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COMPLIANCE WITH HAND HYGIENE AMONG HEALTH CARE PROVIDERS: EFFECTS OF A SIX SIGMA IMPROVEMENT PROJECT

Mahmoud A. Shahin.[1]

[1]Nursing Department, Al-Ghad International Colleges for Applied Medical Sciences- KSA

*Corresponding author:
Name: Dr. Mahmoud Abdul Hameed Shahin,
Address: Al-Ghad International Colleges for Applied Medical Sciences- KSA.
E-Mail: Mahmood81us@yahoo.com

ABSTRACT

Background: Good hand hygiene (HH) is of vast importance in mitigating the spread of hospital-acquired infections in hospitals, which are associated with higher morbidity and mortality rates and a greater cost of treatment. Good HH alone can significantly reduce the transmission of infection; however, adherence to recommended HH practices remains unacceptably low in most hospitals.

Materials and Methods: The present study comprised one group in a pretest–posttest preexperimental design. All staff at the Prince Sultan Cardiac Centre were included and 520 observations were randomly obtained from these individuals before and after interactions with patients, with a similar number of observations collected after the implementation of the HH Six Sigma improvement program.

Results: Half of the total observations were collected regarding nurses; the majority of the involved staff were 30 years to 39 years of age, and more than half of them were female. HH was performed in 65.4% of the occasions prior to contacting patients and in 82.3% of the occasions after contacting patients. After adding reminding posters, implementing educational programs, and affixing alcohol dispensers on the doors of patient rooms, HH compliance improved significantly and was performed by 90% of staff before contacting patients and by 93.5% of them after contacting patients. Females as compared with males and nurses as compared with technicians demonstrated significantly more HH compliance before contacting their patients.

Conclusion: HH compliance improved significantly after implementing the quality improvement program. Our study results can be utilized as a backbone for any HH improvement program in hospitals. The completion of randomized longitudinal studies is recommended to ensure the sustainability of the improvement program effect on HH.

Keywords: Hand hygiene, Compliance, Hospital-acquired infections, Six Sigma.

1.0 Introduction

Hospital-acquired infection (HAI) is becoming one of the most important health concerns of communities. It may affect patients, hospitals, and insurance companies as well as governments around the world. The concern regarding HAI is not only due to the magnitude of the problem in terms of the associated morbidity, mortality, and cost of treatment but also because of the belief that most of these infections are preventable. HAIs include any infection that occurs in a patient during the process of care in a hospital that was not present or incubating at the time of admission. This includes infections acquired in the hospital that appear after discharge as well as occupational infections among the staff of the facility. HAIs are a major global health problem and are identified as the first priority for Global Patient Safety Challenge by the World Health Organization (Organization, 2017).

The prevalence of HAIs is estimated to be 1.4 million worldwide. It leads to 50,000 attributable mortalities and two million attributable cases of morbidity in developed countries every year (Astagneau, Rioux, Golliot, & Brücker, 2001), as well as an extra 14 days of hospital stay on average and an addition of £3,154 of health care expenses per patient per year (García-Martín et al., 2001). In the United States, the five major HAIs identified were central line-associated infections, ventilator-associated pneumonia, surgical site infections, *Clostridium difficile* infections, and catheter-associated urinary tract infections. The annual cost of these five major HAIs in the United States is estimated to be $9.8 billion (Zimlichman et al., 2013).

With the increasing severity of illness and complexity of treatment, especially in combination with the presence of multidrug-resistant pathogen infections, health care practitioners are reversing back to the basics of infection preventions by employing simple measures like good hand hygiene (HH) (Mathur, 2011). HH practice refers to any action of hand cleansing for the purpose of decreasing hand colonization with transient flora (Organization, 2017). Recently, undisputed evidence has been presented that strict adherence to HH reduces the risk of cross-transmission of infections (Mathur, 2011). There are enough scientific data to support the theory that, if properly implemented, HH alone can significantly reduce the risk of cross-transmission of infection in health care facilities.

Proper HH is the single most important, simplest, and least expensive means of reducing the prevalence of HAIs and the spread of antimicrobial resistance (Organization, 2009a). Good HH prompted significant reductions in infection-related outcomes, even in settings with a high infection rate in critically ill patients. The transmission of HAIs has also been documented to reduce with an improvement in HH. Evidence suggests that adherence to HH practices has significantly reduced the rates of acquisition of pathogens on hands and has ultimately lowered the rates of healthcare-associated infections in hospitals.

Use of an alcohol hand rub can substitute hand-washing when hands are not visibly soiled; to this effect, an alcohol-based hand rub can be used routinely to decontaminate hands. On the other hand, alcohols, chlorhexidine, and other antiseptic agents have poor activity against spores; therefore, it's recommended to wash hands with soap and water when hands are visibly dirty or contaminated (Edmonds et al., 2010). HH is important to protect each patient against the harmful pathogens that may be carried on health care providers' hands, and to protect health care providers and the health care environment from harmful pathogens. HH should be used before and after contact with each patient (Mathur, 2011).

In most health care institutions, adherence to recommended hand-washing practices remains unacceptably low (Boyce & Pittet, 2002; Organization, 2009a; Trampuz & Widmer, 2004). A review of 34 published studies of hand-washing adherence among health care workers found that adherence rates varied from 5% to 81% (Lau, 2012). Among different hospital specialties, intensive care units (ICUs) were found to have the highest prevalence rate of HAIs. At the same time, health care providers in ICUs also displayed the lowest HH compliance rate when compared with staff members working in other specialties (Erasmus et al., 2010).

HH compliance is influenced by both individual and institutional factors. Many studies have been carried out to assess the reasons behind poor HH compliance in health care institutions; furthermore, some studies included an implementation of remedies to overcome this problem. On the other hand, most of these studies did not follow a scientific methodology in choosing the proper solution to overcome the poor HH compliance rate among health care workers; moreover, they depended on the results of a single study or the opinion of the researcher rather than on the demonstrated results of an improvement tool.

Although existing evidence-based research and systematic reviews have identified many factors affecting HH compliance among health care workers in general hospital settings, to our knowledge, no study to date has explored specifically the factors that affect HH compliance and the implementation of compliance improvement strategies using a quality improvement tool in the intensive care setting. The study aims to identify the current staff HH compliance rate in the ICUs of the Prince Sultan Cardiac Centre in Buraydah, Saudi Arabia. In addition to that, it aims to utilize a Six Sigma quality improvement tool to increase staff HH compliance in health care institutions.

2.0 Materials and Methods

This descriptive observational study used one group pretest–posttest preexperimental design to carry out the study. The convenience sampling technique was used wherein all accessible health care providers who work at the Prince Sultan Cardiac Centre were included in the study. A random sampling technique was employed to compile the hand-washing observations of health care workers before and after contacting patients. The total number of involved health care workers from the Prince Sultan Cardiac Centre was 160, including physicians, nurses, technicians, and others. The number of random HH observations recorded for the staff was 520 both before and after contacting patients. A similar number of observations were taken over one month after the implementation of an HH improvement program.

The study included all departments of the Prince Sultan Cardiac Centre in Buraydah City, Saudi Arabia [i.e., the ICU, coronary care unit (CCU), cardiac operation room, emergency room, cardiac surgical intensive care unit (CSICU), cardiac catheterization laboratory, outpatient clinic, and cardiology ward]. In order to assess the compliance with HH among health care providers at the hospital, data collection was carried out using an observational checklist. This observational checklist was adopted from the Joint Commission International Accreditation HH and glove use monitoring form (Commission, 2016) and included

information about the day, time, unit, profession, and nature of HH before contacting and after contacting patients using soap and water or an alcohol-based hand rub.

A piloting of the tool was conducted involving 20 health care workers to test its feasibility and efficiency. Minor recommended modifications were made accordingly. Then, the tool's validity and reliability were tested again using content validity and interrater reliability. The observational checklist was filled in by trained observers who made rounds in the hospital units and spent time observing the staff during their daily practice of HH. The health care providers were monitored for HH before contacting the patients and after as well. Over one month, data collection was carried out over the day and night shift in all critical care units. This data collection was repeated again for one month after the implementation of the HH quality improvement program.

A Six Sigma quality improvement tool was used in this study to choose the vital few alternative solutions of the current problem. Six Sigma is a powerful tool for solving complex problems introduced by engineer Bill Smith during his tenure at Motorola in 1986 and is used in many industrial sectors (Webber & Wallace, 2011). However, it has only recently been used for the improvement in the health care delivery. Six Sigma utilizes five steps that comprise the acronym DMAIC (Define, Measure, Analyse, Improve, and Control), as follows: define the system, the voice of the customer and their requirements, and the project goals. Measure key aspects of the current process and collect relevant data; calculate the 'as-is' process capability. Analyse the data to investigate and verify cause-and-effect relationships. Seek out the root cause of the defect under investigation. Improve or optimize the current process based upon data analysis using some techniques. Control the future state process finally to ensure that any deviations from the target are corrected before they result in defects using statistical process control.

The collected data were tabulated, scored, and analysed. Descriptive, comparative and inferential statistics were carried out using the SPSS software version 22 (IBM Corp., Armonk, NY, USA). An official permission was obtained from the Ministry of health and the management of King Fahad Specialist Hospital to implement the study at the Prince Sultan Cardiac Centre. The study proposal was initially submitted to the institutional review board (IRB) of the King Fahad Specialist Hospital for approval. The purpose of the study and the procedure were explained to the participants. No harm was expected to be done to the patients or participants. Anonymity, confidentiality, and all other ethical issues of scientific research were considered during the implementation of this study. A clear announcement about the study was put on the bulletin boards of all units, including a complete description of the purpose and the procedure of the study. The results of the study were submitted to the hospital administration upon completion of the study and before publication.

3.0 Results

3.1 Characteristics of sample units

One hundred sixty personnel from all professions represented the total number of health care providers involved in this study from the critical care units of the Prince Sultan Cardiac Centre; however, the study sample included 520 random observations taken from health care

providers randomly over one month during the day and night shifts. The sociodemographic characteristics of the observations sample are shown in Table 1.

Table 1: Socio-demographic data

	Characteristics	Frequency	%
Profession	Doctor	154	29.6
	Nurse	260	50
	Technician	98	18.8
	Other	8	1.5
Age	20-29 years	200	38.5
	30-39 years	228	43.8
	40-49 years	92	17.7
Gender	Male	218	41.9
	Female	302	58.1
Shifts	Day	420	80.8
	Night	100	19.2

Half of the total observations were taken from nurses, while physicians composed almost 30%, followed by technicians and other professions. The age group of the majority of the health care workers was 30 years to 39 years, while the minority was in the age group of 40 years to 49 years. With regard to gender, more than half of observations collected were for female health care providers (58.1%). The majority of observations for this study were compiled during the day shifts, as the workload was significantly higher during the day shifts; on the other hand, less than 20% of the observations collected reflected the HH practices of the staff from the night shifts.

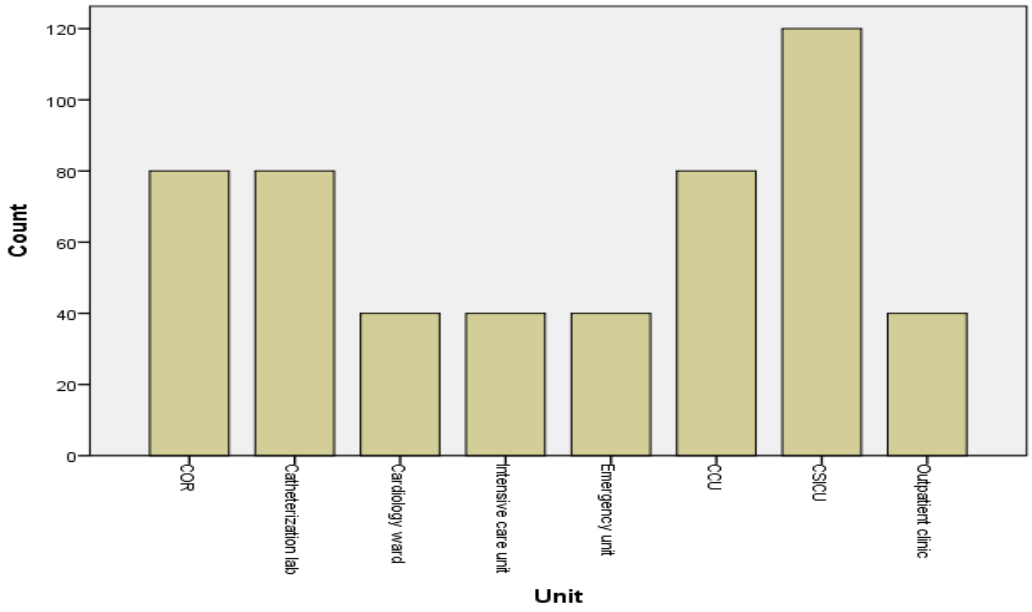

Figure 1: Number of observations according to units

Figure 1 illustrates the number of HH observations based on the different units, which was relatively proportional to the number of staff members in each unit, with the highest being from the CSICU. A similar percentage of observations were taken from the cardiac operation room, catheterization lab, and CCU (15.4%); followed by a similar percentage of observations from the cardiology ward, ICU, outpatient clinic, and emergency unit (7.7%).

3.2 Hand hygiene practices before the interventions

Table 2: Hand Hygiene before and after contacting patients

HH Before contacting patients			HH After contacting patients		
	Frequency	%		Frequency	%
ABHR	180	34.6	ABHR	238	45.8
HW	160	30.8	HW	190	36.5
Gloves	58	11.2	Missed	92	17.7
Missed	122	23.5	Total	520	100
Total	520	100			

(ABHR=Alcohol Based Hand Rub, HW= Hand Washing)

Based on the reports of the observers, almost one-third of the staff washed their hands using an alcohol-based hand rub, 30.8% employed hand-washing, and 11.2% wore gloves, while 23.5% did not wash their hands at all prior to contacting patients. After contacting patients, on the other hand, 45.8% of the staff washed their hands using an alcohol-based hand rub, 36.5% employed hand-washing, and 17.7% did not wash their hands at all (Table 2).

Most of the literature reviews published to date have considered the use of an alcohol-based hand rub or soap and water for proper hand-washing. On the other hand, many designated the health care provider to be failing HH if they wore gloves without hand-washing, as HH is highly important (Horan, Andrus, & Dudeck, 2008).

Table 3: HH before intervention

	Before contacting patients		After contacting patients	
	Frequency	%	Frequency	%
Not washed	180	34.6	92	17.7
Washed	340	65.4	428	82.3
Total	520	100	520	100

Based on the mere fact that wearing gloves without hand-washing is not enough to protect the patient and prevent infection, proper HH was performed before contacting patients in the present study in 65.4% of the occasions, while no HH was done in almost 34.6% of the occasions (1.9 Sigma level). On the contrary, HH was performed in 82.3% of the occasions after contacting patients, but not done in 17.7% of the occasions (2.43 Sigma level). There was a significant difference in term of HH when comparing staff HH practices before and after contacting patients. Health care providers' HH after contacting patients was significantly higher (Table 3).

3.3 Hand hygiene practices after the interventions

Using a statistical analysis of Six Sigma methodology and after many brainstorming sessions to choose the vital few solutions that were likely to have the maximum impact on the problem, alcohol hand rub dispensers were put on the doors of each patient room to make the process of HH highly accessible and easier, and to remind the staff about it through visual prompting. Additionally, an educational program was provided to the staff and expressive posters were placed above the head of each patient's bed to remind the health care provider about the importance of hand washing in the hospital setting.

Table 4: Hand Hygiene before and after contacting patients

HH Before contacting patients			HH After contacting patients		
	Frequency	%		Frequency	%
ABHR	244	46.9	ABHR	274	52.7
HW	222	42.7	HW	212	40.8
Gloves	24	4.6	Missed	34	6.5
Missed	30	5.8	Total	520	100
Total	520	100			

(ABHR=Alcohol Based Hand Rub, HW= Hand Washing)

Following these interventions, data collection was carried out again using the same tools, and found that 46.9% of the staff washed their hands using an alcohol-based hand rub, 42.7% completed hand-washing, and 4.6% wore gloves, while 5.8% of them did not take any precautions before contacting patients. In the same circumstances, 52.7% of the staff washed their hands using an alcohol-based hand rub, 40.8% used water and soap, and 6.5% of them did not wash their hands after contacting patients at all (Table 4).

Table 5: HH after intervention

	Before contacting patients		After contacting patients	
	Frequency	%	Frequency	%
Not washed	54	10.4	34	6.5
Washed	466	89.6	486	93.5
Total	520	100	520	100

After implementing the improvement plan, HH practices were performed before contacting patients by almost 90% of the staff, while HH was not considered in 10% of the occasions (2.78 Sigma level). On the other hand, HH after contacting patients was performed in 93.5% of the occasions, while no HH was performed in 6.5% of the occasions (3.01 Sigma level). When conducting chi-squared cross-tabulation, it was clear that the difference in HH before and after contacting patients was not significant; however, the compliance with hand-washing was still higher after contact with patients (Table 5).

3.4 Difference in hand hygiene before and after the improvement project

The difference in the compliance of health care providers to HH before and after conducting the improvement plan is illustrated in Tables 6 and 7.

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Table 6: Difference in hand hygiene before touching patients before and after manipulation

Chi-Square Tests	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	89.491[a]	1	.000		
Continuity Correction[b]	86.656	1	.000		
Likelihood Ratio	90.594	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	89.319	1	.000		
N of Valid Cases	520				

Regarding the HH practices of the staff before and after the interventions were introduced, a significant difference was noticed in hand-washing practices before touching patients between the two periods (P = 0.00) (Table 6).

Table 7: Difference in hand hygiene after contacting patients before and after manipulation

Chi-Square Tests	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	169.240[a]	1	.000		
Continuity Correction[b]	163.246	1	.000		
Likelihood Ratio	129.989	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	168.914	1	.000		
N of Valid Cases	520				

Similarly, a significant difference was noticed in hand-washing practices after touching patients pre- and post-implementation of the interventions (P = 0.00) (Table 7). HH compliance was significantly better after implementing the suggested remedies both before touching patients and after contacting them.

3.5 Other significant factors of hand hygiene

The results revealed that there were no significant differences in hand-washing practices before or after contacting patients depending on the unit or the shift considered. However, after implementing the improvement program, female health care providers had a significantly higher HH compliance rate before contacting patients than did males, while no significant difference was noticed between the two genders after contacting patients. In contrast, nurses were significantly better in terms of HH compliance than technicians were before contacting patients after the HH improvement program implementation.

4.0 Discussion

Half of the HH observations taken were reflective of the nurses' performance in the critical care departments, followed by the compliance of physicians and then technicians and other professions. Additionally, more than half of observations were representative of female health care workers. The findings regarding the proportions of profession type and gender are mainly a reflection of the number of nurses versus other health care providers as well as the ratio for females to males at the Prince Sultan Cardiac Centre. The demographics of the study are congruent with the results of many other studies of HH and are an accurate reflection of the composition of most of health care institutions around the world (Erasmus et al., 2010; Silva, Andrade, & Silva, 2014). Due to the high workload and observation opportunities, HH observations were mainly collected during the day shift, while one-fifth of them were taken during night shifts. For a better representation, the number of observations taken from each department was proportional to the number of staff working there.

HH practices employing alcohol hand rub and hand-washing with soap are the main techniques used for infection control and disease prevention at health care institutions. Some studies considered the theory that alcohol hand rub is more effective against various pathogens (e.g., viruses and bacteria) in comparison with hand washing with either medicated or nonmedicated soaps (Grayson et al., 2011; Pittet & Donaldson, 2005). It requires less time and cost, is more accessible, and less irritative to the skin. What's more, wearing gloves alone is not enough and is considered to be an inefficient and unsafe method to prevent the spread of HAIs (Organization, 2009b). Prior to patient contact, only two-thirds of staff complied with HH using alcohol hand rub or water and soap, in comparison with almost four-fifths of them who compiled with such after contacting patients. These significant findings are reflected in many other studies that showed a better adherence to HH protocols after patient contact (Salama, Jamal, Al Mousa, Al-AbdulGhani, & Rotimi, 2013). Notably, it appears that health care providers are paying less attention to the safety of their patients versus their own safety through significantly better compliance with HH after contacting patients.

To implement the Six Sigma improvement project on HH compliance among health care providers, brainstorming and a fishbone diagram (root cause analysis) were utilized to identify the barriers that interfere with optimal HH in order to find the easiest solution of the problem. The results included, but were not limited to, the availability of HH products and dispensers, degree of business, nonconvenience, dislike towards or problem with the HH products, forgetfulness, and perception toward the necessity of HH. Notably, most HH studies published to date did not describe the factors affecting HH compliance among health care providers. However, the studies emphasized that the factors behind poor HH practices are multiple and may vary according to the setting and the resources available. Lack of appropriate preparations and equipment to enable HH performance, cultural or religious background, membership of a certain professional category, operation in certain care areas of the hospital, understaffing and overcrowding, and wearing gloves can all play an important role in hindering good practices (Allegranzi et al., 2007).

A similar result about the barriers was reported in a recent study, which pointed out that the lack of HH facilities and equipment, variable training and staff perceptions were the most significant barriers to effective staff HH (Mearkle, Houghton, Bwonya, & Lindfield, 2016). Studies emphasized that HH barriers interfere with HH compliance among health care workers. In a study conducted in 2013 to test a theory-based instrument designed to identify

barriers and levers to best HH practice among health care practitioners, the researchers concluded that the greater the number of barriers to HH reported in the hospital, then the lower the level of compliance with HH among health care providers would be (Dyson, Lawton, Jackson, & Cheater, 2013).

By applying the Pareto principle to identify the vital few causes, two solutions were chosen based on the causes; these were (1) alcohol dispensers on patients' doors and (2) posters and an educational program. In a meta-analysis that included 14 studies, it was found that the improvement strategies utilized to enhance HH adherence included increasing the availability of alcohol-based hand rub, education for staff, reminders (both written and verbal), the provision of different types of performance feedback, administrative support, and staff involvement (Gould, Moralejo, Drey, Chudleigh, & Taljaard, 2010).

The occurrence of HH adherence increased significantly after implementing an improvement program, especially before contacting patients. It was clear that the majority of staff complied with HH before and after contacting patients; however, compliance after contacting patient remained still higher. The attention on staff safety over patients' safety stayed the same after the improvement program implementation, but in a less significant manner. This result was congruent with a study conducted in Kuwait that used an educational HH campaign and reflected that the compliance with HH by health care workers improved significantly by almost one-fifth (Salama et al., 2013).

Regarding the factors that affected staff compliance to HH, female health care providers were more highly influenced by program implementation, showing a significantly higher HH compliance rate before contacting patients than their male counterparts. A similar result was found by different articles that studied the gender effect on HH in Australia and China (Han, Dou, Zhang, & Zhu, 2011; van de Mortel, Bourke, McLoughlin, Nonu, & Reis, 2001).

In the current study, after program implementation, nurses were significantly better in terms of HH compliance than were technicians before contacting patients. In a study conducted in Kuwait, investigators also found that compliance with HH was significantly higher among nurses versus among physicians and other health care professionals (Salama et al., 2013). Similarly, a study in Turkey found that the compliance rate of HH among nurses was higher than that among doctors (Karaaslan et al., 2014).

5.0 Conclusion and recommendations

HH compliance is the key to preventing the spread of HAIs at the health care institutions. Nurses constitute the vast majority of health care providers; as such, more attention should be paid to them, as their compliance with HH is highly required. Staff HH adherence before contacting patients was clearly less than that after patient contact for all health care professionals in the present study. Just by installing alcohol dispensers on the doors of patient rooms, by offering an educational program, and by installing some reminding posters, HH compliance was improved significantly, especially in females as compared with males and among nurses versus technicians and other health care professionals prior to patient contact.

Our study results can be employed as a backbone for any HH improvement program in the hospitals and health care facilities in Saudi Arabia; however, tailored solutions should be

considered based on the underlying causes and reasons behind poor staff compliance in each institution. Furthermore, randomized, longitudinal studies are recommended to assess the compliance of health care workers with HH over time and to ensure the sustainability of the quality improvement program effect on HH compliance among health care workers.

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Declaration

The author declares that there are no conflicts of interest to report pertaining to this research.

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