A Retrospective Evaluation of Antibiotic Prescriptions at Outpatients Department at Tema Polyclinic, Ghana

Authors
Joel Jeffrey Idun - Acquah [1], Harriet Affran Bonful [2]

[1] National Malaria Control Programme, Ghana Health Service, Accra
[2] Department of Epidemiology and Disease Control, University of Ghana School of Public Health

Corresponding Author
Joel Jeffrey Idun-Acquah, National Malaria Control Programme, Box KB 493, Korle-Bu, Accra, E-mail: idunach@yahoo.com, Phone: 0208096771 / 0267854998

Abstract
The excessive and irrational consumption of antibiotics is a major driver for the emergence of antimicrobial resistance. It is therefore, important to monitor and evaluate their use on regular basis, especially at the primary care level to ensure that they are being appropriately used to safeguard their efficacy over a longer period. The study was aimed at evaluating prescriptions of antibiotics at the outpatients department of Tema Polyclinic, Ghana. Records of 470 outpatients were obtained by systematic random sampling from the OPD register for the period 1st January to 30th June, 2019. Sociodemographic characteristics of patients, signs and symptoms presented, and diagnoses made were recorded. Data on dose, frequency and duration of treatment for all medicines given were also recorded. Frequencies and proportions were used to determine antibiotic prescriptions, types prescribed, prescribing indicators and demographic variables (at 95% confidence interval). Pearson's Chi-square was used to identify possible associations between antibiotic prescription and other variables. Antibiotics were prescribed for 54.9% of patients (n=258) with Penicillins (47.5%, n=142), Cephalosporins (15.4%, n=46) and Quinolones (15.1%, n=45) as the top three classes from which antibiotics were prescribed. Most frequently prescribed specific antibiotics were: amoxicillin (20.7%, n=62), co-amoxiclav (18.4%, n=55), ciprofloxacin (15.1%, n=45), cefuroxime (9.7%, n=29) and flucloxacillin (8.4%, n=25). Urinary tract infections (UTI) (13.6%, n=35), enteric fever (6.2%, n=160, respiratory tract infections (RTI) (6.2%, n=16) and gastroenteritis (4.7%, n=12) were the diagnoses for which most antibiotics were prescribed. Antibiotic prescription was significantly associated with age ($p < 0.009$), category of prescriber ($p < 0.001$), occupation ($p = 0.03$), marital status ($p = 0.022$) and the following diagnoses: UTI ($p = 0.001$), enteric fever ($p = 0.001$), RTI ($p=0.013$) and furunculosis ($p=0.002$). The appropriateness of antibiotic choice for specified diagnosis as stated in the standard treatment guideline (STG) was 78.3% (n=173). Of this, 87.9% (n=152), 94.8% (n=164) and 71.7% (n=124) respectively, were appropriate for antibiotic dose, frequency and duration of treatment. There is the need to strengthen antibiotic stewardship at the polyclinic to ensure appropriate prescribing and adherence to STG.

Keywords: Antibiotics, Prescription, Outpatients, Tema Polyclinic

Introduction

Over prescription of antibiotics at outpatients department (OPD) is a phenomenon that is common not only in developing countries but the developed ones as well, although it is proportionately higher in the former than the latter (Willemsen *et al.*, 2007; Bjerrum *et al.*, 2011; Rebnord *et al.*, 2017; Tillekeratne *et al.*, 2017). It is a major public health concern since several studies have identified association of development of antimicrobial resistance with increased use of antibiotics (Bronzwaer *et al.*, 2002; Masterton, 2002; Cars, Hedin and Heddini, 2011; Ndomondo-Sigonda *et al.*, 2017; WHO, 2018b, 2018a). Within a decade, consumption of antibiotics has increased by 36% with developing countries accounting for most of the consumption(Van Boeckel *et al.*, 2014).

In the WHO-Africa region, a systematic review of prescribing indicators at primary healthcare centres over a 20-year period showed antibiotic prescription rate of 46.8%. (Ofori-Asenso, Brhlikova and Pollock, 2016). In Ghana, antibiotic prescription rates range from 18.9% to 59.9% from studies conducted between 2010 and 2017 in various parts of the country (Ahiabu *et al.*, 2016; Turkson *et al.*, 2016; Prah *et al.*, 2017). At the Tema Polyclinic (TPC), percentage antibiotic prescription from the rational use of medicine indicators for three conservative years was above 45% (53.3% in 2016, 51.9% in 2017 and 46.0% in 2018) (TPC, 2019), well above the WHO recommendation of

30%. Regular evaluation of such prescriptions will help identify antibiotic prescription patterns that will aid the Drugs and Therapeutics Committee to implement appropriate strategies to address this challenge.

Method

This was a retrospective cross-sectional study carried out at Tema Polyclinic in the Greater Accra Region. At a confidence interval of 95%, antibiotic prescription rate of 59.9% (Ahiabu *et al*., 2016) and a design effect factor of 1.25, a sample size of 470 was obtained. The first patient record from 18,135 records for the period was picked by a simple ballot of the first 39 sequential numbers. Every 39th record number from the first randomly selected record was chosen until the total of 470 records was selected. Records of patients visiting for review of previous infections were excluded.

The sociodemographic characteristics of patients (including possession of valid NHIS card), signs and symptoms presented, laboratory investigations and result as well as diagnoses made and treatments given were recorded from the sampled records. Data on dose, frequency and duration of treatment for all medicines given were also recorded. A checklist was used to assess the availability of STGs in the consulting rooms.

Data were entered using EPI-Info version 7.2.2.6 and analysed using SPSS Statistics 20. Frequencies and proportions were used to determine antibiotic prescriptions, types prescribed, prescribing indicators and demographic variables (at 95% confidence interval). Appropriateness of antibiotic prescription in terms of choice of antibiotic, dose, frequency and duration were determined by comparing the prescription with the recommendations for that diagnosis by the STG (7th edition). Prescriptions that did not have antibiotics were classified as not applicable (N/A). Prescriptions with antibiotics but diagnosis not stated in the STG were also classified as N/A. Pearson's Chi-square was used to identify possible associations between antibiotic prescription and other variables.

Ethical Considerations

Approval for the study was obtained from the management of Tema Polyclinic and Ghana College of Pharmacists while Ethical approval was given by the Ethics Review Committee of the Ghana Health Service (Approval #: GHS-ERC 004/11/19).

Results

Socio-demographic characteristics of patients

Four hundred and seventy (470) patient folders were analysed in this study. Patients were between the ages of 2 months to 96 years (mean age =31 years, SD=22.5) with under 5 age group having the highest number (18.3%, n=86). The majority of patients were females (60.9%, n=286) while more than half were not married (59.8%, n=271).

Prescription of Antibiotic Types and Diagnoses for which Antibiotics were Prescribed

More than half of the patients received an antibiotic prescription (54.9%, n = 258) and the majority was intended for oral administration (figure 1).

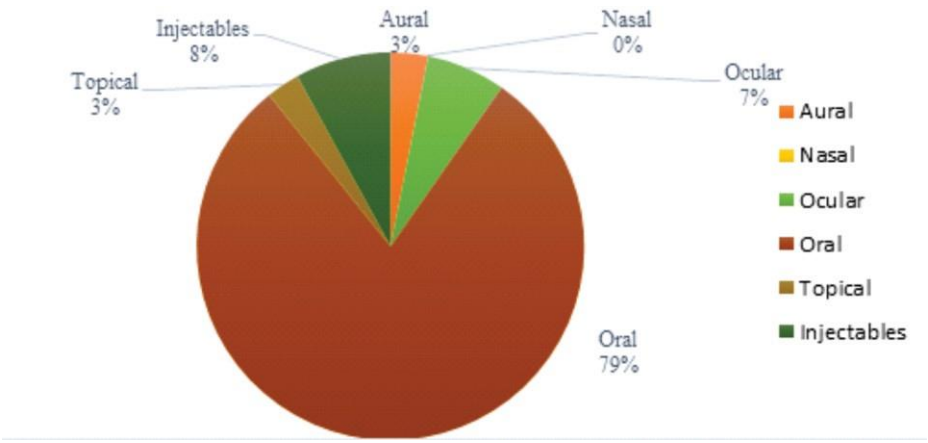

Figure 1: Distribution of antibiotic prescribed by route of administration

The top three classes from which antibiotics were prescribed were penicillins (47.5%, n=142), cephalosporins (15.4%, n=46) and quinolones (15.1%, n=45). Amoxicillin (20.7%, n=62), co-amoxiclav (18.4%, n=55), ciprofloxacin (15.1%, n=45), cefuroxime (9.7%, n=29) and flucloxacillin (8.4%, n=25) were the topmost five specific types of antibiotics prescribed (Table 1).

Table 1: Distribution of specific types of antibiotics prescribed to patients at Tema Polyclinic OPD

Class of Antibiotics	Antibiotic Type	Frequency (N=299)	% of Antibiotic Types	% of Antibiotic Class
Penicillins	Amoxicillin	62	20.7	
	Co-Amoxiclav	55	18.4	
	Flucloxacillin	25	8.4	**47.5**
Cephalosporin	Cefuroxime	29	9.7	
	Ceftriaxone	11	3.7	
	Cefixime	6	2	**15.4**
Quinolone	Ciprofloxacin	45	15.1	**15.1**
Aminoglycoside	Neomycin	11	3.7	
	Gentamycin	7	2.3	**6.0**
Tetracycline	Tetracycline	11	3.7	
	Doxycycline	4	1.3	**5.0**
Macrolide	Azithromycin	8	2.7	**2.7**
Sulphonamide	Cotrimoxazole	5	1.7	**1.7**
Others	Chloramphenicol	5	1.7	
	Mupirocin	3	1.0	
	Clindamycin	2	0.7	
	Others	10	3.3	**6.7**
Total		**299**	**100**	**100**

UTI, enteric fever, RTI, gastroenteritis and furunculosis were the topmost five conditions for which antibiotics were prescribed (Table 2).

Table 2: Topmost 15 Conditions for which antibiotics were prescribed

Condition	Frequency(n)	% of antibiotic prescription
UTI	35	13.6
Enteric Fever	16	6.2
RTI	16	6.2
Gastroenteritis	12	4.7
Furunculosis	11	4.3
Dermatitis	9	3.5
Pneumonia	9	3.5
Common Cold	8	3.1
Dental Caries	8	3.1
Laceration	8	3.1
Peptic Ulcer Disease	8	3.1
Pharyngitis	8	3.1
Kerato-conjunctivitis	7	2.7
Bronchitis	6	2.3
Tonsillitis	6	2.3
Others (n<6)	91	35.3
Total	**258**	**100**

Appropriateness of antibiotic prescriptions

Out of the 258 prescriptions with antibiotics, 221 (85.7%) had diagnosis in the STG. Of the prescriptions with applicable diagnosis, 78.3% (n=173) had the choice of antibiotics recommended by the STG. Out of those who had appropriate antibiotic choice, 87.9% (n=152) had appropriate dose, 94.8% (n=164) had appropriate dosing frequency and 71.7% (n=124) had appropriate duration of antibiotic prescription recommended by the STG. Table 3 gives the summary of appropriateness of antibiotics prescription per STG recommendation.

Table 3: Distribution of Antibiotic Prescription According to Appropriateness of Type, Dose, Dosing Frequency and Duration of Treatment

Characteristic	Frequency	Percent (%)
Appropriate Antibiotic choice		
Yes	173	78.3
No	48	21.7
Total	**221**	**100**
Appropriate Dose		
Yes	152	87.9
No	21	12.1
Total	**173**	**100**
Appropriate Dosing Frequency		
Yes	164	94.8
No	9	5.2
Total	**173**	**100**
Appropriate Duration		
Yes	124	71.7
No	49	28.3
Total	**173**	**100**

Factors associated with antibiotic prescription

Chi-square test of association at 95% confidence interval showed significant associations between antibiotic prescription and the following factors: age (p=0.009), category of prescriber ($p < 0.001$), occupation (p=0.03) and marital status (p=0.022). There were no significant associations between antibiotic prescription and sex of patient and NHIS status as summarized in Table 4.

Table 4: Association of antibiotic prescription with various variables

Variable	No Antibiotic Prescribed, n (%)	Antibiotic Prescribed, n (%)	Chi-Square Value	*p*-value
Age Group				
< 5	35 (7.4)	51 (10.9)	18.6752	0.009
5 - 9	6 (1.3)	20 (4.3)		
10 - 19	25 (5.3)	23 (4.9)		
20 - 29	29 (6.2)	54 (11.5)		
30 - 39	23 (4.9)	35 (7.4)		
40 - 49	35 (7.4)	28 (6.0)		
50 - 59	28 (6.0)	20 (4.3)		
> 60	31 (6.6	27 (5.7)		
Total	212 (45.1)	258 (54.9)		
Sex				
Male	81 (17.2)	103 (21.9)	0.1437	0.705
Female	131 (33.0)	155 (33.0)		
Total	212 (45.1)	258 (54.9)		
Category of Prescriber				
Medical Officer	81 (17.2)	83 (17.7)	18.0533	< 0.001
Physician Assistant	67 (14.3)	111 (23.6)		
Nurse Prescriber	12 (2.6)	30 (6.4)		
Intern- Physician Assistant	52 (11.1)	34 (7.2)		
Total	212 (45.1)	258 (54.9)		
Occupation				
Student	31 (6.6)	43 (9.1)	10.7407	0.030
Public/Civil Servant	6 (1.3)	11 (2.3)		
Artisan	6 (1.3)	19 (4.0)		
Trading	30 (6.4)	20 (4.3)		
Others	10 (2.1)	8 (1.7)		
Total	83 (17.7)	101 (21.5)		
NHIS Status				
No Insurance	62 (13.2)	96 (20.4)	3.635	0.057
Has Insurance	149 (31.7)	158 (33.6)		
Total	211 (44.9)	254 (54.0)		
Marital Status				
Single	103 (21.9)	168 (35.7)	9.6744	0.022
Married	76 (16.2)	67 (14.3)		
Divorced	10 (2.1)	9 (1.9)		
Widowed	10 (2.1)	10 (2.1)		
Total	199 (42.3)	254 (54.0)		

Among the topmost five diagnoses for which antibiotics were prescribed, UTI (p= 0.001), enteric fever (p = 0.001), RTI (p = 0.013) and furunculosis (p = 0.002) were significantly associated with antibiotic prescription. Gastroenteritis (p = 0.804) was however, not significantly associated with antibiotic prescription (Table 5).

Table 5: Association of antibiotic prescription with topmost 5 diagnoses

Variable	No Antibiotic prescribed, n (%)	Antibiotic prescribed, n (%)	Chi-Square Value	*p*-value
UTI				
No	204 (43.4)	222(47.2)	12.1112	0.001
Yes	9(1.9)	35(7.4)		
Total	213(45.3)	257(54.7)		
Enteric Fever				
No	212(45.1)	241(51.3)	11.0697	0.001
Yes	1(0.2)	16(3.4)		
Total	213(45.3)	257(54.7)		
RTI				
No	210	242	6.2007	0.013
Yes	3	15		
Total	213	257		
Gastroenteritis				
No	202	245	0.0613	0.804
Yes	11	12		
Total	213	257		
Furunculosis				
No	213	246	9.3357	0.002
Yes	0	11		
Total	213	257		

Availability of STGs in the consulting rooms

The study found that the polyclinic had purchased 15 copies of the STG and essential medicines list in October, 2017. Out of this, a copy was placed in each of the eight consulting rooms. However, audit of the consulting rooms showed that none of them had copies of the STG.

Discussion

The study retrospectively assessed antibiotic prescription at Tema Polyclinic with the objective of identifying gaps in prescriptions and making recommendations to address them.

Most of the patients (18.3%) were in the under 5 years category. This group has less developed immune system which makes them more vulnerable to infections, especially respiratory tract infections. They therefore visit health facilities frequently for care (Paul, Wilkinson and Routley, 2014). More than half (66.1%) of the patients accessed care at the facility with NHIS card. One of the major goals of a national health insurance scheme is ensuring access to healthcare service by eliminating the barrier of cost (Gobah and Zhang, 2011). The result from the study gives an indication of achieving this goal although it is below the 90.3% obtained in a related study in the Eastern region of Ghana(Ahiabu *et al*., 2016).

Prescription of Antibiotics, Types and Diagnosis for Which Antibiotics were Prescribed

Antibiotic prescription rate and use at the primary healthcare level is considered higher than expected (less than 30% recommended by WHO), especially in developing countries

(Bjerrum *et al*., 2011; Tillekeratne *et al*., 2017; Sarwar *et al*., 2018). Misconceptions about antibiotics, diagnostic uncertainty, meeting patients demand or request for antibiotics, unavailability of treatment guidelines, knowledge and practices of the prescriber are among the factors accounting for this (Murray, Del Mar and ORourke, 2000; OBrien *et al*., 2015; McKay *et al*., 2016; Nakwatumba *et al*., 2017). Antibiotic prescription rate from the study was 54.9%, similar to 55.2% obtained in a study at the University of Cape Coast hospital (Prah *et al*., 2017) but lower than over 80% obtained in two separate studies in Sri-Lanka and Pakistan (Tillekeratne *et al*., 2017; Sarwar *et al*., 2018). Thus, there is the need to do more sensitization for prescribers to reduce antibiotic prescription at the polyclinic to the 30% recommended by the WHO.

The majority of the antibiotics were for oral administration (figure 1), a good step considering the risk associated with injection use such as necrosis, anaphylactic shock etc (Santos and Nitrini, 2004). Orally taken medications are also more convenient and easier to administer without the involvement of a trained personnel.

The top three classes from which antibiotics were prescribed were Penicillins, Cephalosporins and Quinolones. Amoxicillin, amoxicillin-clavulanic acid, ciprofloxacin, cefuroxime, flucloxacillin and ceftriaxone are antibiotics that have been identified as the commonly prescribed antibiotics from five studies in different parts of Ghana (Anamuah-Mensah, 2009; Ahiabu *et al*., 2016; Turkson *et al*., 2016; Opoku, 2017; Prah *et al*., 2017; Duah, 2018). These were also the most prescribed antibiotics from this study.

UTI, enteric fever, RTI, gastroenteritis and furunculosis were the top five conditions at the OPD for which antibiotics were prescribed. These conditions are similar to observations from similar studies in various parts of Ghana for which antibiotics were prescribed (Anamuah-Mensah, 2009; Ahiabu *et al*., 2016; Opoku, 2017; Duah, 2018).

Appropriateness of Antibiotic Prescriptions

The choice of antibiotics, dose and duration of treatment has an influence on the development of antibiotic-resistant strains of bacteria (Olofsson and Cars, 2007). Their prescription should therefore, be guided by this. Using the STG recommendation, 78.3% of records could be assessed based on the diagnosis. This is however, higher than that obtained in a similar study where only 52.5% of prescriptions could be assessed using recommended guidelines(Smith *et al*., 2018), although different national guidelines were used in the various study.

Inappropriate prescription of antibiotics include unnecessary prescription of antibiotics, wrong antibiotic choice when an antibiotic is indicated, administration of wrong dose and prescription of antibiotic for the wrong length of time (CDC, 2019). In a cross sectional study in 2013 for children under 14 years in an emergency department in Spain, inappropriate antibiotic prescription was 51.9%, wrong antibiotic choice was 35.2% while wrong posology was 24.1% (Croche Santander *et al*., 2018). These figures are higher compared with that obtained in this study, 18.6 % for inappropriate antibiotic choice, 8.1% for inappropriate dosing, 3.3% for inappropriate dosing frequency and 19.0% for inappropriate treatment duration. The 8.1% inappropriate dose and 19.0% inappropriate duration are however higher than 6.1% and 2.4% respectively, obtained in a study on antibiotic prescription in a secondary healthcare facility in Kyrgyzstan. However, 3.3% inappropriate dosing interval obtained in this study is better than the 9.9% obtained in the Kyrgyzstan study(Baktygul *et al*., 2011).

The inappropriate prescriptions may be due to challenges with compliance with the STG and may be possibly worsened by the absence of STGs in the consulting rooms. A study in Kenya in 2017 identified that only 33.9% of antibiotic encounters were appropriately prescribed and identified non-availability of guidelines and/or poor compliance as the reasons (Momanyi *et al*., 2018). Therefore, provision of new STGs in the consulting rooms (as well as personal copies for prescribers) and training of prescribers on the use of the STG may help in addressing this issue.

Factors Associated with Antibiotic Prescription

Age, category of prescriber, occupation and marital status were significantly associated with antibiotic prescription. Diagnosis of UTI, enteric fever, RTI and furunculosis were also significantly associated with antibiotic prescription. These are among the most commonly presented infections at OPDs in Ghana (GHS, 2018) and antibiotics are recommended for their management by the STG. However, laboratory results are required in confirming the diagnoses. Other studies have identified association of antibiotic prescription with UTI, RTI, age (older children), patients' influence, time pressure, financial incentives, institutional environment and qualification of prescriber (OBrien *et al*., 2015; Liu *et al*., 2019). There was no significant association between antibiotic prescription and sex of patient, NHIS status and diagnosis of gastroenteritis.

Conclusion

Antibiotics were prescribed for more than half of the patients, with the majority of them intended for oral administration. Penicillins, cephalosporins and quinolones were the topmost classes of antibiotics prescribed. The majority of antibiotic prescriptions had diagnosis in the STG. Of these, a significant majority had appropriate choice of antibiotics, dose, dosing interval and duration of antibiotic treatment. More attention needs to be placed on antimicrobial stewardship to ensure improved prescription practices.

Study Limitations

Only the diagnoses made by prescribers were used in determining the appropriateness of choice, dose, dosing frequency and duration of antibiotic treatment. Other key indicators such as laboratory and clinical assessment were not used in determining the validity or otherwise of the diagnosis made.

The association between antibiotic prescription and some of the study variables is not absolute and cannot be attributed mainly to these variables due to the study design (retrospective cross-sectional). However, it points out variables that can be

studied further with a more robust study design to determine the true association.

Acknowledgements

We would like to acknowledge Dr. Sally D. Quartey and the Drugs and Therapeutics Committee of Tema Polyclinic for their support and technical advice throughout the data collection. Special thanks to Pharm. Irene A. Boateng and Mr. Edwin Martey for assisting with data collection and entries.

Competing Interests

The authors declare that they have no competing interests.

Funding

Funding for the original study was provided by Joel Jeffrey Idun-Acquah.

References

Ahiabu, M. A. *et al.* (2016) 'A retrospective audit of antibiotic prescriptions in primary health-care facilities in Eastern Region, Ghana', *Health Policy and Planning*, 31(2), pp. 250–258. doi: 10.1093/heapol/czv048.

Anamuah-Mensah, M. (2009) *A survey of antibiotic usage at Holy Trinity Medical Centre*. Available at: http://ir.knust.edu.gh/handle/123456789/377 (Accessed: 1 September 2019).

Baktygul, K. *et al.* (2011) 'An assessment of antibiotics prescribed at the secondary health-care level in the Kyrgyz Republic.', *Nagoya journal of medical science*, 73(3–4), pp. 157–168. doi: 10.18999/nagjms.73.3-4.157.

Bjerrum, L. *et al.* (2011) 'Health Alliance for prudent antibiotic prescribing in patients with respiratory tract infections (HAPPY AUDIT) -impact of a non-randomised multifaceted intervention programme.', *BMC family practice*, 12, p. 52. doi: 10.1186/1471-2296-12-52.

Bronzwaer, S. L. A. M. *et al.* (2002) 'The Relationship between Antimicrobial Use and Antimicrobial Resistance in Europe and participants in the European Antimicrobial Resistance Surveillance System', *Emerging Infectious Diseases @BULLET*, 8(3), pp. 278–282. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2732471/pdf/01-0192_FinalR.pdf.

Cars, O., Hedin, A. and Heddini, A. (2011) 'The global need for effective antibiotics - Moving towards concerted action', *Drug Resistance Updates*, 14(2), pp. 68–69. doi: 10.1016/j.drup.2011.02.006.

CDC (2019) *Antibiotic Prescribing and Use in Doctor ' s Offices*. Available at: https://www.cdc.gov/antibiotic-use/community/programs-measurement/measuring-antibiotic-prescribing.html#f2 (Accessed: 5 February 2020).

Croche Santander, B. *et al.* (2018) 'Appropriateness of antibiotic prescribing in paediatric patients in a hospital emergency department', *Anales de Pediatría (English Edition)*, 88(5), pp. 259–265. doi: 10.1016/J.ANPEDE.2017.06.002.

Duah, N. A. (2018) *Prescription Practices and Patterns of Antibioitics Used in Children Attending The Princess Marie Louise Children's Hospiatl*. Available at: http://ugspace.ug.edu.gh/handle/123456789/25873 (Accessed: 1 September 2019).

GHS (2018) *The Health Sector in Ghana, Facts and Figures*. Available at: http://www.ghanahealthservice.org/downloads/Facts+Figures_2018.pdf (Accessed: 27 March 2019).

Gobah, F. K. and Zhang, L. (2011) 'The National Health Insurance Scheme in Ghana: Prospects and Challenges: a cross-sectional evidence', *Global Journal of Health Science*, 3(2), pp. 90–101. doi: 10.5539/gjhs.v3n2p90.

Liu, Chenxi *et al.* (2019) 'Intrinsic and external determinants of antibiotic prescribing: A multi-level path analysis of primary care prescriptions in Hubei, China', *Antimicrobial Resistance and Infection Control*, 8(1), pp. 1–12. doi: 10.1186/s13756-019-0592-5.

Masterton, R. G. (2002) 'Surveillance studies: how can they help the management of infection?', *Journal of Antimicrobial Chemotherapy*, 46(90002), pp. 53–58. doi: 10.1093/jac/46.suppl_2.53.

McKay, R. *et al.* (2016) 'Systematic Review of Factors Associated with Antibiotic Prescribing for Respiratory Tract Infections', *Antimicrobial Agents and Chemotherapy*, 60(7), pp. 4106–4118. doi: 10.1128/aac.00209-16.

Momanyi, L. *et al.* (2018) *Appropriateness of Antibiotic Prescribing and Compliance to Guidelines at a Referral Hospital in Kenya: A Point Prevalence Survey*. Available at:https://pure.strath.ac.uk/ws/portalfiles/portal/81396076/Momanya_*et al*_MURIA2018_Appropriateness_of_antibiotic_prescribing_and_compliance.pdf (Accessed: 5 February 2020).

Murray, S., Del Mar, C. and O'Rourke, P. (2000) 'Predictors of an antibiotic prescription by GPs for respiratory tract infections: a pilot', *Family Practice*, 17(5), pp. 386–388. doi: 10.1093/fampra/17.5.386.

Nakwatumba, S. *et al.* (2017) 'Compliance to guidelines for the prescribing of antibiotics in acute infections at Namibia's national referral hospital: a pilot study and the implications', *Expert Review of Anti-Infective Therapy*, 15(7), pp. 713–721. doi: http://dx.doi.org/10.1080/14787210.2017.1320220.

Ndomondo-Sigonda, M. *et al.* (2017) 'Medicines Regulation in Africa: Current State and Opportunities', *Pharmaceutical Medicine*, 31(6), pp. 383–397. doi: 10.1007/s40290-017-0210-x.

O'Brien, K. *et al.* (2015) 'Clinical predictors of antibiotic prescribing for acutely ill children in primary care: An observational study', *British Journal of General Practice*, 65(638), pp. e585–e592. doi: 10.3399/bjgp15X686497.

Ofori-Asenso, R., Brhlikova, P. and Pollock, A. M. (2016) 'Prescribing indicators at primary health care centers within the WHO African region : a systematic analysis (1995 – 2015)', *BMC Public Health*. doi: 10.1186/s12889-016-3428-8.

Olofsson, S. K. and Cars, O. (2007) 'Optimizing Drug Exposure to Minimize Selection of Antibiotic Resistance', *Clinical Infectious Diseases*, 45(Supplement_2), pp. S129–S136. doi:

10.1086/519256.

Opoku, M. M. (2017) *Assessment of Antibiotics Prescribing Practices at the Sunyani Municipal Hospital in 2015*. University of Ghana. Available at: http://ugspace.ug.edu.gh/handle/123456789/23711.

Paul, S. P., Wilkinson, R. and Routley, C. (2014) 'Management of respiratory tract infections in children', *Nursing: Research and Reviews*, 7(SUPPL. 5), p. 135. doi: 10.2147/NRR.S43033.

Prah, J. *et al.* (2017) 'Antibiotic prescription pattern in a Ghanaian primary health care facility', *Pan African Medical Journal*, 28, pp. 1–10. doi: 10.11604/pamj.2017.28.214.13940.

Rebnord, I. K. *et al.* (2017) 'Factors predicting antibiotic prescription and referral to hospital for children with respiratory symptoms: Secondary analysis of a randomised controlled study at out-of-hours services in primary care', *BMJ Open*, 7(1), pp. 1–8. doi: 10.1136/bmjopen-2016-012992.

Santos, V. dos and Nitrini, S. M. O. O. (2004) 'Prescription and patient-care indicators in healthcare services.', *Revista de saude publica*, 38(6), pp. 819–26. doi: /S0034-89102004000600010.

Sarwar, M. R. *et al.* (2018) 'Antimicrobial use by WHO methodology at primary health care centers: a cross sectional study in Punjab, Pakistan', *BMC Infectious Diseases*, 18(1), pp. 1–9. doi: 10.1186/s12879-018-3407-z.

Smith, D. R. M. *et al.* (2018) 'Defining the appropriateness and inappropriateness of antibiotic prescribing in primary care', *Journal of Antimicrobial Chemotherapy*, 73, pp. ii11–ii18. doi: 10.1093/jac/dkx503.

Tillekeratne, L. G. *et al.* (2017) 'Antibiotic overuse for acute respiratory tract infections in Sri Lanka: a qualitative study of outpatients and their physicians', *BMC Family Practice*, 18(1), pp. 1–10. doi: 10.1186/s12875-017-0619-z.

TPC (2019) *Tema Polyclinic 2018 Annual Report*.

Turkson, J. T. *et al.* (2016) *Exploratory assessment of prescribing pattern at Cape Coast Teaching Hospital*. Available at: https://psgh.org/page/GJP_V11_N1_2016_ori3 (Accessed: 27 March 2019).

Van Boeckel, T. P. *et al.* (2014) 'Global antibiotic consumption 2000 to 2010: an analysis of national pharmaceutical sales data.', *The Lancet. Infectious diseases*, 14(8), pp. 742–750. doi: 10.1016/S1473-3099(14)70780-7.

WHO (2018a) *Antibiotic Resistance: Key Facts*. Available at: https://www.who.int/news-room/fact-sheets/detail/antibiotic-resistance (Accessed: 7 January 2019).

WHO (2018b) *High levels of antibiotic resistance found worldwide, new data shows*. Available at: https://www.who.int/news-room/detail/29-01-2018-high-levels-of-antibiotic-resistance-found-worldwide-new-data-shows (Accessed: 27 February 2019).

Willemsen, I. *et al.* (2007) 'Appropriateness of antimicrobial therapy measured by repeated prevalence surveys', *Antimicrobial Agents and Chemotherapy*, 51(3), pp. 864–867. doi: 10.1128/AAC.00994-06.