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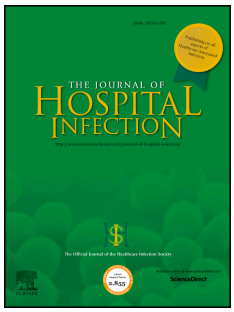

Psychometric Evaluation of a Measure of Factors Influencing Hand Hygiene Behaviour to Inform Intervention

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Psychometric Evaluation of a Measure of Factors Influencing-Hand Hygiene Behaviour to Inform Intervention

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Running title: Evaluation of a hand hygiene measure

Psychometric Evaluation of a Measure of Factors Influencing Hand Hygiene Behaviour to Inform Intervention

Background. Although the hand hygiene (HH) procedure is simple, the related behaviour is complex and is not readily understood, explained, or changed. There is a need for practical tools to provide data that can guide healthcare managers and practitioners not only on the 'what' (the standards that must be met), but also the 'how' (guidance on how to achieve the standards).

Aim. To develop a valid questionnaire to evaluate attitudes to the factors that influence engagement in HH behaviour that can be readily completed, administered, and analysed by healthcare professionals to identify appropriate intervention strategies. Construct validity was assessed using confirmatory factor analysis, predictive validity through comparison with self-reported HH behaviour, and convergent validity through direct unit-level observation of HH behaviour.

Methods. The Capability, Opportunity, Motivation- Behaviour (COM-B) model was used to design a 25-item questionnaire that was distributed to Intensive Care Unit (ICU) personnel in Ireland. Direct observation of HH behaviour was carried out at two ICUs.

Findings. A total of 292 responses to the survey (response rate 41.0%) were included in the analysis. Confirmatory factor analysis resulted in a 17-item questionnaire. Multiple regression revealed that a model including Capability, Opportunity, and Motivation, was a significant predictor of self-reported Behavioural intention ($F(3,209) = 22.58$, $p < 0.001$). However, the Opportunity factor was not found to make a significant contribution to the regression model.

Conclusion. The COM-B HH questionnaire is reliable and valid and provides data to support the development, and evaluation, of HH interventions that meet the needs of specific healthcare units.

Key Words. Hand hygiene, Behaviour, Questionnaire, Measure, Healthcare, Intensive Care Unit.

Abbreviations. Capability, Opportunity, Motivation- Behaviour (COM-B); Confirmatory Factor Analysis (CFA); Comparative Fit Index (CFI); Goodness-of-Fit Index (GFI); Hand Hygiene (HH); Hand Hygiene Behaviour (HH); Intensive Care Unit (ICU); Root Mean Square Error of Approximation (RMSEA).

Psychometric Evaluation of a Theory-Based Measure of Factors influencing Hand Hygiene Behaviour

Introduction

Good hand hygiene (HH) behaviour is considered to be the single most important intervention for preventing the occurrence of HAIs[1, 2]. However, HH behaviour among health care workers has been historically low [1]. Although the HH procedure itself is simple, the behaviour related to HH is complex and is not readily understood, explained, or changed [3, 4].

A frequently used strategy of interventions to improve HH compliance is to use a bundled intervention whereby several strategies are used together [4,5]. However, there is a lack of guidance for hospital managers and clinicians as to how limited resources can be best invested in interventions that are likely to be effective [4,5]. In fact, it has been suggested that the development and/or the selection of interventions to implement changes in healthcare practice is often done on the basis of intuition [6-8].

A commonly used approach to gain insights on level of HH compliance is through direct observation. However, the presence of observers has been shown to inflate levels of HH compliance (a Hawthorne effect)[9,10]. Other issues with direct observation are that many healthcare institutions set very high targets (90-100%) for hand HH compliance [11,12]. It has been argued that these targets also lead to over-reporting of HH compliance [11,12]. Therefore, there is a need for practical tools to provide data that can guide not only on the 'what' (the standards that must be met), but also the 'how' (guidance on how to achieve targets).

The aim of this study was to develop a valid questionnaire to evaluate attitudes to the factors that influence engagement in HH behaviour. As the questionnaire was designed to be completed, administered, and analysed by healthcare professionals, it had to be concise, and the responses readily interpreted. The information generated by the questionnaire could then be used by healthcare practitioners and managers to guide the design or selection of interventions to improve HH compliance to meet the needs of specific units, or groups of healthcare professionals.

METHOD

Design

A cross-sectional survey design was used.

Participants and Setting

Any healthcare professionals who were working in an ICU in the Republic of Ireland were eligible to participate in this study.

Instrument development

A 25 item questionnaire was derived based upon the Capability, Opportunity, Motivation-Behaviour (COM-B) model of behaviour [13]. The COM-B model proposes that interactions between Capability, Opportunity, and Motivation result in the performance of a particular Behaviour (Figure 1).

- Capability is defined as the individual's psychological and physical capacity to engage in hand hygiene behaviour [13]. The five COM-B HH questionnaire items in

the Capability subscale were designed to assess whether the respondent believed they had the knowledge, training, and ability to carry out HH in the ICU.

- Opportunity is defined as the factors that are outside the individual that make the behaviour possible or prompt it. The seven items in the Opportunity subscale were designed to assess whether the resources were available to make HH possible (e.g. time, facilities, prompts and protocols), and whether the social environment supported HH behaviour (e.g. other healthcare providers engage in HH).
- Motivation is defined as the cognitive processes that energize and direct behaviour. The eight items in the Motivation subscale were concerned with assessing the respondents' belief in the utility of HH, and whether they, and others in the unit, strive for high levels of appropriate HH behaviour.

Participants indicated their attitudes to the items in all subscales on a five-point scale from 'strongly disagree' (1) to 'strongly agree' (5). The five items in the Behaviour subscale are concerned with the self-reporting of the extent to which the respondent complies with each of the WHO's five moments of HH behaviour: (1) before patient contact; (2) before aseptic technique; (3) after body fluid exposure; (4) after patient contact; and (5) after contact with patient surroundings [1]. For these questions, participants indicated the frequencies with which they complied with the HH indications on a five-point scale from 'never' (0) to 'always' (4).

Demographic information on gender, role, number of years of ICU experience, and hospital were also collected. The COM-B HH questionnaire was piloted with eight ICU nurses and doctors. Based on their feedback, minor changes were made (e.g. adding more specialty roles) to the content.

Ethical Consideration

Ethical approval was obtained from the Clinical Research Ethics Committees at Galway University Hospital, Cork University Hospital, Beaumont Hospital, and Sligo University Hospital.

Procedure

The anonymous COM-B HH questionnaire was distributed by a member of staff (doctors, nurses, and allied health professionals) at three ICUs in the Republic of Ireland, and at the Irish Association of Critical Care Nurses' annual conference. Participants were given the opportunity to complete either a paper copy of the questionnaire or an online version. If they wished, participants could enter into a prize draw for one of three 50 Euro vouchers.

In addition to the questionnaire survey, direct observation of HH behaviour was carried out at two of the ICUs in which the COM-B HH questionnaire was distributed during February and March 2017. One ICU had an 11-bed bay with two isolation rooms (ICU 1), and the other had a five-bed bay (ICU 2). Approximately two hours of observations were carried out of ICU staff on each of seven shifts (three mornings, two afternoons, one evening, and one night shift) over a period of five days per unit. Verbal consent was provided by all healthcare providers to be observed. The healthcare provider was observed by either one or two trained HH auditors. The auditors were part of the research team, and independent from the units and hospitals in which the observations were carried out. At each bedspace, an observer unobtrusively observed staff during 20-minute sessions, and then moved to another bedspace. The sequence of the observations at bedspaces was random. Observations were carried out in

accordance with each of the five WHO moments of HH [1]. The observers recorded whether a HH moment was completed or missed.

Statistical Analysis

Initial data screening

The skewness, kurtosis, and correlation between the items within each proposed factor were evaluated using SPSS. Items with high levels of skewness or kurtosis were discarded from further analysis.

Construct validity

Construct validity is concerned with whether the items in the subscale reflect the same construct [14]. The construct validity of the instrument was established through a confirmatory factor analysis (CFA) technique as implemented by EQS for Windows. In order to evaluate the 'fit' of the data to the model, the χ^2 statistic was used in association with, the Comparative Fit Index (CFI), the Goodness-of-Fit Index (GFI), and the Root Mean Square Error of Approximation (RMSEA) using a robust maximum likelihood method to estimate parameters.

The GFI and chi-square are absolute fit indices. A non-significant chi-square is indicative of a good model fit. However, chi-square is affected by sample size, number of variables, and assumes multivariate normality [15]. The CFI is an incremental fit index that results in a statistic from 0 to 1. Generally, a value of 0.9 or higher is considered to be the minimum for model acceptance for both the CFI and GFI [16]. The RMSEA is calculated based on sample size, the noncentrality parameter, and degrees of freedom for the target model [17]. Models

that are good descriptors of the data should produce RMSEA values of less than .05, with values less than .08 considered to be a 'reasonable fit'.

Internal consistency

Internal consistency is the extent to which items within a subscale are inter-correlated. Internal consistency was assessed using Cronbach's alpha. Cronbach's alpha values of greater than 0.70 are generally considered to provide evidence of good internal consistency [18].

Predictive validity

The predictive validity of the instrument was assessed by using a multiple regression to examine the predictive validity of the COM-B variables (i.e. Capability, Opportunity, and Motivation) on self-reported HH behaviour using SPSS.

Convergent validity

The convergent validity of the self-reported HH behaviour was assessed via comparison to observations of HH behaviour in two of the ICUs in which the COM-B HH questionnaire was distributed. It is important to indicate that the questionnaire responses and observations are not matched to the same individual. This was due to the practicalities of getting staff in the ICU to complete questionnaires while they were working, and ethical considerations. Therefore, only descriptive data is reported.

RESULTS

A response rate of 41.0% (231/563) was obtained. A total of 213 of these respondents were included in the CFA (18 responses were discarded as they had one or more missing

responses). Of the included responses, 80.3% were female (171/213). A total of 72.8% (155/213) of the respondents were nurses, 16.4% (35/213) were doctors, and 10.8% (23/213) were allied health professionals. The respondents reported a mean of 10.3 years of clinical experience (st dev=8.2), with responses received from healthcare professional from 17 hospitals in the Republic of Ireland.

For the direct observation of HH moments, 194 observations of HH opportunities were completed in ICU 1, and 141 observations in ICU 2. Of these 335 observations, 224 (66.9%) were carried out by two observers, with the remaining observations of HH opportunities carried out by one observer. For those observations made by two observers, there was an agreement of 88.3% between the observers. The 26 observations of HH opportunities for which the observers disagreed were not included in the analysis.

Statistical Analysis

Initial Screening

Three items from the Motivation factor were removed from further analysis due to excessively high levels of skewness and kurtosis. Examining the data from the Behaviour factor demonstrated it was not suitable to include in the CFI, as there were very high levels of skewness and kurtosis in all of the items. For the Behaviour factor, none of the respondents indicated that they ‘never’ or ‘always’ washed their hands. A total of 80% (852/1065) of the responses to the five items in the Behaviour factor were either ‘sometimes’ or ‘often’. The Cronbach’s alpha values of the three remaining factors (i.e. Capability, Motivation, and Opportunity) were also evaluated during this stage. Cronbach’s alphas were found to be 0.7 or higher for each of the three factors. The Cronbach’s alpha for the behaviour factor was 0.65.

Construct validity

The remaining 17 items were entered into a CFA with a three-factor model with correlations allowed between all factors. The fit was not found to be acceptable (χ^2= 316.8, df= 116, p<0.001; CFI= 0.78; GFI= 0.80; and RMSEA= 0.09). A number of iterative changes were made to the model. This process led to correlates of errors between four pairs of measurement errors. The correlations between the pairs of measurement error terms were based upon the Lagrange multiplier test for adding parameters, and were consistent with theory. The pairs of items are within the same subscale and are part of the same construct (Figure 2). These adaptations resulted in a model with an acceptable level of fit on two of the indices (χ^2= 187.8, df =112, p<0.001; CFI= 0.92; GFI= 0.88; and RMSEA= 0.06). Figure 1 shows the standardized solution for the final model. The correlations between the three subscales are represented by curved arrows, the arrows from the items (rectangular boxes) to the factors (elliptical circles) are the factor loadings, and the arrows pointing to the items on the left of Figure 2 represent the measurement error.

Internal consistency

As can be seen from Figure 1, all of the Cronbach's alpha values are greater than 0.7 for all three revised subscales included in the CFA. Therefore, there is evidence of internal consistency for the three subscales.

Predictive validity

Initial screening found no issues with multicollinearity or any other violations of the assumptions of multiple regression. The multiple regression revealed that a model including capability, opportunity, and motivation was a significant predictor of self-reported behaviour,

F(3,209) =22.58, p<0.001, and explained 25% of the variance in behavioural intention (see Table 1). However, the opportunity factor was not found to make a significant contribution to the regression model (Table 1).

Convergent validity

Table 2 provides a comparison between the observed HH behaviour and the COM-B HH questionnaire data on self-reported behaviour from the two ICUs for which observational data was collected. The responses to the questionnaire suggest that there may be an overestimation of perceived HH behaviour when self-report is compared to observed behaviour for all moments of HH with the exception of moment four, which was lower than observed (Table 2).

DISCUSSION

HH is most commonly studied and assessed through direct observation. Although direct observation can provide information on the levels of compliance (with the caveats identified in the introduction), it does not provide information on how compliance levels can be improved. It is suggested that the COM-B HH questionnaire has value in identifying specific issues in particular units pertaining to HH behaviour. This information may be used to direct appropriate local-level interventions, and assess the impact of the intervention.

The final COM-B HH questionnaire consisted of 22 items divided into four subscales: Capability (5 items), Opportunity (7 items), and Motivation (5 items), and Behaviour (5 items). There was empirical support for the internal consistency of the measure, as well as for construct and predictive validity. A concise questionnaire is advisable from the perspective of reducing the burden on the participants, and maximizing response rate [19]. The final version

of the COM-B HH questionnaire, along with instructions for scoring, has been published online in the Measurement Instrument Database for the Social Sciences at: www.midss.org/com-b-hand-hygiene-behaviour-questionnaire so is available for immediate use by practitioners. The evidence of its convergent validity is less conclusive. However, although further testing is required with a different sample of healthcare professionals, we are confident in the validity of the measure.

The Capability and Motivation factors were found to be predicative of self-reported HH behaviour in our sample of responses. This suggests that, at least in Ireland and likely other developed countries, the focus of any interventions should be upon increasing capability (e.g. by providing more focused HH training based upon where there are identified deficits in understanding) and motivation (e.g. by reminding others to engage in HH, or focusing on senior staff modelling appropriate HH behaviour). A recent systematic review of HH interventions in ICU found that education (79% of included studies) and training (68% of included studies) were the most commonly used interventions [5]. In terms of motivation, persuasion (e.g. performance feedback) was included in 66% of the included studies in this review. However, other motivational methods such as modelling (highlighting of examples of desired behaviour in order to encourage others to emulate this behaviour), incentivisation (rewards to motivate individuals to engage in a behaviour), or coercion (potential punishment to discourage individuals from engaging in a behaviour) were rarely used [5]. Bundled interventions are commonly used to improve HH compliance [5,10]. The data collected using the COM-B HH questionnaire can be used to identify which components should be included in a bundled intervention to ensure that finite resources are being used effectively.

The Opportunity factor was not found to be a significant predictor of self-reported HH behaviour in our sample. However, this finding may not be the same in low-income countries. For example, Borg et al [20] identified issues with infrastructure (e.g. number of sinks, poor quality of HH products) as key issues in eight low-income countries. Therefore, this is a factor that may not be predictive of behaviour in better resourced healthcare systems, but may be relevant in less well funded systems where facilities to support appropriate HH behaviour may be more limited. Data collected using the COMB-HH questionnaire allows a determination to be made as to whether there are specific issues that are preventing healthcare professionals from taking the opportunity to engage in HH behaviour.

Strengths and Limitations

The strengths of the study are that we received a relatively large number of responses, and followed best practice in the development of the COM-B HH questionnaire items [21]. However, there are also some limitations. We have separated those limitations in terms of those associated directly with the development of the COM-B HH questionnaire, and those associated with the direct observation used to evaluate the convergent validity of the questionnaire.

The first limitation with the questionnaire was the total response rate of 41%. However, although lower than desirable, the response rate is not atypical for questionnaire studies conducted among medical professionals [22]. Secondly, as part of the post-hoc analysis, changes were made to the original three-factor model for the questionnaire. This means that the analysis is now framed in an exploratory rather than confirmatory mode [16]. However, given that this is a new instrument, we believe that this approach is acceptable. Thirdly, it is likely that respondents over-estimate their own levels of appropriate HH behaviour [23,24].

However, despite the limitation on the reporting of HH behaviour, self-reports remain an important source of information about handwashing knowledge and other determinants of handwashing behaviour [23]. Finally, this paper only describes the initial development of the COM-B HH questionnaire. Other aspects of psychometrics that should be examined are: reproducibility (does the same factor structure result from the analysis of another sample of responses with ICU or another domain of healthcare?); responsiveness (is the questionnaire sensitive to changes?); and interpretability (can qualitative meaning be assigned to the quantitative scores?)[21].

The direct observation of HH behaviour was carried out to assess the convergent validity of the COM-B HH questionnaire. The first limitation is that the observations were carried out in only two ICUs over a finite period of time. Therefore, the amount of data collected is limited and it is not known if these findings generalise to other ICUs. We found an overall level of HH compliance of 64.2% across the two ICUs in our study. This figure is considerably lower than the overall compliance level in the Irish healthcare system in 2017 of 90.5% [25]. However, the levels of HH compliance found in our study are broadly comparable to those reported in the research literature. For example, in a recent systematic study on the impact of HH interventions, the mean level of compliance across the 16 included clinical trials was 57% [26]. The published target level of HH compliance in the Irish healthcare system in 2017 was 90% [25], so may reflect some of the issues of over-reporting in response to the setting of high targets for hand HH compliance[11,12]. Finally, the questionnaire responses and observations are not matched to the same individual. As a result, we were only able to report unit-level descriptive results.

CONCLUSIONS

The behaviour related to HH is complex and is not readily understood, explained, or changed. There is a need for easy to use and valid tools to provide data on the factors that influence the HH behaviour of healthcare professionals in particular units in order to provide information on how hand hygiene compliance can be improved. The COM-B HH questionnaire has the potential to provide senior leaders, practitioners, and researchers with an understanding of HH and inform the development of evidence-based interventions.

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Conflict of interest statement

The Authors declare no conflict of interests.

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Table 1. Outcomes of multiple regression analysis considering factors that predict self-reported hand hygiene behaviour.

	B	SE	β	R^2
Constant	2.34	0.18		
Capability	0.15	0.05	0.24*	
Opportunity	0.03	0.04	0.06	0.25
Motivation	0.14	0.05	0.26*	

* p<.01.

Table 2. Comparison of self-report hand hygiene behaviour and observed hand hygiene compliance at two ICUs.

WHO moments of HH	Respondents reporting they '*often*' washed their hands*	Observed compliance
1. Before patient contact	80.8% (84/104)	65.5% (19/29)
2. Before aseptic technique	96.2% (100/104)	55.2% (21/38)
3. After body fluid exposure	99% (103/104)	63.0% (17/27)
4. After patient contact	76.0% (79/104)	89.4% (34/38)
5. After contact with patient surroundings	60.6% (63/104)	61.0% (124/203)
All moments	**82.5% (429/520)**	**64.2% (215/335)**

* No respondents reported '*always*' washing their hands.