Effectiveness of Preventive Nursing Program for Multidrug-Resistant Organism Transmission: A Quasi-experimental Study

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Abstract: Multidrug-resistant organism infections are a major public health problem. Promoting nurses' practice in preventing multidrug-resistant infections can reduce hospital transmission. This quasi-experimental study investigated the effectiveness of a preventive nursing program for multidrug-resistant organism transmission. The study was carried out in the Department of Internal Medicine in a tertiary hospital in south Thailand. Participants in this study were registered nurses. Two wards were randomly selected as the experimental ward and two as the control ward, then participants from each ward were purposively selected. Finally, there were 60 participants, n = 31 from the experiment wards and n = 29 from the control wards. The experimental group received a 4-week program, whereas the control group followed the usual practice. Then, the practices in preventing multidrug-resistant organism transmission of the experimental and control groups were assessed 4 and 12 weeks after the program ended. The instruments for data collection included a demographic data form and a preventive practice observation form. Data were analyzed using descriptive statistics and a chi-square test.

The results showed that, at 4 and 12 weeks after completion of the program, nurses in the experimental group had a significantly higher proportion of correct practices (hand hygiene, use of personal protective equipment, patient placement, patient transport, patient care equipment management, environmental management, and linen and infectious waste management of multidrug-resistant organism transmission) than before receiving the program and in the control group. The findings suggest that the program effectively improves nurses' correct practices in preventing multidrug-resistant organism transmission. The program can be applied to promote and support preventive practices among nurses. However, long-term follow-ups with the incidence of multi-drug-resistant organism transmission should be further studied. In addition, as this study was conducted with nurses working in the internal medicine wards of a tertiary hospital, it is necessary to evaluate the program's effectiveness with different samples prior to its wider implementation.

Keywords: Multidrug-resistant organisms, Nurses, Practices, Prevention, Transmission

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Introduction

The increasing of multidrug-resistant organisms (MDRO) is a problem of concern in many countries, including Thailand. MDRO refers to microorganisms

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with non-susceptibility to at least one agent in three or more antimicrobial categories.[1] In the US, the Centers for Disease Control and Prevention (CDC) estimated that over 2.8 million MDRO infections occur annually resulting in over 35,000 deaths.[2] In the EU and European Economic Area (EEA), there were 670,000 MDRO infections and around 33,000 deaths caused by such infections in 2020, with particularly high percentages of resistance to third-generation cephalosporins and carbapenem-resistant *Klebsiella pneumoniae*, carbapenem-resistant *Acinetobacter* species, and *Pseudomonas aeruginosa* in many countries.[3] The magnitude and trend of MDRO infections among hospitals in Thailand are high due to the rising rate of MDROs, especially multidrug-resistant gram-negative bacteria (MDR-GNB). The National Antimicrobial Resistance Surveillance Thailand (NARST) reported that the tendency of *Acinetobacter* spp., *Klebsiella pneumoniae* and *Pseudomonas aeruginosa* was rising, with resistance to carbapenem.[4] MDRO infections cause multiple impacts on clients, family or caregivers, healthcare workers, hospitals, and countries. For individuals, the impacts comprised increased morbidity and risk of death and high mortality rate,[5] severe complications,[6] increased readmissions,[7] and prolonged length of hospital stay.[8] Therefore, practices to prevent MDRO transmission are required, particularly among nurses.

Nurses are key to preventing and controlling infection in healthcare settings because they perform most daily care procedures, which are close contact and carry risks of MDRO transmission. Implementing practices to prevent MDRO transmission is the role of nurses, who must uphold suitable procedures for all clients throughout their hospitalization. Essential practices are hand hygiene, contact precautions and environmental cleansing/disinfection. Even though hand hygiene is widely considered the most critical activity for hospital prevention that can significantly reduce MDRO infections, studies indicate that overall hand hygiene compliance rate among nurses was only 39%.[9,10] Hand hygiene compliance among nurses was low in some cases.[11] Research has demonstrated a lower compliance rate of personal protective equipment (PPE) use and contamination during PPE removal due to incorrect sequences, the doffing technique and the use of PPE.[12] Besides, although environmental measures of environmental cleaning are essential to reduce MDRO transmission, nurses who care for cases with MDRO are confused about using different disinfectants to clean in the post-discharge period.[13] In addition, many healthcare settings had limited isolation rooms for cohort placement and lacked isolation materials for patient placement.[14] Therefore, it is essential to enhance nurses' practice in preventing the transmission of MDRO infections.

Several studies have investigated the efficacy of interventions for preventing the transmission of MDROs. Those interventions included multimodal strategies comprising system change, education and training, monitoring, audit and feedback, reminders and culture change, persuasion, and role models to improve healthcare workers' practice, leading to increased performance for preventing MDRO transmission.[15,16,17] Previous programs were not sufficiently based on psychological behavior change theory. A systematic review of interventions for improving healthcare workers' hand hygiene compliance demonstrated that a program should have a rigorous basis on behavior change theory and consider social influence, attitude, and intention to yield higher effectiveness.[18] Therefore, intervention development should be based on a theoretical framework considering cognitive behavioral factors to approach behavior change.

Literature Review and Conceptual Framework

The practices of nurses in preventing the transmission of MDRO infection include hand hygiene, use of PPE, patient placement, patient transport, patient care equipment management, environmental management, management of linen and infectious waste management.[19]

Hand hygiene refers to rubbing alcohol on the hands or rinsing them with soap and water.[20] Use of PPE includes gown, mask, face shield or goggles, and gloves during care activities that provide opportunities to transfer MDROs to staff hands and clothing.[19] Moreover, MDRO infection cases should be placed in a single room.[19] Non-critical equipment should be used with a single client. Equipment should be thoroughly cleaned and disinfected if use with multiple clients is necessary.[21] Healthcare workers should perform environmental cleaning and disinfecting of handled surfaces and equipment in the client's immediate vicinity based on the hospital guidelines.[19] Staff handling contaminated linen should wear appropriate PPE. In the patient care area, soiled linen should be carefully rolled up without shaking and placed in a properly labelled, leak-proof container. Hand hygiene should be practiced before application and after removal of PPE.[2] Moreover, infectious waste should be placed in a designated receptacle for reprocessing or a special waste container. Staff must wear protective gloves when handling waste and remove and dispose of them hygienically.[2] From a literature review, multiple factors have been reported to be associated with the preventive practices of nurses. The most critical factors are individual factors, which include attitude toward the performance of the practice, subjective norms, and perceived behavioral control.[22,23,24,25] The attitudes toward infection prevention and control were significant predictors of compliance to preventive practice[26] and the prevention of MDRO transmission.[27] Subjective norms directly affected nurses' intention to prevent and control MDRO[22] and were associated with hand hygiene.[24] Moreover, perceived behavioral control directly affected adherence to guidelines to control MDRO among nurses in intensive care units and nurses' MDRO management and intention to perform this.[22] Therefore, improving nurses' practices in the prevention of MDRO transmission should consider these influential factors of behavioral intention.

The conceptual framework for this study was based on the theory of planned behaviors (TPB), which consists of three main concepts: attitude, subjective norms, and perceived behavior control.[28] According to Ajzen, human behavior is determined by intention. The intention is determined by attitude toward the behaviors (negative or positive evaluations of behavior), subjective norms (prevailing societal approval or disapproval of others' behaviors), and perceived behavioral control (individual's perception of the ease or difficulty associated with executing the behaviors). Thus, increasing these three constructs (attitude, subjective norms, and perceived behavioral control) will strengthen the intention to achieve healthy behavior outcomes. For prevention and control of MDRO transmission, TPB was effective in predicting healthcare workers' compliance with infection control practices,[29] and the intention and the hand hygiene behavior of healthcare workers.[30] A systematic review suggested TPB as the improvement strategy in intervention to improve hand hygiene compliance.[18] Thus, TPB is the potential in the interventions to change and improve the behavior of nurses for practice. Understanding the effective interventions to encourage the prevention of MDRO transmission among nurses is essential. A systematic review showed that combined interventions, including education, feedback, and reminders, effectively enhanced nurses' hand hygiene.[18]

The program for prevention of MDRO transmission among nurses in this study was based on the TPB to raise attitude, subjective norms and perceived behavioral control with a combination of several interventions in three main components. First, raising a positive attitude toward the preventive practice of MDRO transmission involved providing knowledge through education and training about the prevention of MDRO transmission and group discussion about the consequences of incorrect practices. Second, raising subjective norms included perceived expectations and social pressures to prevent MDRO transmission, contributing to the intention to improve practice through group discussions. Lastly, raising perceived behavioral control involves the presence or absence of facilitators and barriers to MDRO prevention by providing feedback on preventive practice, group

discussion about the problem of practices, support, incentive, verbal encouragement and persuasion. When nurses had better attitudes, subjective norms, and perceived behavior control toward the preventive practices of MDRO transmission, they would have higher intentions to perform such practices, which could lead to improvements in the preventive practice for MDRO transmission in terms of hand hygiene, use of PPE, patient placement, patient transport, patient care equipment management, environmental management, management of linen, and infectious waste management. Thus, a program for the prevention of MDRO transmission for nurses based on such a behavioral theory as the TPB was needed to increase intention and change their behavior in MDRO transmission prevention.

Study Aim and Hypotheses

This study investigated the effectiveness of the Nursing Preventive Program for Multidrug-Resistant Organism Transmission (NPP-MDROT). It was hypothesized that at weeks 4 and 12 after the completion of the NPP-MDROT, the nurses in the experimental group would have a proportion of correct practices in the prevention of MDRO transmission significantly higher than before receiving the program and higher than those in the control group.

Methods

Design: The quasi-experimental design was used with two groups (pretest-posttest) and a non-equivalent control group design. The Transparent Reporting of Evaluations with Non-randomised Designs (TREND) checklist was utilized as a guideline for this study report.

Sampling and Setting: This study was conducted at a tertiary care hospital in the Southern region of Thailand. The sample size was determined based on the proportion of the previous quasi-experimental research of multifaceted strategic methods on correct practices of healthcare workers in the prevention of MDRO infection,[31] with the proportion of healthcare workers with proper practices after intervention in the control and experimental groups of 0.53 and 0.88, respectively. A significance level of .05 and power of .80 based on the results from the previous study[31] were set. From the calculation, the number of participants was 27 per group. To compensate for possible incomplete data and loss of participants, we added 15% to the sample size.[32] Therefore, the sample size was 31 per group, totaling 62 participants.

Four medical wards were selected from 11 wards in the Department of Internal Medicine using simple random sampling. Two of these wards were randomly selected as the experimental ward and two as the control ward; the participants were registered nurses who were purposively selected based on inclusion criteria of 1) working full-time in the Internal Medicine Department and 2) being willing to participate in a research project. Exclusion criteria were 1) infection control ward nurses (ICWN) and 2) head ward nurses. The discontinuation criteria were as follows: 1) wish to withdraw from the study and 2) not completing participation in intervention sessions. In the control group, two participants discontinued participation because they were relocated to a new department. The final number of participants used for data analysis was 31 and 29 in the experimental and control groups, respectively.

Ethical Considerations: The study was approved by the Research Ethics Committee of the Faculty of Nursing, Chiang Mai University (study code: 2563-EXP107). The research purpose and methodology were clearly communicated to all participants, ensuring transparency in the study. Participants were provided with the freedom to decline participation or withdraw from the study at any point, without facing any adverse consequences. After the participants agreed to participate, they were asked to sign a consent form.

Instruments: Two forms were used for data collection:

A demographic data questionnaire was developed by the primary investigator (PI) to collect information

including age, education level, work duration, and previous training in MDRO prevention.

The PI developed the *Preventive Practice Observation Form* based on a literature review of the practice guidelines for the prevention of MDRO.[19,20] Observation of preventive practice included 1) hand hygiene, 2) use of PPE, 3) patient placement, 4) patient transport, 5) patient care equipment management, 6) environmental management, 7) management of linen, and 8) infectious waste management. An example of an item is: "Remove and discard gloves in the infectious waste bin." The recording is done by marking in the section of nurse's practice, indicated as correct practice (perform preventive practice procedure correctly), incorrect practice (not perform preventive practice procedure correctly or entirely), and no practice (not perform preventive practice procedure). The observation is calculated into the preventive practices compliance by dividing the correct preventive practices by the total preventive practices opportunities and multiplying by 100 in the formula.[20] This form was examined for content validity by six experts (a physician specialized in MDRO, a nursing instructor specialized in infection prevention and control, two infection control nurses, and two clinical nurses with experience caring for MDRO cases. The Scale Content Validity Index was 0.9, and inter-rater reliability was 1 in this study.

The NPP-MDROT and implementation: The program was developed by the PI based on a comprehensive literature review related to the TPB.[28] Its content was examined by the same panel of six experts mentioned above and revised on their suggestions. The NPP-MDROT was implemented for a period of four weeks and comprised three components. The first component involved raising nurses' positive attitude toward preventive practices of MDRO transmission by providing knowledge through education and training about MDRO transmission prevention, hand hygiene and use of PPE, and group discussion about the consequences of incorrect practices. The second component included raising subjective norms in perceived expectations and social pressures to improve the preventive practices of MDRO transmission through group discussions.The last component covered raising perceived behavioral control concerning the presence or absence of facilitators and barriers to the performance of MDRO prevention by providing feedback on preventive practice, group discussion about problems of practices, support for practices, incentives on preventive practice, verbal encouragement, and persuasion. The details are shown in **Table 1**.

Standard Hospital Practices: These involved activities in preventing MDRO transmission based on a CDC guideline[16] consisting of hand hygiene, use of PPE, patient placement, patient transport, patient care equipment management, environmental management, management of linen, and infectious waste management.

Data Collection: This study was conducted from March 2021 to June 2022. The PI recruited four research assistants (RAs) who were ICWNs from four wards assigned as the experimental and control groups (two research assistants for the experimental and two for the control group). The RAs were trained in a two-hour lecture and discussion through PowerPoint presentations on hand hygiene and using PPE, and one-hour practice on hand hygiene and use of PPE according to WHO[20] and CDC guidelines.[19] Moreover, the training was conducted to administer the Preventive Practice Observation Form. The RAs collected data by observing the preventive practices of the participants in the pre-test and post-test and recorded the practice immediately after each observation activity. The observations were carried out during different random time slots on five days (three days for morning and two days for afternoon shifts) a week for four consecutive weeks to avoid a Hawthorne effect. Each observation began from the start of each of the preventive practices until the end of each practice. Participants were informed about the study but unaware of the starting time of observation and the person who would observe them since the observer was a part of the operation in the unit.

The experimental group received the 4-week NPP-MDROT in addition to the hospital's standard practices for MDRO cases, while the control group followed only the hospital's standard practice for MDRO cases. Both groups' practices were assessed at 4 and 12 weeks after the program ended.

Data Analysis: This was conducted using the SPSS program version 25.0. The sample's demographic characteristics were analyzed using descriptive statistics, including frequency, percentage, mean and standard deviation, and range. An Independent t-test was used to test the mean of age and work experiences in the medical ward. The proportion of practices for preventing MDRO transmission between participants who received the NPP-MDROT and those who did not, as well as between before and after the NPP-MDROT, was compared using Chi-square test.

Results

Demographic characteristics of the sample

There were 31 nurses in the experimental group and 29 in the control group. All of them were female, and most were in the age range of 22-44 years. All nurses in both groups graduated with bachelor's degrees and had work experience in the medical ward of 1-5 years. For the training, nearly half of the nurses in the experimental group and the control group had been trained, and most of the nurses in both groups received information about the prevention of MDRO transmission. There were no significant differences in all demographic data between groups (**Table 2**).

Table 2. Demographic characteristics of nurses in experimental and control groups

Variables	Experimental Group (N = 31)		Control Group (N = 29)		p-value
	N	%	N	%	
Gender					-
Female	31	100	29	100	
Age (years old)					.815[a]
20-30	24	77.42	23	79.30	
31-40	5	16.13	3	10.35	
> 40	2	6.45	3	10.35	
Range	22-44		22-44		
± SD	27.774±6.168		28.137±5.786		
Level of Education					-
Bachelor degree	31	100	29	100	
Work experiences in medical ward (year)					
1-5	21	67.74	24	82.75	.864[a]
6-10	7	22.59	2	6.90	
11-15	3	9.67	3	10.35	
Range	1-15		1-15		
± SD	4.483±4.073		4.3103±3.733		
Hospital training about preventing MDRO transmission					
Yes	13	41.94	8	27.59	.306[b]
No	18	58.06	21	72.41	
Obtaining information about preventing MDRO transmission.					
Received	30	96.77	27	93.10	[c]
Not receive	1	3.23	2	6.90	

Note. [a] = Independent-sample t-tests, [b] = Chi-square test

[c] = Chi-square test was not possible because Chi-square assumption requires at least five observations in every cell of the 2x2 table. All expected values need to be at least 5.

Effectiveness of the NPP-MDROT

After the program ended, the experimental group results showed significant differences in the proportion of overall correct practices between baseline and four weeks, between baseline and 12 weeks, and between 4 and 12 weeks. There were substantial differences in the proportion of hand hygiene and use of PPE (**Table 3**).

Table 3. The comparison of the proportion of overall correct practices and activity in the prevention of MDRO transmission in the experimental group at baseline, 4, and 12 weeks after completing the program (n = 31)

Practice	Baseline (1)		4 weeks (2)		12 weeks (3)		p-value		
	Correct practices /N	%	Correct practices /N	%	Correct practices /N	%	(1) vs (2)	(1) vs (3)	(2) vs (3)
Overall	1,017/1,531	66.42	1,194/1,444	82.68	1,155/1,514	76.28	<.001	<.001	<.001
- Hand hygiene	156/339	46.01	178/248	71.77	180/290	62.06	<.001	<.001	.017
- Use of PPE	544/714	76.19	630/754	83.55	608/746	81.50	<.001	.013	.295
- Patient placement	12/14	85.71	13/13	100	13/13	100	-	-	-
- Patient transport	10/10	100	9/9	100	8/8	100	-	-	-
- Patient care equipment management	56/76	73.68	64/74	86.48	60/69	86.96	.05	.046	.934
- Environmental management	78/109	71.56	65/76	85.52	77/91	84.61	.026	.028	.869
- Management of linen	52/80	65.00	55/65	84.61	60/74	81.08	.008	.025	.582
- Infectious waste management	109/189	57.67	180/205	87.80	149/174	85.63	<.001	.016	.533

Note. Chi-Square

When compared between groups, there were no significant differences in the proportion of overall correct practices between the experimental and control groups at baseline. There were differences in the proportion of overall correct practices between the groups four weeks and 12 weeks after the program ended (**Table 4**).

Table 4. Comparison of proportion of overall correct practice in prevention of MDRO transmission between the experimental group and control group at baseline, 4, and 12 weeks after completing the program

Practice	Time	Experimental Group		Control Group		p-value
		Correct practice /N	%	Correct practice /N	%	
Overall	Before	1,017/1,531	66.42	1,097/1,674	65.53	.568
	Week 4	1,194/1,444	82.68	1,094/1,595	68.58	<.001
	Week 12	1,155/1,514	76.28	1,027/1,557	65.96	<.001

Note. Chi-Square

Regarding each practice, there were no significant differences in the proportion of nurses' correct practices between the groups at baseline in all activities: hand hygiene, use of PPE, patient care equipment management, environmental management, management of linen, and infectious waste management (**Table 5**). The proportion of nurses with each correct practice in the prevention of MDRO transmission between the groups at four weeks after the program ended was significantly different (i.e., in hand hygiene, use of PPE, patient

care equipment management, environmental management, management of linen, and infectious waste management - see **Table 5**). In addition, these differences were still apparent at 12 weeks after the program ended for hand hygiene, use of PPE, environmental management, and infectious waste management (**Table 5**).

Table 5. Comparison of proportion of nurses' correct practice and activity in prevention of MDRO transmission between the experimental group and control group before the program, at weeks 4, and 12 after the program

Practice	Experimental Group		Control Group		p-value
	Correct practice /N	%	Correct practice /N	%	
Baseline					
- Hand hygiene	156/339	46.01	136/288	47.22	.763
- Use of PPE	544/714	76.19	634/875	72.45	.091
- Patient placement	12/14	85.71	12/15	80.00	-
- Patient transport	10/10	100	11/11	100	-
- Patient care equipment management	56/76	73.68	46/70	65.71	.294
- Environmental management	78/109	71.56	84/137	61.37	.092
- Management of linen	52/80	65.00	54/84	64.29	.924
- Infectious waste management	109/189	57.67	120/194	61.85	.404
At 4 weeks					
- Hand hygiene	178/248	71.77	170/314	54.14	< .001
- Use of PPE	630/754	83.55	578/763	77.75	< .001
- Patient placement	13/13	100	12/12	100	-
- Patient transport	9/9	100	10/10	100	-
Patient care equipment management	64/74	86.48	50/72	69.44	.013
- Environmental management	65/76	85.52	73/110	66.36	.003
- Management of linen	55/65	84.61	58/83	69.87	.036
- Infectious waste management	180/205	87.80	143/2296	62.44	< .001
At 12 weeks					
- Hand hygiene	180/290	62.06	148/280	52.85	.026
- Use of PPE	608/746	81.50	567/828	68.47	< .001
- Patient placement	13/13	100	12/15	80.00	-
- Patient transport	8/8	100	7/7	100	-
- Patient care equipment management	60/69	86.96	50/65	76.92	.130
- Environmental management	77/91	84.61	70/112	62.50	< .001
- Management of linen	60/74	81.08	58/80	72.50	.209
- Infectious waste management	149/174	85.63	115/170	67.64	.001

Note. Chi-Square

Discussion

The NPP-MDROT could increase the preventive practice of nurses. This significant improvement might be due to the elements of the NPP-MDROT that were developed based on the TPB covering three main components, including attitude, subjective norms and perceived behavior control that led to individuals' behavioral intention to engage a behavior.[28]

In this study, the NPP-MDROT raised attitudes toward the preventive practices of MDRO transmission. There was education and training and group discussions about the consequences of incorrect practices, which could enhance positive attitudes that led to the increased

intention of practice and improved performance of nurses for prevention and control of MDRO transmission. When they evaluated that the correct practices could reduce MDRO transmission and the consequences of such transmission, particularly in patient safety, they would develop a positive attitude toward preventive practices. Consistently, training was a factor in enhancing the attitudes and practices of healthcare workers to prevent and control MDRO infections.[33] Moreover, a positive attitude was significantly associated with hand hygiene compliance,[25] in line with a previous study.[34] Congruently, education and demonstrations improved healthcare workers' confidence in performing practices.[35] It is noteworthy that a higher proportion of participants in the experimental group received hospital training about preventing MDRO transmission than the control group. This might also explain the higher compliance to MDRO transmission prevention in the experimental group due to the increased awareness of MDRO transmission prevention and correct practices gained from the hospital training.

Furthermore, the NPP-MDROT raised subjective norms regarding the prevention of MDRO transmission through group discussions about the subjective norm for practices in preventing MDRO transmission. Social norms interventions showed effectiveness in changing the clinical behaviors of health professionals and a positive effect on patient health outcomes in various health service contexts.[35] The ward head and colleagues provided subjective norms as they expected that all the nurses in the ward would have correct practices in preventing the transmission of MDROs and recognize the importance of such practices. When the participants were aware that their ward and organization emphasized the importance of preventing MDRO transmission and expected nurses to have correct practices, they might develop an intention to improve their practices as others expected.

Lastly, the NPP-MDROT raised perceived behavioral control regarding preventing MDRO transmission through feedback on preventive practice, outcomes and practice, support, incentives, verbal encouragement and persuasion. Feedback might help the nurses recognize the problems in their practices and identify the solutions to address those problems to reduce MDRO transmission. In addition, feedback helps to reflect appropriate practices to reduce MDRO transmission while correcting inappropriate practices. This can facilitate the changes in nurses' behaviors through continuous learning and self-development toward correct practices of reducing MDRO transmission. A systematic review evidenced these behavior changes; audit and feedback were significant for interventions to reduce MDRO infections.[35] The result from the group discussion about barriers and facilitators for practice in preventing MDRO transmission showed that most of the participants had an intention to perform the correct practices. The ward head listened attentively to the participants' problems, suggested solutions, and provided support regarding practices, which helped improve nurses' intention to perform practices. In addition, the NPP-MDROT provided adequate support for hand hygiene by arranging alcohol-based hand rub at the end of every bed. Such support for practices by providing adequate equipment and supplies that meet the nurses' needs could increase the convenience of practices in preventing MDRO transmission. Similarly, a previous study showed that the hospital's support in training and providing basic hand hygiene supplies improved the correct hand hygiene practices of health care professionals.[36] Additionally, the PI and the ward head gave verbal persuasion to encourage the intention to correct practice for preventing MDRO transmission. When nurses believed that they could control the performance of their behaviors to achieve the correct practices, they developed an intention to change their practices even though it might have been difficult. These strategies also helped participants believe they were important individuals in preventing MDRO transmission and had control over their performance, as they had received training to perform those practices. Furthermore, the NPP-MDROT provided incentives for nurses who could perform correct practices

in preventing MDRO transmission, which helped encourage nurses to continue correct practices and make other nurses desire to perform correct practices. Incentive is the process of motivating workers to make more effort in their work, such as receiving recognition from the administrators and honoring an outstanding worker, which makes other workers willing and enthusiastic to be more efficient.[37]

Our findings on the effect of the NPP-MDROT on practices in preventing MDRO transmission among nurses are consistent with previous studies. The TPB could be adopted for hand hygiene behavior and significantly impact both the intention and the behavior among healthcare workers.[30] Other researchers[38] found that an education program based on TPB could increase attitude, subjective norms, perceived behavioral control, and intention and enhance the hand hygiene practices of nurses.

Another point worth noting is that the behavior changes of nurses in MDRO transmission prevention may be influenced by many contextual factors such as policies, organizational cultures, and support for MDRO transmission prevention. The discussion with participants during program implementation revealed barriers and needs regarding the hospital's support for patient care equipment to improve MDRO transmission prevention. Furthermore, such prevention is affected by the knowledge and practices of clients and their families. Further research is recommended to take into account these factors that are important to the effectiveness of programs to improve MDRO transmission prevention.

Limitations

The practice activities of nurses in infection prevention were assessed by observation in the morning and afternoon shifts. However, late-night shift observations were impossible due to the high nursing workload and the limited number of nurses. The preventive practices of nurses were assessed by direct observation that might be affected by the Hawthorne effect. Therefore, further studies may need to adjust the assessment method by using the combined estimation method or technology, such as application-assisted direct observation and camera-assisted observation, to reduce the observation bias. This study was conducted on nurses working in the medical wards of a tertiary hospital in southern Thailand. Thus, generalizability to other settings may be limited.

Conclusion and Implications for Nursing Practice

The study results confirm that the NPP-MDROT effectively enhances practices in preventing MDRO transmission among nurses. The findings support the use of TPB, a social psychology theory, to improve the practices in the prevention of MDRO transmission for nurses. Nurses can incorporate this program into their routine patient care to improve their attitudes towards practices in MDRO transmission prevention and raise subjective norms and perceived behavioral control to achieve better patient outcomes during hospitalization. The program content can be used in training nursing students and new graduate nurses to prepare them for actual practices, or it can be utilized to review the understanding of ward nurses to enhance their practices in MDRO transmission prevention. Nursing administrators can create policies to support compliance with MDRO transmission prevention by minimizing barriers in practices and facilitating effective practices. However, it is recommended to conduct further testing to evaluate the effectiveness of this program in different settings before considering its implementation in actual practice.

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Appendix

Table 1. Nursing Preventive Program for Multidrug-Resistant Organism Transmission (NPP-MDROT)

Time	Objectives of Activity	Activity
Week 1 (2 hours)	To increase knowledge, understanding, and attitudes of nurses about the importance of preventing MDRO transmission	**Activity 1 Education about the prevention of MDRO transmission** 1. Provided education to nurses through lecture and PPT. The contents covered the situation of MDRO infection, the impacts and pathways of MDRO transmission, and preventive practices. Education took approximately 60 minutes. 2. Gave the practice guideline for prevention of MDRO transmission to nurses to review 3. Allowed nurses to ask questions for better understanding and share opinions
	To raise nurses' perceptions of their own practice in the prevention of MDRO transmission	**Activity 2 Feedback** 1. Gave feedback about practice in preventing MDRO transmission using the results of observation before the initiation of the program 2. Introduced the evaluation and feedback to nurses to enhance their understanding of incorrect practice in the prevention of MDRO transmission: 1.1 Individually: Gave verbal and written feedback in a sealed letter - Gave feedback to nurses individually every day - Sent sealed letters to nurses every Friday. The contents included the overall picture of the practices of the entire ward and of the individual nurses. Asked about barriers to correct practice in prevention of MDRO. Had nurses shared their problems and barriers to seek solutions together? 1.2 In group: Conducted activities as follows: - Prepared a board every Friday to present the results of practice and gave feedback - Presented the results of observation of practice in preventing MDRO transmission before starting group activity each week
	To raise nurses' perceived behavior control in the practice of prevention of MDRO transmission and raise nurses' awareness of the consequences of incorrect practice	**Activity 3 Group discussion** The topics of the group discussion were problems related to incorrect practice in preventing MDRO transmission and the consequences of incorrect practice.
	- To encourage nurses in their practice to prevent MDRO transmission	**Activity 4 Rewarding and encouraging nurses with correct practice in preventing MDRO transmission** The PI conducted activities as follows:

Table 1. Nursing Preventive Program for Multidrug-Resistant Organism Transmission (NPP-MDROT) (Cont.)

Time	Objectives of Activity	Activity
	To encourage nurses with correct practice in preventing MDRO transmission to be a role model for their colleagues	1. Rewarding nurses - Explained the details of the activities and how to select nurses with correct practice by considering the observation result from the practice in preventing MDRO transmission and nomination by colleagues. The nurse with the highest vote was rewarded. Rewarding was performed from weeks 2-4 of group activities. 2. Encouraging the nurses about preventive practices - Praised the nurses for correct practice and gave encouragement for changing toward a correct practice in preventing MDRO transmission.
Week 2 (2 hours)	To increase nurses' knowledge, understanding, and attitude about the importance of hand hygiene and use of personal protective equipment	The group activities in the 2nd week consisted of 4 activities: education and training on hand hygiene and the use of PPE, feedback, group discussion about the subjective norms for practice in preventing MDRO transmission, and rewards for nurses. **Activity 1 Education and training in hand hygiene and use of personal protective equipment**
	To allow nurses to acknowledge their own practice in preventing MDRO transmission	1. Gave lecture about hand hygiene and use of PPE using PowerPoint presentation. The nurses had an opportunity to ask questions and share opinions. 2. Gave a demonstration of hand hygiene and use of PPE and asked for return demonstration. 3. Gave feedback and encouragement and praise for correct practice to increase nurses' confidence in their correct practice to prevent multidrug-resistant organism transmission. All activities took about 50 minutes.
	To raise nurses, perceived behavior control in the practice of prevention of MDRO transmission	**Activity 2 Feedback** Presented the results of overall observation of practice to prevent MDRO, including both correct and incorrect practice. Nurses were encouraged to change their practice in preventing MDRO transmission.
	To allow nurses to acknowledge the subjective norm for practice in preventing MDRO transmission	**Activity 3 Group discussion about the subjective norms for practice in preventing MDRO transmission** The topic for group discussion included subjective norms for practice in preventing MDRO transmission. Group discussion took about 20 minutes.
	To encourage nurses to perform practice in preventing MDRO	**Activity 4 Rewarding the nurses** Nurses with correct practice in preventing MDRO transmission were repeat of rewards. The nurse whose name was nominated and had good observation results was rewarded. In case of discrepancy between the nomination and the observation results, nurses in the group voted. The nurse with the highest vote was rewarded.

Table 1. Nursing Preventive Program for Multidrug-Resistant Organism Transmission (NPP-MDROT) (Cont.)

Time	Objectives of Activity	Activity
Week 3 (1 hour)	To allow nurses to acknowledge their own practice in preventing MDRO transmission	The group activities in Week 3 consisted of feedback, group discussion about barriers and facilitators of practice in preventing MDRO transmission and rewarding nurses with correct practice. **Activity 1 Feedback** Presented the overall observation results of practice in preventing MDRO transmission in the past week and the areas for improvement. Praised and encouraged nurses for their practice in preventing MDRO transmission.
	To build nurses' confidence in their ability to perform practice in preventing MDRO transmission with increasing facilitators and decreasing barriers to practice	**Activity 2 Group discussion about barriers and facilitators for practice in preventing MDRO transmission** The topics for group discussion were barriers and facilitators for practice in preventing MDRO transmission. The group discussion took approximately 30 minutes.
	To provide nurses with encouragement for practice in preventing MDRO transmission	**Activity 3 Rewarding nurses** The nurses with correct practice in preventing MDRO transmission were repeat of rewards.
Week 4 (1 hour)	To allow nurses to acknowledge their own practice in preventing MDRO transmission	Week 4 consisted of 3 activities: feedback, group discussion, and rewarding nurses. **Activity 1 Feedback** Gave feedback on the correct and incorrect practice in preventing MDRO transmission in the past week
	To build nurses' confidence in their ability to perform practice in preventing MDRO transmission with increasing facilitators and decreasing barriers to practice	**Activity 2 Group discussion about the results of facilitators for practice in preventing MDRO transmission** From the presentation of the group discussion results in Week 3 to head nurses for considering promoting facilitators for practice in preventing MDRO transmission among nurses, group discussion in this week focused on the topic of the results of facilitators for practice in preventing MDRO transmission. This took about 20 minutes.
	To provide nurses with encouragement for practice in preventing MDRO transmission	**Activity 3 Rewarding nurses** The nurses with correct practice in preventing MDRO transmission were repeat of rewards.

ประสิทธิผลของโปรแกรมการป้องกันการแพร่กระจายเชื้อดื้อยาต้านจุลชีพหลายขนานสำหรับพยาบาล: การวิจัยกึ่งทดลอง

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บทคัดย่อ: การติดเชื้อดื้อยาต้านจุลชีพหลายขนานเป็นปัญหาสาธารณสุขที่สำคัญ การส่งเสริมการปฏิบัติของพยาบาลในการป้องกันการแพร่เชื้อดื้อยาต้านจุลชีพหลายขนาน สามารถลดการแพร่กระจายเชื้อในโรงพยาบาลได้ การศึกษาครั้งนี้เป็นการวิจัยกึ่งทดลองสองกลุ่ม (ทดสอบก่อนและหลังการทดลอง) และมีกลุ่มควบคุมเพื่อศึกษาประสิทธิผลของโปรแกรมการป้องกันการแพร่กระจายเชื้อดื้อยาต้านจุลชีพหลายขนานสำหรับพยาบาล ดำเนินการวิจัยที่แผนกอายุรกรรมในโรงพยาบาลตติยภูมิแห่งหนึ่งในภาคใต้ของประเทศไทย กลุ่มตัวอย่างคือพยาบาลวิชาชีพที่ปฏิบัติในแผนกอายุรกรรม โดยสุ่มเลือกหอผู้ป่วย 2 แห่งเป็นหอผู้ป่วยกลุ่มทดลอง และอีก 2 แห่งเป็นหอผู้ป่วยกลุ่มควบคุม จากนั้นคัดเลือกผู้เข้าร่วมวิจัยจากแต่ละหอผู้ป่วยแบบเจาะจง จนได้ผู้เข้าร่วมวิจัยจำนวน 60 คน n = 31 จากหอผู้ป่วยกลุ่มทดลอง และ n = 29 จากหอผู้ป่วยกลุ่มควบคุม กลุ่มทดลองได้รับโปรแกรม 4 สัปดาห์ในขณะที่กลุ่มควบคุมปฏิบัติตามมาตรการปกติของโรงพยาบาล ประเมินการปฏิบัติการป้องกันการแพร่กระจายของเชื้อดื้อยาต้านจุลชีพหลายขนานของกลุ่มทดลองและกลุ่มควบคุมใน 4 และ 12 สัปดาห์หลังเสร็จสิ้นโปรแกรม เครื่องมือในการรวบรวมข้อมูล คือ แบบข้อมูลประชากรและแบบสังเกตการปฏิบัติเพื่อป้องกัน วิเคราะห์ข้อมูลโดยใช้สถิติเชิงพรรณนาและการทดสอบไคสแควร์

ผลการวิจัยพบว่า หลังเสร็จสิ้นโปรแกรม 4 และ 12 สัปดาห์ พยาบาลกลุ่มทดลองมีสัดส่วนการปฏิบัติถูกต้องสูงขึ้นอย่างมีนัยสำคัญในการทำความสะอาดมือ การใช้อุปกรณ์ป้องกันส่วนบุคคล การแยกผู้ป่วย การเคลื่อนย้ายผู้ป่วย การจัดการอุปกรณ์การแพทย์ การจัดการสิ่งแวดล้อม ตลอดจนการจัดการผ้าเปื้อน และการจัดการมูลฝอยติดเชื้อในการป้องกันการแพร่เชื้อดื้อยาต้านจุลชีพหลายขนานเมื่อเปรียบเทียบกับก่อนได้รับโปรแกรมและในกลุ่มควบคุม ผลการวิจัยชี้ให้เห็นว่าโปรแกรมมีประสิทธิภาพในการปรับปรุงการปฏิบัติที่ถูกต้องของพยาบาลในการป้องกันการแพร่กระจายเชื้อดื้อยาต้านจุลชีพหลายขนาน สามารถนำโปรแกรมนี้ไปประยุกต์เพื่อส่งเสริมและสนับสนุนการปฏิบัติในการป้องกันของพยาบาล อย่างไรก็ตามการศึกษาในอนาคตควรมีการติดตามอุบัติการณ์ของการแพร่กระจายเชื้อดื้อยาต้านจุลชีพหลายขนานในระยะยาว นอกจากนี้เนื่องจากการศึกษานี้ดำเนินการกับพยาบาลที่ทำงานในหอผู้ป่วยอายุรกรรมของโรงพยาบาลระดับตติยภูมิ จึงจำเป็นต้องประเมินประสิทธิผลของโปรแกรมเพิ่มเติมก่อนที่จะนำไปใช้ต่อไป

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