Original article

Association of national and hospital factors to hospitals' alcohol-based handrub consumption in Europe: Results of the European PROHIBIT study

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Abstract

Objectives: Hand hygiene is considered the most effective way to reduce the transmission of (multidrug-resistant) organisms and to prevent healthcare-associated infections. Hand rubbing with alcohol-based handrub (AHR) has become the gold standard for hand hygiene. Data on AHR consumption are easy to obtain and can serve as an approximation for hand hygiene compliance. As described earlier, AHR consumption varies among European hospitals. In the current study the role of various hospital and country indicators for AHR consumption is analysed.

Methods: As part of the European Prevention of Hospital Infections by Intervention and Training (PROHIBIT) project hospital-based data on infection prevention and control (IPC) structure and organisation and hospital-wide AHR consumption were obtained from acute care hospitals. National indicators such as income, public health expenditure, national hand hygiene campaigns, IPC training, and the six Hofstede dimensions were identified. Univariable and multivariable linear regression analysis using generalized linear models were performed to estimate the association between AHR consumption and indicators on hospital and on country level.

Results: Data of 232 hospitals from 22 European countries were analysed. Multivariate risk factor analysis showed independent associations between AHR consumption and private and university-affiliated hospitals (multiplicative effect, 95% confidence interval: 1.76, 1.21-2.55; and 1.39, 1.17-1.64, respectively), high-income countries (3.61, 2.94-4.43), and countries offering national curricula for the training of IPC nurses (3.77, 2.32-6.13). However, no cultural dimension was independently associated with AHR consumption.

Conclusion: Country indicators such as high-income, national training on IPC, and hospital type and status are positively associated with AHR consumption in Europe.

Introduction

Healthcare-associated infections (HAI) are considered the most frequent adverse event in healthcare delivery, resulting in increased morbidity and mortality, prolonged hospital stay, and disability [1]. An estimated 3.2 million patients acquire an HAI in acute care hospitals in Europe every year [2], with emerging antimicrobial resistance contributing to the burden of HAI [3, 4].

Hand hygiene is considered the most effective way to reduce the transmission of (multidrug-resistant) organisms and to prevent HAI. Hand disinfection with alcohol-based handrub (AHR) has replaced hand washing because it is a simple act and effectively reduces microorganisms on hands [5, 6]. Hand rubbing with AHR has become the gold standard for hand hygiene. Numerous promotion activities for hand hygiene improvement have been described in the literature, and many countries have committed to the implementation of hand hygiene campaigns [7,8,16,17]. Provision of AHR at the point of care, performance monitoring with feedback to healthcare workers (HCWs), and support by hospital managers have been identified as the three most important interventions in hand hygiene promotion [11, 18, 19].

Compliance with hand hygiene can be measured by direct observation or by indirectly measuring AHR consumption. While direct hand hygiene observation is costly and time-consuming, data on AHR consumption are easy to obtain and can serve as an approximation for hand hygiene compliance. Correlation between AHR consumption and observed hand hygiene compliance has been described [7-10]. Both methods direct hand hygiene observation and AHR consumption suggest that hand hygiene compliance needs improvement [2, 11, 12, 13].

As published earlier, the “Prevention of Hospital Infection by Intervention and Training” (PROHIBIT) survey identified variation of AHR consumption among European hospitals, with

higher consumption in Northern Europe and lower consumption in Eastern and Southern Europe [11]. Variation may be explained with differences in resources, the role of infection prevention and control (IPC), legal aspects, and cultural norms [14, 15]. The current paper analyses the role of hospital and country indicators as facilitators for AHR consumption in European acute care hospitals.

Methods

PROHIBIT is a European Commission Framework 7 project addressing IPC activities in Europe on various levels (www.prohibit.unige.ch). One of four scientific work packages measured organisation and structure of IPC in European hospitals. European IPC experts were invited to act as national contact points and to enrol up to 30 hospitals to participate in the PROHIBIT survey between September 2011 and March 2012. In case more than 30 hospitals participated in the survey, 30 institutions were selected randomly to avoid over-representation of countries. Detailed information about the survey method is described elsewhere [11, 21]. In total, 309 hospitals from 24 countries contributed data to the PROHIBIT reference dataset. Of these, only hospitals reporting data on hospital-wide AHR consumption were eligible to be analysed in the current study (Supplementary Table S1) [11]. Institutional structure and IPC organization as well as retrospective data on AHR consumption were reported by the local IPC professionals for the year 2010 (Supplementary Table S1).

On the national level, the following indicators were identified: public healthcare expenditure (HCE) as proportion on the general domestic product (GDP) for 2010 [22], income class according to the World Bank for 2010 [23], national hand hygiene campaigns between 2000 and 2009 [17], education and training of IPC professionals as reported by the “Training in infection control in Europe” (TRICE) project in 2010 [24], and the six Hofstede dimensions on national culture [25] (Supplementary Table S2). The latter describe value differences between countries.

Statistical analysis

All categorical variables were dummy coded and continuous variables were categorized where appropriate. Numbers and percentages or medians with interquartile ranges were

calculated for descriptive analysis. The primary outcome was log-transformed AHR consumption in millilitres per patient-day for 2010. The level of analysis was the hospital.

Univariable and multivariable linear regression analysis using generalized linear models were performed to estimate the association between AHR consumption and variables on hospital level (hospital structure), IPC-level (organisation of IPC), and on country level (income class, public health expenditure, national hand hygiene campaigns, available training for IPC professionals (nurses and doctors), and the six Hofstede dimensions). Multivariable analysis was performed after testing each variable in a univariable model. Then, for every level (hospital-level, IPC-level and country-level) a multivariable model was calculated with the level parameters only. All variables with a p-value ≤0.2 in the univariable analysis were included in the multivariable model and significant independent variables were calculated by stepwise backward variable selection. The exclusion criteria were the smallest value and the p ≥0.05 in the Type III test. Analogous, one final model was calculated with all variables of all three levels. Regression coefficients were converted to the measures of effect using an exponential transformation and referred to as the multiplicative effect (ME) of the analysed parameters. Clustering on the country level was taken into account in all models by applying generalized estimating equations (GEE).

Results

Of the PROHIBIT reference dataset, 232 hospitals from 22 countries provided data on hospital-wide AHR consumption, representing 5.7 million patients and 35.5 million patient-days (Supplementary Table S1). Hospitals were predominantly public (86%) with a median (interquartile range [IQR]) of 425 (269-777) beds. Median (IQR) AHR consumption was 21 (9-37) ml per patient-day. Table 1 and 2 summarise hospital characteristics and IPC organisation. Table 3 summarises country-level variables. Hospitals were most often located in high-income countries (86%).

Table 4 summarises the results of the univariable analysis. AHR consumption was associated with private and university-affiliated hospitals (multiplicative effect [ME], 95% confidence interval [95%CI]: 1.60, 1.14-2.25 and 1.31, 1.08-1.60, respectively), and with specialised and hospitals ≥ 600 beds (ME, 95%CI: 1.29, 1.02-1.63 and 1.28, 1.05-1.55, respectively). On the country level, AHR consumption was associated with high income (ME, 95%CI: 2.08, 1.23-3.51), offering national IPC training for both doctors and nurses (ME, 95%CI: 1.89, 1.01-3.56 and 3.13, 1.89-5.18, respectively), and with the Hofstede dimension “Indulgence versus restraint” (ME, 95%CI: 1.23, 1.10-1.36).

Table 5 summarises the results of the multivariable model. Only four variables remained in the model: private and university-affiliated hospitals (ME, 95%CI: 1.76, 1.1.21-2.55 and 1.39, 1.17-1.64, respectively), high-income countries (ME, 95%CI: 3.61, 2.94-4.43), and offering IPC training for nurses (ME, 95%CI: 3.77, 2.32-6.13). No Hofstede dimension was independently associated with AHR consumption.

Discussion

This study shows that AHR-consumption in private and university-affiliated hospitals is significantly higher compared to other hospital types. Similarly, AHR consumption is higher in hospitals from high-income countries, and from countries offering IPC training for nurses.

While the level of income is associated with AHR consumption, healthcare-expenditure as per GDP is not. Thus, purchasing AHR is linked to financial capacity of a hospital more than it is associated with a proportion of HCE. We speculate that a country with higher HCE as per GDP can have less financial capacity to purchase AHR on an international market than a high-income country spending less to healthcare as per GDP. In addition, high-income countries may have an attitude towards generally valuing wellbeing of their citizens. Thus, cultural context of a country, which is influenced by the level of income, has an influence on behaviour and may have an important role in spending more money for safety [26]. Higher AHR consumption in University hospitals may be due to both having an academic attitude towards patient safety, and having a larger budget compared to general hospitals. The fact that offering national IPC training, at least for nurses, is associated with AHR consumption is encouraging. It suggests that change of attitude by increasing the number of trained professionals may have a positive effect on patient safety. For example, participating hospitals in Poland showed AHR consumption above average even though HCE as per GDP was below the European average [22] but a national training for IPC nurses was in place [24].

Rather unexpectedly, national hand hygiene campaigns had no association with AHR consumption, not even in the univariable model. A number of national hand hygiene campaigns were reported success stories (“Hand hygiene Australia” in Australia, “Aktion Saubere Hände” in Germany, “cleanyourhands campaign” in the United Kingdom). Hand hygiene compliance measured by direct observation significantly increased in all campaigns.

However, while direct hand hygiene observations (in selected hospital departments) can detect short time improvement, AHR consumption (as a hospital-wide measure) may not. For example, “hand hygiene Australia” stopped measuring AHR consumption because the data were perceived too variable and inaccurate compared to direct hand hygiene observations (personal communication L Grayson).

The “indulgence versus restraint“ dimension was associated with AHR consumption in the univariable analysis. This is an interesting finding because people from indulgent countries have a more optimistic attitude towards life, are more extraverted, foster friendships, and function in teams rather than as individualists. This finding completes the above-mentioned association of income to AHR consumption, and is in line with reports about the role of organisational culture in the prevention of HAI and transmission of multidrug-resistant organisms (15, 27). However, given that there was no association in the multivariable model neither for this nor for any other Hofstede dimension, interpretation must be cautious.

The current study has some limitations: firstly, participation in the survey was based mainly on hospital interest rather than on a systematic and randomised sampling process. Due to this, the current data may have overestimated IPC activities and AHR consumption in European hospitals. A randomly selected sample would have improved representation of European hospitals. However, the questionnaire could not have been imposed on hospitals, and thus, the number of participating hospitals and data quality most likely would have been lower. Secondly, data were obtained by questionnaire rather than by observation [11, 21]. As already mentioned, the national campaigns’ specific details or time-distance to the survey were not taken into consideration.

Despite these limitations, the results show the impact of national IPC training on AHR consumption. Organisational aspects such as private setting and university-affiliation, and level of income point towards the importance of resource availability in purchasing AHR, and

thus, investing in patient safety. As a consequence, IPC training activities should be intensified and harmonised in Europe, in order to support implementation of IPC in all countries [28].

Transparency declaration

The authors declare that they have no conflicts of interest.

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Contribution of authors

SH, FS, PG, and WZ designed the study and reviewed and commented on the manuscript. PG was the work package leader of PROHIBIT. SH was the project manager of the PROHIBIT work package. FS analysed the data and SH and WZ interpreted the results and wrote the manuscript.

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Table 1 Hospital characteristics of European hospitals reporting on alcohol-based handrub consumption — The Prevention of Hospital Infection by Intervention and Training (PROHIBIT) survey

Variable	All hospitals, n=232
Status	
Public, n (%)	200 (86.2)
Private, n (%)	19 (8.2)
Public and private, n (%)	13 (5.6)
University-affiliation, n (%)	75 (32.3)
Type	
Primary care, n (%)	46 (19.8)
Secondary care, n (%)	102 (44.0)
Specialized care, n (%)	78 (33.6)
Other, n (%)	6 (2.6)
Size	
Hospitals with ≥ 600 beds, n (%)	78 (33.8)
Isolation capacity	

Single-bedrooms (%), median (IQR)	5.6 (2.4-12.2)
Number of acute care admissions (N) in 2010, median (IQR)	19,021 (10,266-31,236)
Number patient-days in 2010 patient days, median (IQR)	104,521 (59,251-197,351)
Average length of stay in 2010, median (IQR)	6.17 (5.01-7.29)
Average hospital bed occupancy (%) in 2010, median (IQR)	69 (55-80)

IQR, interquartile range

Table 2 Organisation of infection prevention and control in European hospitals reporting on alcohol-based handrub consumption — The Prevention of Hospital Infection by Intervention and Training (PROHIBIT) survey

Variable	**All hospitals, n=232**
IPC professionals per 100 hospital beds, median (IQR)	0.5 (0.3-0.8)
*Affiliation of the infection control programme**	
Department of nursing, n (%)	19 (8.2)
Service of infectious diseases, n (%)	18 (7.8)
Hospital administration, n (%)	47 (20.3)
Microbiology, n (%)	34 (14.7)
Own department or service, n (%)	95 (40.9)
Other, n (%)	54 (23.3)
Link-nurse system, n (%)	156 (67.2)
Surveillance of AHR consumption	
In any setting, n (%)	206 (88.8)
Hospital wide, n (%)	189 (81.5)

Feedback of to HCWs ≥ twice a year, n (%)	64 (27.6)
IPC committee is provided with AHR data, n (%)	146 (62.9)
Direct hand hygiene observations, n (%)	177 (76.3)
Type of feedback on hand hygiene compliance to HCWs	
Individual, immediately after audits, n (%)	112 (48.3)
Part of general feedback to ward staff, n (%)	101 (43.5)

*Multiple answers possible

AHR, alcohol-based handrub; HCW, healthcare worker; ICU, intensive care unit; IPC, infection prevention and control; IQR, interquartile range

Table 3 Country indicators of European hospitals reporting on alcohol-based handrub consumption — The Prevention of Hospital Infection by Intervention and Training (PROHIBIT) survey

Variable	All hospitals, n=232
Hospital of a high-income country in 2010[a], n (%)	200 (86.2)
Hospital of a country with total (public and private) HCE defined as the proportion of GDP in 2010 above the European median (9.0%)[b], n (%)	123 (53.0)
Hospital of a country with public HCE defined as the proportion of GDP in 2010 above the European median (6.5%)[b], n (%)	136 (58.6)
Hospital of a country that organized one or more national hand hygiene campaigns in 2000-2009[c], n (%)	122 (52.6)
Hospital of a country offering a national curriculum or training programme for IPC doctors[d], n (%)	116 (52.3)
Hospital of a country offering a national curriculum or training programme for IPC nurses[d], n (%)	145 (65.3)
Hospital of a country offering IPC training courses based on the European core curriculum[d], n (%)	139 (66.2)
Hospital of a country where information about the six autonomous dimensions of the national culture model according to Hofstede[e] is available	232 (100.0)

GDP, gross domestic product; HCE, health care expenditure

[a]Countries' income grouping according to World Bank methods in 2010 [23]
[b]HE defined as the share of the GDP in 2010 [22]
[c]Presence of a national hand hygiene campaign [17]
[d]State of the art of training IPC professionals in Europe according to the TRICE project [24]
[e]Six autonomous dimensions of the national culture model according to Hofstede [25]

Table 4 Results of the univariable models for consumption of alcohol-based handrub — The Prevention of Hospital Infection by Intervention and Training (PROHIBIT) survey

		Univariable models	
Variables	**Category**	*ME (95% CI)*	*p-value*
Hospital parameters (hospital-level variables)			
Hospital Status			
Public	Yes	0.75 (0.63-0.90)	0.002
Private	Yes	1.60 (1.14-2.25)	0.007
Public and private	Yes	0.93 (0.66-1.32)	0.700
University hospital	Yes	1.31 (1.08-1.60)	0.006
Hospital Type			
Primary care	Yes	0.77 (0.64-0.93)	0.006
Secondary care	Yes	0.89 (0.69-1.14)	0.350
Tertiary care	Yes	1.73 (0.54-5.52)	0.356
Specialized care	Yes	1.29 (1.02-1.63)	0.031
Hospital Size			
≥ 600 beds	Yes	1.28 (1.05-1.55)	0.014
Proportion of single-bedrooms	≥ median	1.15 (0.87-1.52)	0.311
Length of stay	≥ median	0.92 (0.70-1.20)	0.547
Hospital bed occupancy	≥ median	0.91 (0.65-1.28)	0.586
IPC personnel per 100 beds	≥ median	1.13 (0.89-1.45)	0.316
IPC parameters (IC-level variables)			
Affiliation of IPC programme			

Department of nursing	Yes	0.79 (0.60-1.04)	0.092
Infectious Diseases department	Yes	1.61 (0.93-2.79)	0.087
Hospital administration	Yes	1.18 (0.80-1.74)	0.416
Microbiology department	Yes	0.84 (0.68-1.03)	0.088
Own (independent) department	Yes	0.98 (0.76-1.25)	0.860
Other affiliation	Yes	0.90 (0.70-1.16)	0.416
Link-nurse system established	Yes	0.99 (0.74-1.32)	0.938
Surveillance of AHR consumption			
In any area of the hospital	Yes	0.93 (0.48-1.79)	0.825
Hospital wide	Yes	0.82 (0.57-1.19)	0.297
Direct hand hygiene observations	Yes	1.08 (0.72-1.62)	0.701
Feedback			
Formal feedback about AHR consumption to the HCWs ≥ twice a year	Yes	1.15 (0.88-1.50)	0.299
Individual feedback immediately after direct hand hygiene observation	Yes	1.01 (0.81-1.25)	0.949
General feedback to ward staff	Yes	1.14 (0.88-1.48)	0.316
Feedback about AHR consumption to the IC committee	Yes	1.08 (0.80-1.46)	0.604
Country parameters (country-level variables)			
High income country[a]	Yes	2.08 (1.23-3.51)	0.006
Total (public and private) HE defined as the share of the GDP (2010)[b]	per percent point	1.17 (1.03-1.33)	0.016
Private HE defined as the share of the GDP (2010) [b]	per percent point	1.17 (1.03-1.34)	0.019
Presence of national HH campaign[c]	Yes	0.96 (0.53-1.75)	0.893
Presence of a national curriculum or programme for training of IPC doctors[d]	Yes	1.89 (1.01-3.56)	0.048
Presence of a national curriculum or programme for training of IPC nurses[d]	Yes	3.13 (1.89-5.18)	<0.0001
National IPC training courses are (at least partially) based on the European core curriculum[d]	Yes	1.22 (0.62-2.42)	0.570
Hofstede's cultural dimensions[e]			
Individualism versus Collectivism (IDV)	per 10 score points	1.02 (0.88-1.18)	0.824

Indulgence versus Restraint (IND)	per 10 score points	1.23 (1.10-1.36)	<0.001
Long Term versus Short Term Normative Orientation (LTO)	per 10 score points	0.93 (0.82-1.05)	0.221
Masculinity versus Femininity (MAS)	per 10 score points	0.94 (0.85-1.03)	0.176
Power Distance Index (PDI)	per 10 score points	0.92 (0.83-1.01)	0.076
Uncertainty Avoidance Index (UAI)	per 10 score points	0.93 (0.83-1.04)	0.221

AHR, alcohol-based hand rub consumption; HCE, health care expenditure; HCW, healthcare worker; IPC, infection prevention and control; ICU, intensive care unit; ME, multiplicative effect; 95% CI, 95% confidence interval; GDP, gross domestic product
[a]Countries' income grouping according to World Bank methods in 2010 [23]
[b]HE defined as the share of the GDP in 2010 [22]
[c]Presence of a national hand hygiene campaign [17]
[d]State of the art of training IPC professionals in Europe according to the TRICE project [24]
[e]Six autonomous dimensions of the national culture model according to Hofstede [25]
Generalized linear models (GLM) were performed to estimate the association between log-transformed AHR consumption and the analysed parameters. Regression coefficients were converted to the measures of effect using an exponential transformation and referred to as the multiplicative effect (ME) of the analysed parameters. Clustering on the country level was taken into account in all models by applying generalized estimating equations (GEE).

Table 5 Results of multivariable models for consumption of alcohol-based handrub — The Prevention of Hospital Infection by Intervention and Training (PROHIBIT) survey

		Multivariable models with level variable only (level-models)		**Multivariable model with all variables (final model)**	
Variables	**Category**	ME (95% CI)	p-value	ME (95% CI)	p-value
Hospital parameters *(hospital-level variables)*					
Hospital Status					
Private	Yes	1.70 (1.19-2.43)	0.004	1.76 (1.21-2.55)	0.003
University hospital	Yes	1.36 (1.11-1.68)	0.004	1.39 (1.17-1.64)	<0.001
Country parameters *(country-level variables)*					
High income country[a]	Yes	3.58 (2.95-4.34)	<0.001	3.61 (2.94-4.43)	<0.001
Presence of a national curriculum or programme for training of IPC nurses[d]	Yes	3.91 (2.39-6.40)	<0.001	3.77 (2.32-6.13)	<0.001
Cultural dimension[e]					
Indulgence versus Restraint (IND)	per 10 score points	1.23 (1.10-1.36)	<0.001		

IPC, infection prevention and control; ME, multiplicative effect; 95% CI, 95% confidence interval.
[a]Countries' income grouping according to World Bank methods in 2010 [23]
[d]State of the art of training IPC professionals in Europe according to the TRICE project [24]
Generalized linear models (GLM) were performed to estimate the association between log-transformed AHR consumption and the analysed parameters. Regression coefficients were converted to the measures of effect using an exponential transformation and referred to as the multiplicative effect (ME) of the analysed parameters. Clustering on the country level was taken into account in all models by applying generalized estimating equations (GEE).