Journal of Hospital Infection 137 (2023) 61—68

Available online at www.sciencedirect.com

Journal of Hospital Infection

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

Validity of self-reported compliance and behavioural determinants of observed compliance: an application of the COM-B hand hygiene questionnaire in nine Dutch hospitals

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ARTICLE INFO

Article history:
Received 8 March 2023
Accepted 13 April 2023
Available online 26 April 2023

Keywords:
Hand hygiene compliance
COM-B hand hygiene questionnaire
Self-reported compliance
Hand hygiene observation
Behavioural determinants
Environmental determinants

SUMMARY

Background: Hand hygiene compliance (HHC) can be influenced by behavioural determinants, but knowledge on this remains scarce. The Capability, Opportunity, Motivation-Behaviour (COM-B) hand hygiene questionnaire was developed by Lydon *et al.* to gain insight into self-reported behavioural determinants and self-reported HHC.

Aims: To determine the validity of self-reported HHC using the COM-B questionnaire; and investigate the influence of self-reported behavioural determinants on observed HHC, taking environmental determinants into account.

Methods: This was a cross-sectional study, from September to November 2019, in nine hospitals in the Netherlands. Healthcare workers (HCWs) completed the COM-B questionnaire, and direct hand hygiene observations were performed. In addition, information on environmental determinants (workload, ward category, hospital type and ward infrastructure) was collected. Validity of self-reported HHC was determined using the intra-class correlation coefficient (ICC). Univariable and multi-variable regression analyses were performed to investigate the relationship between behavioural and environmental determinants and observed HHC.

Findings: The ICC showed no association between self-reported HHC and observed HHC [0.04, 95% CI -0.14 to 0.21]. In univariable regression analyses, ward category and the opportunity and motivation subscales were significantly associated with observed HHC. In multi-variable regression analysis, only ward category and the motivation subscale remained significant.

Conclusion: Self-reported HHC is not a valid substitute for direct hand hygiene observations. Motivation (behavioural determinant) was significantly associated with HCC, while almost none of the environmental determinants had an effect on observed HHC. In further

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https://doi.org/10.1016/j.jhin.2023.04.012

development of hand hygiene interventions, increasing the intrinsic motivation of HCWs should receive extra attention.

Introduction

Semmelweis demonstrated the effect of proper hand hygiene in 1847, and it remains one of the most important and effective measures in preventing healthcare-associated infections in healthcare organizations [1,2]. In 2009, the World Health Organization (WHO) formulated the Five Moments of Hand Hygiene to facilitate healthcare workers (HCWs) to disinfect their hands at the correct times [2]. These Five Moments have been incorporated into national and international infection prevention and control (IPC) policies and the curricula of nurses and physicians [3], resulting in HCWs being well informed about the Five Moments and when to apply them during their work.

Hand hygiene behaviour can be measured in multiple ways, where a distinction can be made between direct methods (e.g. direct unobtrusive observations) and indirect methods (e.g. automated monitoring or product consumption) [3,4]. Both methods have their limitations. For instance, direct observations of hand hygiene compliance (HHC) are labour-intensive and prone to the Hawthorne effect [3,5]. However, the validity of self-reported HHC, a more efficient alternative to direct observations, is also debatable [6]. Direct hand hygiene observations are considered the gold standard as indirect methods are less accurate [2,3,6].

Despite the fact that the Five Moments should be well known among HCWs, HHC often remains low and maintaining the long-term effects of interventions is challenging [4,7]. A recent systematic review by Bredin *et al.* showed weighted pooled HHC of 52% for nurses and 45% for physicians [4]. In order to increase HHC and implement successful interventions, it is important to identify determinants that influence HHC. Studies investigating the determinants of HHC have shown that both behavioural determinants (e.g. attitude, self-efficacy, habit, risk perception, social norms and safety culture on a ward) [8—11] and environmental/situational determinants (e.g. workload or staff shortage, type of ward, availability of facilities) [9,12,13] could influence HHC on a ward.

Although it is known that HHC is influenced by behavioural determinants, knowledge about this should be expanded to further improve intervention strategies. To gain more insight into the behavioural determinants of HHC, Lydon *et al.* developed the Capability, Opportunity, Motivation-Behaviour (COM-B) hand hygiene questionnaire [14]. The COM-B questionnaire provides information on self-reported behavioural determinants of hand hygiene (i.e. the capability, opportunity and motivation subscales) and self-reported HHC (i.e. the behaviour subscale).

The COM-B questionnaire has been applied in various ways in recent studies, both in clinical settings [15—18] and in non-clinical settings [19,20]. Lambe *et al.* and Herbec *et al.* used the COM-B questionnaire to develop a semi-structured interview to gain insight into the perceived barriers and enablers of hand hygiene behaviour of HCWs [15,16]. Castro-Sánchez *et al.* used the questionnaire to evaluate an intervention focused on a personal protective equipment support programme [18]. Brown *et al.* distributed the questionnaire to identify predictors of handwashing and use of hand sanitizer among the US population [19].

This large regional study aimed to determine the validity of self-reported HHC obtained through the COM-B questionnaire by comparing this with observed HHC. Furthermore, the influence of self-reported behavioural determinants assessed with the COM-B questionnaire (i.e. capability, opportunity and motivation) on observed HHC was investigated, taking environmental determinants into account.

Methods

Study design

This cross-sectional observational study was performed in nine hospitals in the Rotterdam-Rijnmond region in the Netherlands. Data were collected as part of the ongoing 'Roll Up Your Sleeves' project [12]. In this project, HHC is observed on different wards and among different HCWs in the Rotterdam-Rijnmond region. The data are presented to the hospitals as a ranking in order to stimulate friendly competition between hospitals [12].

Data collection

The hand hygiene variables used in this study were: (1) self-reported behavioural determinants (capability, opportunity and motivation) and self-reported HHC (behaviour); (2) directly observed HHC; and (3) environmental determinants (ward category, hospital type, workload and ward infrastructure).

Self-reported behavioural determinants and self-reported HHC

Between September and November 2019, the COM-B questionnaire [14] was distributed among all HCWs working on wards where direct hand hygiene observations were undertaken. The project leaders of the 'Roll Up Your Sleeves' project distributed the link of the online survey to the team managers of each ward, who sent it to all the HCWs on their ward. During the study period, the project leaders received three updates on the number of responses per ward in order to focus attention on wards with lower response rates. The questionnaire was distributed among the HCWs before the hand hygiene observations took place. This questionnaire consists of four subscales (i.e. capability, opportunity, motivation and behaviour), with five or seven items per subscale. The questions are answered using a five-point Likert scale, ranging from strongly disagree to strongly agree. Each given answer is equal to a certain score between one and five. The questionnaire provides insight into self-reported behavioural determinants of hand hygiene (i.e. the capability, opportunity and motivation

subscales) and self-reported HHC (i.e. the behaviour subscale). The original questionnaire was translated into Dutch for this study, and turned into an online survey. The results of the COM-B hand hygiene questionnaire of a particular ward were only included when five or more HCWs from that ward completed the questionnaire, resulting in the inclusion of 957 completed questionnaires from 70 wards.

Directly observed HHC

HHC was observed between September and November 2019 using the Hand Hygiene Australia observation instrument [2,21]. An average of five trained medical students observed HCWs unobtrusively during their normal work routines between 8.00 and 10.30 a.m. to investigate whether they complied with the Five Moments of Hand Hygiene as described by WHO [2]. During 2.5-h observation periods, at least three nurses were followed and observed. Other HCWs who assisted the observed nurses or physicians were also included in the observation. Furthermore, the training of the students and the observation method were the same as used previously by the present authors [12]. HHC was observed among nurses and physicians on different wards and in different types of hospitals. In total, 3728 hand hygiene opportunities were observed on 125 wards in nine hospitals.

Environmental determinants

Ward categories. Wards were categorized into: internal wards, surgical wards, neurology wards, intensive care units, paediatric wards, emergency wards, gynaecology/obstetrics wards and mixed wards. Mixed wards included: urology/gynaecology wards; ear, nose and throat wards; short stay wards; and cardiology/neurology wards.

Types of hospitals. Of the nine participating hospitals, there was one academic teaching hospital (Hospital 1), two non-academic teaching hospitals (Hospitals 3 and 6), four general peripheral hospitals (Hospitals 4, 5, 8 and 9) and two specialized hospitals (Hospitals 2 and 7).

Workload. Between September and November 2019, occupancy information was collected for the wards where hand hygiene observations were performed. Each day, after the hand hygiene observation, the students asked the team managers three questions: 'How many patients are hospitalized right now?', 'How many beds in total are available for patient care on the ward?', and 'How many nurses are working right now?'. Following the study by Chang *et al.*, the continuous variable workload was defined as the number of hand hygiene opportunities per hour [22]. The workload was categorized as low (≤12 opportunities/h), medium (13–20 opportunities/h) or high (>20 opportunities/h).

Infrastructural audit. Between December 2017 and March 2018, a self-developed digital infrastructural audit was carried out in eight of the nine hospitals. Only one hospital did not participate, due to a lack of time of involved staff members. The audit was based on the 'WHO ward infrastructure survey' [23]. Each audit was performed by IPC practitioners from the hospital concerned. In this audit, the presence or absence of alcohol-based hand rub (ABHR), the location of ABHR dispensers, the presence or absence of hand hygiene posters, and periodic internal hand hygiene audits was investigated

Table I
Hand hygiene compliance (HHC)

	N wards	HHC	95% CI
Hospital			
Hospital 1	29	66%	57.1–73.0
Hospital 2	2	88%	82.0–94.8
Hospital 3	34	64%	56.5–70.9
Hospital 4	12	69%	57.9–82.6
Hospital 5	14	58%	47.4–67.0
Hospital 6	17	56%	43.6–69.5
Hospital 7	4	79%	48.9–100
Hospital 8	3	82%	69.9–98.2
Hospital 9	10	60%	42.0–75.5
Ward category			
Internal ward	40	63%	55.3–67.8
Surgical ward	16	62%	50.0–72.1
Neurology ward	7	52%	34.3–70.2
Intensive care unit	10	70%	54.7–83.0
Paediatric ward	16	81%	71.6–88.7
Emergency ward	9	54%	34.2–71.2
Gynaecology/obstetrics ward	7	71%	60.4–84.3
Mixed ward[a]	20	62%	49.7–73.0
Hospital type			
Academic teaching hospital	29	66%	57.1–73.0
Non-academic teaching hospital	51	62%	55.1–67.6
General hospital	39	65%	57.1–70.2
Specialized hospital	6	82%	65.3–96.7
Workload [22]			
Low (≤12 hand hygiene opportunities/h)	81	64%	58.3–67.7
Medium (13–20 hand hygiene opportunities/h)	42	66%	59.3–72.6
High (>20 hand hygiene opportunities/h)	2	56%	N.A.
Infrastructural audit[b]			
ABHR per patient room (median 1, range 0–4)	95	64%	62.1–72.8
ABHR within point of care (median 100%, range 0–100%)	95	64%	54.4–65.1
ABHR on hallway ward (median 7, range 1–19)	54	63%	8.7–83.4
Hand hygiene posters in hallway (reference group: yes)	65 (68%)	65%	58.9–69.8
Hand hygiene posters in hallway (median 2, range 0–4)	96	63%	55.9–76.6
Periodic internal hand hygiene audits (reference group: yes)	54 (57%)	61%	54.0–66.1

CI, confidence interval; N.A., not applicable; ABHR, alcohol-based hand rub.

[a] Mixed wards include: urology/gynaecology wards; ear, nose and throat wards; short stay wards; and cardiology/neurology wards.

[b] Infection prevention and control practitioners were asked to complete the audit (when applicable) for two single patient rooms, two double patient rooms, two triple patient rooms and two multiple occupancy patient rooms on one ward.

Table II
Capability, Opportunity, Motivation-Behaviour (COM-B) hand hygiene questionnaire

		Cap.	Opp.	Motiv.	Behav.
	N respondents questionnaire	Average score[a]	Average score	Average score	Average score
Hospital					
Hospital 1	379	81%	69%	75%	63%
Hospital 2	29	87%	76%	74%	65%
Hospital 3	162	76%	75%	78%	56%
Hospital 4	15	86%	75%	83%	64%
Hospital 5	171	82%	69%	76%	62%
Hospital 6	63	83%	73%	79%	64%
Hospital 7	24	83%	72%	76%	62%
Hospital 8	6	80%	75%	83%	63%
Hospital 9	108	81%	72%	78%	61%
Ward category					
Internal ward	258	81%	71%	77%	60%
Surgical ward	77	76%	69%	75%	58%
Neurology ward	33	80%	66%	73%	63%
Intensive care unit	64	84%	72%	80%	65%
Paediatric ward	236	82%	72%	77%	64%
Emergency ward	65	79%	69%	74%	61%
Gynaecology/obstetrics ward	83	78%	71%	74%	58%
Mixed ward[b]	141	81%	73%	78%	62%
Hospital type					
Academic teaching hospital	379	81%	69%	75%	63%
Non-academic teaching hospital	225	78%	74%	79%	58%
General hospital	300	81%	71%	77%	62%
Specialized hospital	53	85%	74%	75%	64%
Workload [22]					
Low (≤12 hand hygiene opportunities/h)	689	81%	72%	77%	62%
Medium (13–20 hand hygiene opportunities/h)	224	79%	71%	75%	61%
High (>20 hand hygiene opportunities/h)	44	79%	64%	72%	61%
Infrastructural audit[c]					
ABHR per patient room (median 1, range 0–4)	684	80%	71%	77%	61%
ABHR within point of care (median 100%, range 0–100%)	684	80%	71%	77%	61%
ABHR on hallway ward (median 7, range 1–19)	349	82%	73%	78%	63%
Hand hygiene posters in hallway (reference group: yes)	684	47%	41%	44%	36%
Periodic internal hand hygiene audits (reference group: yes)	684	64%	55%	60%	49%

HHC, hand hygiene compliance; Cap, capability; Opp., opportunity; Motiv., motivation; Behav., behaviour; ABHR, alcohol-based hand rub.
[a] This percentage was calculated by dividing the score of a subscale by the maximum score that could be achieved for that subscale. The maximum score was calculated by multiplying the number of respondents of the questionnaire by 25 for capability, motivation and behaviour (i.e. five questions, maximum of five points) and by 35 for opportunity (i.e. seven questions, maximum of five points).
[b] Mixed wards include: urology/gynaecology wards; ear, nose and throat wards; short stay wards; and cardiology/neurology wards.
[c] Infection prevention and control practitioners were asked to complete the audit (when applicable) for two single patient rooms, two double patient rooms, two triple patient rooms and two multiple occupancy patient rooms on one ward.

(Supplementary Table S1, see online supplementary material). IPC practitioners were asked to complete the audit (when applicable) for two single patient rooms, two double patient rooms, two triple patient rooms and two multiple occupancy patient rooms on one ward.

Data analyses

In this study, HHC was calculated by dividing the number of correct hand hygiene opportunities by the total number of observed hand hygiene opportunities. The average score for

each subscale of the COM-B questionnaire was calculated by dividing the total score of that subscale by the number of respondents that completed the questionnaire.

The intraclass correlation coefficient for consistency (ICC) was calculated to investigate the association between self-reported HHC (i.e. the behaviour subscale) and observed HHC. The ICC was also used to analyse correlation between the four subscales of the COM-B questionnaire.

Univariable and multi-variable regression analyses were performed to investigate the association between self-reported behavioural determinants (i.e. the capability, opportunity and motivation subscales), environmental determinants (i.e. ward category, hospital type, workload and ward infrastructure) and observed HHC. In the regression analyses, the self-reported behavioural determinants and environmental determinants were independent variables, and observed HHC (i.e. gold standard) was the dependent variable. Hospital was included as a random effect and not a fixed effect in the analyses, as the sample size was too small. Results have been presented with 95% confidence intervals (CI) and *P*-values, and $P<0.05$ was considered to indicate significance. All data were analysed using SPSS Version 25 (IBM, Armonk, NY, USA).

Results

In total, 125 wards were observed in nine hospitals, with overall HHC of 64.6% (range 56.1–88.3%) (Table I). Paediatric wards had the highest HHC (81%), and neurology wards had the lowest HHC (52%). The COM-B questionnaire was completed by 957 HCWs (Table II). The capability subscale had the highest average score, and the behaviour subscale had the lowest average score.

The ICC showed no association between self-reported HHC (i.e. subscale behaviour) and observed HHC. The ICC was 0.04 (95% CI-0.14 to 0.21), indicating no agreement between outcomes in the different outcome measurements (Figure 1). The ICC of the four subscales of the COM-B hand hygiene questionnaire showed strong correlation between the different subscales, similar to the development and validation study of Lydon *et al.* [14] (data not shown).

Univariable regression analysis, with observed HHC as the dependent variable, showed that ward category and the opportunity and motivation subscales were significantly associated with observed HHC on a ward (Table III). Marginal R^2 of these variables were 14% for ward category, 10% for the opportunity subscale and 14% for the motivation subscale. The other environmental determinants (i.e. hospital type, workload and ward infrastructure) were not associated with observed HHC (Table III). Multi-variable regression analysis including ward category, the opportunity subscale and the motivation subscale showed that ward category ($P=0.03$) and the motivation subscale (B=4.5, 95% CI 0.8–8.3; $P=0.02$) remained significantly associated with observed HHC. The combined marginal R^2 for ward category and the motivation subscale was 29%.

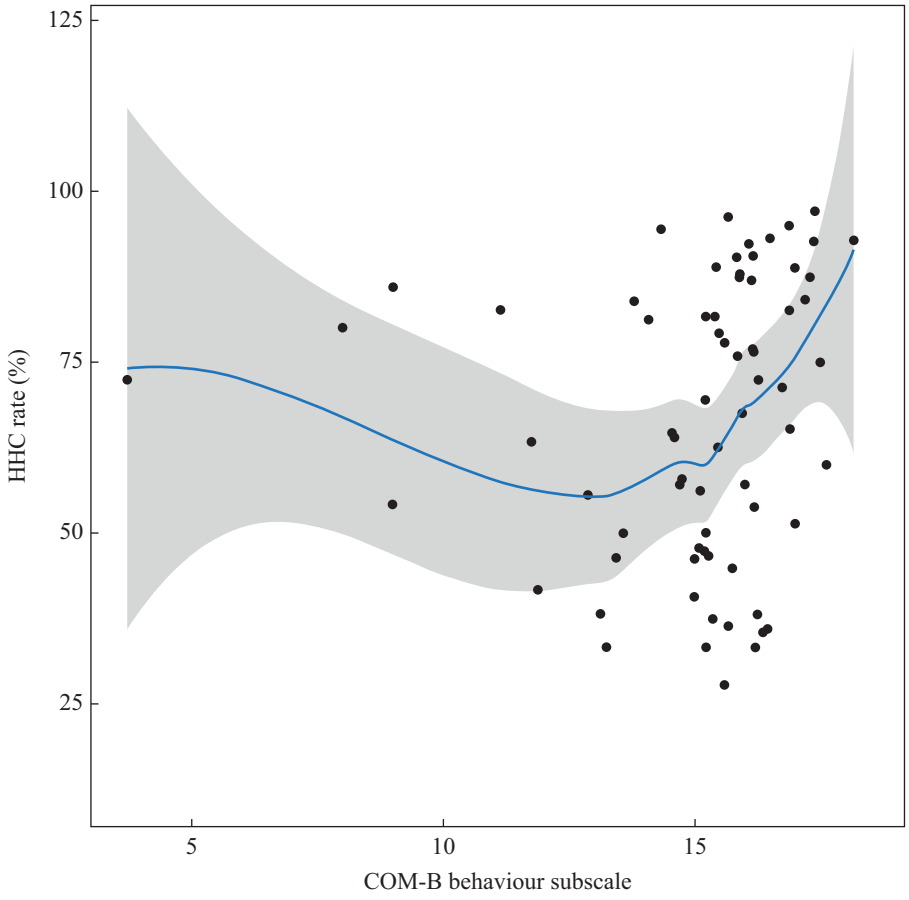

Figure 1. Association between average self-reported hand hygiene compliance (HHC) (i.e. behaviour subscale) and observed HHC. COM-B, Capability, Opportunity, Motivation-Behaviour hand hygiene questionnaire.

Table III
Univariable and multi-variable regression analysis with hand hygiene compliance

	Univariable			Multi-variable		
Characteristic	Beta	95% CI	*P*-value	Beta	95% CI	*P*-value
COM-B hand hygiene questionnaire						
Average capability score	1.0	-1.1 to 3.1	0.35			
Average opportunity score	3.7	1.2 to 6.3	0.01[a]	0.9	-2.4 to 4.1	0.61
Average motivation score	4.9	2.0 to 7.9	0.002[a]	4.5	0.8 to 8.3	0.02*
Ward category			0.01[a]			0.03*
Internal ward	Reference	—		Reference	—	
Surgical ward	-1.0	-12.0 to 10.0		-0.9	-16.3 to 14.5	0.91
Neurology ward	-13.0	-29.0 to 3.5		-13.2	-35.0 to 8.6	0.24
Intensive care unit	7.6	-6.1 to 21.0		8.8	-7.5 to 25.2	0.29
Paediatric ward	19.0	7.0 to 30.0		19.0	6.5 to 31.5	0.004*
Emergency ward	-11.0	-26.0 to 3.2		-0.8	-17.3 to 15.7	0.93
Gynaecology/obstetrics ward	11.0	-4.9 to 27.0		15.0	-4.4 to 34.3	0.14
Mixed ward	-0.6	-11.0 to 10.0		2.5	-11.1 to 16.1	0.72
Hospital type			0.18			
Academic teaching hospital	Reference	—				
Non-academic teaching hospital	-4.3	-18.0 to 9.6				
General hospital	-0.8	-15.0 to 13.0				
Specialized hospital	16.0	-4.9 to 37.0				
Workload						
No. hand hygiene opportunities per hour	0.3	-0.8 to 1.4	0.57			
Infrastructural audit						
Median no. of ABHR per patient room	-4.0	-11.0 to 3.0	0.26			
% of ABHR within POC	-0.1	-0.2 to 0.01	0.09			
Median no. of ABHR in hallway	0.1	-1.1 to 1.2	0.93			
No. of hand hygiene posters in hallway	2.5	-0.5 to 5.4	0.11			
Periodic internal hand hygiene audits	-5.3	-14.0 to 3.3	0.23			

COM-B, Capability, Opportunity, Motivation-Behaviour hand hygiene questionnaire; CI, confidence interval; POC, point of care; ABHR, alcohol-based hand rub.
[a] $P<0.05$ was considered to indicate significance.

Discussion

This study found no correlation between self-reported HHC and observed HHC. Furthermore, of all the self-reported behavioural determinants and the environmental determinants, only the motivation subscale and ward category were significantly associated with observed HHC on multi-variable analysis. A higher HHC was observed on wards with more motivated HCWs, and on intensive care units, paediatric wards and gynaecology/obstetrics wards.

In this study, self-reported HHC (i.e. subscale behaviour) on a ward was compared with observed HHC on the same ward. Although observed HHC in this study was rather high (64.6%), no correlation was found with self-reported HHC. This emphasizes the fact that direct hand hygiene observations cannot be replaced by self-reported HHC as measured with the COM-B questionnaire, as the outcomes are not the same. This supports the findings of several other studies, including systematic reviews on the validity of self-reported HHC [3,6,24]. In addition, in recent years, HCWs have received direct feedback on their hand hygiene behaviour after hand hygiene observations more often [12,25,26]. Despite insight into their own behaviours, HCWs still usually overestimate their own abilities compared with the results of direct objective observations [6]. This suggests that there is no place for self-reported HHC to be used in decision making.

The COM-B questionnaire has been applied in several studies since its development by Lydon *et al.* in 2019 [14—20]. However, only Zheng *et al.* distributed and analysed the questionnaire in a similar way and setting as in the present study [17]. They distributed the COM-B questionnaire among 499 HCWs, and reported that opportunity and motivation directly affected hand hygiene behaviour [17]. This is in line with the present study, which also found, in the univariable analyses, that opportunity and motivation were significantly associated with observed HHC on a ward.

Furthermore, multi-variable analysis showed that motivation had a significant impact on HHC on a ward. Examples of items in this subscale were: 'Hand hygiene compliance is considered important by my seniors in this unit', 'I strive for complete compliance with the Five Moments of Hand Hygiene' and 'We remind each other to engage in hand hygiene in this unit' [14]. Two main topics can be extracted from these items: (1) having a good safety culture where colleagues can address each other; and (2) intrinsic motivation of HCWs. Lambe *et al.* also used the COM-B questionnaire, but they used it as a guideline for semi-structured interviews to gain insight into barriers and enablers of hand hygiene behaviour [15]. They

reported that the interviewees felt that they had the knowledge and skills to perform appropriate hand hygiene behaviour, and that social influence and modelling by senior leaders were important determinants for appropriate hand hygiene behaviour [15]. This was also found in the study by Kingston *et al.*, who conducted a survey to study hand hygiene attitudes and practices among nurses [27]. Their study showed the importance of a strong cultural or social norm regarding HHC, and highlighted the significant contribution of role models [27]. The importance of role models was also reported in other studies [3,8]. Furthermore, Diefenbacher *et al.* reported the influence of empathy on the HHC of HCWs, specifically the 'before' hand hygiene moments (i.e. Moments 1 and 2) [28]. It is likely that when a HCW feels more empathy for a patient, the HCW will be more motivated to perform the correct hand hygiene behaviour. Hand hygiene interventions that focus on increasing empathy or motivation could therefore increase HHC, particularly relating to critical sites (i.e. Moment 2).

This study has a number of strengths. First, to the authors' knowledge, this is the first study to investigate the influence of both behavioural and environmental determinants on HHC. The authors were able to investigate an extensive set of determinants, including the capability, opportunity, motivation and behaviour subscales; ward category; hospital type; workload; and ward infrastructure. In addition, this study used both self-reported data from HCWs and objectively observed hand hygiene data from the same ward. Second, this study was a multi-centre study, including different types of hospitals, wards and HCWs, which increases the generalizability of the results and reduces the risk of selection bias. Another strength was the size of the dataset, with >3500 hand hygiene opportunities collected and analysed, and almost 1000 completed COM-B questionnaires. The hand hygiene opportunities were observed by objective students with no bonds to the observed hospital or the intentions of the study. This reduces the chance of observer bias (i.e. detection bias).

This study also had a few limitations. First, the COM-B hand hygiene questionnaire was not completed by all wards on which direct hand hygiene observations were performed. Also, the number of responses per ward differed, which could have led to over- or underestimation of the actual situation on a ward. To minimize this, only those wards that had at least five responses on the COM-B hand hygiene questionnaire were included in this study. Furthermore, it is likely that the more motivated HCWs completed the questionnaire (i.e. participation bias), which could mean that the finding of a significant effect of motivation on HHC was an underestimation. Due to the way the questionnaire was distributed by team leaders in hospitals, the authors were not able to provide insight regarding the number of HCWs that completed the questionnaire compared with the number of HCWs that were asked to complete the questionnaire. Third, the infrastructural audit was performed 1 year before the hand hygiene observations and the COM-B questionnaire were executed. In this year, changes could have been made in, for example, the number of ABHR dispensers or hand hygiene posters. However, the hospitals indicated that the situation was unchanged between the time of the hand hygiene observations and the time of the infrastructural audit. Furthermore, the infrastructural audit was not completed by all hospitals and all wards, which may have influenced the power of the study regarding the infrastructure. Also, the study was only performed in one country, which reduces generalizability. Finally, the observation of HHC was performed between 8.00 and 10.30 a.m.; extrapolations of the outcome to other time slots during the day should be made with caution, especially as HHC during night shifts can differ compared with day shifts [29—31]. Additionally, the number of hand hygiene moments that can be observed in these 2.5 h is entirely dependent on the number of hospitalized patients that need care in the specific time window and the capacity of the observers.

To conclude, this study showed that self-reported HHC measured with the COM-B questionnaire was not associated with observed HHC, and therefore is not a valid substitute for direct hand hygiene observations. Motivation was significantly associated with HHC on a ward, and ward category was the only environmental determinant to affect observed HHC. In further development of hand hygiene interventions, increasing the intrinsic motivation of HCWs should receive extra attention.

Acknowledgements

The authors wish to thank all the hospitals participating in the 'Roll Up Your Sleeves' project and the cooperating Rijnmond hospitals [stichting Samenwerkende Rijnmond Ziekenhuizen (SRZ)]. In particular, the authors wish to thank J.M.J.J. Vermeeren, one of the founders of the 'Roll Up Your Sleeves' project, for all of her dedication and enthusiasm over the years to increase HHC in the Rotterdam-Rijnmond region. Furthermore, the authors wish to thank the members of the 'Roll Up Your Sleeves' project group: W.W. Vrijland, J.M.J.J. Vermeeren, C.M. Waltmans-den Breejen, S. Hartog, E. Kraan, M. Swijnenburg, R. Amin, D. Tulling, G. van Nielen, F. Heijnen, P. Gantvoort, W. van Vianen, M. van Groningen, J. Mackloet, S. Visser and C. Vlasveld-van Dijk.

Conflict of interest statement
None declared.

Funding source
This study is part of ongoing surveillance programmes supported and funded by SRZ. However, the Board of Directors of SRZ were in no way involved in the data management, data analysis or writing of the manuscript.

Ethical approval
The study protocol was approved by the Medical Ethics Board of Erasmus University Medical Centre, Rotterdam. In the Netherlands, it is not necessary to collect informed consent from HCWs before observing their behaviour, although all participating hospitals were informed about the study prior to commencement.

Author contributions
Design of the study: MD, DN, MV, EB.
Data collection: MD, MV, EB.
Data analyses: DN, MD.
Writing the manuscript: all authors.
All authors read and approved the final manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jhin.2023.04.012.

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