WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Algorithm on Antibiotic Dispensing: An Intervention for Medication Adherence for Patients with Urinary Tract Infection

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A B S T R A C T

Antibiotic non-adherence has long been a problem worldwide, and using a pharmaceutical care algorithm as an intervention approach to improve patient medication adherence on antibiotic therapy could be a promising start toward reducing the growing number of non-adherent patients on antibiotic therapy. The purpose of this study is to determine how efficient an algorithm on antibiotic dispensing is in keeping patients adherent to their prescribed antibiotic therapy. The algorithm was based on literature that shows the factors that affect patient non-adherence to antibiotic treatment. This research will use a quantitative quasi-experimental and interventional research design with a predetermined set of criteria, as well as an interventional random sampling technique to reach its objectives. A purposive random sampling strategy is used to select forty-eight participants, who are subjected to the study using the dependent t-test and the independent t-test to see if there is a statistically significant difference in the clinical indicators of patients before and after pharmacological therapy. The research tools that are being used to quantify these data are pre and post urinalysis tests and the PMAI questionnaire. The results reveal a substantial change in the level of the mean pus cells of experimental patients before and after they were exposed to an antibiotic algorithm regimen. Similarly, the control group's pus cell level is shown to be significantly different before and after therapy. Meanwhile, when it comes to medication adherence, both the experimental and control groups have significantly greater levels of adherence after being exposed to the antibiotic algorithm than the control group. However, the experimental group's degree of adherence was found to be significantly higher in comparison to the control group based on the gathered statical data. Therefore, the study demonstrates that an antibiotic dispensing algorithm can significantly improve patient adherence to antibiotic medication

Keywords: antibiotic dispensing, algorithm, intervention, antibiotic resistance, antibiotic treatment, urinary tract infection, medication adherence, recovery rate, pus cells

1. Introduction

Non-adherence to antibiotic medication has long been a burden to the healthcare system. The number of patients participating in this phenomenon has always been increasing over the years. Not only are the consequences of this is crucial, an approach to control such a high number of non-adherent patients is not much paid attention to as well as solutions to reduce this number are almost close to none. If patients continuously practice non-adherence, grave consequences like failure in prescribed treatment, the recurrence of diseases and complications, entails additional consultations, tests, and treatment, and ultimately, even death is possible to occur [1].

Amidst the COVID-19 pandemic, which has been present and thriving for almost two years, the use of antibiotics is in high demand, and patients tend to become reliant on this medication more than before. Despite its importance, a meta-analysis revealed that 86.97% of patients are non-adherent to antibiotic therapy. [2] This makes antibiotic resistance a problem, especially once this phenomenon continues without intervention. In the Philippines, instances of non-adherence to antibiotic therapy led to a higher number of antibiotic resistant infections, which has now been declared a significant public health threat. Evidence shows that antibiotic resistance is a pervasive problem in the country. [3] The Philippine Action Plan to Combat AMR: One Health Approach has identified the effects of antibiotic resistance which are increased mortality rates, longer hospital admission stays, admission to the intensive care unit (ICU), and the spread of resistant microorganisms to other patients [4].

In rural areas where patients are more likely to become part of the trend of non-adherence with antibacterial therapy, it is only appropriate that the predetermined factors are the basis of the dispensing algorithm. A recent incident on the spread of E. coli bacteria in Davao del Norte due to water contamination has affected numerous residents within the area of Santo Tomas, a municipality of Davao del Norte. [5] More so, antibiotics are the first line of action to eradicate such bacteria. Therefore, these patients must be adherent to their medication therapy to achieve full efficacy and avoid major consequences as an effect of non-adherence with their medication therapy.

A pharmaceutical care algorithm as an intervention approach in improving patient medication adherence on antibiotic therapy will serve as a promising start in reducing the increasing number of nonadherent patients on antibiotic therapy. The algorithm will cover activities from drug counseling to monitoring. The formulation of the dispensing algorithm is based on the Patient Medication Adherence Instrument (PMAI) questionnaire, which illustrates the knowledge and adherence of the patient. Most journals attribute knowledge as a factor to medication adherence, along with accessibility and dose scheduling. This intervention will provide an avenue for community pharmacists to have a structured approach in improving patient adherence to antibiotic medication. The algorithm considers the major factors that affect medication adherence. Alongside the possible factors are recommendations for each possible factor. This intervention shows a promising possibility of becoming a novel method in decreasing and overcoming the long occurring antibiotic non-adherence among patients prescribed with antibiotic medication.

2. Methodology

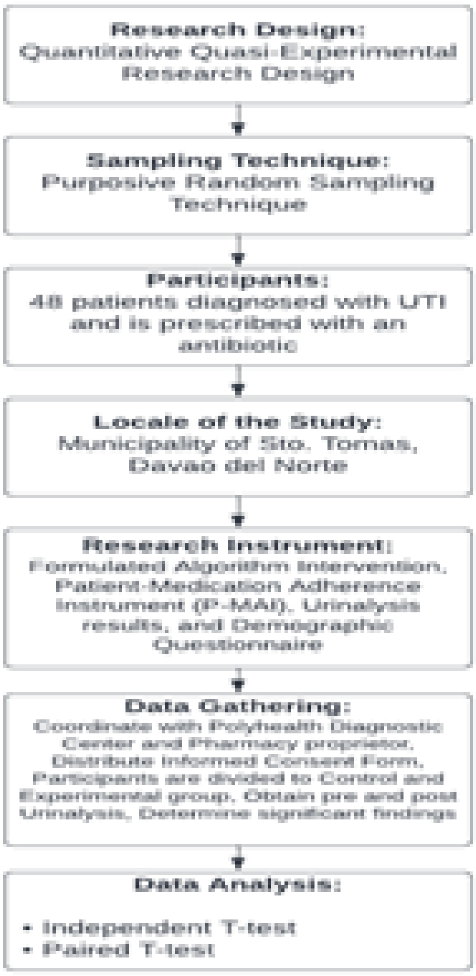

Figure 1. Methodology

2.1 Research Design

This study will use a quantitative quasi-experimental and interventional research design making use of a purposive random sampling technique of which a criterion is set. This criterion is focused on patients diagnosed with UTI in the PolyHealth diagnostic center. Laboratory urinalysis before and after antibiotic treatment should be done at the diagnostic center wherein patients will receive a control number to be presented to the Farmacia Erinor to identify the patients who will be part of the research.

A quasi-experimental research design will allow the researchers to assess the effectiveness of an algorithm-based intervention to improve patient adherence with antibiotic medication. Researchers will then be able to evaluate the effectiveness of an algorithm-based intervention in improving as well as potentially reduce the high number of patients which are non-adherent with their antibiotic therapy.

2.2 Research Instrument

The researchers have formulated an algorithm-based intervention based on the pre-determined factors found in numerous studies. The pre-determined factors are patient knowledge, patient forgetfulness, and incidence of adverse effects. These factors have a great effect on the adherence of the patient with antibiotic therapy. This intervention aims to give recommendations or suggestions to overcome these barriers. The algorithm shows the flow of how pharmacists should counsel the patient. This research will test the effectiveness of such intervention and if the data will have good results, this instrument may help the community to improve the assessment on the effectiveness of an algorithm-based intervention in improving patient adherence with antibiotic therapy.

This study will make use of the formulated algorithm for the community pharmacists and patients, and the researchers will make use of the P-MAI and urinalysis results. To assess the level of patient adherence with antibiotic therapy, the researchers will use the PATIENT-Medication Adherence Instrument (PMAI). Non-adherence is defined when the total score ranged from 9 to 35 (calculated total score<80%); whilst adherence was defined as a total score, which ranged from 36 to 45 (calculated total score at least 80%).

The urinalysis results will serve as an objective marker for the patient's adherence to antibiotic therapy. An increased number of WBCs seen in the urine under a microscope and/or a positive test for pus cell esterase indicates an infection or inflammation somewhere in the urinary tract. The normal range in the bloodstream is between 4,500-11,000 WBCs per microliter. A normal range in the urine is lower than in the blood and may be from 0-5 WBCs per high power field (wbc/hpf) [34].

2.3 Data Analysis/ Statistical Tool

This study used an experimental research approach to examine the health changes of some individuals who have been diagnosed with urinary tract infections in Santo Tomas, Davao Del Norte. The approach's main purpose is to come up with an interpretation of the occurrence in the experiment. It will be conducted with a total of 48 residents, 23 with algorithm intervention and 25 without algorithm intervention, from Santo Tomas, Davao Del Norte who have been diagnosed with urinary tract infection and undergone antibiotic therapy for treatment.

The experimental data will be analyzed to determine the effectiveness of an algorithm-based intervention and its influence on the improvement of patients' health upon taking antibiotic therapy among Santo Tomas, Davao Del Norte residents. The researchers will analyze and interpret the data using the following methods:

Mean. This variable will be used to ascertain the level of effectiveness of the algorithm-based intervention, and of the improvement of antibiotic adherence among the residents of Santo Tomas, Davao Del Norte.

Standard Deviation. This variable will be employed to determine the dispersion of the data in relation to the mean.

Paired t-test. This test will help in comparing the clinical indicators of the patients upon diagnosis of UTI and after the antibiotic therapy.

Independent t-test. This test will compare the results between the means of the two groups which are those with algorithm and without algorithm.

2.4 Ethical Considerations

The study will be done in accordance with the rules of the Committee on Human Research. All participants will be given a written consent upon identification by the pharmacist as a viable candidate for the research. They will also be given the freedom to choose whether he/she will continue or withdraw from the study based on the agreement set by both parties. The disclosure of the identity of the participants will be depending on their own decision, whether they choose to approve it or not.

The researchers will ensure not to use any form of procedure that may lead to physical or psychological harm to the participants. They will also guarantee that confidentiality will be conserved.

The pharmacist will be handing out a standardized questionnaire to the chosen participants that will provide information beneficial to the research. The PATIENT-Medication Adherence Instrument (P-MAI) will be utilized as the standardized questionnaire in which the researchers were able to ask permission from the author. An agreement will also be made between the researchers and the pharmacist-in charge regarding the collection of data from the participants. Minimum public health standards will be followed consistent with the DOH Administrative Order No. 2021-0043 in conducting the study in accordance with the guidelines set by the Inter-Agency Task Force for the Management of Emerging Infectious Diseases (IATF-EID).

The researchers will be governed by the Data Privacy Act of the Philippines. Individuals and institutions who took part in the study will be kept anonymous. Only essential data will be used in the study, which will be disclosed to the participants. The researchers and pharmacist-in-charge will ensure to keep the information private and manage it responsibly. The photographs taken either in the center or in the Pharmacy would revolve first prior to the consent of the participant, either if he or she approves or disapproves.

The data gathered will be analyzed with the use of SPSS software. Tables will be used to show the interpreted data which will be set down and discussed in the results and discussions of the third chapter of this paper. The conclusion of the study will be carried out in Chapter 4, and the finished research paper will be summed up to a journal containing an abstract, introduction, and methodology, which will be published in (website). After the completion and publication of the research study, the remaining data in the researchers' hand will be destroyed by shredding or tearing the papers and deleting any electronic files holding the participants' information so that the material cannot be read or rebuilt.

Lastly, the researchers were able to acquire an approval under the San Pedro College Ethics Committee, with REC protocol number: 2022-0183.

3. Results and Discussion

This chapter presents in full the overall data of the study which mainly aims to assess the effectiveness of an algorithm intervention. It also sought to detect the level of the following clinical indicators upon diagnosis of UTI, and after the antibiotic treatment of the two groups (control group and the experimental group). Descriptive and inferential statistics were applied to determine if there is a significant drop in the level of pus cells of patients and if the algorithm boosts their degree of medical adherence towards taking antibiotics.

3.1 Effect of Algorithm on Pus Cell and Medical Adherence

The data on pus cells and medication adherence were obtained, and the findings are displayed in tables 1A and 1B below. This was done so that the influence of the algorithm on the pus cell level of patients with UTI could be evaluated, as well as their medical adherence in terms of taking antibiotics. **Table 1** shows that after the 7-day intervention, the level of pus cells in urine of the patients with UTI improved. 17 patients manifested within normal limits, 4 patients still on the outside normal limits, and 2 were lost to follow-up in the experimental group. Contrarily, on the control group that has no intervention, only 5 patients manifested within normal limits, 2 were lost to follow-up, and 18 patients still manifested outside the normal limits. The findings of the study signifies that the patients in the experimental group (the group that received the algorithm) had a significantly higher rate of recovery (81.0 percent) than those in the control group (the group that did not receive the algorithm), which showed a recovery rate of 21.7 percent. These findings provide more evidence that utilizing an appropriate antibiotic algorithm is a useful strategy for combating illness.

Table 1 - Level of Pus Cells in Urine of Experimental and Control Group.

Patients No.	**Experimental**			**Control**		
	Before	**After**	**Remarks (After)**	**Before**	**After**	**Remarks (After)**
1	High (5>)		Normal	High (5>)	Low (4<)	Normal
2	High (5>)	Low (4<)	Normal	High (5>)	N/A	Lost to follow up
3	High (5>)	Low (4<)	Normal	High (5>)	High (5>)	**Outside Normal limits**
4	High (5>)	Low (4<)	Normal	High (5>)	Low (4<)	Normal
5	High (5>)	N/A	Lost to follow up	High (5>)	High (5>)	**Outside Normal limits**
6	High (5>)	N/A	Lost to follow up	High (5>)	High (5>)	**Outside Normal limits**
7	High (5>)	Low (4<)	Normal	High (5>)	High (5>)	**Outside Normal limits**
8	High (5>)	High (5>)	**Outside Normal limits**	High (5>)	Low (4<)	Normal
9	High (5>)	Low (4<)	Normal	High (5>)	High (5>)	**Outside Normal limits**
10	High (5>)	High (5>)	**Outside Normal limits**	High (5>)	High (5>)	**Outside Normal limits**
11	High (5>)	Low (4<)	Normal	High (5>)	Low (4<)	Normal
12	High (5>)	High (5>)	**Outside Normal limits**	High (5>)	High (5>)	**Outside Normal limits**
13	High (5>)	Low (4<)	Normal	High (5>)	High (5>)	**Outside Normal limits**
14	High (5>)	High (5>)	**Outside Normal limits**	High (5>)	High (5>)	**Outside Normal limits**
15	High (5>)	Low (4<)	Normal	High (5>)	N/A	Lost to follow up
16	High (5>)	Low (4<)	Normal	High (5>)	High (5>)	**Outside Normal limits**

17	High (5>)	Low (4<)	Normal	High (5>)	High (5>)	**Outside Normal limits**
18	High (5>)	Low (4<)	Normal	High (5>)	High (5>)	**Outside Normal limits**
19	High (5>)	Low (4<)	Normal	High (5>)	High (5>)	**Outside Normal limits**
20	High (5>)	Low (4<)	Normal	High (5>)	High (5>)	**Outside Normal limits**
21	High (5>)	Low (4<)	Normal	High (5>)	High (5>)	**Outside Normal limits**
22	High (5>)	Low (4<)	Normal	High (5>)	High (5>)	**Outside Normal limits**
23	High (5>)	Low (4<)	Normal	High (5>)	High (5>)	**Outside Normal limits**
Recovery rate			**81.0%**	High (5>)	Low (4<)	Normal
				High (5>)	High (5>)	**Outside Normal limits**
				Recovery rate		**21.7%**

Table 2 - Mean Degree of Adherence Between Experimental and Control Group.

ITEMS	**MEAN LEVEL OF ADHERENCE**					
	Experimental			**Control**		
	Before	**After**	**Remarks (After)**	**Before**	**After**	**Remarks (After)**
1.) I take my medication(s) everyday as directed	3.26	4.76	Very great extent	2.92	2.96	Moderate
2.) I do not take medication(s) MORE than directed	3.22	4.71	Very great extent	3.24	3.17	Moderate
3.) I do not take medication(s) LESS than directed	3.26	4.29	Great extent	3.08	3.09	Moderate
4.)I have a good understanding of my illness	3.96	4.29	Great extent	3.04	3.00	Moderate
5.) I am confident that my medication(s) are helping me	4.09	4.29	Great extent	3.00	3.17	Moderate
6.)I am satisfied with the information that my doctor has shared with me	4.04	4.50	Very great extent	3.20	3.41	Moderate
7.) I am able to make a decision together with my doctor regarding the medication(s) that have been given to me	3.87	4.45	Great extent	2.80	3.17	Moderate
8.)I know how to take my medication(s) (eg. dose, frequency)	4.00	4.62	Very great extent	2.84	3.17	Moderate

9.) I know why I am taking my medication(s) (eg. indication)	4.35	4.57	Very great extent	3.32	3.48	Moderate
Overall Mean	**3.78**	**4.50**	**Very great extent**	**3.05**	**3.18**	**Moderate**

Legend: 1.0-1.5 = Very Low Extent; 1.51-2.50 = Low Extent; 2.51-3.50 = Moderate Extent; 3.51-4.50 = Great Extent; 4.51-5.00 = Very Great Extent

According to the findings of the study, the patients who were a part of the experimental group (the group that was given the algorithm) had a significantly higher level of medication adherence, with a mean value of 4.50 thus it implies very great extent in the mean degree of medication adherence. In comparison, the patients who were a part of the control group (the group that was not given the algorithm), showed a mean value of 3.18 which implies moderate to the mean degree of medication adherence.

These data provide more support for the hypothesis that following a disease-specific antibiotic regimen is an effective method for both illness prevention and disease treatment. When the algorithm is accessible, the process of carefully monitoring whether medicine that has been given is taken at the right time, in the right amount, and in accordance with the guidelines may be thoroughly tracked. In a similar manner, ensuring that adequate medication adherence is maintained helps to guarantee that antibiotics will have the most beneficial effect feasible.

3.2 Statistical Analysis

Table 3 - Testing the Significant Difference on the Clinical Indicators of the Patients Before and After the Medication Therapy.

A. Dependent variable: Level of pus cells					
Test Variables		**Mean Pus Cell level**	**T value**	**P value**	**Remarks***
Experimental Group	Before	5.00	9.220	0.000	Significant
	After	4.19			
Control Group	Before	5.00	4.022	0.022	Significant
	After	4.78			
B. **Dependent variable: Medication Adherence**					
Test Variables		**Mean Medication Adherence level**	**T value**	**P value**	**Remarks***
Experimental Group	Before	3.78	4.22	0.005	Significant
	After	4.50			
Control Group	Before	3.05	2.501	0.037	Significant
	After	3.18			
C. RECOVERY RATE					
Test variables		**Mean**	**T value**	**P value**	**Remarks***
Experimental Group		81.0	4.754	0.000	Significant
Control group		21.7			

*Calculation was performed at 0.05 level of significance

Dependent t-test analysis showed that there is significant difference ($p<0.05$) in the mean pus cells of experimental patients before and after exposure to antibiotic algorithm regimen. Likewise, the pus cell level of the control group was found to be significantly different before and after treatment.

Meanwhile, in terms of medication adherence, both the experimental and control groups were found to have significantly ($p<0.05$) higher degree of medication adherence after exposure to antibiotic algorithm as compared with the control group. However, the level of adherence in the experimental group was found to be relatively high at a mean value of 4.50 as compared with the control group with mean value of 3.18. This indicates that the algorithm has substantially increased the level of medical adherence among patients with UTI as compared to those who have not followed any algorithm for antibiotic regimen. This is signified with the recovery rate indicating that there is a significant difference ($p<0.05$) between the experimental group and control group post exposure with the antibiotic regimen algorithm.

To determine if there is a significant difference between the change in pus cell levels of the patients in the experimental group (with algorithm application), and the control group (with no algorithm application), an independent t- test was utilized and results are shown in table 3.

Table 4 - Testing the Significant Difference on the Pus Cell Level Between Experimental and Control Group.

Test Variables	Mean Pus Cell level	T value	P value	Remarks
Experimental Group	4.19	4.754	0.000	Significant
Control group	4.78			

*Calculation was performed at 0.05 level of significance

The results of an independent t-test indicate that there is a significant difference ($p< 0.05$) between the average number of pus cells in the experimental group (with application of the algorithm) and those in the control group (with no application of the algorithm). Therefore, it is concluded that the null hypothesis, which states that there is no significant difference between the change in pus cell levels of the patients in the experimental group (with application of the algorithm), and the control group (with no application of the algorithm), is incorrect and must be rejected. These findings add to the growing body of evidence that antibiotic algorithms have the potential to serve as useful tools for effectively treating UTI infections in patients.

To determine if there is a significant difference between the degree of adherence with antibiotic therapy of the patients in the control group (with no algorithm application), and the patients under the experimental group (with algorithm application), an independent t- test was utilized and results are shown in table 4.

Table 5 - Testing the Significant Difference on the Degree of Medication Adherence Between Experimental and Control Group.

Test Variables	Mean Medication Adherence	T value	P value	Remarks
Experimental Group	4.50	9.831	0.000	Significant
Control group	3.18			

*Calculation was performed at 0.05 level of significance

The results of an independent t-test indicate that there is a significant difference ($p<0.05$) between the medication adherence in the experimental group and those in the control group. Therefore, it is concluded that the null hypothesis, which states that there is no significant difference between the medication adherence of the patients in the experimental group (with application of the algorithm), and the control group (with no application of the algorithm), is incorrect and must be rejected. These findings give further evidence that antibiotic algorithms have the potential to serve as beneficial tools for efficiently treating UTI infections in patients. As mentioned by Munoz et al. medication adherence is improved by educational intervention during antibiotic dispensing [37], it is revealed in the figure that pharmaceutical intervention can increase antibiotic adherence in community pharmacy, the results suggests that the algorithm is an important tool in making the patients informed of their medication which in return increase medication adherence among the UTI patients.

4. Conclusion

A pharmaceutical care algorithm as an intervention approach in improving patient adherence with antibiotic therapy will serve as a promising start in reducing the increasing number of nonadherent patients on antibiotic therapy. The purpose of the study is to identify the effectiveness of a counselling algorithm as an intervention in improving the patient adherence with antibiotic therapy in Santo Tomas, Davao del Norte. The study demonstrated how algorithm-based intervention affects the medication adherence and the UTI of the patients. After the monitoring of the participants with intervention, the study's results had already been gathered. The final findings determined the level of effectiveness of the algorithm on antibiotic dispensing in the improvement of patient adherence with antibiotic therapy using the effect size.

It was positively laid out that the group that has the algorithm is highly effective in improving medication adherence, determining significant drop in pus cell levels of patients, and prior to the data, the algorithm enhanced their degree of adherence towards taking antibiotics. Moreso, the clinical indicators for the study; Level of leukocytes, Medication Adherence, and Recovery rate, had the same remarks. for the Level of leukocytes, the experimental group had significant remarks for the before and after comparison on the pus cell levels were different, as well as the controlled group. Next is the Medication adherence, which, again, both groups had a significant remark, but the experimental group had a higher level of medication adherence prior to the intervention made in this group, compared to the controlled group which received none. and lastly, the Recovery rate, to which again both are significant, but the mean value favors the experimental group. On the other hand, the group's results for an independent t-test yielded 4.19 mean pus cell level for the experimental group which received the intervention and 4.78 for the control group that did not receive any intervention and both groups had significant differences. Moreover, it can be determined that the group who received the intervention showed much improvement compared to the group who did not receive any intervention in terms of antibiotic medication adherence and the level of pus cells in the urine. These findings provide further evidence that antibiotic algorithms have the potential to serve as useful tools for effectively treating UTI infections in patients.

Overall, the study shows a high level of effectiveness of algorithm son antibiotic dispensing in improving patient adherence on antibiotic therapy. It can be ascertained that the intervention has effectively managed UTI patients. Especially in these times where the focus of the world is on pandemic, there is a danger that other illnesses may be overlooked. Even in these circumstances, it is important that urinary tract infection is managed regularly as patients with UTI have a higher risk for complications from COVID-19.

Acknowledgements

The researchers would like to extend gratitude as this study would not be possible without the exceptional support of people who have contributed to the success of this study. We would like to thank our panelists, Dean Fatima May R. Tesoro, RPh, MSPharm, and Prof. Jacqueline Padilla, RPh, MSPharm for the suggestions and feedback to enable us to produce a better paper and successful research. To our statistician, Mr. Venchie Badong RCH, MAT, CSSO for his contribution to analyzing our results and information on how we could defend our statistical data. To the San Pedro College Ethics Committee, for monitoring our study to maintain the quality of the research.

Conflict of Interest

The researchers have no conflict of interest.

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