**Reducing the cross infection of *methicillin-resistant staphylococcus aureus* (MRSA)**

 **in an intensive tertiary care hospital in Indonesia through hand hygiene improvement**

Andaru Dahesihdewi1,4\*, Iwan Dwiprahasto2,4, Supra Wimbarti3,4, Budi Mulyono1

1Department of Clinical Pathology and Laboratory Medicine Faculty of Medicine, *Universitas* Gadjah Mada, Yogyakarta

2Department of Pharmacology and Therapy Faculty of Medicine, *Universitas* Gadjah Mada Yogyakarta

3Faculty of Psychology, *Universitas* Gadjah Mada Yogyakarta

4Clinical Epidemiology and Bio Statistic Unit Faculty of Medicine, *Universitas* Gadjah Mada Yogyakarta

**ABSTRACT**

Hospital Acquired Infection (HAIs) is the most frequent adverse event that can cause the worsening of patients’ clinical outcome. Hand hygiene is the simple, cost effective way to prevent HAIs. The incidence of hospital acquired (HA) MRSA cross infection is thought to be a good indicator directly describes hand hygiene practices at the point of care. This study aims to evaluate the impact of hand hygiene compliance on HA-MRSA cross transmission in The Intensive Tertiary Care of Sardjito Hospital in Indonesia.

A quasi-experimental before-after design was conducted to evaluate the implementation of the ‘WHO Multi-modal Hand Hygiene Improvement Strategy’ that is adjusted to the local needs, based on the qualitative study result from the Intensive Care from June 2014 to April 2016. All workers who have frequent contact with patients were observed for their hand hygiene compliance by trained observers. Incidences of HA-MRSA were recorded through active surveillance accompanied by microbiology data.

There were 92 healthcare workers (18 medical doctors, 45 nurses, 29 other staffs) and 5,280 patients involved throughout the before and after intervention’s study period. There were 16,313 hand hygiene opportunity observations which resulted in a significantly improved practical accuracy-consistency-sustainability, after intervention in the initial and end-evaluations. There was a significant decrease in the HA-MRSA rate from 12.6% before intervention to 1.2% and 0.3% at the initial and end-evaluations, respectively.

Increasing hand hygiene compliance in the Intensive Care after the intervention reduced HA-MRSA significantly, and suggest such cross infection as an indicator of hand hygiene compliance.

**Keywords:** compliance, hand hygiene, intensive care, MRSA cross transmission

**INTRODUCTION**

*Hospital Acquired Infection* (HAIs) is the most adverse event in patient safety incident in hospital that can cause a worsening of the patients’ clinical outcomes.1,2 Global evidence shows its impact in increasing mortality rates of 18.7% - 75.1%, extending the length of stay (LOS) by 3.9 - 12 days, and increasing health costs by $593 - $40,000/case.3,4,5 *Multidrug-resistant organisms* (MDRO) infection is a critical global problem related to the antimicrobial resistant issue that can cause the difficulties in the choice of treatment and with its impact on the failure of patients cured. Infections by MDRO and HAIs are caused by multiple factors, but one of the most important causes is the poor practice of clean care in healthcare facilities.6,7

Hand hygiene by all health care workers (HCWs), including those outside the medical or nursing staff, also by the patients and their relatives, is the key factor in clean care. It is the simple and cost effective method to prevent HAIs and MDRO transmission.Although hand hygiene is not the only element measured in infection control, there is much evidence to prove that improvements to hand hygiene is a strategic element in reducing the incidence of HAIs. Multi-modal hand hygiene improvement strategy (MHHIS) is developed by WHO to promote practical improvement for several decades in most hospitals worldwide.8,9,10 However, the HCWs’ hand hygiene practices at the point of care, in many developing countries’ hospitals, including those in Indonesia, are still at varying levels.11 In this study, we complemented the WHO MHHIS with our own local needs as the intervention, aimed at improving and sustaining hand hygiene practices for the realization of a safety culture and behavior of health professionals, albeit with limited resources.

Hospital acquired (HA) cross infection by the methicillin-resistant *Staphylococcus aureus* (MRSA) pathogen is predicted to be a more direct indicator of hand transmission due to the pathogen being normally transient flora on the body’s skin. The pathogen could be eradicated by accurate hand hygiene during patients care. This study evaluated the improvement in hand hygiene compliance among HCWs in the Intensive Care at Sardjito Hospital Yogyakarta, Indonesia, and its impact on MRSA cross infection as a direct indicator of clean care.

**METHODS**

**Study design**

 This study was a quasi-experimental before and after analysis designed to evaluate the implementation of the WHO MHHIS that was adjusted to local hospital’s needs, based on a qualitative study. This prospective study was conducted from June 2014 to April 2016, in the Intensive Care Unit (ICU), Intensive Cardiac Care Unit (ICCU) and Pediatric Intensive Care Unit (PICU) of Sardjito Hospital, a public governance hospital providing tertiary care, which is one of the national reference and the main hospital of the Academic Health System in Yogyakarta Indonesia. The 23-months study period was divided into 4 steps which were: The first 7-months for collecting the pre-intervention data base, the second 5-months for the implementation period, the third 7-months for the initial post intervention evaluation and the last 4-months for the end post intervention evaluation. The integrative adjusted MHHIS was intensively implemented in January-May 2015. Hand hygiene compliance and MRSA cross transmission incidence were measured throughout the study period.

**Study population**

 The subjects consisted of HCWs and patients in the targeted units. The subject HCWs were all workers (medical staff, nurses, nurses’ assistants and other staff including dieticians, physiotherapists, administration staff and even cleaning service staff) who had frequent contact with the patients. Patients who were admitted to the targeted units and found to have no MRSA infection were included as study subjects, consecutively. All subjects were given explanation of the study and voluntarily agreed to participate by signing informed consent forms.

**Hand hygiene observation**

 All the subject HCWs were monitored for their hand hygiene practice for one hour during their routine morning care activities by 9 trained observers (3 for each unit) independently and blindingly, resulting in at least 204 opportunity observations per month from each unit throughout the study period. The observation targeted the accuracy of the practices relating to hand hygiene indications and opportunities. Among the subjects, certain doctors (18) and nurses (36), were monitored for the consistency of their hand hygiene practices, which produced a minimum of 30 opportunity observations in each study period (pre-intervention, initial evaluation, end-evaluation). The Observations’ results were recorded in the hospital’s standardized hand hygiene observation checklist, which was created from the WHO hand hygiene monitoring checklist, each specific for accuracy and consistency of the practice.

The observers (infection control nurses and link nurses) were professionals, who have basic training and experiences in patient care, have a clear understanding of the logic care sequence and observation methodology. Re-education, training and the validation of the observers were performed to gain a correct understanding of the hand hygiene indication (5 moments of hand hygiene) and its observation method, twice during study period, in May 2014 (before the study began) and in May 2015 (before the initial evaluation period). Validation testing was carried out after each training session using a hand hygiene simulation slide to target 100% accurate observations. Inter observer variation in the real setting was tested monthly among the 3 observers in each unit during certain ½ hourly periods of care activities, to ensure an inter observer agreement of >0.8. We held re-education sessions to discuss and solve the not satisfactory test results. Finally, to ensure independent observations in each unit, we randomly selected and replaced 1/3 of the data collected by 2 link nurse observers with similar data from infection control nurse (ICN), monthly. All the data inputted on a weekly basis into the computer used the information technology (IT) of International Patient Safety Goals (IPSG) program.

 The accuracy of the hand hygiene practices was measured by their adherence to the recommended indications and procedure (‘5 moments’ and ‘6 steps’ of hand hygiene, based on WHO’s guidelines). This is defined as the number of hand hygiene properly performed divided by the number of recommended opportunities observed during certain care activity periods. The consistency of hand hygiene practices was defined by the accuracy rate achieved by a certain doctor or nurse with at least 30 opportunities for observation during a certain period. The sustainability of the hand hygiene practices was the trend of the hand hygiene accuracy or its consistency rate between periods. Positive sustainability was defined if the accuracy or consistency of the hand hygiene practices’ rate increased or remained stable (for all level of the accomplishment rate) or decreased (for level rate > 90%) but should still be at the more than acceptable level’s targeted of (90%) between the initial and the end-evaluation period.

**MRSA detection method and hospital cross transmission measurements**

Thesubject patients had swabs taken from their nostrils, armpits and groin for MRSA colonization detection upon admission (within 24 hours). Detection of the pathogen was performed in Sub-Microbiology Clinical Laboratory, at Sardjito Hospital, using the rapid screening method (MRSA *Chrom-ID*R), and the result were verified by infectious disease laboratory expert. This method has 96.4% and 98.2% sensitivity and specificity, respectively, compared to the PCR method.12

All the subject patients who showed signs of infection during their hospitalization were assessed using a clinical microbiology examination on an appropriate clinical specimen to find the cause of the pathogens. Methicillin-resistant *S.aureus* infection during the hospitalization of the patient without MRSA-colonization was defined as HA-MRSA cross transmission, and reviewed and recorded by IC nurses using the surveillance form. The incidence of MRSA hospital cross transmission was expressed as the number of new cases per 100 patients with positive culture result at the same period in Intensive Care.

**Intervention**

We implemented the hospital’s adjusted WHO MHHIS, which consisted of managerial component (the consistent commitment of the management team, hand hygiene campaign, coaching system, role models, reward and *dis-reward*, etc), mindfulness education (the hand hygiene education module consisting of local evidence based practices, proof of self-hand hygiene’s effectiveness from laboratory data, and an evidence based model of hand transmission and risk management, the calculation method for hand hygiene facilities support, etc), structuring the availability of supporting facilities by developing the actual plan based on real care activities and needs at place, developing participated hand hygiene reminder on ‘moment-1’ and video, *hand hygiene* monitoring and real time feedback supporting.8,11 Interventions were performed intensively during January-May 2015 by the IC and health promotion team who were trained using mindfulness training.

**Statistical analysis**

This study used a repeated measurement ANOVA to compare the numeric data between periods, chi square to compare the categorical data before and after the intervention, and an interrupted time series analysis to evaluate data trends by time. The confounder variables (such as age, sex, gender, education and professional background, etc) were evaluated using multivariate statistic logistic regression. All the statistical analysis was performed using IBM SPSS statistic 22, stated a significance level at the p value < 0.05.

This research was approved by the Medical and Health Research Ethics Committee (MHREC) Faculty of Medicine *Universitas* Gadjah Mada – Dr.Sardjito General Hospital (Ref: KE/FK/343/EC/2014).

**RESULTS**

There were 92 health care workers (18 medical doctors, 45 nurses and 29 other staff who consisted of pharmacists, physiotherapists, nurses’ assistants, dieticians, administrative staff, and cleaning services staff) and 5,280 patients involved throughout the before and after intervention study period. All the HCWs subjects were monitored for the-accuracy of their hand hygiene practices. Among them, there were 18 doctors and 36 nurses who were observed for the consistency of their hand hygiene practices.

Most of the subjects HCWs were government employees (64.1%), officers (89.1%), less than 55 years old (95.7%), higher than diploma degree of education background (73.9%) and had received training within the last 3 years on WHO hand hygiene recommendation (91.3%). There was no significant difference between those subjects age ≤ 35 years old *vs* > 35 years old (p=0.840) or on the length of they had worked in their units (p=0.215). There were more female than male subjects (64.1% vs 35.9%)

**Evaluation of hand hygiene compliance**

Theevaluation of hand hygiene compliance consisted of the accuracy, consistency and sustainability of the practice which were compared between the study’s periods. There were 16,313 hand hygiene opportunity observations, which consisted of 6,126 opportunities in the pre-intervention period, 7,078 opportunities in the initial post-intervention evaluation period and 3,109 opportunities during the end-evaluation.

Table-1 describes the compliance rate of the accuracy practice between the various HCWs’ characteristics. Overall, there was an increase in the accuracy of hand hygiene practice after intervention. A significant increased was seen in the accuracy practice of the doctors, for the indication of Moment-1 (before touching a patient) and Moment-5 (after touching patients’ surroundings) and for the hand rub. Some parameter of our observations showed increasing levels in the post-intervention period but they were not significant.

(Table-1)

 Table-2 describes the achievement of the targeted threshold of consistency in the pre-intervention and initial evaluation periods. Overall, there was an increase in the achievement level of consistency of hand hygiene practices. There was however a significant difference of achievement level based on the subjects’ professional categories (specialist doctor showed a greater improvement than residence), for their hand rub accuracy and duration of the procedure (20 seconds for hand rub and 40 seconds for hand wash). (Table-2)

The accuracy and consistency of the level of hand hygiene practices was also described by an increasing trend over time. Fig.1 shows the trend of hand hygiene compliance levels among overall practices (Fig.1a), among doctors (Fig.1b) and among nurses (Fig.1c) with R2 at the level of 0.861 (p=0.021), 0.837 (p=0.020), and 0.923 (p=0.043), respectively. This gives good impression of a relatively sustainable practice. (Figure1)

**Incidence of MRSA cross infection**

All the patient subjects (5,280) had nostril, armpit and groin swab specimens for MRSA culture detection, during the study period. There were 935 (17.7%) patients with *S.aureus* colonization and 466 (8.8%) patients with MRSA colonization. There were no differences in the patients’ characteristics for both colonization (such as gender, age, main diagnosis and antibiotic usage; p > 0.05) except for the history of hospitalization within the last 1 year (the more of hospitalization made the higher risk of MRSA colonization, p=0.001).

There was a significant decrease in the MRSA hospital cross infection rate from 12.6% before intervention to 1.2% and 0.3% during the initial and end-evaluation, respectively (p=0.03). Most of the MRSA hospital cross infection were pneumoniae, blood stream infection and wound ulcer. (Table-3)

**DISCUSSION**

We found in this study that there was an increasing of hand hygiene practices among HCWs after intervention period, resulted a significant decreasing on HA MRSA cross transmission in Intensive Care. This study showed the increasing levels in the accuracy, consistency and sustainability of all the HCWs hand hygiene practices. A significant increase in the average level of accuracy in hand hygiene practices was discovered among doctors, hand rub procedures, for all indicated moments except the moment 'before aseptic or clean procedure' and 'after body fluid exposure risk'. The accuracy of hand wash practices and those two moments did not show any significant improvement after the intervention in the initial and end-evaluation period, this is assumed to be because they already had relatively high levels of compliance at the beginning of the study (88.4% and >90% accuracy, respectively). This level of compliance was accomplished because of their rational indications were clear and the HCWs already have positive perceptions on them.The consistency of 6 step hand hygiene procedure and the accurate duration of its performed were also increased significantly. The accuracy and consistency of the hand hygiene practice among HCWs is important for risk management in infection control area.13 The highlight message for the HCWs is how to perform hand hygiene procedure properly in every opportunity indicated due to its efficacy in reducing the hand transient germs flora fit to the hand transmission model. A study in India between March to May 2015, evaluated the number of germs hands’ colonization, before and after proper hand hygiene procedure using alcohol based hand rub among HCWs. This study showed the reducing of germs’ hand colonization up to zero growth after the proper hand hygiene procedure.14 Hereinafter, hospital cross infection of MRSA can be an indicator of the accuracy of a hospital’s hand hygiene practices, since most of them are transmitted through hand contact. Maintaining the highest level of hand hygiene compliance among HCWs needs a sensitive indicator that can describe them directly as real time feedback.8,11

Sardjito Hospital has 813 beds with an occupancy rate of 59.33%-74.56%. It was staffed by 3,000 employees consisting of 371 doctors, 1,171 nurses, and 564 other HCWs (pharmacist, dietician, public health specialists, physiotherapists, medical technicians), and the rest are non-medical staff. It has been operating the WHO MHHIS since 2010 and received an award from the Asia Pacific Infection Control Society for hand hygiene excellent in developing countries in 2011. Further monitoring of its hand hygiene practices after the award has continued hospital wide and unsatisfactory practice have been identified among its HCWs. Although they know that hand hygiene is an important element in the battle to prevent HAIs, and strategies have been in place to promote this, continuous creative and participative efforts are needed to maintain an acceptable level of compliance.15 Our interventions were evaluated their impact on improvement of HCWs hand hygiene compliance and maintenance. This approach is in line with the national program for hospitals’ quality improvement, infection control and health promotion, so it is easier to get support from all parties.16,17,18

The hospital has a target accuracy for hand hygiene of 90% in accordance with the development of an institutional safety culture and the benchmark for national equivalent hospitals as well as for those classed as international hospitals. Nevertheless some of the variables, despite having an increasing rate in the accuracy of their practice, did not succeed in achieving the targeted threshold. Variables that affected the achievement of the threshold for hand hygiene practices were the intervention, professional background and ‘5 moments’ indication. For physician, the moment ‘before touching a patient’ and ‘after touching patient surroundings’, gave a significantly lower proportion (p < 0.05), indicating the need for more intensive and consistent specific strategies.9

 The overall consistency of hand hygiene practices at ‘5 moments’ increased significantly in the post-intervention period. The consistency of practice in procedure ‘steps’ and ‘duration’, both in the post-initial and end-evaluation period, indicates that changes in the staffs’ practice can be sustained over a fairly long period.

 We realize that this study was at risk from various biases. We performed 3 methods to ensure its reliability as the observation of hand hygiene practices in a real point of care setting is very dynamic and cannot be replicated. Observations were done blindingly. This study also has a potential bias from the *Hawthorne* effect. Long-term observation with a relatively large number of observed opportunities aims to reducing this bias.11 Similar studies into the practice of hand hygiene in developed countries, generally used electronic equipment to monitor compliance.19,20

The prevalence rate of patients with either *S.aureus* or MRSA colonization on being admitted to intensive care in this study was in accordance with the result of several studies on epidemiology of both colonization, that was reported at about 6.5%- 38% and 6.74%-15.4% out of all of the patients admitted, respectively. Different patients’ characteristic in hospitalization history were consistent with study report in Brazil (2003) as well as in The United States University Hospital (2009).The absence of difference in the use of antibiotics in both colonization populations was very likely due to the limited record of its history that could be referenced (recall bias). Similar studies in The United States and Australia reported an important risk factor for MRSA colonization was the use of antibiotics.21,22,23

The incidence rate of MRSA cross infection decreased gradually throughout the study period with the overall rate reduced by 97.6% by at the-end evaluation period. In the hospital, patients with MRSA colonization or infections were placed cohorting in the ward in-order to facilitate the consistent implementation of high standard of contact precaution. These MRSA infections were at the 70% - 90% level among the patients who had no colonization, which indicates pathogen transmission was quite high. This is assumed to be in accordance with similar tertiary care and national referral hospital which all have a higher complexity levels of patients’ problems and greater numbers and varieties of HCWs. Infection HA MRSA among patient who previously did not have any colonization could be sourced from other patients, the HCWs or hospital’s environment. The incidence of MRSA infection in critical care units in tertiary care hospitals in South India was 5% in a total 100 patients admitted to critical care units and environment sourced found in PICU. It underlined the necessity of good standard precaution with good compliance of hand hygiene practices, an antibiotic stewardship policy, and surveillance of MRSA to reduce MRSA HAIs.20

Compared to infection by other multi-drug resistant pathogen, MRSA cross infection more directly describe the clean care method at the point of care, because of their colonization on more body area surface which may be prevented by good aseptic methods. The frequency of MRSA incidences or the days when no MRSA episodes occur in intensive care may describe the consistency of the clean care program in place to prevent pathogen transmission, particularly through hand hygiene.6,24,25

Nevertheless, studies from New South Wales (NSW) hospitals in 2005-2006 found that two out of the four clinical indicators of MRSA infection remained unchanged despite significant improvements in hand hygiene compliance. Concurrent clinical and infection control practices possibly influence MRSA infection rates and may modify the effects of hand hygiene compliance.9 Evidence of hand hygiene to reduce transmission and infection by multi-drug resistant organisms in a health-care setting was reported in the WHO’s systematic literature review in 2014. The review states that most studies which evaluate MHHIS showed a significant reduction in MRSA infections, despite short follow-up times.6

Hand hygiene compliance improvement in the Intensive Care at Sardjito Hospital reduced MRSA cross transmission. Proper hand hygiene procedure is an important and effective method to prevent it. Much of the evidence suggests that more than hand hygiene is needed to affect MRSA incidence. Overall, we found that more sensitive measurements of hand hygiene compliance are needed. We suggest a more direct indicator of hand transmission, this may be ‘MRSA free-days’ which is planned to be analyzed and reported later from this study.

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Table 1. Accuracy level of hand hygiene practices pre-post intervention (%)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Target Observation | pre- | initial evaluation | end-evaluation | p |
| Medical Doctor | 67.1 ± 5.9 | 83.3 ± 5.6 | 89.1 ± 3.5 | 0.001\* |
| Nurse | 84.2 ± 6.8 | 89.2 ± 2.6 | 91 ± 2.5 | 0.05 |
| Other staff | 83.2 ± 12.1 | 86.5 ± 1.3 | 80.3 ± 35.7 | 0.678 |
| Before touching a patient | 77.3 ± 18.1 | 91.3 ± 3.1 | 91.7 ± 2 | 0.001\* |
| Before aseptic/clean procedure | 95.7 ± 9.6 | 98.3 ± 5.1 | 99.7 ± 9.5 | 0.903 |
| After body fluid exposure risk | 95.1 ± 6.7 | 93.3 ± 3.8 | 98.8 ± 1.6 | 0.311 |
| After touching a patient | 90.2 ± 4.5 | 95.1 ± 4.9 | 98.4 ± 2 | 0.703 |
| After touching patient surroundings | 72 ± 7.9 | 88.5 ± 4.2 | 90.2 ± 3 | 0.028\* |
| Hand wash | 88.4 ± 11.8 | 90.9 ± 0.9 | 92.8 ± 3 | 0.246 |
| Hand rub | 70.5 ± 9.3 | 84.4 ± 9.4 | 88.7 ± 5.9 | 0.008\* |

Notes: value (% of properly hand hygiene performed among all opportunities observed): x ± SD; p*repeated measurement* ANOVA; \* significance p < 0.05

Table 2. The proportion of accomplishment of hand hygiene consistency practices (for the target threshold: 90%) among doctors and nurses pre-post Intervention

|  |  |  |  |
| --- | --- | --- | --- |
|  | *Pre-* | Post-  | p |
| Sex  |  |  | 0.131 |
| * Male
 | 15 (29.4%) | 39 (75%) |  |
| * Female
 | 21(30.4%) | 46 (82.1%) |  |
| Age  |  |  | 0.062 |
| * > 35 years old
 | 23 (39.7%) | 51 (86.4%) |  |
| * ≤ 35 years old
 | 14 (28%) | 35 (68.6%) |  |
| Staffs’ category |  |  | 0.059 |
| * Doctor
 | 14 (38.9%) | 29 (80.6%) |  |
| * Nurse
 | 23 (32.4%) | 69 (95.8%) |  |
| Doctor  |  |  | 0.031\* |
| * Specialist
 | 3 (18.8%) | 9 (69.2%) |  |
| * Residency
 | 11 (55%) | 20 (87%) |  |
| Education  |  |  | 0.379 |
| * > Diploma
 | 22 (40.7%) | 57 (90.5%) |  |
| * Diploma
 | 13 (37.1%) | 41 (91.1%) |  |
| Hand hygiene method |  |  | 0.047\* |
| * Hand wash
 | 20 (37%) | 46 (85.2%) |  |
| * Hand rub
 | 30 (55.6%) | 52 (96.3%) |  |
| Hand hygiene procedure  |  |  | 0.017\* |
| * Indication
 | 36 (33.6%) | 98 (90.7%) |  |
| * 6 steps procedure
 | 9 (8.4%) | 95 (88%) |  |
| * Duration of practice
 | 6 (5.6%) | 88 (81.5%) |  |

 Notes : the number of subjects (%) of properly hand hygiene performed among 30 opportunities observed that

 were accomplished ≥90% ; p x2 or *Fishers’s exact test* (for expected value < 5); \* significance p < 0,05

Table 3. The incidence rate of MRSA hospital cross transmission (%) during study period

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | pre- | duringintervention | initial-evaluation | end-evaluation | p |
|  | 12.6 (15/119) | 5(7/141) | 1.2 (3/246) | 0.3 (1/388) | 0.030\* |
|  Type of infection |  |  |  |  |  |
|  Sepsis (n) | - | 3 | - | - |  |
|  CAUTI (n) | 2 | - | 1 | - |  |
|  Ulcer (n)  | 5 | 1 | 1 | - |  |
|  Pneumonia (n) | 8 | 3 | 1 | 1 |  |

 Notes: % rate is the proportion of MRSA (+) among all cultures (+); p*repeated measurement* ANOVA; \* significance

 P < 0.05

(a)



R2 0.861 p = 0.021

(b)



R2 0.837 p = 0.020

(c)



R2 0.923 p = 0.043

Fig 1. Time series of hand hygiene practice compliance during study period

 (a) Hand hygiene overall (b) Hand hygiene among doctors (c) Hand hygiene among nurses

 *Observed Fit upper and lower* level