


Trends of Healthcare-associated Infections in a Tunisian University Hospital and Impact of COVID-19 Pandemic

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Abstract

Background: Although efforts to manage coronavirus disease 2019 (COVID-19) pandemic have understandably taken immediate priority, the impacts on traditional healthcare-associated infection (HAI) surveillance and prevention efforts remain concerning.

Aim: To describe trends in HAIs in a Tunisian university hospital through repeated point prevalence surveys over 9 years, assess the impact of measures implemented for COVID-19 pandemic, and to identify associated factors of HAI.

Methods: The current study focused on data collected from annual point prevalence surveys conducted from 2012 to 2020. All types of HAIs as defined by the Centers for Disease Control and Prevention (CDC) were included. Data collection was carried out using NosoTun plug. Univariate and multivariate logistic analysis were used to identify HAI risk factors.

Results: Overall, 2729 patients were observed in the 9 surveys; the mean age was 48.3 ± 23.3 years and 57.5% were male. We identified 267 infected patients (9.8%) and 296 HAIs (10.8%). Pneumonia/lower respiratory tract infections were the most frequent HAI (24%), followed by urinary tract infection (20.9%). The prevalence of infected patients increased from 10.6% in 2012 to 14.9% in 2020. However, this increase was not statistically significant. The prevalence of HAIs increased significantly from 12.3% to 15.5% ($P = .003$). The only decrease involved is bloodstream infections (from 2% to 1%). Independent risk factors significantly associated with HAI were undergoing surgical intervention (aOR = 1.7), the use of antibiotic treatment in previous 6 months (aOR = 1.8), peripheral line (aOR=2), parenteral nutrition (aOR=2.4), urinary tract within 7 days (aOR=2.4), central line (aOR = 6.3), and prosthesis (aOR = 12.8), length of stay (aOR = 3), and the year of the survey. Young age was found as protective factor (aOR = .98).

Conclusion: Contrary to what was expected, we noticed an increase in the HAIs rates despite the preventive measures put in place to control the COVID-19 pandemic. This was partly explained by the vulnerability of hospitalized patients during this period.

Keywords

COVID-19 outbreak, healthcare-associated infection, trend, surveillance, prevalence, infection control

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What do we already know about this topic?

Published data on the burden of healthcare-associated infections (HAIs) and more precisely on trends of HAIs in developing countries is rare. The limited number of studies with a broad scope and the lack of national surveillance systems hamper any attempts to estimate the burden of HAIs at national or regional level in low- and middle-income countries such as Tunisia and especially during COVID-19 outbreak.

How does your research contribute to the field?

By using an identical survey tool and standard HAI definitions for the 9 surveys, we hoped to evaluate trends of HAI in hospitalized patients, mostly, changes in frequency during coronavirus pandemic.

What are your research's implications towards theory, practice, or policy?

The present study revealed an increasing trend in HAIs despite the strengthening of the measures put in place by our hospital to deal with the coronavirus pandemic.

It is a first step to shed the light on this issue, in Tunisia, paving the way to implement a local and hopefully national Surveillance System. Furthermore, a more in-depth analysis of the impact of COVID-19 outbreak will be made after the conduction of the prevalence survey for the year 2021.

Introduction

The full impact of the COVID-19 pandemic on health systems and traditional healthcare-associated infections (HAIs) remains to be determined. Significant infection prevention resource diversion is occurring to help manage the outbreak at the health-system level, which will predictably impact HAI surveillance and prevention efforts.^{1,2}

Implementation of infection control protocols during the COVID-19 pandemic seems to reduce HAIs rates according to a study conducted in Iran.³ In fact, proper training and observance of infection control protocols during an epidemic of infectious diseases such as COVID-19 will reduce the rate of nosocomial infections, what was also observed in the study carried out in the United States.²

Furthermore, essential elements that contributed to the sustained decrease in the incidence of HAIs world while were the national surveillance programs combined with improvement in infection prevention and control (IPC) practices.⁴⁻⁶

In developing countries, HAIs prevalence is two- to threefold higher than Europe or USA.^{7,8} In a research on 2688 patients, the infection rate was estimated 40.06%.⁹ A multicenter study was conducted in 27 hospitals in Algeria, Egypt, Italy, Morocco, and Tunisia to evaluate the prevalence and characteristics of HAIs. The prevalence of HAIs was 10.5%; this was higher in non-teaching centers and moderate-sized hospitals.¹⁰ Furthermore, the magnitude of the problem remains underestimated or even unknown largely because HAI diagnosis is complex and surveillance activities to guide interventions require expertise and resources.^{11,12}

There is a need to determine the extent, subtypes, and trends in HAI over time so that practitioners and policy decision makers can identify priorities for preventive action.¹³ Point Prevalence Surveys (PPS), despite their inherent limitations in terms of accuracy of results and possibility of bias, are a highly feasible alternative, easier to perform even on large scale multicenter studies, less expensive, and less

time consuming.¹⁴⁻¹⁹ By repeating such surveys, trends can be accurately assessed.²⁰

Tunisia is not spared from this scourge. In fact, HAI was the most common adverse event found in a longitudinal observational study conducted in 2016 over a period of 3 months in the Sahloul university hospital (43.4%).²¹ The national surveys of prevalence HAI were held regularly in the health institutions as a surrogate for incidence studies and can be readily repeated and that in the framework of the strategic axis "Surveillance of HAI" of the National Strategy of the hygiene and safety of care.

We aim in this report to describe trends in HAIs in a Tunisian university hospital through repeated point prevalence surveys over 9 years (2012–2020), assess the impact of measures implemented for COVID-19 pandemic, and to identify associated factors of HAI.

Materials and Methods**Setting and Study Design**

Sahloul university hospital is a 683-bed tertiary care research hospital in Sousse, Tunisia, with a capacity of 218 408 outpatients and 20 433 admitted patients in 2020.

It has a long history of activities aimed at risk management and infection control, based on a multimodal and multidimensional approach. Moreover, the hospital's infection control policy includes audit and feedback to improve compliance of the healthcare workforce to good practices; retraining courses and educational programs; continuous surveillance of HAIs; and active support for the WHO Campaign "Save lives: clean your hands."

Infection stewardship by PPS began in 1991, and since 2012, data have been treated with a local protocol and data entry form and updated over the years. Since then, the department of prevention and security of care of the hospital has been carrying out each year a PPS of HAI. Objectives of these studies were to estimate the overall burden of HAIs in Sahloul

hospital. Furthermore, hand hygiene trainings were regularly conducted for all health personnel. We also conduct annually hand hygiene practice audits to determine hand hygiene adherence. On the other hand, other training courses are carried out at the request of the services, for example, training on the management of wastes associated with care. All these measures were reinforced during COVID-19 outbreak.

Annual point prevalence surveys were conducted in March and early April, to limit the influence of seasonal variation in HAIs and to permit comparison among surveys, except for the survey of the year of 2020 which was conducted in the last 2 weeks of June.

Departments included in our analysis were distributed as follows:

- (1) Intensive care units: surgical resuscitation, post-operative general surgery, post-operative cardiovascular and thoracic surgery, medical resuscitation, pediatric resuscitation, and transplant unit
- (2) Surgical services: surgery, orthopedics, pre-cardiovascular and thoracic surgery, neurosurgery, maxillofacial surgery, urology, and burns service
- (3) Medical services: internal medicine, gastroenterology, cardiology, pediatrics, nephrology, neurology, and rehabilitation

Departments' participation was voluntary, and results were handled confidentially.

Data was collected on 1 day with a single visit per department and each bed was surveyed only once. A return visit was carried out in certain departments to collect information from patients whose hospital stay was greater than or equal to 48 hours and who were absent during the visit of the investigator for various reasons (practice of a complementary examination, surgery in the operating room, etc.). In addition, patients who entered on Monday after an authorization to leave during the weekend were included in the study for the previous hospital stay.

At the end of each survey, participating departments received a report on surveillance data as feedback, to encourage infection control activities based on benchmark indicators.

The current study focused on data collected from 2012 to 2020 from all departments except emergency and hemodialysis services as they are day-hospital departments. All types of HAIs as defined by the Centers for Disease Control and Prevention (CDC) were included.^{22,23} No adjustments or modifications of the definitions or other aspects of the methodology were made during the study period.

The surveys were carried out by medical doctors and hygienist technicians trained on the methodology.

Variable Definitions

HAIs are infections that first appear 48 hours or more after hospitalization or within 30 days after undergoing a surgery and a year after placement of an implant or prosthesis.^{24,25}

Definition of device-associated infections included in our survey such as pneumonia/lower respiratory tract infections (Pneu/LRTI), central venous catheter (CVC) associated infection, peripheral venous catheter (PVC) associated infection, and urinary tract infection (UTI) was referred to the CDC National Healthcare Safety Network (NHSN) definitions,²²⁻²⁴ which include laboratory and clinical criteria, along with radiological criteria for Pneu/LRTI.

Data Collection

The study included all patients admitted to the ward at least 48 hours before the survey and not discharged from the ward at the time of the survey. For each ward, data had to be collected in a single day. Data collection for each survey was completed in 2 weeks.

Data collection was carried out using NosoTun plug (national HAI prevalence survey).²⁶

Patient data form was structured according to the following sections: demographic data, admission data, clinical data, antimicrobials (AM) use, and HAI data.

Demographic, admission, and clinical data, useful for identifying patient-based data and risk factors, included ward name, survey date, patient counter, age, sex, date of admission, surgery since admission, and invasive devices in place on survey date (central vascular catheter (CVC), peripheral vascular catheter, urinary catheter, and intubation).

Only any active HAI on the survey date was recorded on the form. Data collected for HAI included presence of a relevant invasive device before onset (intubation for ventilator-associated pneumonia (VAP), central vascular catheter/peripheral vascular catheter for bloodstream infection (BSI) and urinary catheter for urinary tract infections (UTI), HAI present at admission, date of onset, origin of infection (if bloodstream infection, source), and microorganisms' data. AM data (including generic or brand name, route, indication, diagnosis/site of infection, and reason) were collected when a patient was receiving an AM on the day of survey (or in the 24 hours before the day of the survey for surgical prophylaxis).

Statistical Analysis

Statistical analyses were performed using the SPSS statistical package (version 20.0, SPSS Inc, Chicago, IL, USA) and EpiInfo version 6.04 (CDC, Atlanta, GA, USA).

Prevalence rate of HAI was calculated as the percentage of infected patients (with at least one infection) over the total number of patients observed during each survey.

Trends in prevalence over time were evaluated using the Chi-squared test for trend. Unadjusted odds ratios (ORs) and confidence intervals (CIs) were computed through logistic regression modeling.

Continuous variables were tested for normality of distribution by means of Kolmogorov–Smirnov test, difference in distribution was then tested using Student's t-test. Pearson

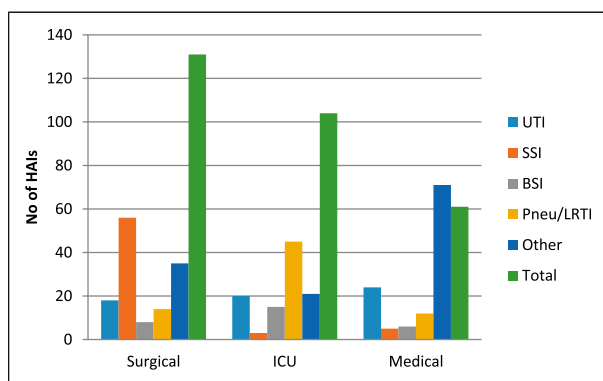


Figure 1. Distribution of HAIs by ward and type of infection, 2012–2020.

Chi-squared tests for categorical variables were used for univariate analyses.

The association of all variables with the occurrence of HAI was assessed using the Chi-squared test. We considered a two-tailed P -value of .05 or less statistically significant. In order to take into account, the influence of risk factors for HAIs, variables with P -value $< .2$ were included in a multiple logistic regression model for multivariate analysis, with stepwise variable selection.

Results

Patients' Characteristics

Overall, 2729 patients were observed in the 9 surveys; the mean age was 48.3 ± 23.3 years and 57.5% were male. At the time of survey, a central vascular catheter was present in 18.5% of observed patients; a peripheral vascular catheter in 60.8%; a urinary catheter the day of the survey in 31.3% and within 7 days in 32.5% and the percentage of mechanically ventilated/intubated patients was 16.1%.

ICU patients were younger (mean age: 44.1 ± 22.7 years), had the highest frequencies of invasive procedures (central lines, peripheral lines, urinary catheter, or mechanical ventilation), and the longest durations of hospital stay pre-survey (43.2% of patients > 8 days).

Diabetes was more frequent in medical patients (22.8%). However, all other comorbidities were higher in ICU patients.

Trend of Healthcare associated Infections (HAIs)

Overall, 267 infected patients (9.8%) and 296 HAIs (10.8%) were identified. Pneumonia/lower respiratory tract infections were the most frequent HAI, accounting for 24% of all cases, followed by surgical site infection (21.6%).

These infections were significantly more frequent in surgical wards (44.3%) than in the medical ones (20.6%) and ICUs (35.1%) ($P=.008$) (Figure 1).

The prevalence of infected patients increased from 10.6% in 2012 to 14.9% in 2020. However, this increase was not statistically significant (Table 1). In fact, from 2012 to 2019, the prevalence of infected patients significantly decreased from 10.6% to 8.5% ($P=.05$). Then, this prevalence significantly increased from 8.5% in 2019 to 14.9% in 2020 ($P=.01$).

The prevalence of HAIs increased significantly from 12.3% to 15.5% ($P=.03$) (Figure 2). From 2012 to 2019, the prevalence of HAIs significantly decreased from 10.6% to 9.5% ($P=.009$). Then, this prevalence significantly increased from 9.5% in 2019 to 15.5% in 2020 ($P=.02$). The only decrease involved bloodstream infections (from 16.3% to 6.5%).

At the time of the surveys, results for microbiological investigation were available for 165 HAIs (55.7%). The proportion of HAI that was microbiologically confirmed decreased from 58.1% in 2012 to 56.5% in 2020 ($P=.1$).

Klebsiella pneumonia (14.5%) was the most common pathogen, followed by *Escherichia coli* (13.7%) and *Pseudomonas aeruginosa* (13.2%).

Overall, the AM use prevalence was 18% (at least one AM). A total of 889 AMs were administered (32.6%). AMs were mainly administered for treatment of community acquired infection ($n = 352$; 45.7%), for HAI ($n = 208$; 27%) and for surgical prophylaxis ($n = 155$; 20.1%). Considering all 9 surveys, monotherapy was delivered in 491 patients, combination of 2 antibiotics in 282 patients, and of 3 in 91 patients. All the 267 patients with at least one HAI were under antibiotic therapy. Antimicrobial resistance was found in 32.1% of cases.

Distribution of causative pathogens varied when stratifying by survey (Table 2).

Risk Factors for Healthcare-associated Infections (HAIs)

Surgical wards had the highest (46.8%) and medical wards the lowest (23.2%) prevalence of infected patients (Table 3). Rates were significantly higher in patients with diabetes, obesity, immunodeficiency, infection at the day of admission, who were under antibiotic treatment for the last 6 months, and in patients with invasive procedures or previous surgery (Table 3).

There was no sex difference. A trend effect was apparent for length of hospital stay before the day of survey, with prevalence increasing from 16.1% in patients with ≤ 7 days prior hospitalization to 31.1% in those with >30 days ($P=.000$).

Globally, the year of survey was significantly associated with occurrence of HAI ($P=.024$). However, when using univariable regression, the decrease in prevalence of infected patients was significant for only year 2017 (from 13.9% in 2012 to 12% in 2017, $P=.012$).

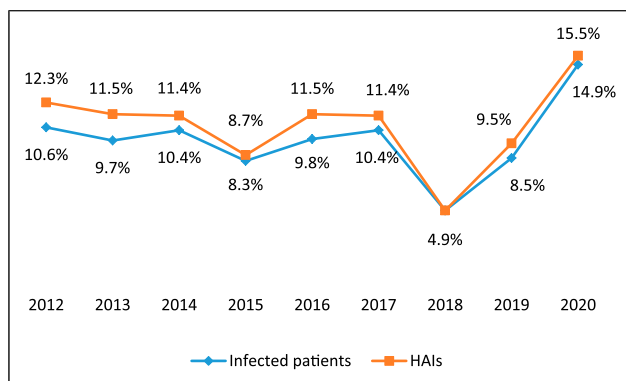
Table 1. Proportion of patients with healthcare-associated infection (HAI) by year and prevalence of HAIs by year and type, 2012–2020.

	2012 (N=350)	2013 (N=331)	2014 (N=298)	2015 (N=288)	2016 (N=287)	2017 (N=307)	2018 (N=266)	2019 (N=306)	2020 (N=296)	p- value	Total (N=2729)
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)		N (%)
Patients with HAIs	37 (10.6)	32 (9.7)	31 (10.4)	24 (8.3)	28 (9.8)	32 (10.4)	13 (4.9)	26 (8.5)	44 (14.9)	.06 ^a .06 ^b	267 (9.8)
Total HAIs	43 (12.3)	38 (11.5)	34 (11.4)	25 (8.7)	33 (11.5)	35 (11.4)	13 (4.9)	29 (9.5)	46 (15.5)	.03 ^a .01 ^b	296 (10.8)
UTI	7 (16.3)	6 (15.8)	11 (32.4)	7 (28)	6 (18.2)	5 (14.3)	2 (15.4)	7 (24.1)	11 (23.9)	.22 ^a .31 ^b	62 (20.9)
SSI	12 (27.9)	11 (28.9)	6 (17.6)	4 (16)	4 (12.1)	9 (25.7)	1 (7.7)	5 (17.2)	12 (26.1)	.38 ^a .05 ^b	64 (21.6)
BSI	7 (16.3)	4 (10.5)	2 (5.9)	1 (4)	5 (15.2)	1 (2.9)	2 (15.4)	4 (13.8)	3 (6.5)	.57 ^a .42 ^b	29 (9.8)
Pneu/LRTI	9 (20.9)	7 (18.4)	2 (5.9)	7 (28)	13 (39.4)	8 (22.9)	6 (46.2)	8 (27.6)	11 (23.9)	.17 ^a .23 ^b	71 (24)
Other	8 (18.6)	10 (26.3)	13 (38.2)	6 (24)	5 (15.2)	12 (34.3)	2 (15.4)	5 (17.2)	9 (19.6)	.12 ^a .13 ^b	70 (23.6)

UTI: urinary tract infection; **SSI:** surgical site infection; **BSI:** bloodstream infection; **Pneu/LRTI:** pneumonia/lower respiratory tract infection; **Other:** other infection.

^aChi-squared test for trend.

^bChi-squared test.

**Figure 2.** Evolution of prevalence rates of infected patients and of HAIs at Sahloul university hospital, 2012–2020.

To consider the influence of risk factors for HAIs, multiple logistic regression analyses with stepwise variable selection were performed.

Factors significantly associated with HAI are summarized in Table 4.

Discussion

Multiple studies indicate that the most common types of adverse events affecting hospitalized patients are adverse drug events, HAIs, and surgical complications.²⁷ The US Center for Disease Control and Prevention identifies that nearly 1.7 million hospitalized patients annually acquire HAIs while being treated for other health issues and that more than 98 000 of these patients (one in 17) die due to HAIs.¹²

By using an identical survey tool and standard HAI definitions for the 9 surveys, we hoped to then evaluate changes in frequency of HAI in hospitalized patients. Based on these surveys, there was a 3.2% increase in prevalence of HAI between 2012 and 2020, largely driven by increases in Pneu/LRTI and SSI, partially offset by reductions in UTI and BSI.

The results of this study suggest that relatively little has changed in either the rates of HAIs or the profile of infection types. Although the increase of prevalence of infected patients was not statistically significant, the prevalence of HAIs increased significantly from 12.3% to 15.5%.

Our results were not in line with some studies where proper implementation of infection control protocols during the COVID-19 outbreak reduces the rate of HAI.¹⁻³

Explanations for these changes are speculative. In Tunisia, as elsewhere, as less acutely ill patients are increasingly managed in ambulatory settings, the residual core of hospitalized patients may have higher acuity, and so may be more prone to HAI.

Furthermore, we have noticed an increase in prevalence of HAI in 2020. This may be explained by the fact that the period of the survey was different from other years. In fact, while the period of surveys was always in March and early April, in 2020, the prevalence survey was conducted in the last 2 weeks of June. During this period, all efforts were focused on managing the corona virus pandemic, as a result, only critical patients have been hospitalized. In fact,

Table 2. Distribution of laboratory-confirmed HAIs by causative pathogen, 2012–2020.

	2012 (n=32) (%)	2013 (n=39) (%)	2014 (n=24) (%)	2015 (n=16) (%)	2016 (n=22) (%)	2017 (n=26) (%)	2018 (n=10) (%)	2019 (n=27) (%)	2020 (n=38) (%)	Total (n=234) (%)
<i>Klebsiella pneumoniae</i>	15.6	15.4	8.3	12.5	22.7	7.7	30	14.8	13.2	14.5
<i>Escherichia Coli</i>	12.5	12.8	16.7	12.5	13.6	11.5	0	18.5	15.8	13.7
<i>Pseudomonas aeruginosa</i>	12.5	10.3	20.8	18.8	9.1	11.5	20	25.9	2.6	13.2
<i>Acinetobacter</i>	6.2	12.8	8.3	25	13.6	11.5	20	3.7	10.5	11.1
<i>Staphylococcus aureus</i>	18.8	10.3	25	0	0	11.5	0	7.4	10.5	10.7
<i>Candida albicans</i>	3.1	12.8	0	0	9.1	3.8	10	7.4	5.3	6
<i>Enterococcus</i>	0	0	0	6.3	18.1	18.1	0	0	10.5	5.6
<i>Coagulase-negative staphylococci</i>	0	0	4.2	0	0	3.8	0	0	5.3	1.7
Other	31.3	25.6	16.7	25	13.6	23.1	20	22.2	26.3	23.5

secondary infections after viral illnesses occur frequently and may lead to adverse outcomes.²⁸ Furthermore, significant increases in the national standardized infection ratios for BSI, UTI, and Pneu/LTRI were observed in 2020.²⁹ The largest increase was observed for BSI, and significant increases in Pneu/LTRI incidence and ventilator utilization were seen across all 4 quarters of 2020.²⁹

These constataions may be also explained by staff shortages due to either furloughed or the fact of being infected. In fact, the psychological impact of this pandemic has caused several nurses to have recourse to psychiatric leave. On the other hand, the precautions release following the net decrease in cases with corona virus after the first wave may be an explanation to this increase.

Overall, the described prevalence rate of HAI was lower than that reported in other developing countries,⁷ but higher than the values reported in other studies^{14,30,31} including the ECDC's 2011 report,³² which estimates a prevalence rate of 6% (country range 2.3%–10.8%) in European acute-care hospitals (6.1% in Italy). This difference in the reported values is due in part to the different characteristics of the hospitals included in the European survey which collects results from primary, secondary, tertiary care, and specialized hospitals in different countries. However, the prevalence rate of HAI in our hospital remains higher even when comparing results from tertiary care hospitals only (7.2%).

According to our study, surgical wards were the most affected wards, unlike what reported in other studies, where intensive care units were the most affected ones.^{14,30-32} This may be explained by the fact the main activity of our hospital is surgical.

As confirmed by existing literature, Pneu/LRTI and SSI were the most common HAIs in all surveys.^{7,30-32}

Although invasive devices represent an unavoidable infection risk for the critically ill patient, this risk goes well beyond an acceptable level in the developing world, especially for incidence of Pneu/LRTI and catheter-related bloodstream infections in both adult and pediatric patients.⁷ Furthermore, SSI is both the most frequently studied

and the leading HAI hospital-wide in the developing world.⁷ The alarming global burden of avoidable complications resulting from unsafe surgery has been highlighted by WHO.^{33,34}

At the time of the surveys, results for microbiological investigation were available for 165 HAIs (55.7%). *Klebsiella pneumoniae* was the most frequent microorganism, followed by *Escherichia coli*. Our results were similar to that found in literature,^{14,32} which can be explained by the high frequency of UTIs. Antimicrobial resistance was found in 32.1% of cases, a similar result to other literature reports which further underline a widespread use of broad spectrum antibiotics combined in multidrug protocols that is often necessary to counteract the increasing prevalence of AM resistance.^{30-33,35,36} On the other hand, the excessive and inappropriate use of antibiotics is the prime mover of the rapidly increasing prevalence of antibiotic-resistant microorganisms.³⁷

Application of a comprehensive HAI prevention strategy was associated with significant reduction in the proportion of patients with HAI from 7.6% to 4.3%, and in the total prevalence of HAIs from 8.6 to 4.3 per 100 patients over a 4 year period in the study conducted by ML Ciofi degli Atti et al.³⁸

Hand hygiene is frequently cited as the single most important measure to prevent transmission of infections.³⁹ Following implementation of an educational program to improve hand hygiene and minimize patient handling in a neonatal intensive care unit in Hong Kong, a reduction in HAI from 11.3 to 6.2 per 1000 patient-days was observed.⁴⁰

With the onset of the corona virus pandemic, there has been a strengthening of the application of hygiene standard precautions in our hospital during the 2 last years, and more particularly the respect of hand hygiene, through training sessions dedicated to all health professionals. We have also made a reorganization of departments in order to respect the rule of the march forward, and patient isolation. Despite all these measures, we noticed that the prevalence rates remain relatively high, which further demonstrates the value of incidence studies to better assess the burden of HAIs. Our

Table 3. Risk factors for healthcare-associated infection: results of univariable analysis.

	HAI	No HAI	OR [95% CI]	P-value
	N (%)	N (%)		
Gender				
Male	159 (10.1)	1410 (89.9)	-	.48
Female	108 (9.3)	1050 (90.7)		
Age (mean±SD)	45.77 ± 22.81	48.66 ± 23.33	-	.055
Type of ward				
Surgical	125 (46.8)	1205 (48.9)	-	-
ICU	80 (30)	184 (7.5)	4.2 [3–5.8]	.000
Medical	62 (23.2)	1073 (43.6)	.5 [4–.8]	.000
Year				
2012	37 (13.9)	313 (12.7)	-	.024
2013	32 (12)	299 (12.1)	-	.69
2014	31 (11.6)	267 (10.8)	-	.94
2015	24 (9)	264 (10.7)	-	.34
2016	28 (10.5)	259 (10.5)	-	.73
2017	32 (12)	275 (11.2)	-	.95
2018	13 (4.9)	253 (10.3)	.4 [2–.8]	.012
2019	26 (9.7)	280 (11.4)	-	.36
2020	44 (16.5)	252 (10.2)	-	.10
Diabetes	69 (26)	453 (18.6)	1.5 [1.1–2]	.004
Obesity	37 (14.1)	174 (7.1)	2.1 [1.5–3.1]	.000
Under nutrition	11 (4.3)	64 (2.6)	-	.13
Immunodeficiency	24 (9.3)	117 (4.8)	2 [1.3–3.2]	.002
Infection the day of admission	56 (34.6)	281 (17.9)	2.4 [1.7–3.4]	.000
Antibiotic treatment in 6 months	81 (50.3)	402 (25.9)	2.8 [2–4]	.000
Central line	109 (41)	393 (16.1)	3.6 [2.8–4.7]	.000
Peripheral line	184 (70)	1468 (59.8)	1.5 [1.2–2]	.001
Urinary catheter the day of survey	138 (52.3)	707 (29)	2.6 [2–3.5]	.000
Urinary tract within 7 days	149 (56.4)	723 (29.9)	3 [2.3–4]	.000
Mechanical ventilation	77 (29.2)	358 (14.6)	2.4 [1.8–3.2]	.000
Parenteral nutrition	73 (27.5)	361 (14.7)	2.2 [1.6–2.9]	.000
Other invasive procedure	73 (28.4)	336 (13.9)	2.4 [1.8–3.3]	.000
Surgical intervention	174 (65.7)	981 (40.3)	2.8 [2.2–3.7]	.000
Prosthesis in the year	34 (13.7)	34 (1.5)	10.6 [6.5–17.5]	.000
Length of stay (days)				
≤ 7	43 (16.1)	938 (38.1)	-	.000
8–30	141 (52.8)	969 (39.4)	3.2 [2.2–4.5]	.000
>30	83 (31.1)	555 (22.5)	3.3 [2.2–4.7]	.000

ICU: Intensive care unit; SD: Standard deviation; OR: Odds Ratio; CI: Confidence interval

results were not in line with some other publications where the increased focus on hand hygiene, environmental cleaning, patient isolation, and use of PPE during 2020, combined with continued inpatient antimicrobial stewardship programs and a marked decline in outpatient antibiotic prescribing, have resulted in decreases in the *Clostridioides difficile* infection standardized infection ratios during 2020 compared to 2019.^{41,42}

Risk factor analysis is consistent with data in the literature.^{14,32,35,43,44} Statistically significant risk for HAI occurrence was independently associated with increased

length of stay, undergoing a surgical intervention, putting on a prosthesis, use of urinary catheter, peripheral line and central line, parenteral nutrition, obesity, and the use of antibiotic treatment during the last 6 months. Appropriate urinary catheter indication is certainly an area which requires further analysis to assess possible overuse and guide practical interventions.⁴⁴ Central lines are a well-known risk factor for BSIs, and several studies document the effectiveness of care bundles for insertion and management.^{38,45} Prevention of central-line-associated BSIs was also the focus of studies in children in pediatrics ICUs and cardiac ICUs.^{46,47}

Table 4. Risk factors for healthcare-associated infection: results of multivariable analysis.

	Adjusted OR	95% CI	P-value
Age	.98	.97–.99	.007
Prosthesis	12.8	5.7–28.8	.000
Central line	6.3	3.6–10.8	.000
Length of stay			
≤ 7	-	-	.000
8–30	3	1.8–4.9	.000
>30	3.2	1.6–6.3	.001
Urinary tract within 7 days	2.4	1.5–3.7	.000
Parenteral nutrition	2.4	1.2–4.7	.013
Obesity	2.2	1.2–4.2	.014
Peripheral line	2	1.3–3.2	.002
Antibiotic treatment in 6 months	1.8	1.2–2.8	.005
Surgical intervention	1.7	1.1–2.6	.009
Year			
2012	-	-	-
2013	1.6	.7–3.6	.29
2014	1.9	.8–4.3	.12
2015	0.6	.2–1.8	.41
2016	1.5	.6–3.6	.33
2017	3.1	1.4–6.9	.006

OR: Odds Ratio; **CI:** Confidence interval

Our study has some limitations. Indeed, although repeated PPSs represent a more feasible alternative for hospital-wide surveillance of all HAIs, the study has likely some limitations inherent to the study design and reduced periods of observation. Continuous surveillance, especially prospective active surveillance, is the gold standard to improve patient safety. Furthermore, we did not assess the impacts of antimicrobial stewardship programs, and as the HAI prevention program was applied in the whole hospital, we did not compare with a control group.

Monitoring HAI rates allows benchmarking and provides baseline data for planning preventive interventions and assessing effectiveness. Point prevalence surveys are cheaper and easier than incidence rate monitoring, but can be just as useful, especially when repeated. We will thus continue to conduct standardized annual surveys to drive continued improvements in patient safety and quality of care.

This is the first report to look at the impact of COVID-19 on HAI rates at a teaching hospital in Tunisia. Substantial increases in Pneu/LTRI and SSI were observed. The year 2020 marked an unprecedented time for hospitals, many of which were faced with extraordinary circumstances of increased patient caseload, staffing challenges, and other operational changes that limited the implementation and effectiveness of standard infection prevention practices.²⁹

Conclusion

Ongoing surveillance of HAIs is an essential component of hospital infection control programs. The goals are to assess the

burden of infectious diseases, identify important problems, monitor the efficacy of specific interventions, and support rational hospital policies. HAIs were reported to be significantly decreased in hospitals that adopted surveillance programs. Hospital-wide surveillance programs are highly labor intensive and tend to divert resources needed to implement control measures and prevention activities. Consequently, they are often of minimal interest to hospital policymakers except during major outbreaks such as severe acute respiratory syndrome (SARS) or Corona virus (COVID-19).

It has become increasingly apparent that hospital support for surveillance programs needs to be justified by improved outcomes. To accomplish these goals, they must be closely linked to effective interventional strategies.

Contrary to what was expected, we noticed an increase in the HAIs rates despite the preventive measures put in place to control the COVID-19 pandemic. This was partly explained by the vulnerability of hospitalized patients during this period. However, a more in-depth analysis of the impact of COVID-19 outbreak will be made after the conduction of the prevalence survey for the year 2021.

Declaration of Conflicting Interests

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Ethics Approval

The data collected was strictly confidential. The research protocol was neither harmful to health nor patient safety or privacy. Furthermore, the research ethics boards of the hospital approved these surveys.

Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request

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References

1. Stevens MP, Doll M, Pryor R, Godbout E, Cooper K, Bearman G. Impact of COVID-19 on traditional healthcare-associated infection prevention efforts. *Infect Control Hosp Epidemiol*. 2020;41(8):946-947. doi: [10.1017/ice.2020.141](https://doi.org/10.1017/ice.2020.141).
2. Cole J, Barnard E. The impact of the COVID-19 pandemic on healthcare acquired infections with multidrug resistant organisms. *Am J Infect Control*. 2021;49(5):653-654. doi: [10.1016/j.ajic.2020.09.013](https://doi.org/10.1016/j.ajic.2020.09.013).
3. Jabarpour M, Dehghan M, Afsharipour G, et al. The Impact of COVID-19 Outbreak on nosocomial infection rate: a case of Iran. *Can J Infect Dis Med Microbiol*, 2021;2021:1-6. doi: [10.1155/2021/6650920](https://doi.org/10.1155/2021/6650920).
4. Haley RW, Culver DH, White JW, et al. The efficacy of infection surveillance and control programs in preventing nosocomial infections in us hospitals. *Am J Epidemiol*. 1985; 121(2):182-205. doi: [10.1093/oxfordjournals.aje.a113990](https://doi.org/10.1093/oxfordjournals.aje.a113990).
5. European Centre for Disease Prevention and Control. *Healthcare-Associated Infections Surveillance Network*. (Accessed May 5, 2021). <https://ecdc.europa.eu/en/about-us/partnerships-and-networks/disease-and-laboratory-networks/hai-net>
6. Agodi A, Auxilia F, Barchitta M, et al. Trends, risk factors and outcomes of healthcare-associated infections within the Italian network SPIN-UTI. *J Hosp Infect*. 2013;84(1):52-58. doi: [10.1016/j.jhin.2013.02.012](https://doi.org/10.1016/j.jhin.2013.02.012).
7. Allegranzi B, Nejad SB, Combescure C, et al. Burden of endemic health-care-associated infection in developing countries: systematic review and meta-analysis. *Lancet*. 2011;377(9761): 228-241. doi: [10.1016/S0140-6736\(10\)61458-4](https://doi.org/10.1016/S0140-6736(10)61458-4).
8. Bagheri Nejad S, Allegranzi B, Syed SB, Ellis B, Pittet D. Healthcare-associated infection in Africa: a systematic review. *Bull World Health Organ*. 2011;89(10):757-765. doi: [10.2471/BLT.11.088179](https://doi.org/10.2471/BLT.11.088179).
9. Maa S-H, Lee H-L, Huang Y-C, et al. Incidence density and relative risk of nosocomial infection in Taiwan's only children's hospital, 1999-2003. *Infect Control Hosp Epidemiol*. 2008; 29(8):767-770. doi: [10.1086/589724](https://doi.org/10.1086/589724).
10. Amazian K, Rossello J, Castella A, et al. Prevalence of nosocomial infections in 27 hospitals in the Mediterranean region. *East Mediterr Health J*. 2010;16(10):1070-1078. doi: [10.26719/2010.16.10.1070](https://doi.org/10.26719/2010.16.10.1070).
11. Allegranzi B, Pittet D. Preventing infections acquired during health-care delivery. *Lancet*. 2008;372(9651):1719-1720. doi: [10.1016/S0140-6736\(08\)61715-8](https://doi.org/10.1016/S0140-6736(08)61715-8).
12. Klevens RM, Edwards JR, Richards CL, et al. Estimating health care-associated infections and deaths in US. Hospitals 2007. *Public Health Rep*. 2002;122(2):160-166. doi: [10.1177/003335490712200205](https://doi.org/10.1177/003335490712200205).
13. The Canadian Nosocomial Infection Surveillance Program, Taylor G, Gravel D, et al. Assessing the magnitude and trends in hospital acquired infections in Canadian hospitals through sequential point prevalence surveys. *Antimicrob Resist Infect Control*. 2016;5(1):19. doi: [10.1186/s13756-016-0118-3](https://doi.org/10.1186/s13756-016-0118-3).
14. Antonioli P, Manzalini MC, Stefanati A, et al. Temporal trends of healthcare associated infections and antimicrobial use in 2011-2013, observed with annual point prevalence surveys in Ferrara University Hospital. *Italy. J Prev Med Hyg*. 2016;57(3): E135-E141.
15. Llata E, Gaynes RP, Fridkin S. Measuring the Scope and Magnitude of Hospital-Associated Infection in the United States: The Value of Prevalence Surveys. *Clin Infect Dis*. 2009; 48(10):1434-1440. doi:[10.1086/598328](https://doi.org/10.1086/598328).
16. The French Prevalence Survey Study Group. Prevalence of nosocomial infections in France: results of the nationwide survey in 1996. *J Hosp Infect*. 2000;46(3):186-193. doi: [10.1053/jhin.2000.0833](https://doi.org/10.1053/jhin.2000.0833).
17. Eriksen HM, Iversen BG, Aavitsland P. Prevalence of nosocomial infections in hospitals in Norway, 2002 and 2003. *J Hosp Infect*. 2005;60(1):40-45. doi: [10.1016/j.jhin.2004.09.038](https://doi.org/10.1016/j.jhin.2004.09.038).
18. Gikas A, PEDIADITIS J, PAPADAKIS JA, et al. Prevalence study of hospital-acquired infections in 14 Greek hospitals: planning from the local to the national surveillance level. *J Hosp Infect*. 2002;50(4):269-275. doi: [10.1053/jhin.2002.1181](https://doi.org/10.1053/jhin.2002.1181).
19. Danchaivijitr S, JUDAENG T, SRIPALAKIJ S, NAKSAWAS K, PLIPAT T. Prevalence of nosocomial infection in Thailand 2006. *J Med Assoc Thail Chotmaihet Thangphaet*. 2007;90(8):1524-1529.
20. Zingg W, Huttner BD, Sax H, Pittet D. Assessing the burden of healthcare-associated infections through prevalence studies: what is the best method? *Infect Control Hosp Epidemiol*. 2014; 35(6):674-684. doi: [10.1086/676424](https://doi.org/10.1086/676424).
21. Ghali H, Cheikh AB, Bhiri S, et al. Évènements indésirables dans un hôpital universitaire tunisien : incidence et facteurs de risque. *Santé Publique*. 2020;32(2):189. doi: [10.3917/spub.202.0189](https://doi.org/10.3917/spub.202.0189).
22. Garner JS, Jarvis WR, Emori TG, Horan TC, Hughes JM. CDC definitions for nosocomial infections 1988. *Am J Infect Control*. 1988;16(3):128-140. doi: [10.1016/0196-6553\(88\)90053-3](https://doi.org/10.1016/0196-6553(88)90053-3).
23. Horan TC, Andrus M, Dudeck MA. CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. *Am J Infect Control*. 2008;36(5):309-332. doi: [10.1016/j.ajic.2008.03.002](https://doi.org/10.1016/j.ajic.2008.03.002).
24. Sallam SA, Arafa MA, Razek AA, Naga M, Hamid MA. Device-related nosocomial infection in intensive care units of Alexandria University Students Hospital. *East Mediterr Health J*. 2005;11(1-2):52-61.

25. Revelas A. Healthcare - associated infections: a public health problem. *Niger Med J*. 2012;53(2):59. doi:10.4103/0300-1652.103543.
26. Hamza R, Dhidah L. Première enquête nationale tunisienne de prévalence de l'infection nosocomiale : principaux résultats. *Health Co*. 2007. <https://www.hygienes.net/boutique/hygienes-2/premiere-enquete-nationale-tunisienne-de-prevalence-de-linfection-nosocomiale-principaux-resultats/>. Published online
27. Haque M, Sartelli M, McKimm J, Abu Bakar MB. Health care-associated infections – an overview. *Infect Drug Resist*. 2018; Volume 11:2321-2333. doi: 10.2147/IDR.S177247.
28. Kumar G, Adams A, Herrera M, et al. Predictors and outcomes of healthcare-associated infections in COVID-19 patients. *Int J Infect Dis*. 2021;104:287-292. doi: 10.1016/j.ijid.2020.11.135.
29. Weiner-Lastinger LM, Pattabiraman V, Konnor RY, et al. The impact of coronavirus disease 2019 (COVID-19) on healthcare-associated infections in 2020: a summary of data reported to the national healthcare safety network. *Infect Control Hosp Epidemiol*. 2021;1-14. doi: 10.1017/ice.2021.362. Published online
30. Lyytikäinen O, Kanerva M, Agthe N, Möttönen T, Ruutu P. Healthcare-associated infections in Finnish acute care hospitals: A National Prevalence Survey 2008. *J Hosp Infect*. 2005; 69(3):288-294. doi: 10.1016/j.jhin.2008.03.005.
31. Behnke M, Hansen S, Leistner R, et al. Nosocomial infection and antibiotic use. *Dtsch Aerzteblatt Online*. 2013. doi: 10.3238/arztebl.2013.0627. Published online
32. European Centre for Disease Prevention and Control. Point Prevalence Survey of Healthcare-Associated Infections and Antimicrobial Use in European Acute Care Hospitals :2011 2012. Publications Office; 2013. <https://data.europa.eu/doi/10.2900/86011>. Accessed May 4, 2021
33. World Health Organization & WHO Patient Safety. (2008). *The Second Global Patient Safety Challenge : Safe Surgery Saves Lives*. World Health Organization; 2008. <https://apps.who.int/iris/handle/10665/70080>
34. Haynes AB, Weiser TG, Berry WR, et al. A surgical safety checklist to reduce morbidity and mortality in a global population. *N Engl J Med*. 2009;360(5):491-499. doi: 10.1056/NEJMs0810119.
35. Sinatra I, Carubia L, Marchese V, et al. Prevalence survey of healthcare-associated infections and antimicrobial use at the University Hospital “Paolo Giaccone” Italy, Palermo. *J Prev Med Hyg*. 2013;54:200-204.
36. Mazzeo F, Capuano A, Motola G, et al. Antibiotic use in an Italian university hospital. *J Chemother*. 2002;14:332-335. doi: 10.1179/joc.2002.14.4.332.
37. van Hauwermeiren E, Iosifidis E, Kärki T, Suetens C, Kinross P, Plachouras D. Development of case vignettes for assessment of the inter-rater variability of national validation teams for the point prevalence survey of healthcare-associated infections and antimicrobial use in European acute care hospitals. *J Hosp Infect*. 2019;101(4):455-460. doi: 10.1016/j.jhin.2019.01.018.
38. Ciofi degli Atti MLCuttini M, Ravà L, et al. Trend of healthcare-associated infections in children: annual prevalence surveys in a research hospital in Italy, 2007–2010. *J Hosp Infect*. 2012;80(1):6-12. doi: 10.1016/j.jhin.2011.11.004.
39. Siegel JD, Rhinehart E, Jackson M, Chiarello L. 2007 guideline for isolation precautions: preventing transmission of infectious agents in health care settings. *Am J Infect Control*. 2007;35(10): S65-S164. doi: 10.1016/j.ajic.2007.10.007.
40. Lam BCC. Hand hygiene practices in a neonatal intensive care unit: a multimodal intervention and impact on nosocomial infection. *PEDIATRICS*. 2004;114(5):e565-e571. doi: 10.1542/peds.2004-1107.
41. KathleenMcMullen M, BarbaraSmith A, Rebmann T. Impact of SARS-CoV-2 on hospital acquired infection rates in the United States: Predictions and early results. *Am J Infect Control*. 2020; 48(11):1409-1411. doi:10.1016/j.ajic.2020.06.209.
42. Department of Health and Human Services website. The intersection of antibiotic resistance (AR), antibiotic use (AU), and COVID-19. 2021. <https://www.hhs.gov/sites/default/files/antibiotic-resistance-antibiotic-use-covid-19-paccarb.pdf>. Accessed October 11, 2021.
43. Kritsotakis EI, Dimitriadis I, Roubelaki M, et al. Case-mix adjustment approach to benchmarking prevalence rates of nosocomial infection in hospitals in Cyprus and Greece. *Infect Control Hosp Epidemiol*. 2008;29(8):685-692. doi: 10.1086/588704.
44. Harbarth S, Sax H, Gastmeier P. The preventable proportion of nosocomial infections: an overview of published reports. *J Hosp Infect*. 2003;54(4):258-266. doi: 10.1016/S0195-6701(03)00150-6.
45. Kaplan HC, Lannon C, Walsh MC, Donovan EF. For the Ohio Perinatal Quality Collaborative Ohio statewide quality-improvement collaborative to reduce late-onset sepsis in pre-term infants. *PEDIATRICS*. 2011;127(3):427-435. doi: 10.1542/peds.2010-2141.
46. Jeffries HE, Mason W, Brewer M, et al. Prevention of central venous catheter-associated bloodstream infections in pediatric intensive care units a performance improvement collaborative. *Infect Control Hosp Epidemiol*. 2009;30(7):645-651. doi: 10.1086/598341.
47. Miller MR, Griswold M, Harris JM, et al. Decreasing PICU catheter-associated bloodstream infections: nachri's quality transformation efforts. *PEDIATRICS*. 2010;125(2):206-213. doi: 10.1542/peds.2009-1382.