



The Impact of Healthcare Providers' Knowledge on Appropriate Prescribing of Antibiotics

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ABSTRACT

Background: In-depth knowledge of antibiotic principles is widely considered a necessary condition for appropriate prescribing of antibiotics. The study aimed at determining the impact of healthcare providers' level of knowledge in bacteriology and principles of antibiotic prescribing on their abilities to prescribe antibiotics appropriately.

Methods: A structured questionnaire survey targeting all doctors, nurses and healthcare providers within Health Service Areas abounding and including five selected public hospitals in Lesotho was carried out. The questionnaire tested respondents' knowledge in bacteriology of infections and principles of antibiotic prescribing. Relevant data on antibiotic prescriptions were also collected concurrently with the survey. Data were analysed to establish respondents' level of knowledge and the influence of same on their abilities to prescribe antibiotics appropriately.

Results: In inpatient and outpatient departments, 53.3% and 62.5% of respondents demonstrated inadequate levels of knowledge in the bacteriology and treatment of infections, respectively. Of the prescriptions analysed, 57.0% in the inpatient department and 19.1% in the outpatient department were classified as inappropriate. Appropriateness of antibiotic prescriptions was positively associated with healthcare providers' level of knowledge in inpatient but not outpatient settings.

Conclusion: A majority of healthcare providers appear to lack sufficient knowledge in bacteriology of infections and principles of antibiotic prescribing. In respect to antibiotic prescribing among inpatients but not outpatients the study demonstrated a positive correlation between healthcare providers' knowledge and their abilities to prescribe antibiotics appropriately.

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Introduction

Optimal and judicious selection of antimicrobial agents for therapy of infectious diseases requires clinical judgement and detailed knowledge of pharmacological and microbial factors (1). As important as this seems to be in appropriate treatment of infections, healthcare providers' decisions to prescribe antibiotics is made rather lightly most often without regard to the potential infecting

microorganism or to the pharmacological features of the prescribed antibiotics (1). This said, however, it is difficult to state whether or not such light decisions as healthcare providers purportedly make when they prescribe antimicrobial agents are attributable to their lack of knowledge in the bacteriology and treatment of infections. In the opinions of some schools of thought, causes of inappropriate prescribing are attributable to either providers' insufficient knowledge of infectious diseases and antibiotic treatment or the insufficient use of such knowledge (2). These opinions being true, one would expect that healthcare providers' demonstration of good level of knowledge in bacteriology of infections

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and the therapeutic profiles of antibiotics would positively impact on appropriate prescribing and use of antibiotics. Contrary to such expectations, some studies actually reported not finding any associations between inappropriate prescribing of antibiotics and providers' knowledge in infectious diseases and the characteristics of prescribed antibiotics (3). Among reasons these or the researchers gave in possible explanation of their findings, was their speculation that knowledge may after all not be an important determinant of the appropriateness of antibiotic prescriptions. By these considerations the actual impact of the level of healthcare providers' knowledge on their abilities to prescribe antibiotics appropriately can be said to be still debatable.

In this study, we attempt to determine a relationship between healthcare providers' level of knowledge and appropriateness of antibiotic prescribing in their clinical environments of practice. It is anticipated that results would provide further insight into what impacts healthcare providers' knowledge in bacteriology and infection treatment actually have on the appropriateness of antibiotics they prescribe.

Methods

A structured questionnaire survey (Appendix 1) aimed at investigating factors influencing antibiotic prescribing patterns in Lesotho and which targeted all healthcare providers (both doctors and nurses) within Health Service Areas (HSAs) abounding five hospitals selected for this study was carried out from June 15th to July 15th 2009. Out of 74 healthcare providers targeted, 67 respondents were reached with questionnaires. Of these 67 questionnaires, 38 were completed and returned from doctors and 11 from nurse healthcare providers. Of the 38 doctor respondents returning questionnaires, 29 practised in both outpatient and inpatient settings, while 8 practised only in outpatient settings and one practised only in inpatient settings. All nurse respondents practised in outpatient settings of study sites.

Healthcare providers' knowledge in bacteriology of infections and principles of appropriate prescribing of antibiotics were investigated using a set of questions administered in a questionnaire designed for the purpose. To ensure the stability and validity of the survey tool, questionnaires were first tested in a pilot study involving ten participants at a study site outside any of the five HSAs where the actual study was carried out. Necessary alterations to the subject content to ensure relevance of questions asked were made based on results of the pilot data and questions raised by participants of the pilot study. Questions specifically tested what was considered basic for prescribers to know in order to select correctly from a list of three most commonly prescribed antibacterial agents in respondents' clinical environments of practice in treating an infection described in a hypothetical or

presumed clinical case. Information on the morphological characteristics of pathogens presumed to be causative agents of infections in the hypothetical cases were provided. From their knowledge of the costs and activities of the given antibiotics against the presumed pathogens as identified by their Gram's stain characteristics, respondents were expected to select which of three listed antibiotics or any other antibiotic of their choice they would preferably prescribe in treating the infection. A correct selection of an antibiotic was interpreted as a respondent having knowledge of the morphological characteristics of the infecting pathogens and the therapeutic and cost profiles of antibiotics to be used in treating their infections.

Respondents' answers to questions were assessed and adequately scored using a prepared marking guide. We classified respondents with scores in the ranges of 0 – 49 and 50 – 100 as having inadequate and adequate knowledge, respectively. Data capture and analysis was done using Microsoft Excel[®] and Statistical Analysis Systems[®] SAS for Windows 9.1[®].

Data on antibiotic prescriptions from both inpatient and outpatient settings of study site hospitals and affiliate clinics were concurrently collected during the period of the survey. These were analysed to determine the appropriateness of antibiotic prescriptions from study sites. On the basis that prescription data collection was done concurrent to the survey, we logically assumed that analysed prescriptions were written by respondents to questionnaires.

The methodology used in the prescription assessment determined how appropriately antibiotics were prescribed based on prescribers' use of documented principles of prescribing antibiotics. It enabled prescriptions to be categorised into seven predefined categories of appropriateness. These included prescription categories A1 and A2 which represented categories of antibiotic prescriptions written appropriately for the empiric treatment of infections with absolute (A1) and possible (A2) bacterial aetiologies; prescription category B in which prescriptions written inappropriately for the treatment of infections were classified; and prescription category C which categorised prescriptions written appropriately for definitive treatment of infections. Prescription categories D and E denoted categories of prescriptions appropriately (D) and inappropriately (E) prescribed for the prevention of infections, while category F prescriptions were of antibiotics considered inappropriately prescribed in clinical scenarios for which the use of antibiotics was not justified.

By being prescribed for infections in which bacterial pathogens were not absolutely established as aetiological agents, category A2 prescriptions could be considered as inappropriate according to the definition of a judiciously prescribed antibiotic by the WHO and Gaur and English (4,5). In empiric or non-definitive antibiotic treatment of infections, presence of bacterial pathogens is often

Table 1. Frequency distribution of respondents' score range classifications according to patient type settings.

Prescriber Qualification	Inadequate knowledge (0 – 49)			Adequate knowledge (50 – 100)			Total	
	IP only	OP only	Both IP and OP	IP only	OP only	Both IP and OP	n	(%)
	n	n	n	n	n	n		
Physician specialists	1	1	4	0	1	4	11	(22)
Surgical consultants	0	0	2	0	0	0	2	(4)
General practitioners	0	4	9	0	2	10	25	(51)
Subtotal (Doctors)	1	5	15	0	3	14	38	(78)
Nurses	0	10	0	0	1	0	11	(22)
Total	1	15	15	1	3	14	49	(100)

IP: Inpatients; OP: Outpatients; n: number of respondent qualifications with designated knowledge levels given practice environment; N: Total number of respondent qualifications within all designated knowledge levels; (%) : N of each qualification as per cent of total N of 49.

assumed. Such prescriptions are justified on the basis of presenting clinical signs and symptoms and an identified site of infection suggests bacterial pathogens as a cause of the treated condition. Antibiotics can be considered prescribed appropriately in such circumstances provided the selection of the agents are based on their costs and therapeutic effectiveness against bacterial pathogens known to be commonly associated with the infection at the site as principles require (6). On the basis of this we considered category A2 prescriptions as appropriate though bacterial pathogens had not been absolutely established as aetiological agents of treated infections.

Impacts of healthcare providers' level of knowledge on their abilities to prescribe antibiotics appropriately was investigated by establishing the existence of any similarities between percentage frequencies of respondents with adequate or inadequate levels of knowledge and antibiotic prescriptions categorised as appropriate or inappropriate. We hypothesised that the percentage of healthcare providers with adequate knowledge would be the same as the percentage of appropriate antibiotic prescriptions if providers knowledge as tested impacts on appropriateness of antibiotic prescriptions. We determined for this reason the percentages of respondents with adequate and inadequate levels of knowledge and compared them with the percentages of antibiotic prescriptions categorised as appropriate and inappropriate. We compared the percentages using a 2-sample test of proportions and considered a value of $p < 0.05$ to be statistically significant.

In the circumstances of all prescriptions assessed being written by respondents one would expect the proportions of respondents with adequate and inadequate knowledge to be the same as the proportions of prescriptions categorised as appropriate and inappropriate. In the setting of this study, where all assessed prescriptions might not necessarily be written by respondents of the survey, such computed proportions may be found not to be as exact as expected. Deviations of values of computed from

expected proportions however would be within limits that would allow interpretations to be made in regard to what impact healthcare providers' level of knowledge has on their abilities to prescribe antibiotics appropriately. While small deviations in the proportions would suggest the existence of a positive correlation of healthcare providers' knowledge and appropriateness of antibiotic prescriptions, large deviations in the converse will denote providers' level of knowledge not significantly determining the appropriateness of antibiotic prescriptions.

Results

Assessment of healthcare providers' knowledge

Table 1 shows the prescriber qualifications, patient setting, and knowledge level. Most of the respondents (38) are doctors who practice in both inpatient and outpatient settings. The remainder (11) are nurses, all whom work exclusively with outpatients. Only one nurse (11%) exhibited adequate knowledge of antibiotic prescribing, while nearly half of doctors (45%) did so.

Assessment of appropriateness of antibiotic prescriptions

Frequency distributions of prescriptions according to their categories of appropriateness are shown in Table 3. Of a total of 307 inpatient antibiotic prescriptions assessed for their appropriateness, 43.0% (n = 132) were categorised as appropriate and 57.0% (n = 175) as inappropriate. Of a total of 865 outpatient prescriptions assessed, 80.9% (n = 700) were categorised as appropriate and 19.1% (n = 165) as inappropriate.

Association of knowledge and ability to prescribe antibiotics appropriately

Table 4 summarizes the knowledge level and the appropriateness of the prescriptions. We compared the proportion of prescribers demonstrating inadequate knowledge to the proportion of inappropriate prescriptions. In the inpatient departments, the two percentages were not significantly different (53.3% inadequate knowledge

Table 2. Frequency distributions of adequacy of respondents' knowledge for appropriate prescribing of antibiotics according to practice types.

Qualifications	Inadequate		Adequate		% Inadequate		% Adequate	
	IP	OP	IP	OP	IP	OP	IP	OP
Physician specialists	5	5	4	5	55.6	50.0	44.4	50.0
Surgical consultants	2	2	0	0	100	100	0	0
General practitioners	9	13	10	12	47.4	52.0	52.6	48.0
Subtotal (Doctors)	16	20	14	17	53.3	54.1	46.7	45.9
Nurses	0	10	0	1	-	90.9	-	9.1
Total (All above)	16	30	14	18	53.3	62.5	46.7	37.5

IP: Inpatients; OP: Outpatients

vs. 57.0% inappropriate prescriptions, $p > 0.05$). In the Outpatient Department, the percentage inadequate knowledge (62.5%) was significantly greater than the percentage inappropriate prescriptions (19.1%, $p < 0.0001$).

Discussion

Assessment of healthcare providers' knowledge

Rather unexpected, the results of our study have shown a majority of healthcare providers demonstrating gross lack of knowledge in the types and morphological characteristics of bacterial pathogens, the activity pattern and cost properties of antibiotics as they would be required as necessary knowledge in selecting antibacterial agents appropriately. This finding appears not akin to care providers in Lesotho alone. Sosa *et al.*, similarly

established a general lack of knowledge required for appropriate prescribing of antibiotics in acute respiratory and diarrhoeal infections among doctors in seven countries in Latin America and the Caribbean (7). This said however, with nearly half of doctors and about only a tenth of nurse care providers not having knowledge at adequate levels in antibiotic prescribing in the sites selected for this study in Lesotho, the situation can be described as grievous. Considered a tenet of appropriate prescribing of antibiotics lack of this knowledge among healthcare providers may be identified as a significant factor attributable to inappropriate prescribing of antibiotics within our study area hospitals and associate clinics (1, 8). The results highlight the dire need for the urgent institution of educational programs that would

Table 3. Percentage frequency distributions of prescription categories in inpatient and outpatient departments.

Prescription Appropriateness	Antibiotic Prescription categories	Frequencies of Prescription categories			
		Inpatient Prescriptions		Outpatient Prescriptions	
		n	n%	n	n%
Appropriate	Prescription Category A1	55	17.9	299	34.6
	Prescription Category A2	44	14.3	378	43.8
	Prescription Category C	4	1.3	0	0
	Prescription Category D	29	9.4	23	2.7
	Subtotal	132	43.0	700	80.9
Inappropriate	Prescription Category B	92	30.0	57	6.6
	Prescription Category F	55	17.9	106	12.2
	Prescription Category E	28	9.1	2	0.2
Subtotal	175	57.0	165	19.1	
Total		307	100	865	100

Prescription category Definitions - **A1**: Antibiotic prescriptions written appropriately for the empiric treatment of infections with absolute bacterial aetiologies; **A2**: antibiotic prescriptions written appropriately for the empiric treatment of suspected bacterial aetiologies; **B**: antibiotic prescriptions written inappropriately for the treatment of infections; **C**: antibiotic prescriptions written appropriately for definitive treatment of infections; **D**: antibiotic prescriptions written appropriately for the prevention of infections; **E**: antibiotic prescriptions written inappropriately for the prevention of infections; and **F**: antibiotic prescriptions written inappropriately in clinical scenarios for which the use of antibiotics were not justified.

Table 4. Percentage frequencies of respondents with adequate and inadequate knowledge and of appropriate and inappropriate prescriptions in inpatient and outpatient departments.

Assessed variables	Levels of assessment	Percentage frequencies	
		Inpatient Departments	Outpatient Departments
Knowledge level of respondents	Adequate knowledge	46.7%	37.5%
	Inadequate knowledge	53.3%	62.5%
Antibiotic prescription appropriateness	Appropriate (A1+A2+C+D)	43.0%	80.9%
	Inappropriate (B+E+F)	57.0%	19.1%
95% Confidence Intervals	Per cent inadequate knowledge	36.1% - 69.8%	48.4% - 74.8%
	Per cent inappropriate prescriptions	51.4% - 62.4%	16.6% - 21.8%
<i>p</i> -value Test of proportions	Inadequate knowledge vs. Inappropriate prescriptions	0.70	< 0.0001

upgrade the knowledge level of healthcare providers in antibiotic prescribing. Educational interventions have been shown by some studies to have positive effects on appropriateness of antibiotic prescriptions (9).

Impacts of knowledge on the appropriateness of antibiotic prescriptions

We found that the percentage of prescribers with adequate knowledge nearly matched the percentage of inappropriate prescriptions in inpatient departments. From this result we conclude that there is a strong correlation between theoretical knowledge and practical application in this patient setting. In a study in which they investigated appropriateness of antibiotic choice in selected diseases in paediatric inpatients in an Italian hospital, Principi *et al.*, similarly found that inadequate knowledge of the physician plays a role in producing high percentage of inappropriate antibiotic prescriptions (8).

Although other studies have shown that many intervening factors cause inappropriate prescribing in outpatient departments (10-12), we found a relatively low percentage of inappropriate prescriptions in the outpatient department compared to the inpatient department.

Further, the percentage of inappropriate prescriptions was significantly lower than the percentage prescribers with inadequate knowledge. Due to more severe infections encountered and treated in inpatient than outpatient settings, antibiotic prescribing may be more complicated in the former than the latter. In handling such complications, healthcare providers may be more challenged to use their knowledge in the treatment of infections than they will in outpatient settings. In outpatient settings where less severe infections are treated, antibiotic prescribing may appear to be more casually done without much application of theoretical knowledge. It is also possible that antibiotic prescribing is routinely done according to treatment guidelines rather than being in response to challenging needs of prescribers to use their knowledge in prescribing the agents appropriately.

Limitations of the study

Although the number of respondents (67) was small, it formed over 90% of the targeted total population of 74 healthcare providers within five health service areas (HSAs) which the study covered. A high percentage of respondents (73%) completed the survey in its entirety. These five HSAs in total embodied five hospitals which accommodated 50% of the total hospital beds of all hospitals in Lesotho, the country of study (13). Therefore, results of the study should truly reflect the prevailing situation in the five HSAs where the study was carried out. Another limitation of the study is the assumption that all assessed prescriptions might be written by respondents of the survey. Since we did not have a 100% response rate to our questionnaires, all analysed prescriptions might not necessarily be written by respondents of the survey. This limitation was accounted for in the analysis of results of prescription and health care providers' knowledge assessment to determine the impact of knowledge on prescription appropriateness. This said however and for more authentic results of studies of this type, we recommend a redesign of the study methodology to link prescriptions with care providers who write them. This way it would be possible to sort out only prescriptions written by respondents for analysis.

Conclusion

The study establishes a lack of adequate knowledge in bacteriology of infections and principles of antibiotic prescribing among a majority of healthcare providers within the clinical environments of this study. It also established a strong positive correlation between healthcare providers' knowledge and the appropriateness of antibiotic prescription from inpatient but not outpatient settings. Other factors by these results may be more pivotal than knowledge in determining appropriateness of antibiotic prescriptions in outpatient settings. We recommend urgent institution of educational programs

to upgrade the knowledge level of healthcare providers in antibiotic prescribing. It will be an important step for the health authorities to take towards the promotion of appropriate prescribing of antibacterial agents in the clinical environments for our study.

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Appendix 1. Survey tool assessing impact of prescribers' knowledge on appropriate antibiotic prescribing: An extract of a survey tool used to investigate factors contributing to patterns of antibiotic prescribing in Lesotho public health institutions

Questionnaire number			
Name of Health Service area			
Location of Practice:	Urban	<input type="checkbox"/>	Rural
		<input type="checkbox"/>	

Questions

Questions 1 – 3 of main survey (Respondents' Demographic data)

1. Please indicate your qualification by ticking any of the following

i.	Physician Specialist/Consultant	<input type="checkbox"/>	1
ii.	Surgical Consultant	<input type="checkbox"/>	2
iii.	General Medical Practitioner	<input type="checkbox"/>	3
iv.	Nurse clinician	<input type="checkbox"/>	4
v.	Registered Nurse	<input type="checkbox"/>	5
vi.	Nursing assistant	<input type="checkbox"/>	6

2. For how long have you been in practice after your qualification?

i.	Equal to or less than 5 years	<input type="checkbox"/>	1
ii.	6-10yrs	<input type="checkbox"/>	2
iii.	More than 10 years	<input type="checkbox"/>	3

3. With respect to your practice type, which of the following applies to you

i.	Practice in a Government owned hospital	<input type="checkbox"/>	1
ii.	Practice in a CHAL hospital	<input type="checkbox"/>	2
iii.	Practice in both Private Clinic and either Govt or CHAL Hosp	<input type="checkbox"/>	3

Questions 13 – 19 of main survey (Knowledge test Questions)

13. Please indicate signs and hallmarks of an infection you consider necessary as guiding principles in prescribing antibiotics in the clinical conditions listed below.

iv.	Upper respiratory tract infection
v.	Lower respiratory tract infection
vi.	Non sexually transmitted Urinary tract infection

14. Pyrexia as a clinical sign in a patient always justifies the prescription of an antibiotic.

Agree 1 Disagree 2

15. If your answer to question 13 above is "Disagree", please indicate which other possible clinical conditions may cause pyrexia in a patient to necessitate further investigation before the prescription of an antibiotic.

16. To what degree do you consider the following factors when deciding to prescribe an antibiotic for a patient?

- i. Knowledge of bacterial morphology and Gram's stain results
 Not at all 1 Minor degree 2 Major degree 3
- ii. Site of infection
 Not at all 1 Minor degree 2 Major degree 3
- iii. Patient factors e.g. allergic responses or side-effects to certain antibiotics
 Not at all 1 Minor degree 2 Major degree 3

17. Please indicate in each of the cases below which microbes or class of microbes are most likely to be target pathogens for antibiotic prescription.

- i. Upper respiratory tract infection
- ii. Lower respiratory tract infection
- iii. Non sexually transmitted Urinary tract infection

18. Gram-positive cocci bacteria have been isolated from an infected surgical wound of a patient. Please indicate which of the following available antibiotics you will preferably prescribe empirically for this patient pending CST results

- i. Ampicillin 1
- ii. Cotrimoxazole 2
- iii. (3rd generation cephalosporin(TGC) 3
- iv. Not sure of which of the above to use 4
- v. Other (please specify)

19. Gram-negative aerobic bacilli have been isolated from an infected surgical wound of a patient. Please indicate which of the following commonly available antibiotics you will prescribe for an empirical treatment of this infection.

- i. Ampicillin 1
- ii. Cotrimoxazole 2
- iii. (3rd generation cephalosporin(TGC) 3
- iv. Not sure of which of the above to use 4
- v. Other (please specify)