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Development and pilot testing of remote active learning tool as antimicrobial stewardship co-interventions

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Abstract

An online education tool is known for its cost-effectivity as an antimicrobial stewardship intervention, yet only a limited number of studies have been done in developing country settings. This pilot was therefore conducted to assess the feasibility, acceptability, and effect of the prescriber-directed distance learning model and analyze feedback for future intervention. The research procedure was outlined in the preparation, conduct, and evaluation phases under antimicrobial resistance control committee supervision. The preparatory phase included learning tool planning and finalization to be disseminated in the conduct phase. A pre- and post-test was used to assess the attendees' knowledge, attitude, and practice regarding AMS and to collect feedback on intervention components before and after the educational intervention was delivered. Test scores were compared using paired t-test, and feedback was analyzed as aggregates as barriers or facilitators of AMS intervention. A total of 203 subjects were included in the analysis, with a 99% recruitment rate and a 96.7% adherence rate. Proportions of subjects with adequate knowledge and attitudinal scores improved from initially 36.9% and 21.2% before intervention into 83.3% and 51.7%, respectively. The mean knowledge score in the pretest (6.1±1.2) increased significantly in the posttest (7.6±1.1) with a p-value less than 0.001. Knowledge of antimicrobial classification and prescription workflow were the main topics with the least number of correct answers. Facilitators identified in the feedback were access to workflow, guideline, resistance pattern, and course, while antimicrobial availability was regarded as a barrier to optimal AMS implementation. The findings suggest the feasibility and acceptability of the evaluated protocol. Protocol modification and expansion of study recruitment hold the potential to improve AMS intervention efficacy.

Keywords: antibiotic resistance, antimicrobial stewardship, distance education, multidisciplinary communication, pilot study, prescriber-directed

1. Introduction

Misuse and inappropriate antimicrobial prescription couples are the main drivers of antimicrobial resistance worldwide. The trend of this erroneous practice continues to increase at an alarming rate, yet the ideal practice standard establishment remains an arduous journey (1). Accumulating body of evidence revealed that higher mortality risk and healthcare costs, particularly in developing countries, were directly imposed by antimicrobial resistance (2). It has been demonstrated that the limited discovery of novel antimicrobial agents lags far behind resistance rate growth, leaving antimicrobial efficacy preservation as the most strategically viable option (3).

Antimicrobial stewardship (AMS) endorsed by the centers for disease control and prevention presents a multidimensional approach in combating antimicrobial resistance which factors in realistic hospital workflow and key stakeholders' involvement (4). Nation-wide adoption of the AMS was formulated through recently published national guideline by the Indonesian Ministry of Health (5). The actual implementation of AMS fundamentally relies on the small-scale units at the organizational level; hence, uniquely tailored AMS measures are imperative to achieve their effectiveness. Integral multidisciplinary participation is also a prerequisite to constituting an impactful AMS (6).

The effectiveness of AMS in reverting the consequences of antimicrobial resistance was well established, and the online platform was recognized for its cost-effectiveness. However, studies performed in developing countries are lacking and render the proposed successful models of AMS biased toward developed countries. Furthermore, behavior change was rarely assessed in the previous studies (7–9). Despite the recommendation against education as a sole AMS intervention, (10) pilot testing may reveal actual feasibility, and the effect of the isolated intervention, hence, provides constructive

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feedback for future development as AMS co-intervention is in larger research. This study sought to develop and pilot test an online learning tool intended for future use as co-intervention paired with compatible AMS efforts. The pilot testing process was performed as a part of a continuing quality improvement project to promulgate the world antimicrobial awareness week campaigned by the World Health Organization (WHO).

2. Material and methods

2.1. General study design

A prospective quasi-experimental study with one-group pretest-posttest design was performed. The design was opted/chosen in this pilot study instead of a randomized controlled study to test for field testing purpose and optimize uptake and feasibility. Primary outcomes of interest include feasibility and acceptability. Secondary outcomes include parameters constituting effect size and barriers and facilitators for actual AMS intervention. The tested tool would undergo further improvement under local antimicrobial resistance control committee oversight to develop an openly accessible tool to help strengthen AMS practice in supervised regional primary and secondary healthcare facilities. Research protocol complied with CONSORT 2010 statement extension for pilot and feasibility trials (11) and was approved by the research committee of Universitas Udayana/Sanglah General Hospital (approval number 63/UN14.2.2.VII.14/LT/2021), and individual consent was obtained from all study participants.

2.2. Study setting

The intervention occurred in a tertiary hospital in Indonesia with the capacity of 710 beds which translates to 259,150 bed-days, targeting active antimicrobial prescribers throughout the study period of December 2020 to January 2021. The antimicrobial resistance control committee consists of experts in infectious disease and related subspecialties from various departments (intensivist, clinical microbiology, internal medicine, pediatrics, and surgery).

2.3. Study population and sample

Study participants included attending physicians responsible for antimicrobial prescription who fulfilled the following sets of eligibility criteria. Inclusion criteria include on-duty healthcare worker and direct participation in antimicrobial prescription during the study period. Decline to participate and failure to finish the posttest were assigned as exclusion and drop-out criteria, respectively. The minimum sample size required was gauged from the paired t-test sample size formula with a minimal clinically important difference set as 30%. The sampling frame was extracted from the hospital employee list as a sampling frame while taking different departments and a drop-out rate of 10% into consideration to produce a total of 151 samples.

2.4. Tool development and intervention

Learning tool

Education materials were chosen by the antimicrobial resistance control committee members based on their respective expertise to cover the leading issues regarding antimicrobial prescription in the light of international, national, and local guideline. The framework of which followed a realistic workflow in prescribing practice encompassing prophylactic, therapeutic, and prudent implementation of antimicrobial use. Overall outline and duration for each material components were as follows: prophylactic antimicrobial administration principles (15 minutes), fundamentals of therapeutic antimicrobial use (15 min), prudent antimicrobial use implementation (15 min), practical insights from a microbiological perspective (15 min), and problem-based discussion (1 h). Methods of delivery include didactic teaching, clinical case discussion, and guideline promotion. The combined materials of approximately 2 h in total duration were then disseminated in a pre-recorded webinar format for time-limited asynchronous online learning.

Survey

A questionnaire with suitable content was constructed to assess knowledge, attitude, and practice and was divided into dedicated sections thereof. The knowledge section incorporated ten multiple-choice questions with one correct answer and four plausible distractors provided for each. One point was assigned for each correctly answered question and zero point otherwise, yielding a maximum score of ten. The attitude and practice sections featured 5-point Likert-type items (1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, 5 = strongly agree) in response to 5 statements, yielding a maximum score of 25 for each section. Higher scores reflected good practice in all sections of the survey. Informed consent and participant characteristics obtention were mandatory before access to the pretest questionnaire was granted. Additional questions on supporting and inhibiting factors for AMS implementation with free-text responses were added to the posttest questionnaire.

Procedure

The research protocol was made up of three phases, namely preparation, conduct, and evaluation. In the initial preparatory phase, the original education tool and questionnaire draft were assembled and piloted to 37 subjects with equivalent authority and qualification recruited from external institution. The objective of the preliminary pilot was to ensure adequate internal consistency of the questionnaire through content revision, and none of the results were included in the current analysis. The finalized questionnaire was created using an online form readily accessible in multiple platforms for user convenience. In the following phase, participants were invited to take a pretest and given a seven-day period to use the tool before the posttest form was accessible. Unique credentials for each participant were generated from individual initials to access the webinar and posttest online forms. The pilot data was then presented to antimicrobial resistance control committee members for evaluation and feedback.

2.5. Study outcomes and statistical analysis

Primary outcomes

Feasibility was assessed by the enrollment percentage of eligible subjects, while acceptability was represented by the percentage of subjects who finished the posttest.

Secondary outcomes

Univariate analysis was used to tabulate the frequency of baseline subject characteristics and survey results. Scores were deemed adequate with the lowest thresholds of 7 for knowledge section and 20 for attitude and practice sections. The effect size of the intervention was analyzed quantitatively using a paired t-test for pre- and posttest knowledge, attitude, and practice scores. Barriers and facilitators to the intervention were analyzed qualitatively as aggregates.

3. Results

A total of 212 of 251 subjects (84.5%) retrieved in the sampling frame fulfilled the inclusion criteria. Two subjects were excluded and another 7 subjects dropped out, resulting in 210/212 (99%) recruitment rate and 203/210 (96.7%) adherence. The subjects had a mean age of 48.1±9.3 years and were mostly (69%) males (Table 1). Almost one-fourth of whom represented the department of surgery with over ten years of working experience in nearly two-third of the subjects. Less than half of the subjects participated in previous learning course and completed it in 1–5 years prior.

The proportion of subjects with adequate pretest (36.9%) and posttest (83.3%) knowledge and adequate pretest (21.2%) and posttest (51.7%) attitude increased after intervention. The reverse was true for adequate pretest (88.7%) and posttest (82.3%) practice score. Mean knowledge, attitude, and practice scores in pretest were 6.1±1.2 (range 3–9), 17.8±2.7 (range 13–25), and 21.9±2.5 (range 6–25), respectively. Posttest scores for aforementioned section in consecutive order were 7.6±1.1 (range 5–10), 19.2±2.7 (range 12–25), and 22.1±2.7 (range 13–25). Score improvements for knowledge, attitude, and practice section were 1.6, 1.3, and 0.2 in decreasing order. The improvement was statistically significant in knowledge section ($p < 0.001$) and insignificant in attitude ($p = 0.898$) and practice ($p = 0.194$) sections.

Table 1. Baseline characteristics

	N	%
Gender		
Male	140	69.0
Female	63	31.0
Department		
Surgery	47	23.1
Pediatrics	31	15.3
Internal medicine	25	12.3
Obstetrics and gynecology	20	9.9
Neurology	16	7.9
Ophthalmology	14	6.9
Cardiology and vascular medicine	13	6.4
Otorhinolaryngology head and neck surgery	13	6.4
Dermatology and venereology	10	4.9
Anesthesiology and intensive care	8	3.9
Pulmonology	6	3.0
Working experience		
<5 years	28	13.8
5–10 years	55	27.1
>10 years	120	59.1
Previous antimicrobial stewardship learning course		
Yes	99	48.8
No	104	51.2
Time elapsed since course completion		
<1 year	9	9.1
1–5 years	46	46.5
>5 years	44	44.4

The majority of subjects answered correctly to Q1 in pretest and Q1 and Q10 in posttest. Q6 had the lowest proportion of correct response after intervention. The highest knowledge score improvement was observed in Q8, leveraging its correct responses proportion which was initially the lowest in pretest (Table 2). Q11, on the other hand, had the highest proportion of maximum attitudinal score at both the pre- and post-test. The lowest proportion of maximum attitudinal score was observed for Q13 in pretest and Q12 in posttest. The only increment in the proportion of the maximum attitudinal score was at Q13 (Table 3). The proportion of the maximum practical score for Q17 and Q18 remained the lowest and highest after intervention occurred. Improvement in the proportion of maximum practical score was evident solely for Q16 (Table 4).

Table 2. Responses on AMS knowledge survey

Topics	N (%) correct		Difference
	Pretest	Posttest	
1. Antimicrobial mechanism of action	92.6	94.6	2.0
2. Appropriate prophylactic antimicrobial administration practice	42.9	62.6	19.7
3. Prophylactic antimicrobial prescribing principles	69.9	91.6	21.7
4. Principles of prudent antimicrobial use	85.7	87.2	1.5
5. AWaRe antimicrobial classification	62.1	77.8	15.7
6. Antimicrobials under reserve classification of AWaRe	20.2	41.4	21.2
7. Fundamental terms relating to antimicrobial resistance	89.2	92.6	3.4
8. Antimicrobial prescribing practice workflow	4.4	69.5	65.1
9. Clinical decision following culture and sensitivity test results	49.7	50.7	1.0
10. The role of attending physicians in AMS implementation	90.1	94.6	4.5

Table 3. Responses on AMS attitude survey

Statements	Test	SDA (%)	DA (%)	U (%)	A (%)	SA (%)
11. The importance of pharmacology and microbiology comprehension in rational antimicrobial prescribing	Pre	0.5	0	0	4.9	94.6
	Post	0	0	0	6.4	93.6
12. Resistance pattern is not considered when choosing antimicrobial agent to treat severe infection	Pre	51.2	22.2	6.9	7.4	12.3
	Post	52.2	18.7	7.4	10.8	10.8
13. Antimicrobial resistance control committee involvement in prescribing antimicrobial agents within "access" category is optional	Pre	42.4	22.7	12.8	10.3	11.8
	Post	12.8	18.7	14.3	23.6	30.5
14. The rate of new antimicrobial agents' discovery is disproportionate to the development of resistance	Pre	3.0	4.4	5.9	25.1	61.6
	Post	3.0	2.0	6.4	20.2	68.5
15. Prevalent third-generation cephalosporins use leads to increased risk of *C. difficile* colitis	Pre	1.5	3.0	12.8	39.4	43.3
	Post	0.5	3.9	11.8	36.9	46.8

Table 4. Responses on AMS practice survey

Statements	Test	SDA (%)	DA (%)	U (%)	A (%)	SA (%)
16. Single-dose antimicrobial prophylaxis in 100 ml normal saline is administered intravenously for 15–30 min starting 30–60 min before surgical incision	Pre	3.9	2.0	8.4	27.6	58.1
	Post	1.0	0.5	7.4	30.5	60.6
17. Ceftriaxone has dose-dependent characteristic and is administered intravenously at 24 h interval	Pre	10.3	10.8	9.9	25.6	43.3
	Post	10.8	10.8	8.9	26.1	43.3
18. Culture specimen should be obtained before antimicrobial administration in sepsis management	Pre	0.5	0.5	3.0	9.8	86.2
	Post	0	1.5	4.9	12.8	80.8
19. Coordination with the antimicrobial resistance control committee is warranted in the absence of improvement despite sensitivity test guided antimicrobial treatment	Pre	1.5	0	2.5	16.3	79.8
	Post	1.0	1.0	2.0	23.6	72.4
20. Local guideline serves as a reference in hospital antimicrobial administration practice	Pre	7.4	3.0	11.3	19.2	59.1
	Post	2.5	3.0	7.9	27.6	59.1

Barriers and facilitators for AMS implementation were recapitulated in five main themes (Table 5). Access to workflow, guideline, resistance pattern, and course were regarded as facilitators, while antimicrobial availability was regarded as a barrier to optimal AMS implementation. Only 5.4% of subjects did not provide any remark on antimicrobial availability, as opposed to nearly half of all subjects that of workflow access.

Table 5. Barriers and facilitators to AMS implementation

Themes	Adequate (%)	Inadequate (%)	Abstain (%)
Availability of antimicrobials listed in local guideline	36.0	58.6	5.4
Access to antimicrobial administration workflow	37.4	13.3	49.3
Access to local guideline	66.0	22.2	11.8
Access to local resistance pattern	50.7	38.4	10.8
Learning course	51.7	13.3	35.0

4. Discussion

The current feasibility study attempted to guide AMS efforts reinvention, especially focusing on educational intervention for its excellent versatility. Development and dissemination of the learning tool encompassed education, persuasion, and enablement functions of behavior change interventions (7). The innovative distance learning model was matched with field testing methods to ensure real assessment of resources and management in addition to procedural and scientific evaluation. Single intervention delivery followed by feedback analysis allowed to generate future directions to modify educational cointervention and plan its complementary intervention. To the best of our knowledge, this study was the first to investigate prescriber-directed distance learning intervention in lower-middle-income countries such as Indonesia. High recruitment and adherence rates with minor refusal and drop-out rates confirmed the feasibility and acceptability of the study protocol, while a postintervention survey validated the effectiveness of learning tools in improving knowledge.

Based on the knowledge survey results, more emphasis should be given to some aspects of the knowledge section particularly on the WHO Access, Watch, and Reserve (AWaRe) classification and antimicrobial prescribing practice workflow. The two topics are interrelated in the sense that decision-making in antimicrobial dispensing is closely regulated within the workflow according to the AWaRe classification system. These are the cornerstone of daily clinical practice for prescribers as primary decision-maker in healthcare facilities, thus suggesting the propensity for "gatekeeper" intervention to be a direct problem solver. Similarly, the transfiguration of attitude and practice would benefit from intervention with a restriction and/or enablement function. In the current hospital-wide pilot study, for instance, AMS efforts would benefit from online preauthorization prescribing practice and adequate AWaRe classification-compliant pharmacy supply.

AMS practice postulates good governance, monitoring and feedback, support, and research as educational accompaniment (12). Clearer descriptions and stakeholder roles in AMS regulation and practice policy should be instilled by the governance counterpart in AMS implementation. Ongoing monitoring and support by multidisciplinary healthcare personnel partaking in antimicrobial dispensing encourage AMS implementation sustenance. An ideal future large-scale intervention and education cointervention should set out population-wide thorough knowledge survey and monitoring and feedback analysis ahead of definitive intervention formulation on the basis of best available evidence. The current initiative calls for forthcoming AMS advancement and implementation outreach.

There were some limitations to this study that may or may not directly affect the study conclusion. The lack of randomization was the primary concern when opting for field testing strategy. Nonetheless, the high uptake and retention rate demonstrated its importance in the referring conclusion. Nature characteristics of this intervention rendered the Hawthorne effect as inevitable. Other limitations may include regression to the mean and unmeasured covariates such as assessment duration.

The pilot study of this quality improvement model was critical in ensuring a feasible protocol and outlining its potential pitfalls for actual implementation. Current protocol and tool were appropriate for further module modification and paired with restricting and/or enabling intervention. Future work with more extensive involvement is required in reshaping the future of AMS intervention models in developing areas.

Conflict of interest
The author reports no conflicts of interest in this work.

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Authors' contributions
Concept: I.W.S., I.G.A.G.U.H., A.B.S., N.N.D., Design: I.W.S., A.B.S., Data Collection or Processing: I.W.S., I.G.A.G.U.H., A.B.S., N.N.D., Analysis or Interpretation: I.W.S., I.G.A.G.U.H., A.B.S., N.N.D., Literature Search: A.B.S., Writing: I.W.S., A.B.S.

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