International Journal of Infectious Diseases 104 (2021) 15–18

Contents lists available at ScienceDirect

International Journal of Infectious Diseases

journal homepage: www.elsevier.com/locate/ijid

# The impact of universal face masking and enhanced hand hygiene for COVID-19 disease prevention on the incidence of hospital-acquired infections in a Taiwanese hospital

Shih-Hao Lo[a], Chun-Yu Lin[a,b,c], Ching-Tzu Hung[b], Jyun-Ji He[d], Po-Liang Lu[a,c,*]

[a] Division of Infectious Diseases, Department of Internal Medicine, Kaohsiung Medical University Hospital, Kaohsiung Medical University, Taiwan
[b] Infection Control Center, Kaohsiung Medical University Hospital, Kaohsiung Medical University, Kaohsiung, Taiwan
[c] College of Medicine, Kaohsiung Medical University, Kaohsiung, Taiwan
[d] Department of Resource Management, Kaohsiung Medical University Hospital, Kaohsiung Medical University, Kaohsiung, Taiwan

ARTICLE INFO

*Article history:*
Received 8 September 2020
Received in revised form 27 November 2020
Accepted 23 December 2020

*Keywords:*
Coronavirus disease 2019
Hospital-acquired infection
Multidrug-resistant organism

ABSTRACT

*Objectives:* During the coronavirus disease 2019 (COVID-19) pandemic, strict infection control measures have been implemented in healthcare settings and hospitals, including respiratory and hand hygiene. This study investigated the impact of these control measures on the incidence rates of hospital-acquired infections (HAI) and multidrug-resistant organisms (MDRO) in a Taiwan medical center.
*Methods:* This study compared the consumption of personal prevention resources and the incidence density of HAI and MDRO in a medical center in Taiwan from January to May 2020, encapsulating the COVID-19 outbreak period in the study, to baseline data from the same timeframe in 2018 and 2019.
*Results:* There was no significant difference between the number of inpatient days in 2020, 2018 and 2019. The consumption of either alcohol for hand hygiene or surgical masks significantly increased in 2020. However, the overall HAI incidence density did not significantly differ from the rate at the baseline period. It was found that the incidence density of MDRO was significantly lower in 2020, especially in carbapenem-resistant *Acinetobacter baumannii* and vancomycin-resistant Enterococcus.
*Conclusions:* A collateral benefit of the COVID-19 prevention measures on the incidence density of MDRO was observed in a hospital in Taiwan where the incidence of COVID-19 was low.


## Introduction

Since December 2019, coronavirus disease 2019 (COVID-19) has spread rapidly from Wuhan, Hubei Province, People's Republic of China, around the world (Chen et al., 2020). COVID-19 was first detected in Taiwan on 21 January 2020 (Cheng et al., 2020). During the stressful and distressing time of the severe acute respiratory syndrome (SARS) epidemic in 2003, the Taiwanese government implemented wide-ranging preventive actions, including: public health education, medical resources allocation, enhanced case identification, high-risk group quarantine, and restriction of patient visitors in healthcare facilities or hospitals (Hsu et al., 2020; Wang et al., 2020). These measures markedly increased the consumption of face masks, alcohol-based hand rubs, medical gloves and gowns in healthcare systems and amongst the general public (Kampf et al., 2020).

Hands are the most common vehicle for many pathogens, and hand washing is effective in preventing droplet, fomite and contact transmission, which are important routes in hospital-acquired infection (HAI) (Gould, 1991). In the COVID-19 pandemic, hand hygiene and mask wearing have become two of the most important personal measures to prevent disease outbreak for healthcare workers (Ma et al., 2020). It is unclear whether these measures, being strictly compulsory in hospital settings during the COVID-19 epidemic, are effective in reducing HAI and multidrug-resistant organisms (MDRO). This study investigated the relationship between increased consumption of personal prevention resources and HAI pathogens.

## Methods

This study compared the inpatient days of different hospital departments, consumption of personal prevention resources and

* Corresponding author at: Division of Infectious Diseases, Department of Internal Medicine, Kaohsiung Medical University Hospital, Kaohsiung Medical University, No. 100, Tzyou 1st Road, Kaohsiung 807, Taiwan.
*E-mail address:* d830166@kmu.edu.tw (P.-L. Lu).

https://doi.org/10.1016/j.ijid.2020.12.072

the incidence density (events per 1000 patient days) of HAI and MDRO in a 1700-bed medical center in Taiwan from January to May 2020, encapsulating the COVID-19 outbreak period in the study, with baseline data in the same timeframe from 2018 and 2019. MDRO referred to four major pathogens only: methicillin-resistant *Staphylococcus aureus* (MRSA), carbapenem-resistant *Pseudomonas aeruginosa* (CRPA), carbapenem-resistant *Acinetobacter baumannii* (CRAB), and vancomycin-resistant Enterococcus (VRE). The incidence density of each HAI – including respiratory tract, blood stream, urinary tract, and surgical site infections – were recorded. The HAI surveillance was performed via experienced infection control nurses who were supervised by physicians. For hand hygiene, the amount of hand soap or 75% alcohol used were indicators of hand hygiene frequency. The defined daily dose/1000 inhabitants per day (DID) was applied to reveal the intensity of use of antimicrobial agents (Hsueh et al., 2005).

The data were expressed as average (standard deviation). One-way analysis of variance (ANOVA) with Tukey's post-hoc test were applied to analyze the difference among different years. Pearson's regression model was used to detect the correlation between consumption of resources and MDRO incidence density.

## Results

The number of inpatient days in a general ward, intensive care unit (ICU) or total beds decreased during the COVID-19 period, and there was no significant difference as compared with the numbers from 2018 and 2019 (Figure 1A). Different departments and ICUs were further compared. The 2020 results revealed a significant decrease in the pediatric department (33% and 30% reduction, $p < 0.001$ for 2018 and 2019, respectively) and surgery intensive care unit inpatient days (6% and 7% reduction, $p = 0.006$ and $p = 0.003$ for 2018 and 2019, respectively) (Figure 1B and C). In contrast, the consumption of either alcohol or surgical masks significantly increased in 2020 as compared with the previous two years (ca. 150% and 144%, $p = 0.001$ and $p = 0.008$, respectively). The use of N95 masks tended to increase but did not reach a statistically significant difference ($p = 0.08$) (Figure 2A and B).

Nosocomial urinary tract infections significantly decreased in 2019 and 2020 when compared with 2018 ($p = 0.011$); however, no significant decrease in other nosocomial infection sites was observed (Figure 3A). The overall HAI incidence density did not significantly differ from the rate at the baseline period. It was found that the total inpatient number isolated with MDRO was significantly lower in 2020 ($p = 0.005$). Further analysis revealed that CRAB and VRE were significantly lower in 2020 than in 2018 and 2019 ($p = 0.011$, $p = 0.005$ respectively), and MRSA or CRPA slightly decreased but had no statistically significant difference (Figure 3B). This result is the same for the incidence density of MDRO (Figure 3C). The DID data of the antibiotics revealed an overall decline in 2019 (10% reduction, $p = 0.029$) but there was no significant change in carbapenem usage. The use of glycopeptide significantly increased in 2020, as compared with 2018 and 2019 (25.6%, 21.1% increase, respectively, $p = 0.002$) (Figure 3D). The correlation between resources consumption and MDRO incidence density disclosed a significant inverse correlation between 75% alcohol and two MDROs, CRAB and VRE, but not CRPA and MRSA (Table 1).

## Discussion

In contrast with other countries, Taiwan has had no severe outbreak of COVID-19; therefore, it has not faced a shortage of medical resources, even with enhanced hand hygiene and the massive need for surgical masks for hospital-acquired infection. This study found that the consumption of alcohol for hand hygiene and surgical mask usage was significantly higher in 2020 than that of the previous two years. However, these measures did not affect overall nosocomial infection in a hospital where the hand hygiene rates reached about 95% in 2018–2019 and almost 100% adherence in 2020 to the mandate of wearing surgical masks when seeing patients, not even during outbreaks and epidemic situations. Nevertheless, the incidence density of MDRO, including CRAB and VRE, was significantly decreased during the COVID-19 epidemic.

The current hospital is a 1700-bed tertiary care medical center in southern Taiwan and receives various types of patients. In 2019, the patient proportion of internal medicine versus surgery was 34.3% vs. 26.5%, respectively. The hospital has instigated strategies in response to the COVID-19 pandemic (Chang et al., 2020). From January 2020, it emphasized personal protection, including hand hygiene and mask wearing. The hospital authority established an

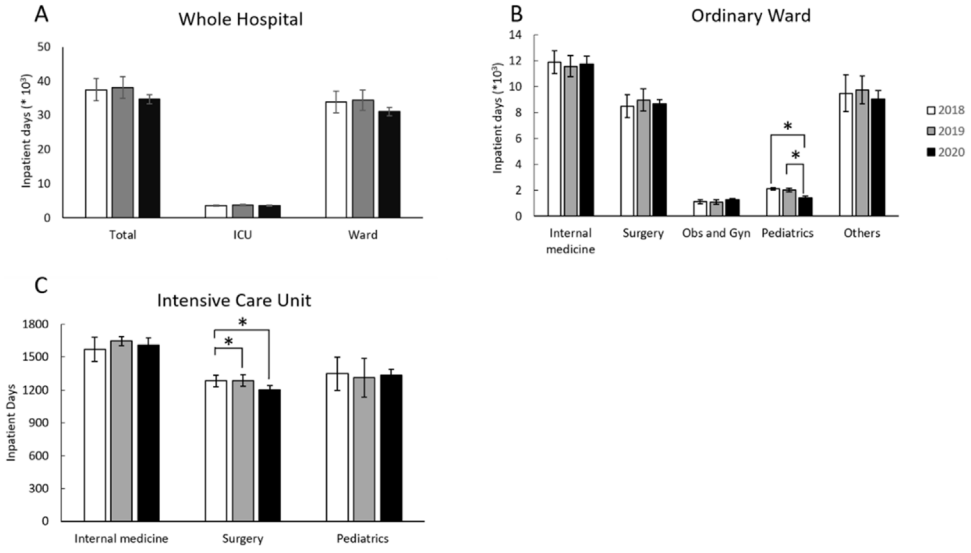


**Figure 1.** Inpatient days of the whole hospital (A), an ordinary ward (B), and the intensive care unit (C).
ICU = intensive care unit, Obs = obstetrics, Gyn = gynaecology.
*$p < 0.05$.

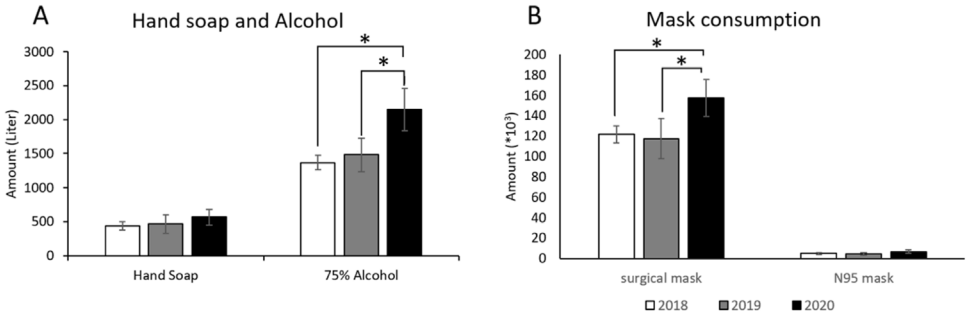


**Figure 2.** (A) The consumption of hand soap and alcohol; (B) the consumption of masks, including surgical masks and N95s, from different years.
*$p < 0.05$.

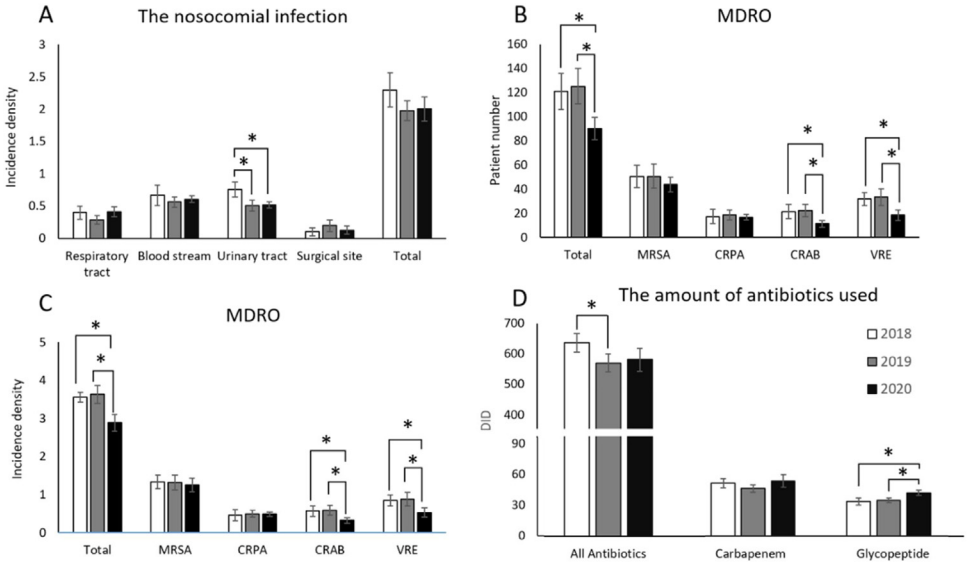


**Figure 3.** (A) Nosocomial infection incidence density; (B) MDRO-infected or MDRO-colonized patient numbers; (C) MDRO incidence density; (D) the DID of antibiotics. MDRO = multidrug-resistant organism; DID = defined daily dose per 1000 inhabitants per day; MRSA = methicillin-resistant *Staphylococcus aureus*; CRPA = carbapenem-resistant *Pseudomonas aeruginosa*; CRAB = carbapenem-resistant *Acinetobacter baumannii*; VRE = vancomycin-resistant Enterococcus.
* $p < 0.05$.

**Table 1**
The R-square of Pearson Correlation between resources consumption and MDRO incidence density. A significant inverse correlation between alcohol consumption and incidence density was observed for total MDRO, CRAB, and VRE rather than CRPA and MRSA. The VRE correlates to most personal prevention resources.

| | | Correlations | | | | |
|---|---|---|---|---|---|---|
| | | Total MDRO | MRSA | CRPA | CRAB | VRE |
| Hand soap | R-square | −0.0406 | −0.0033 | 0.433 | −0.389 | −0.536* |
| | *p*-Value | 0.133 | 0.908 | 0.107 | 0.152 | 0.040 |
| 75% Alcohol | R-square | −0.779** | −0.0250 | 0.235 | −0.646** | −0.678** |
| | *p*-Value | 0.001 | 0.369 | 0.399 | 0.009 | 0.005 |
| Surgical mask | R-square | −0.742** | −0.126 | 0.148 | −0.508 | −0.784** |
| | *p*-Value | 0.002 | 0.655 | 0.600 | 0.053 | 0.001 |
| N95 mask | R-square | −0.495 | 0.038 | 0.219 | −0.453 | −0.597* |
| | *p*-Value | 0.061 | 0.893 | 0.433 | 0.090 | 0.019 |

MDRO = multidrug-resistant organism; MRSA = methicillin-resistant *Staphylococcus aureus*; CRPA = carbapenem-resistant *Pseudomonas aeruginosa*; CRAB = carbapenem-resistant *Acinetobacter baumannii*; VRE = vancomycin-resistant Enterococcus.
* $p < 0.05$.
** $p < 0.01$.

epidemic prevention and response team and held daily conferences to augment the function of the hospital infection control center. Practices of restricting visitor numbers, stopping non-emergency medical services such as elective surgery and general health examination services, setting up a triage station outside the hospital building, and reducing ICU visitor numbers and duration were implemented. The routine measures of clinical care were not changed, including the nurse to patient ratios, time allowed for sterilizing environments and disinfection methods after patient discharge. The above strategies aimed to reduce the cross-contact that leads to COVID-19 transmission may also reduce the chance of MDRO transmission.

For the total inpatient days, there was a slight decrease in 2020 but no statistical difference (92.6% and 91.0%, $p$ = 0.361 and $p$ = 0.222 for 2018 and 2019, respectively); however, there was a significant decrease in pediatric ordinary ward and surgical ICU. This may be attributed to temporarily stopping non-emergency medical services and the widespread fear of COVID-19, especially for the patients. Because there is a significant portion of MDRO in the surgical ICU (Jia et al., 2015) this may affect the incidence of MDRO as compared with other pathogens during this period.

During the SARS outbreak in Hong Kong in 2003, an increase in MRSA was noticed in an ICU when gloves and gowns were worn all the time (Yap et al., 2004). MRSA colonization or infection decreased when the mandatory infection control education program was executed (Lee et al., 2009). The change in prevalence of MDRO varied between hospitals as different infection control measures were applied during the pandemic. During the COVID-19 crisis, most people have been hyper-aware, especially healthcare workers, about hand hygiene and other infection control activities. Cole and Barnard proposed that COVID-19 has increased the awareness of basic infection control measures and subsequently reduced the incidence of MRDO HAIs (Cole and Barnard, 2020; Roshan et al., 2020). The increased consumption of hand sanitizers reflected improved hand hygiene practices. In contrast to hand sanitizers, the consumption of hand soap did not differ from previous years, which may have been due to hand hygiene in hospitals being performed by the dry clean method via alcohol. The effect of strict prevention measures on HAI in such environments was interesting; nevertheless, there was no obvious change over the years in the overall IR of HAI. During the COVID-19 pandemic, non-emergency hospitalizations and elective surgery admissions have significantly decreased. On the other hand, inpatients' medical conditions during the same period were generally more severe and had more comorbidities that required medical care. Severely ill patients may have been more vulnerable to infection, and this may partially explain the lack of significant change in HAI rate, whereas respiratory and hand hygiene were enhanced.

The incidence density of MDRO, especially CRAB and VRE, was significantly decreased in 2020. The reduction was inversely correlated with hand sanitizing using alcohol or other disease control resource consumption. Infections with CRAB and VRE, two of the most difficult-to-eradicate pathogens, seemed effectively controlled under these strict measures. The incidence of MDRO may be related to antibiotic selective pressure (Hsueh et al., 2005). Because there was no large-scale outbreak in Taiwan, and the rapid diagnosis of COVID-19 by polymerase chain reaction (PCR) testing, overuse of other antibiotics and carbapenem did not occur. The DID of glycopeptide increased but VRE incidence did not, whereas the enhanced prevention measures were successful for COVID-19 prevention.

This study had some limitations such as small sample size, short study period and the inclusion of only one medical center; therefore, more data from hospitals worldwide are required to corroborate these findings. In conclusion, a collateral benefit from COVID-19 prevention measures on the incidence of MDRO was observed in a hospital in Taiwan where the incidence of COVID-19 was low.

## Funding

This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

## Declaration of interest

There is no any conflicts of interest.

## Ethics

This study did not use any animal or human subjects, and Institutional Review Board (IRB) approval had been obtained. IRB number: KMUHIRB-E(I)-20200196.

## Acknowledgments

We would like to thank the staff from the Division of Medical Statistics and Bioinformatics, the Department of Medical Research, Kaohsiung Medical University Hospital, and Kaohsiung Medical University for their assistance in this study.

## References

Chang YT, Lin CY, Tsai MJ, Hung CT, Hsu CW, Lu PL, et al. Infection control measures of a Taiwanese hospital to confront the COVID-19 pandemic. Kaohsiung J Med Sci 2020;36:296–304, doi:http://dx.doi.org/10.1002/kjm2.12228.

Chen N, Zhou M, Dong X, Qu J, Gong F, Han Y, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. Lancet 2020;395:507–13, doi:http://dx.doi.org/10.1016/S0140-6736(20)30211-7.

Cheng SC, Chang YC, Fan Chiang YL, Chien YC, Cheng M, Yang CH, et al. First case of coronavirus disease 2019 (COVID-19) pneumonia in Taiwan. J Formos Med Assoc 2020;119:747–51, doi:http://dx.doi.org/10.1016/j.jfma.2020.02.007.

Cole J, Barnard E. The impact of the COVID-19 pandemic on healthcare acquired infections with multidrug resistant organisms. Am J Infect Control 2020;5726, doi:http://dx.doi.org/10.1016/j.ajic.2020.09.013.

Gould D. Nurses' hands as vectors of hospital-acquired infection: a review. J Adv Nurs 1991;16:1216–25, doi:http://dx.doi.org/10.1111/j.1365-2648.1991.tb01531.x.

Hsu YC, Liu YA, Lin MH, Lee HW, Chen TJ, Chou LF, et al. Visiting policies of hospice wards during the COVID-19 pandemic: an environmental scan in Taiwan. Int J Environ Res Public Health 2020;17:2857, doi:http://dx.doi.org/10.3390/ijerph17082857.

Hsueh PR, Chen WH, Luh KT. Relationships between antimicrobial use and antimicrobial resistance in Gram-negative bacteria causing nosocomial infections from 1991–2003 at a university hospital in Taiwan. Int J Antimicrob Agents 2005;26:463–72, doi:http://dx.doi.org/10.1016/j.ijantimicag.2005.08.016.

Jia XQ, Pang F, Chen JZ, Jiang LX. Prevalence and clinical distribution of multidrug-resistant bacteria (3537 isolates) in a tertiary Chinese hospital (January 2012-December 2013). Pathol Biol (Paris) 2015;63:21–3, doi:http://dx.doi.org/10.1016/j.patbio.2014.12.002.

Kampf G, Scheithauer S, Lemmen S, Saliou P, Suchomel M. COVID-19-associated shortage of alcohol-based hand rubs, face masks, medical gloves and gowns — proposal for a risk-adapted approach to ensure patient and healthcare worker safety. J Hosp Infect 2020;105:424–7, doi:http://dx.doi.org/10.1016/j.jhin.2020.04.041.

Lee TC, Moore C, Raboud JM, Muller KP, Green K, Tong A, et al. Impact of a mandatory infection control education program on nosocomial acquisition of methicillin-resistant *Staphylococcus aureus*. Infect Control Hosp Epidemiol 2009;30:249–56, doi:http://dx.doi.org/10.1086/596042.

Ma QX, Shan H, Zhang HL, Li GM, Yang RM, Chen JM. Potential utilities of mask-wearing and instant hand hygiene for fighting SARS-CoV-2. J Med Virol 2020;92:1567–71, doi:http://dx.doi.org/10.1002/jmv.25805.

Roshan R, Feroz AS, Rafique Z, Virani N. Rigorous hand hygiene practices among health care workers reduce hospital-associated infections during the COVID-19 pandemic. J Prim Care Community Health 2020;11:, doi:http://dx.doi.org/10.1177/2150132720943331 2150132720943331.

Wang CJ, Ng CY, Brook RH. Response to COVID-19 in Taiwan: big data analytics, new technology, and proactive testing. JAMA 2020;323:1341–2, doi:http://dx.doi.org/10.1001/jama.2020.3151.

Yap FH, Gomersall CD, Fung KS, Ho PL, Ho OM, Lam PK, et al. Increase in methicillin-resistant *Staphylococcus aureus* acquisition rate and change in pathogen pattern associated with an outbreak of severe acute respiratory syndrome. Clin Infect Dis 2004;39:511–6.