain.[33] The influx of new drugs with names that look-alike and sound-alike has made prescription interpretation more difficult, thereby aggravating medication errors and their attendant uncertainty.[37-38]

Hospital pharmacists are sometimes by-passed in the medication process in some of our resource-limited hospital environments when in-patients/their relatives are asked to buy prescribed, but unavailable medicines (due to stock-outs) in the hospitals from outside sources, which are then procured and handed over directly to the nurses for onward administration to the patients (especially during emergency). Prescriptions could also be given to out-patients to be filled outside the hospital (for stock-out reasons). These are common practices in our healthcare environment. Lack of pharmacists' input in ascertaining product quality, source and dosage regimen, and interception of errors, undermines pharmaceutical care and puts the patient at risk. With potential for medication errors at different stages in medication process,[17] it calls for more pharmacists' involvement in minimizing these errors and uncertainty, to enhance patient safety.[39-42]

The Model: The pervasive effects of healthcare uncertainty on PE, DE, and MAE have been discussed by several researchers.[17,28-29] The model shows the relationship between healthcare uncertainty, medication errors, pharmaceutical care and patient outcomes. The model also demonstrates the effect of uncertainty on medication errors on the one hand, and the ameliorating effect of pharmaceutical care on medication errors on the other (depicted by opposing arrows in Fig. 1). There is also the probability that when prescribing errors are not detected, they could exacerbate dispensing and medication administration errors. Likewise, undetected dispensing errors could lead to administrative errors, with attendant consequences, sometimes fatal. The consequences of undetected DEs and MAEs could create uncertainty (doubt) in the physician's decision-making process (e.g. during medication review) and leading to dosage adjustments.[18] Also represented are the possibilities of aggravated prescribing and medication administration errors occurring when pharmaceutical care process is by-passed in some resource-limited settings, where patients or their relatives had to procure medications for in-patient use, from outside the health facility by themselves, and given directly to the nurses or physicians for onward administration (shown by direct arrows from PEs and MAEs to patient). The use of robust and functional drug formulary systems and expanded pharmaceutical care activities would minimize medication errors and enhance patient outcomes.

Increasing the awareness of MEs and uncertainty would enhance the need and scope of pharmaceutical care activities in hospitals. Pharmacists should be more actively involved in detecting errors at all levels of medication process. Continuing education, effective use of drug information system and interprofessional cooperation are key to minimizing medication errors and achieving positive patient outcomes under uncertain healthcare scenarios.[43-45]

Limitations and Strengths of the Study

Limitations – Only the perspectives of pharmacists in the tertiary hospitals were surveyed instead of including those of the doctors and nurses. Combining the results of pharmacists in the two hospitals instead of comparing health institution-specific analyses could also affect the results. Limiting the study to two health institutions, also limits the generalizability of the results. The validity of Likert scale attitude measurement could be compromised due to social desirability.

Strengths – The research helps to identify the aspect(s) of medication errors management that need(s) more attention in hospital settings. The critical role of pharmaceutical care in mitigating medication errors in healthcare systems is highlighted. Use of Likert continuum allows the qualitative data to be converted to quantitative data and subsequent analysis. Using a mathematical model (Path analysis) to solve medication errors-related problems, adds clarity to problems encountered with medication errors and pharmaceutical care activities in the presence of uncertainty.

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Author Contribution:

The lead author contributed to the following: conceived the concepts on the content, wrote the first and final draft of the manuscript and funded the publication of the manuscript. Both authors designed the research instrument, agreed with the manuscript results and conclusion, reviewed and approved the final manuscript. The second author carried out the field work.

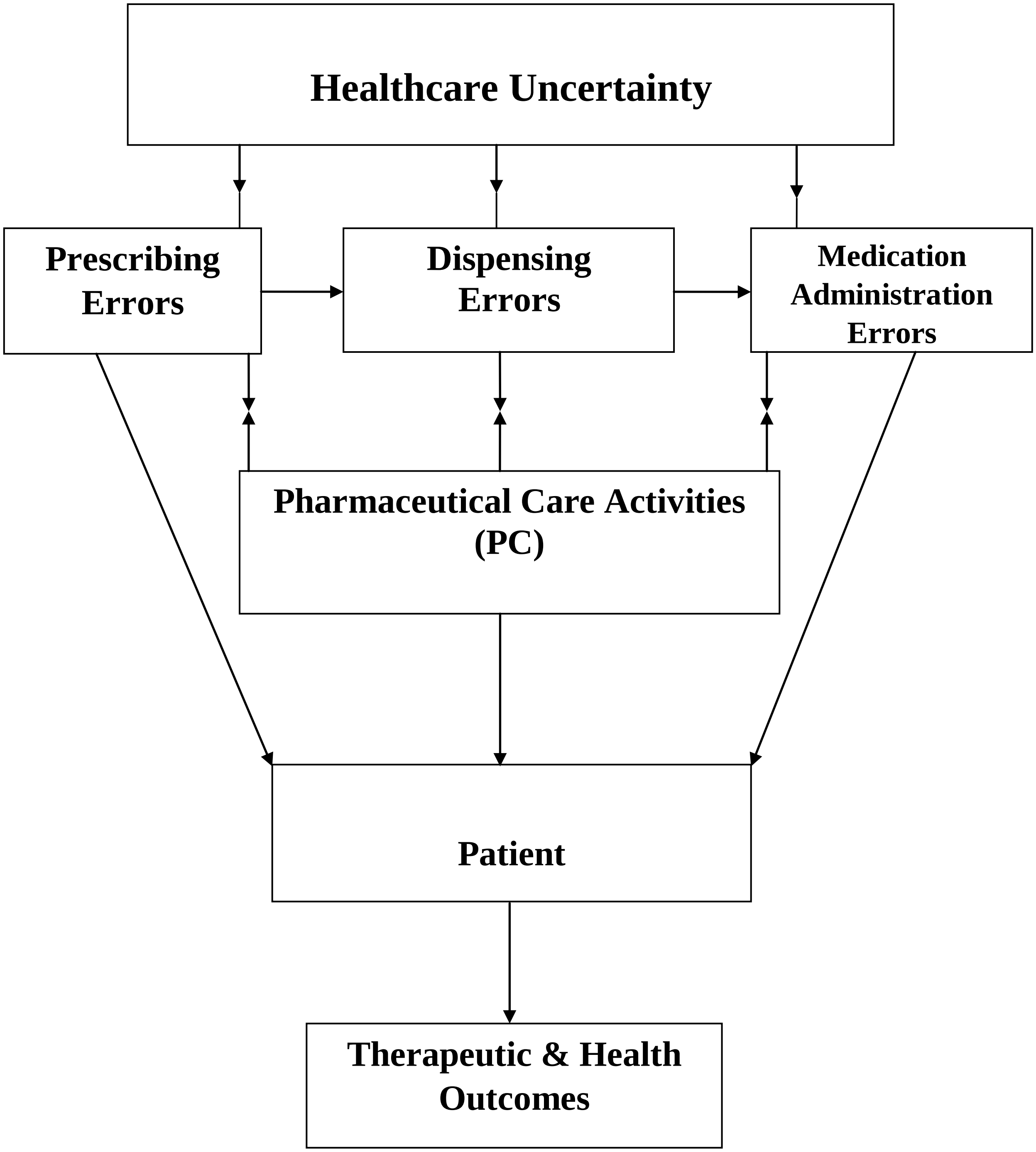

Fig. 1: Relationship between Medication Errors, Healthcare Uncertainty, Pharmaceutical Care and Therapeutic Outcomes

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