CMAJ Open

Impact of COVID-19 on Hand Hygiene Performance Measured using Group Electronic Monitoring

Victoria Williams MPH CIC[1*], Adam Kovacs-Litman MD[2*], Matthew P. Muller

MD PhD[2,3,], Susy Hota MD MSc[2,4], Jeff E. Powis MD MSc[2,6], Daniel R. Ricciuto

MD[6], Dominik Mertz MD MSc[7], Kevin Katz MD[8], Lucas Castellani MD[9], Alex

Kiss PhD[10], Amber Linkenheld-Struk[1] CIC, Jerome A. Leis MD MSc[1,2,10]

[1] Sunnybrook Health Sciences Centre, Toronto, Ontario, Canada
[2] Department of Medicine, University of Toronto, Toronto, Ontario, Canada
[3] Division of Infectious Diseases, St. Michael's Hospital, Toronto, Ontario, Canada
[4] University Health Network, Toronto, Ontario, Canada
[5] Division of Infectious Diseases, Michael Garron Hospital, Toronto, Ontario, Canada
[6] Division of Infectious Diseases, Lakeridge Health, Oshawa, Ontario, Canada; Peterborough Regional
Health Centre, Peterborough, Ontario, Canada
[7] Hamilton Health Sciences, Hamilton, Ontario, Canada
[8] North York General Hospital, Toronto, Ontario, Canada
[9] Sault Area Hospital, Sault Ste Marie, Ontario, Canada
[10] Sunnybrook Research Institute, Toronto, Ontario, Canada

[*] Williams and Kovacs-Litman contributed equally to this study.

Corresponding author:
Jerome A. Leis, MD MSc FRCPC
Sunnybrook Health Sciences Centre
2075 Bayview avenue
Toronto, Ontario M4N 3M5
tel: 416 480-4243
email: jerome.leis@sunnybrook.ca

Running head: COVID-19 and hand hygiene

Word count: 1818 (excluding abstract, references, table, figures)

Key words: hand hygiene, electronic monitoring, COVID-19, quality improvement

1

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Abstract

Background: Hand hygiene (HH) is a routine precaution in the provision of healthcare to prevent transmission of infections including COVID-19. Despite this, reliable reports on HH performance throughout the pandemic are lacking as most hospitals continue to rely on direct observation to measure this quality indicator.

Methods: Across 12 Ontario hospitals, a group electronic hand hygiene monitoring system (GEHHMS) was installed prior to the pandemic providing continuous measurement of HH adherence across 978 ward and 367 critical care beds. We performed an interrupted time series study of institutional HH adherence in association with COVID-19 inpatient census and Ontario daily COVID-19 case count during the first wave of the pandemic. A Poisson regression model was used to assess the association between hospital COVID-19 census and institutional HH adherence while adjusting for the correlation within inpatient units.

Results: At baseline HH adherence was 46.2% (6344721/13737789) and improved beginning in March to daily peak of 78.6% (67269/85286) on March 30th, 2020. Each patient admitted with COVID-19 was associated with improved HH adherence (IRR 1.0621; 95% CI, 1.0619-1.0623; p < 0.0001). Increasing Ontario daily case count was similarly associated with improved HH (IRR 1.003, 95% CI 1.0023-1.0032; p < 0.0001), however the association was smaller compared to the effect of hospital COVID-19 cases (p<0.0001).

Interpretation: Wave one of the COVID-19 pandemic was associated with significant improvement in HH adherence measured using GEHHMS. Future research should seek to determine whether improvement strategies that focus on healthcare worker perception of personal risk can achieve sustainable improvements in HH performance.

2

Introduction

Hand hygiene (HH) is a routine precaution recommended to be applied universally in the

provision of healthcare to prevent transmission of infections including COVID-19.[1,2] Despite its

importance, reports on HH performance throughout the pandemic are lacking as most hospitals

continue to rely on direct observation to measure this quality indicator, which is widely

recognized to be inaccurate due to sampling and observer biases.[3-5]

Our hospital network introduced a group electronic hand hygiene monitoring system

(GEHHMS) prior to the pandemic.[6] This system works by measuring 100% of all hand sanitizer

and soap dispenser activations via a signal to a wireless hub. Total dispenser activations at a unit

level are divided by a previously validated estimate of the number of HH opportunities (HHOs)

per patient-hour multiplied by the hourly census of patients on the unit in order to derive an

estimate of hand hygiene adherence.[7,8]

Equipped with this more accurate method of measuring HH performance, we sought to

assess the impact of the COVID-19 pandemic on HH adherence. We hypothesized that the

global spread of COVID-19 coupled with widespread public awareness would augment HH

practices. We performed the following interrupted time series study to assess the impact of both

provincial COVID-19 case counts and hospital-level COVID-19 admissions on HH adherence.

Methods

Hand hygiene Improvement Preventing And Controlling Transmission (HH-IMPACT) is a

quality improvement network of acute care hospitals in Ontario, Canada. GEHHMS of 1345

3

inpatient beds (978 ward and 367 critical care) was performed across 51 inpatient units (31 wards and 20 critical care units) spanning 12 acute care hospitals (5 university and 7 community teaching hospitals) participating in HH-IMPACT from November 1, 2019 to July 5, 2020. All 31 wards received minimum weekly feedback on HH performance while the 20 critical care units began to receive this feedback January 6th, 2020, onward. Throughout the study period, all units continued to receive feedback on HH performance through automated email reports, posters, and in-person huddles on the unit.[6]

The exposure variable was the number of daily active COVID-19 cases from March 1st, 2020, onward as part of the first wave of community-transmission. Daily hospitalized COVID-19 census included only those admitted to HH-IMPACT hospitals with laboratory-confirmed COVID-19 requiring transmission-based precautions at the start of each day, as prospectively recorded by each hospital's Infection Prevention and Control program. The number of new daily COVID-19 cases was the number of laboratory-confirmed cases in the community reported publicly across Ontario. The outcome variable was institutional HH adherence as measured by DebMed Electronic HH Compliance System (DebMed SC Johnson Professional) which was installed on all alcohol handrub and sink soap dispensers inside and outside each patient room between 2017 and 2019. GEHHMS remained in place until July, 2020, and then interrupted due to a pandemic-related shortage in hand sanitizer resulting in study end.

Aggregate peak and nadir HH performance was compared over time in association with COVID-19 hospital census and Ontario daily COVID-19 case count. A zero inflated Poisson regression model was used to assess the association between hospital COVID-19 census and institutional HH adherence. Using segmented regression analysis, a hospital-based analysis was performed with three time periods: Study start to first COVID-19 inpatient in March; first

4

COVID-19 inpatient to peak COVID-19 inpatient census; and peak COVID-19 inpatient census

to study end. The model accounted for clustering within units and incorporated an

autoregressive component for days within a unit to capture the serial nature of the data. Results

were expressed as incidence rate ratios (IRR) and their associated 95% confidence intervals. A

date-based analysis was repeated with three time periods: Study start to March 1st, 2020 being

the first documented community transmission of COVID-19 in Ontario; March 1st to April 24th,

2020, being the peak daily COVID-19 case count in Ontario; April 24th, 2020 to study end on

July 4th, 2020. A group variable was created with Ontario and hospital case counts and an

interaction term between the two variables to assess statistical differences between both

predictors in relation to the outcome of HH adherence. Research Ethics Board approval or

quality improvement designation was obtained for this initiative at each of the participating sites.

Results

Table 1 provides baseline characteristics of the 12 acute care hospitals including baseline HH

performance (November-December, 2019). Admission of patients with COVID-19 varied across

hospital sites with maximum daily inpatient census from 3 to 84. One site did not have any

admissions confirmed COVID-19 positive.

Figure 1 depicts changes in daily aggregate HH adherence plotted against HH-IMPACT

hospital COVID-19 census and daily case count across Ontario. HH adherence remained stable

until end of February, 2020 with average HH adherence of 46.2% (6344721/13737789) and

monthly range between 42.5-50.6%. From March 1st onward, a positive inflection in HH

adherence was observed that peaked at 78.6% (67269/85286) on March 30th, 2020, prior to

5

Ontario daily COVID-19 case count peak April 24th, 2020, and peak aggregate COVID-19 inpatient census on April 28th, 2020. Following this peak, HH adherence declined steadily to study end and reached a nadir of 45.4% (44647/98344) by July 5th, 2020.

Figure 2 depicts HH adherence relative to each hospital's first COVID-19 inpatient in March, 2020. Peak HH adherence was 77.5% (67239/86788) by day 20 from first COVID-19 case followed by decline to nadir of 50.0% (51065/102206) by day 99. Between the first COVID-19 inpatient and peak inpatient census, each patient admitted with COVID-19 was associated with improved HH adherence (IRR 1.0621; 95% CI, 1.0619-1.0623; p < 0.0001). Increasing Ontario daily case count from start of community transmission to peak was similarly associated with improved HH (IRR 1.003, 95% CI 1.0023-1.0032; p < 0.0001), however the association was smaller in magnitude compared to the rise in local COVID-19 hospital census (p<0.0001).

Interpretation

Across the majority of Canadian hospitals, direct observation by auditors continues to be used to measure HH performance even though this methodology is recognized to be inaccurate.[3-5] As a result, reliable reports on HH performance throughout the pandemic are lacking. Using a validated GEHHMS, we observed marked practice improvements in HH that reached nearly 80% adherence across our 12 hospital sites during wave one of the COVID-19 pandemic. During peak HH rates, this improvement was equivalent to over 10,000 additional HH events per day across our 12-hospitals. These results demonstrates that high-levels of performance are achievable in a context that enables practice change.

6

The significant improvement seen is consistent with the known enablers of HH practices. Previous studies have highlighted that healthcare workers are more likely to clean their hands after contaminating tasks than before critical tasks associated with risk of transmission to others.[9,10] Outbreaks on hospital units have also been shown to be associated with a sharp increase in HH performance again likely due to heightened self-preservation behaviors.[11] While the same mechanism is likely to explain the change observed in response to COVID-19, there are two notable differences. First, the rise in HH performance was over 3-fold higher than what has been observed with GEHHMS during hospital outbreaks.[11] This accentuated improvement in response to COVID-19 may be related to the higher degree of fear associated with this novel pathogen, especially early in the pandemic. Second, the improved HH performance observed in our study was clearly associated with the perceived risk of COVID-19 as opposed to the actual risk since HH adherence peaked prior to the highest COVID-19 case numbers.

The factors that most strongly influenced healthcare worker risk perception can be gleaned from our study. Compared to daily reported case counts in the community, hospital-level COVID-19 inpatient census was more predictive of improvement with each additional inpatient case associated with an average 6% relative increase in HH adherence. This finding suggests that the local experience of healthcare workers within their hospital influenced risk perception over awareness that COVID-19 transmission was increasing in the community.

Unfortunately, the improvements in HH adherence were not sustained across our 12-hospitals as performance returned to baseline levels within 90-days. Since sustained improvements in HH require longitudinal iterative improvements over years, it is not entirely unexpected that a situational spike in HH performance reverts back to baseline over time. Additionally, the perceived risk of caring for COVID-19 patients most likely decreased over time

7

as healthcare workers became accustomed to caring for COVID-19 patients.[6,11,12] Another potential contributor to this decay in performance is the COVID-19 pandemic itself, which has caused higher levels of healthcare worker burnout that is known to contribute to suboptimal HH rates.[13,14]

Our study has several strengths. It was conducted across a dozen institutions including both academic and community teaching hospitals. The amount of data available through the GEHHMS is enormous with over 26 million HH opportunities across these institutions during the course of this first pandemic wave. Our regression model adjusted for correlation within units and hospitals and findings were consistent across both wards and critical care units suggesting a generalizable behavior change in response to COVID-19. Our study underscores the importance of adopting more accurate methodology for measuring HH performance across Canadian hospitals in order to enable iterative improvement in this important patient safety indicator.

Several important limitations should be noted. As an observational interrupted time series study, we cannot fully exclude confounding factors; however, the changes observed are significant and temporally associated with COVID-19 wave which strongly suggests a causal inference. GEHHMS provide a unit level estimates of HH adherence that cannot differentiate the specific moments of HH. This is particularly important as, during the initial stages of the pandemic, healthcare workers may have been performing hand hygiene at times when it was not required due to anxiety about the pandemic and this could have contributed to the rise in compliance noted. Finally, the study period was limited due to shortages of hand sanitizer that began in July, 2020, which limited our ability to assess the impact of further COVID-19 pandemic waves on HH performance.

8

The high levels of HH adherence achieved during the first wave of the COVID-19 pandemic further validate GEHHMS, while providing potential HH targets. Healthcare worker risk perception is a strong enabler of HH practice changes but may not accurately reflect actual risk. Future research should seek to determine whether improvement strategies that focus on healthcare worker perception of personal risk can achieve sustainable improvements in hand hygiene performance.

9

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Conflicts of interest

None of the authors have any conflicts of interest to declare.

10

References

1. World Health Organization. Infection prevention and control during health care when coronavirus disease (COVID-19) is suspected or confirmed. Interim guidance 29 June 2020; WHO/2019-nCoV/IPC/2020.4. Accessed February 2, 2021.

2. Allegranzi B, Pittet D. Role of hand hygiene in healthcare-associated infection prevention. *Journal of Hosp Infect*, 2009;73:305-15.

3. Kovacs-Litman A, Wong K, Shojania KG et al. Do physicians clean their hands? Insights from a covert observational study. *Journal of Hosp Med*, 2016; 11(12), 862-864.

4. Squires JE, Linklater S, Grimshaw JM, et al. Understanding practice: factors that influence physician hand hygiene compliance. *Infect Control Hosp Epidemiol*. 2014;35:1511–1520

5. Hagel S, Reischke J, Kesselmeier M et al. Quantifying the Hawthorne effect in hand hygiene compliance through comparing direct observation with automated hand hygiene monitoring. *Infect Control Hosp Epidemiol*, 2015; 36(8), 957-962.

6. Leis JA, Powis JE, McGeer et al. Introduction of Group Electronic Monitoring of Hand Hygiene on Inpatient Units: A Multicenter Cluster Randomized Quality Improvement Study. *Clin Infect Dis*, 2020; Apr 9; doi: 10.1093/cid/ciaa412.

7. Nayyar D, Moore C, McCreight L, et al. Hand hygiene opportunities on Canadian acute-care inpatient units: A multicenter observational study. *Infect Control Hosp Epidemiol*, 2018; 39(11), 1378-1380.

8. Diller T, Kelly JW, Blackhurst D, et al. Estimation of hand hygiene opportunities on an adult medical ward using 24-hour camera surveillance: validation of the HOW2 Benchmark Study. *Am Journal of Infect Control*, 2014; *42*(6), 602-607.

11

9. Borg MA, Benbachir M, Cookson BD, et al. Self-protection as a driver for hand hygiene among healthcare workers. *Infect Control*, 2009; 30:578–580.

10. Chang NCN, Resigner HS, Schweizer ML et al. Hand Hygiene Compliance at Critical Points of Care. *Clin Infect Dis*, 2020; Feb8, ciaa130. DOI: 10.1093/cid/ciaa130.

11. Kovacs-Litman A, Muller MP, Powis JE et al. Association between hospital outbreaks and hand hygiene: Insights from electronic monitoring. *Clin Infect Dis*, 2020; Sep 16; DOI: 10.1093/cid/ciaa1405.

12. Knepper BC, Miller AM, Young HL. Impact of an automated hand hygiene monitoring system combined with a performance improvement intervention on hospital-acquired infections. *Infect Control Hosp Epidemiol*, 2020; 1-7.

13. Azoulay E, De Waele J, Ferrer R et al. Symptoms of burnout in intensive care unit specialists facing the COVID-19 outbreak. *Annals of Intensive Care*, 2020; 10(1), 1-8.

14. Manomenidis G, Panagopoulou E, Montgomery A. Job burnout reduces hand hygiene compliance among nursing staff. *Journal of Patient Safety*, 2019; 15(4), e70-e73.

12

Table 1. Baseline characteristics and COVID-19 cases across 12 acute care hospitals with group electronic hand hygiene monitoring.

Hospital	Hospital type	Beds monitored	Critical care units	Critical care beds	Wards	Ward beds	COVID-19 patient-days (maximum bed census)	Baseline hand hygiene (%)
1	University	391	6	83	9	308	1250(24)	1017635/1964367(51.8)
2	University	230	2	45	7	185	846(36)	351619/808571 (43.5)
3	University	56	3	56	0	0	1427(34)	97659/489611 (19.9)
4	University	26	2	26	0	0	215(11)	62758/276829 (22.7)
5	University	30	1	30	0	0	4588(84)	149131/363602 (41.0)
6	Community	120	1	20	3	100	2268(47)	228736/597255 (38.3)
7	Community	166	1	27	4	139	868(21)	400178/799282 (50.1)
8	Community	29	0	0	1	29	1515(35)	51089/102952 (48.2)
9	Community	235	1	18	7	217	734(17)	595630/1000239 (59.5)
10	Community	24	1	24	0	0	1920(38)	75053/201239 (37.3)
11	Community	24	1	24	0	0	123(3)	89172/293774 (30.4)
12	Community	14	1	14	0	0	0	15193/126885 (12.0)

13

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Figure 1. Hand hygiene adherence across 12 acute care hospitals in association with hospital census of COVID-19 patients and overall new daily COVID-19 cases in Ontario.

14

Figure 2. Hand hygiene adherence across 12 acute care hospitals relative to first hospital admission of patient with COVID-19 during the first wave of the pandemic.

15

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
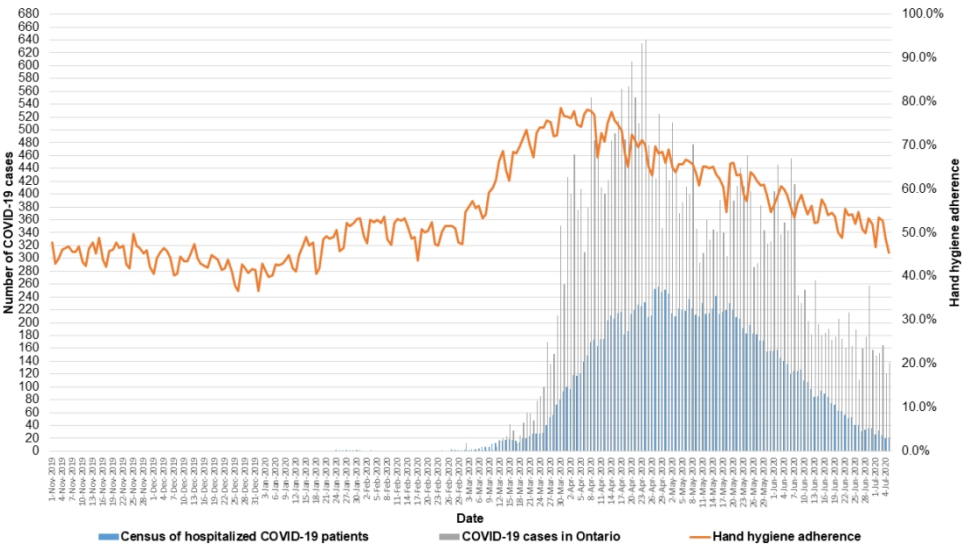51
52
53
54
55
56
57
58
59
60

Figure 1. Hand hygiene adherence across 12 acute care hospitals in association with hospital census of COVID-19 patients and overall new daily COVID-19 cases in Ontario.

108x60mm (300 x 300 DPI)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
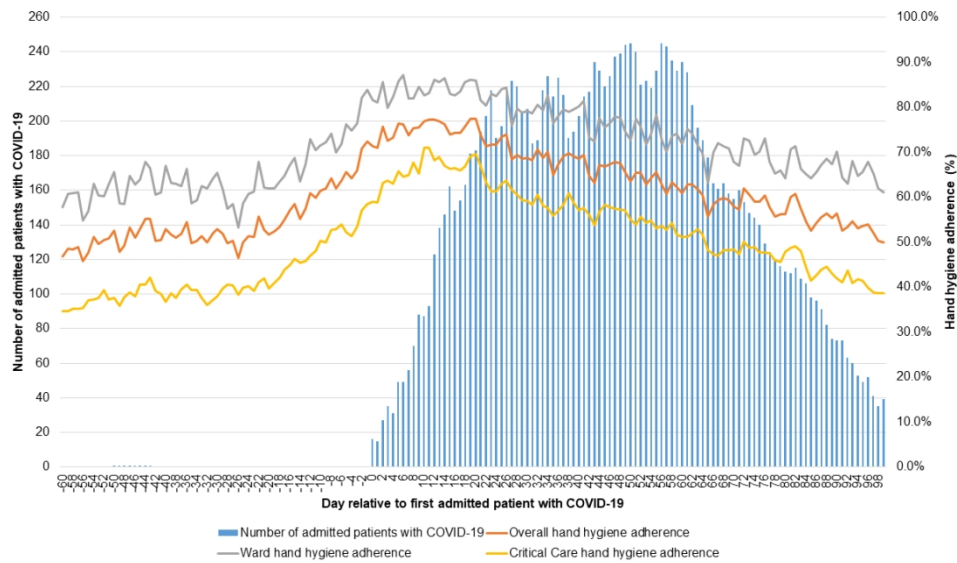51
52
53
54
55
56
57
58
59
60

Figure 2. Hand hygiene adherence across 12 acute care hospitals relative to first hospital admission of patient with COVID-19 during the first wave of the pandemic.

108x60mm (300 x 300 DPI)