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Implementation of multimodal infection control and hand hygiene strategies in acute-care hospitals in Greece: a cross-sectional benchmarking survey

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ABSTRACT

Background: In this first attempt to suggest achievable standards for improvement in hospital infection prevention and control (IPC) in Greece, we assessed main IPC structure and process indicators emphasizing on hand hygiene.

Methods: Acute-care hospitals across the country participated in a cross-sectional survey by completing the World Health Organization Hand Hygiene Self-Assessment Framework (HHSAF) and by providing hospital-level IPC indicators.

Results: Seventeen hospitals completed the survey, comprising 14% of the country's public hospitals. Median IPC staffing levels were 0.8 nurses and 0.5 doctors per 250 beds, respectively. Few hospitals implemented full multimodal IPC programs. HHSAF indicated that appropriate hand hygiene practices and promotion strategies were in place in most hospitals, but mean HHSAF score (289) was lower compared to studies in Italy (332, $p=0.040$) and the USA (373, $p<0.001$). Presence of one additional IPC nurse was independently associated with increases by 53% in the HHSAF median score for training-education ($p=0.035$) and by 38% in the lower 30th percentile score for safety climate ($p=0.049$).

Conclusions: Surveyed hospitals are, on average, at an intermediate level in hand hygiene practice but require improvements on training-education, evaluation-feedback and safety climate. Ensuring adequate IPC nurse staffing levels and systematically implementing multimodal IPC programs may lead to substantial improvements.

Keywords:

Hand Hygiene Self-Assessment Framework; Infection prevention and control; Structure and process indicators; healthcare-associated infection; benchmarking.

INTRODUCTION

Promotion of adequate hand hygiene standards and practices is a critical strategy in reducing the risk of healthcare-associated infections (HAIs) and limiting the spread of antimicrobial resistance in healthcare facilities.[1,2] Major guidelines for appropriate hand hygiene practices in hospital settings have been published more than a decade ago,[3] but compliance with recommendations has been proven challenging and remains low worldwide.[4] Responding to this challenge, the World Health Organization (WHO) has released standardized tools to assess hand hygiene practices and promote improvement programs. A Multimodal Hand Hygiene Improvement Strategy (MHHIS) was released in 2009, describing preventive measures, standards and tools to improve hand hygiene and accompanied by an implementation toolkit to help translate guidelines into practice.[5] The effectiveness of MHHIS in improving hand hygiene practices has been demonstrated in quasi-experimental studies in various settings.[6,7]

In Greece, HAIs are encountered with an average daily prevalence of 9.1% affecting approximately 121,000 acute-care patients each year in the country.[8] Alongside increasing levels of antimicrobial resistance, HAIs have been shown to pose a significant burden on the Greek hospital system in terms of increased length of hospitalization, mortality and costs.[8] However, there is little understanding of current needs in core components for effective infection prevention and control (IPC) programs and there has been no evaluation of the status of implementation of the WHO MHHIS in hospitals in the country to date.

Our objectives in this study were to: (1) describe key IPC infrastructure and processes in acute-care hospitals in Greece; (2) assess, for the first time, the level of implementation of the WHO MHHIS in these facilities; (3) examine the effect of staffing levels on the degree of implementation of MHHIS; and (4) benchmark our results against comparable international data. Our ultimate aim is to illustrate how this benchmarking exercise may help to suggest achievable standards for improvement in hospital hand hygiene and IPC practices.

METHODS

Study design and setting

This cross-sectional survey used a self-administered questionnaire to record main structure and process indicators for IPC at the hospital level, emphasizing on the status of hand hygiene practices. Acute-care hospitals across the country were invited to participate by completing the WHO Hand Hygiene Self-Assessment Framework (HHSAF)[9] and by providing hospital-level IPC indicators in accordance with the protocol of the European Centre for Disease Prevention and Control (ECDC) for conducting prevalence surveys of HAIs in acute-care hospitals.[10]

We recruited hospitals on a voluntary basis using a purposive sampling method. We aimed for maximum variation in our sample by including at least one secondary care and one tertiary care hospital from each of the seven Regional Health Districts across the country. We excluded primary care facilities from our sampling frame in order to obtain a snapshot of the status of IPC programs in high-risk settings where future improvements may have the highest impact. We invited 21 public hospitals to participate in the study, of which 17 (81%) returned the questionnaires. One hospital returned only summed component scores in the HHSAF questionnaire.

Survey tools

The HHSAF was used to assess the status of hand hygiene practice and promotion in participating hospitals. HHSAF is a validated tool,[11] comprising of 27 indicators grouped into 5 sections that reflect the key components of MHHIS: system change, education and training, evaluation and feedback, reminders in the workplace, and promotion of an institutional safety climate for hand hygiene. Each component is scored out of 100 points, for a total maximum score of 500. Hand hygiene implementation progress is classified as: inadequate (score 0-125), basic (126-250), intermediate (251-375), or advanced (376-500).[9] Hospitals achieving an advanced level may

complete a leadership section containing 20 additional indicators scored out of 20 additional points. A score of 12 or higher in the latter identifies hand hygiene reference centers.[9]

In addition, we used the ECDC hospital questionnaire to collect data on hospital type, numbers of beds, discharges and patient-days in the preceding year and IPC structure and process indicators.[10] The latter included: (1) alcohol-based hand rub use (liters in preceding year) as a surrogate indicator of hand hygiene activity; (2) numbers of single-bed rooms, airborne infection isolation rooms and cohorting areas as indicators of the isolation capacity of patients colonized or infected with microorganisms requiring enhanced IPC measures; (3) numbers of inpatient blood culture sets and stool tests for *Clostridium difficile* (enzyme immunoassay for glutamate dehydrogenase and toxin A/B antigens) processed by the microbiology lab in the preceding year and availability of routine microbiological and screening test results to clinicians on weekends as proxies of the capacity of microbiology and diagnostic services; (4) number of full-time IPC nurses and doctors in the hospital; and (5) existence of core components of a multimodal IPC program including guidelines, care bundles, training, audits, surveillance and feedback. Additionally, we asked participants to provide, if available, their most recent estimate of the hospital-wide rate of hand hygiene compliance obtained by direct observation using any available methodology.

Questionnaires were translated in Greek by the authors. The Infection Control Unit of the University Hospital of Heraklion, a 750-bed, tertiary-care institution, provided a help-desk service and coordinated the study. IPC nurses in participating hospitals completed the surveys in November 2016. The HHSAF took, on average, about two hours to complete. The ECDC questionnaire required data from microbiology laboratories, pharmacy departments, human resources and patient admissions, which had a waiting time of about one week. When the required data became available, the ECDC questionnaire took less than 30 minutes to complete.

Data analysis

Hospital characteristics and IPC and hand hygiene indicators were summarized using counts and percentages for categorical data and median values and interquartile ranges (IQR) for ordinal and continuous data. To produce indicators comparable across hospitals and over time, we report alcohol-based hand rub use in liters per 1,000 patient-days per year, single-room beds and airborne infection isolation rooms as a percentages of the total number of beds, and numbers of inpatient blood culture sets and stool tests for *Clostridium difficile* per 1,000 patient-days per year. In line with the reference standard of 1 IPC nurse per 250 hospital beds derived from the landmark SENIC study,[12] and mandated by Greek national legislation (Ministerial Decision Y1.114971/18.02.2014), we report the numbers of full-time IPC staff per 250 beds.

To compare the level of progress of MHHIS implementation in study hospitals with external benchmarks, PubMed was searched for recently published multicenter studies reporting HHSAF scores in other countries. We identified a regional multicenter study in Italy,[13] a nationwide study in the USA,[14] and a study in 91 countries performed by the WHO.[15] We extracted data on the distribution of HHSAF category levels and mean HHSAF scores, and assessed the statistical significance of differences with the current study using chi-squared tests and t-tests, respectively.

Quantile regression with bootstrapped standard errors (1,000 replications) was used to estimate the effects of staffing levels on overall and component HHSAF scores, adjusting for teaching status and number of acute-care beds in participating hospitals. The possibility of heterogeneous associations across the distribution of HHSAF scores was examined by separately considering the 30th and 70th percentile scores.

RESULTS

Study sample

The 17 surveyed hospitals comprised 14% of all acute-care hospitals in the Greek National Healthcare System, had 8,948 beds and admitted 673,191 patients for a total of 2,537,744 patient-days in 2015 (27%, 30% and 30% of the country's total, respectively). Surveyed hospitals ranged in size from 144 to 945 inpatient beds (median, 470 beds); most were non-teaching (71%), tertiary-care (65%) hospitals.

Main IPC infrastructure and process indicators

Table 1 reports main indicators of IPC infrastructure and processes in surveyed hospitals. The median percentages of single-room beds, cohorting areas and isolation rooms were 2.3%, 1.5% and 0.1% of all beds, respectively. Type of isolation capacity varied substantially: one hospital reported not having single-bed rooms, five hospitals (31%) did not utilize cohorting areas, and seven hospitals (41%) did not have rooms for airborne infection isolation. The median IPC staffing levels were 0.8 nurses and 0.5 doctors per 250 hospitals beds; 6 (35%) and 15 (88%) hospitals did not employ full-time IPC doctors and antibiotic stewardship consultants, respectively. Most hospitals perform routine clinical (94%) and screening tests (65%) on weekends and more than half (59%) have a protocol in place for active colonization screening on admission of high-risk patients and/or in high-risk units. Microbiological laboratories had incubated a median of 31.2 inpatient blood culture sets per 1,000 patient-days and had performed a median of 3.0 inpatient stool tests for *C. difficile* per 1,000 patient-days in 2015.

The majority of surveyed hospitals (82%) have an annual IPC plan in place that was approved by their managing directors; however, only 35% produce an approved annual IPC report. Three quarters of the hospitals had evaluated hand hygiene compliance by direct observation in the last two years, with reported compliance proportions ranging between 17% and 56%. The median hand

rub consumption in 2015 was 63.6 liters per 1,000 patient-days, varied widely between hospitals (from 37 to 110 liters per 1,000 patient-days), and had a moderate positive correlation with reported hand hygiene compliance rates (Pearson correlation coefficient, r = 0.45).

Almost all hospitals (94%) participate in the “Procrustes” national surveillance program of infections caused selected multidrug-resistant pathogens and 10 hospitals (59%) report data to a national coordination center for comparative analysis in accordance with the EARS-Net protocol. However, less than a third of the hospitals participate in national or international networks for the surveillance of antimicrobial consumption and very few hospitals have joined networks for targeted or high-risk surveillance of healthcare-associated infections.

A limited number of hospitals implement the full range of core components for a multimodal IPC program in intensive-care units and even less in the wards (**Table 2**). The most prevalent IPC components include guidelines, training and surveillance. Care bundles and feedback is less frequent and very few hospitals implement checklists and audits.

Status of hand hygiene practice and promotion

The median HHSAF overall score was 258 points (IQR, 238 - 358). No study hospital had an inadequate level of WHO MHHIS implementation. Most hospitals attained an intermediate (n=9, 53%) or a basic (n=7, 41%) HHSAF level. One hospital (6%) achieved the advanced level and identified as reference center for hand hygiene promotion, having scored 13 out of 20 in the leadership section of the HHSAF.

The distributions of HHSAF component scores are compared in **Figure 1**. A high median score of 85 (IQR 80 - 100) was obtained in the first section of HHSAF which focused on system changes, product supply and the availability of hand washing facilities, with 77% of study hospitals achieving advanced level in these areas. Overall scores for education and training (median 55, IQR 35 - 75) and reminders in the workplace (median 68, IQR 58 - 83) reflected the achievement of an overall intermediate level in these components. Mandatory or regular training in hand hygiene for all

healthcare workers is required at least annually in most hospitals (81%), but only 20% have a system in place for training and validating hand hygiene compliance observers and almost all hospitals (94%) do not have a dedicated budget for training. The great majority of hospitals displays posters in most or all wards explaining indications for hand hygiene and correct techniques for hand rubbing and hand washing (81%, 94%, and 91%, respectively). However, a minority (25%) uses other workplace reminders, such as screen savers, badges, stickers etc.

Surveyed hospitals obtained only basic progress scores regarding the implementation of evaluation and feedback (median 45, IQR 30 - 58) and institutional safety climate (median 35, IQR 20 - 55) in hand hygiene practice. Most hospitals (69%) reported that hand hygiene compliance is irregularly evaluated by direct observation. More commonly, hand hygiene practices are indirectly monitored by surrogate markers such as alcohol-based hand rub consumption (81%) and/or soap consumption (56%). Immediate feedback is given to healthcare workers at the end of each observation session for hand hygiene in 56% of hospitals. A minority of hospitals (31%) provides regular feedback to hospital staff or administration leaders regarding hand hygiene indicators and their trends over time. Most hospitals reported that executive leaders (chief executive officer, medical director and director of nursing) have made a clear commitment to support hand hygiene improvement (75%, 69%, and 81%, respectively), but only half of the hospitals have established a dedicated hand hygiene team and less than a fifth (19%) have a system in place for designating hand hygiene champions. Patients are informed about the importance of hand hygiene at 63% of hospitals, but a formalized program to engage patients has been implemented at only one (6%) hospital. Initiatives to support local continuous improvement in hand hygiene are also narrowly implemented. Most hospitals (75%) regularly mention hand hygiene in newsletters, clinical meetings and other communications, but only 13% share local innovations in hand hygiene, 6% use e-learning tools and no hospital has a system for personal accountability. Finally, about a third of all hospitals (37%) have established a clear plan for participation in the World Day of Hand Hygiene each May.

A comparative analysis of performance in the Hand Hygiene Self-Assessment Framework in the current survey with international benchmarks is presented in **Table 3**.

Staffing levels and implementation progress in hand hygiene

Quantile regression analysis (**Table 4**), taking hospital size and teaching status into account, showed that presence of one additional IPC nurse was associated with an increase of about 20% in the median total HHSAF score (p=0.090) and a significant increase of about 53% in the median training and education component score (p=0.035). This effect was greater in hospitals scoring in the lower 30th percentile, for which the presence of one additional IPC nurse was also associated with higher institutional safety climate score (increase by 38%, p=0.049). Numbers of IPC doctors, antibiotic stewardship consultants, ward nurses or nursing assistants had negligible effects on HHSAF total or component scores.

DISCUSSION

This study evaluated, for the first time, standardized IPC structure and process indicators in acute-care hospitals in Greece, focusing on the level of implementation of hand hygiene improvement programs in these facilities. Our results reveal that very few hospitals implement the full range of core components for a multimodal IPC program. Existing IPC programs are based mostly on provision of guidelines, training and surveillance targeted in high-risk areas, while care bundles and feedback are less frequent and very few hospitals implement checklists and audits. These programs operate on particularly low staffing levels and with limited availability of patient isolation facilities.

In this context, the overall HHSAF score indicates that, on average, surveyed hospitals have attained an intermediate hand hygiene level. This means that appropriate hand hygiene practices and promotion strategies are in place, but it is now imperative to develop long-term plans for

sustainability of efforts.[9] Specific HHSAF component scores in this study reflect the achievement of advanced level in terms of system change for hand hygiene and intermediate performance regarding the use of reminders in the workplace. Less encouraging results were found regarding staff education, which was at the lower limit of 'intermediate', and only basic progress scores were recorded on practices related to evaluation and feedback and institutional safety climate for hand hygiene. Moreover, a stronger IPC policy should be implemented in order to improve the low rate of hand hygiene adherence (median, 37%) recorded in this study.

Few national or regional studies providing systematic situation analysis of hand hygiene resources, structures, practices and promotion in hospitals have been performed to date.[13–15] Comparison with these external benchmarks shows that surveyed hospitals in Greece have achieved similar standards in terms of system change and reminders in the workplace as those reported in healthcare facilities in the USA,[14] Italy,[13] and other European countries.[15] It also confirms that there is significant room for improvement before Greek hospitals may reach achievable standards in terms of other core components of multimodal hand hygiene strategies.

Creation of a strong institutional safety climate has been identified as the weakest component of hand hygiene multimodal strategies in healthcare facilities in the USA and Italy,[13,14] and was also found particularly weak in the present study. Similar to the situation analyses in USA and Italy,[13,14] there is a clear commitment of executive leaders to support hand hygiene improvement programs in most Greek hospitals, but teams formally dedicated to hand hygiene promotion are still lacking and the designation of hand hygiene champions appears to be considered an unimportant promotion strategy. However, the role of champions has been suggested to be a key role in promoting behavioral changes in infection control,[16] including the improvement of hand hygiene adherence.[17] The systematic implementation of multimodal IPC programs may also help to establish a comprehensive patient safety climate.[13]

Another neglected strategy appears to be the active involvement of patients in hand hygiene promotion activities. A formalized program of patient engagement has been implemented at only

one (6%) of the surveyed hospitals in Greece, compared to 15% of Italian and 45% of US healthcare facilities.[13,14] It may be challenging to refute the myth that patient involvement undermines the relationship between the doctor or healthcare worker and the patient,[18] but the active involvement of patients is a viable strategy for increasing hand hygiene compliance,[19] and guidance to support such initiatives has been developed by the WHO.

Our results show that despite the existence of overall good standards in monitoring practices in participant hospitals, feedback of hand hygiene indicators to healthcare workers and leaders is suboptimal. Audit and feedback can be effective in improving professional practice, especially when adherence to recommendations is low and when feedback is delivered more intensively.[20] However, attempts to increase hand hygiene compliance of healthcare workers through personal or group feedback have met with mixed success.[21,22] Regular audit and feedback has been more effective in improving process indicators that are likely to be influenced by administrative controls,[22] and may help to overcome systemic and practical obstacles to hand hygiene performance.[13]

Importantly, performance on the HHSAF in this study was associated with the level of IPC nurse staffing, particularly in achieving significantly better progress in IPC training and education. The effect was greater in hospitals with the weakest implementation progress, where IPC nurse staffing level was also associated with increased institutional safety climate. Our findings are consistent with those reported from healthcare facilities in the USA,[14] thereby providing further support for the necessity of having adequate proportions of IPC nurses based on the number of inpatient beds. Notably, this study reveals that other staffing levels, including IPC doctors, antibiotic stewardship consultants and ward nurses, may have no effect on the level of implementation of hand hygiene practices and promotion strategies.

The ratio of 1 IPC nurse per 250 hospital beds derived more than 30 years ago remains a commonly cited standard and appears to have been achieved in most US hospitals (median, 1.9 IPC nurses per 250 beds),[14] but less so in European hospitals (median, 1.0 IPC nurses per 250 beds; IQR,

0.54 – 1.66).[23] The standard of 1 IPC nurse per 250 beds was mandated in Greek national law in 2014, but our study reveals that this standard has not been reached in about two thirds of the surveyed hospitals (median, 0.8 nurses per 250 beds). This lack of progress in achieving national standards in critical IPC structure indicators might be partly related to the severe economic crisis affecting Greece since 2009. However, failure to reach the standards set in national recommendations and/or legal requirements for IPC staffing levels has been reported in eight of 17 European countries where such standards where in place,[23] which points out a need to seek more efficient strategies to effectively drive improvements in hospital IPC infrastructure and processes.

Indirect monitoring of hand hygiene activity based on soap and/or hydro alcoholic gel consumption has been adopted in many European countries,[13] and monitoring alcoholic hand rub consumption in hospitals has been recommended by the ECDC for Europe-standardized surveillance purposes.[10,23] The annual volume of alcoholic hand rub use recorded in this study is threefold higher compared to European data (medians, 64 vs 19 liters per 1,000 patient-days, respectively)[23], which might reflect increased hand hygiene activity in efforts to control antimicrobial resistance in Greek hospitals. However, data on alcoholic hand rub consumption are based on volumes purchased or dispensed by hospital pharmacies and not necessarily used by healthcare workers (or visitors and patients). Moreover, the correlation between hand rub consumption volumes and hand hygiene compliance rates in this study was only moderate, suggesting that the former may only be considered a poor indicator of quality in hand hygiene practice.

Data from USA and Europe suggest that the epidemiology of *C. difficile* is rapidly changing and the annual incidence is increasing globally.[24] In this study, we recorded a low number of stool tests for *C. difficile* processed by microbiology laboratories (median 3 tests per 1,000 patient-days per year) and very few of the surveyed hospitals (12%) reported participation in national or international networks for surveillance of *C. difficile* infections. This reflects the fact that *C. difficile* infections have been relatively rare in Greece. In 2012, Greece ranked 26th in 35 European countries in terms of prevalence of nosocomial infections caused by *C. difficile*.[23] More recently, a screening

study dealing exclusively with *C. difficile* infections showed a prevalence of less than 0.5% of hospitalized patients in 25 Greek hospitals.[25]

Our study has limitations that should be acknowledged. First, reported data may not fully reflect the actual status of implementation of IPC and hand hygiene strategies at the national level in Greece because study hospitals were recruited on a voluntary basis. The study sample was, however, large enough and included hospitals from all Regional Health Districts across the country. Second, we cannot exclude the possibility of reporting bias in our results as self-assessment tools were used in this survey. Nevertheless, we expect that the confidentiality and anonymity conditions in data reporting may have mitigated this risk. Also, our results regarding main IPC structure and process indicators are consistent with those recorded previously in a nationally representative sample.[8,23]

In conclusion, surveyed hospitals operate on limited IPC resources and low staffing levels but appropriate hand hygiene practices and promotion strategies are in place. An overall intermediate level of implementation of the WHO MHHIS has been attained and it is now imperative to develop long-term plans for sustainability of efforts. Establishing systems of feedback of hand hygiene indicators to healthcare workers and embedding hand hygiene efforts in a stronger institutional safety climate that includes patient involvement are clearly areas for which international benchmarks have not been reached. Ensuring adequate IPC nurse staffing levels and systematically promoting the implementation of the full range of core components in multimodal IPC programs are critical next steps to achieve a higher level of progress.

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Table 1

Main indicators of infection prevention and control infrastructure and processes in the surveyed Greek hospitals (N = 17)

IPC Indicator	No. (%) of hospitals reporting data	No. (%) of hospitals with zero counts	Median (IQR)
Isolation capacity:			
Single-room beds, % of beds	17 (100)	1 (5.9)	2.3 (1.1 - 5.8)
Infection cohorting areas, % of beds	16 (94.1)	5 (31.3)	1.5 (0.0 - 2.7)
Airborne infection isolation rooms,% of beds	17 (100)	7 (41.2)	0.1 (0.0 - 0.3)
IPC staff per 250 inpatient rooms:			
IPC nurses	17 (100)	0 (0.0)	0.8 (0.7 - 1.1)
IPC doctors	17 (100)	6 (35.3)	0.5 (0.0 - 1.1)
Antibiotic stewardship consultants	17 (100)	15 (88.2)	0.0 (0.0 - 0.0)
Microbiologic & diagnostic services:			
Routine clinical tests on weekends*	16 (94.1)	-	
Routine screening tests on weekends*	11 (64.7)	-	
Targeted colonization screening protocol	10 (58.8)	-	
Blood culture sets per 1,000 PD/year	16 (94.1)	0 (0.0)	31.2 (17.6 - 45.8)
Stool tests for *C. difficile* per 1,000 PD/year	16 (94.1)	0 (0.0)	3.0 (1.4 - 5.3)
Hand hygiene:			
Alcohol hand rub use, liters/1,000PD/year	17 (100)	0 (0.0)	63.6 (52.0 - 78.1)
Percent compliance†	13 (76.5)	0 (0.0)	37.0 (33.0 - 42.0)
Participation in surveillance networks:			
Surgical site infections	1 (5.9)	-	
ICU-acquired infections	2 (11.8)	-	
C. difficile infections	2 (11.8)	-	
Infections caused by CR-GNB	16 (94.1)	-	
Antimicrobial resistance‡	10 (58.8)	-	

Antimicrobial consumption	5 (29.4)	-
IPC program		
Annual plan	14 (82.4)	-
Annual report	6 (35.3)	-

IPC, infection prevention and control; IQR, interquartile range; PD, patient-days; ICU, intensive care unit; CR-GNB, carbapenem-resistant gram–negative bacteria.

*Including both Saturdays and Sundays.

† Hand hygiene compliance % obtained by direct observation using any available methodology.

‡ In accordance with the European EARS-Net protocol.

Table 2

Elements of multimodal infection control practice in the intensive care units and wards of the surveyed Greek hospitals (N = 17)

	Intensive care units					Hospital-wide / wards				
IPC practice element	**PNU**	**BSI**	**SSI**	**UTI**	**AB**	**PNU**	**BSI**	**SSI**	**UTI**	**AB**
Guidelines, n (%)	14 (82.4)	16 (94.1)	13 (76.5)	15 (88.2)	12 (70.6)	12 (70.6)	14 (82.4)	12 (70.6)	13 (76.5)	10 (58.8)
Care bundle, n (%)	8 (47.1)	10 (58.8)	6 (35.3)	8 (47.1)	4 (23.5)	4 (23.5)	9 (52.9)	6 (35.3)	5 (29.4)	4 (23.5)
Training, n (%)	11 (64.7)	12 (70.6)	10 (58.8)	11 (64.7)	10 (58.8)	8 (47.1)	10 (58.8)	9 (52.9)	10 (58.8)	9 (52.9)
Checklist, n (%)	2 (11.8)	3 (17.6)	2 (11.8)	2 (11.8)	2 (11.8)	0 (0.0)	2 (11.8)	1 (5.9)	1 (5.9)	0 (0.0)
Audit, n (%)	4 (23.5)	7 (41.2)	4 (23.5)	5 (29.4)	6 (35.3)	2 (11.8)	5 (29.4)	3 (17.6)	3 (17.6)	3 (17.6)
Surveillance, n (%)	6 (35.3)	15 (88.2)	7 (41.2)	8 (47.1)	7 (41.2)	6 (35.3)	15 (88.2)	8 (47.1)	9 (52.9)	10 (58.8)
Feedback, n (%)	5 (29.4)	11 (64.7)	4 (23.5)	5 (29.4)	4 (23.5)	4 (23.5)	11 (64.7)	4 (23.5)	6 (35.3)	6 (35.3)
All elements, n (%)	0 (0.0)	2 (11.8)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (5.9)	0 (0.0)	0 (0.0)	0 (0.0)
No. of elements, median (IQR)	3 (1-4)	4 (3-5)	2 (1-4)	3 (1-5)	3 (1-4)	2 (1-3)	4 (3-5)	2 (1-4)	3 (1-4)	3 (1-4)

IPC, infection prevention and control; PNU, Pneumonia; BSI, Bloodstream infection; SSI, Surgical site infection; UTI, Urinary tract infection; AB, Antibiotics; IQR, interquartile range.

Table 3

Comparison of performance in the Hand Hygiene Self-Assessment Framework between current survey and international benchmarks

	Greece, 2016 (current survey)	**Italy, 2014** (Bert et al)[13]		**USA, 2012** (Allegranzi et al)[14]		**91 countries, 2015/16** (WHO)[15]	
Variable	**Statistic**	**Statistic**	**p-value***	**Statistic**	**p-value***	**Statistic**	**p-value***
Participating hospitals, n	17	27	-	129	-	807	-
Acute-care hospitals, n (%)	17 (100)	na	-	81 (66)	-	501 (62)	-
Inpatient beds per hospital, mean	542	na	-	125	-	339	-
HHSAF assessment:			0.003		<0.001		<0.001
Inadequate, n (%)	0 (0)	0 (0)		0 (0)		15 (2)	
Basic, n (%)	7 (41)	3 (11)		8 (6)		86 (11)	
Intermediate, n (%)	9 (53)	19 (70)		58 (45)		247 (31)	
Advanced, n (%)	1 (6)	5 (19)		63 (49)		459 (57)	
Leadership score in HHSAF, n (%)	1 (6)	3 (11)	0.961	59 (46)	0.004	363 (45)	0.003
Overall HHSAF score, mean (SD)	288.7 (70.6)	332.2 (63.4)	0.040	373.2 (70.8)	<0.001	373 (91.6)	<0.001
System change, mean (SD)†	82.1 (18.4)	87.4 (16.9)	0.333	100 (5.0)	-	88 (19.3)	0.212
Training and education, mean (SD)†	54.1 (23.7)	70.4 (13.9)	0.017	85 (na)	-	78 (22.5)	<0.001
Evaluation and feedback, mean (SD)†	45.3 (18.7)	na	na	78 (na)	-	70 (25.6)	<0.001
Reminders in workplace, mean (SD)†	68.4 (17.9)	65.7 (17.4)	0.623	73 (na)	-	75 (21.9)	0.218
Institutional safety climate, mean (SD)†	38.5 (22.3)	50.4 (22.9)	0.097	60 (35.0)	-	62 (24.3)	<0.001

n, number; SD, standard deviation; na, not available.

* P-values refer to the statistical significance of differences from the current survey results.

† Median (interquartile range) is shown for component scores in US hospitals.

Table 4. Effects of staffing levels on total and component scores in the Hand Hygiene Self-Assessment Framework

	HHSAF total	System change	Training & education	Evaluation & Feedback	Reminders in the workplace	Institutional safety climate
Per 1 additional FTE:	**% change in median score (95% CI), p-value***					
IPC nurse	19.6 (-3.5 to 42.7), p=0.090	12.1 (-18.2 to 42.3), p=0.403	52.6 (4.3 to 100.8), p=0.035	22.4 (-13.6 to 58.4), p=0.202	15.0 (-26.6 to 56.6) p=0.450	23.3 (-13.9 to 60.5), p=0.199
IPC doctor	1.1 (-9.3 to 11.5), p=0.826	1.2 (-14.1 to 16.5), p=0.867	3.1 (-15.1 to 21.3), p=0.720	0.7 (-11.4 to 12.8), p=0.904	-4.2 (-14.3 to 5.9), p=0.386	-0.7 (-15.6 to 14.2), p=0.922
Antibiotic stewardship consultant	4.3 (-11.4 to 20.0), p=0.562	4.4 (-10.2 to 18.9), p=0.529	11.2 (-15.1 to 37.6), p=0.373	-3.5 (-25.5 to 18.4), p=0.734	3.5 (-31.4 to 38.5), p=0.831	10.0 (-27.8 to 47.8), p=0.578
Ward registered nurse	0.2 (0.0 to 0.4), p=0.063	0.1 (-0.4 to 0.6), p=0.710	0.3 (-0.2 to 0.7), p=0.245	0.2 (-0.2 to 0.5), p=0.337	0.1 (-0.4 to 0.6), p=0.776	0.1 (-0.3 to 0.6), p=0.498
Ward nursing assistant	-0.1 (-0.5 to 0.2), p=0.457	-0.1 (-0.6 to 0.3), p=0.526	-0.2 (-0.9 to 0.5), p=0.541	-0.1 (-0.4 to 0.3), p=0.703	0.2 (-0.3 to 0.6), p=0.480	-0.3 (-0.9 to 0.4), p=0.373
ICU registered nurse	-0.2 (-1.4 to 0.9), p=0.674	-0.5 (-1.8 to 0.8), p=0.399	-0.6 (-2.1 to 0.8), p=0.364	-0.2 (-1.5 to 1.1), p=0.717	-0.4 (-2.3 to 1.4), p=0.630	0.2 (-1.5 to 1.8), p=0.841
ICU nursing assistant	-1.1 (-3.8 to 1.6), p=0.400	-0.7 (-3.8 to 2.4), p=0.645	-1.9 (-6.2 to 2.5), p=0.370	-1.1 (-5.0 to 2.7), p=0.536	-1.2 (-4.7 to 2.3), p=0.474	-2.4 (-5.6 to 0.9), p=0.139
	% change in lower 30th percentile score (95% CI), p-value*					
IPC nurse	25.8 (-0.7 to 52.3), p=0.055	-3.1 (-42.5 to 36.3), p=0.869	41.9 (6.6 to 77.2), p=0.023	7.0 (-20.7 to 34.7), p=0.594	10.0 (-28.6 to 48.6), p=0.585	37.5 (0.2 to 75.5), p=0.049
	% change in higher 70th percentile score (95% CI), p-value*					
IPC nurse	19.9 (-8.1 to 48.0), p=0.149	11.7 (-17.7 to 41.2), p=0.406	30.8 (-23.5 to 85.1), p=0.242	32.4 (-16.4 to 81.3), p=0.175	16.2 (-30.7 to 63.2), p=0.468	24.2 (-21.0 to 69.3), p=0.269

HHSAF, Hand Hygiene Self-Assessment Framework; CI, confidence interval; FTE, Full-time equivalent; IPC, infection prevention and control; ICU, intensive care unit.

*Estimated by quantile regression with bootstrapped standard errors and adjusted for acute-care beds and teaching status.

Figure 1. Box-and-whisker plot of overall and component hand hygiene scores in Greek hospitals participating in the Hand Hygiene Self-Assessment Framework survey (N = 17)