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Research Article

Prepandemic National Prevalence of Hospital Acquired Infections, Risk Factors and Antibiotic Resistance in Tunisia

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Abstract

Background: In Tunisia, there is a poorness of data describing prepandemic Hospital Acquired Infections (HAIs).

Aim: This study aims to describe prevalence and distribution of HAIs in Tunisian public and private hospitals and to identify their main risk factors. **Methods:** A point-prevalence national cross-sectional survey was conducted between November and December 2012. Data were collected using a standardized protocol of the Centre for Disease Control (CDC) Atlanta. **Results:** A total of 132 hospitals representing 67.4% beds in public and private hospitals were surveyed. Of 8608 inpatients included, 575 had at least one HAI corresponding to an overall prevalence of 6.7%. The main factors associated to HAIs were hospitalization in intensive care unit (AOR=3.4 [1.8-6.4]), suprapubic aspiration (AOR=5.3 [2.2-12.5]), central vascular catheter (AOR=3.8 [2.7-5.4]), malnutrition (AOR=1.9 [1.3-2.6]) and immunosuppression (AOR=1.9 [1.5-2.6]. Out of the 575 patients, 199 had a microbiological test (34.6%). One microorganism was identified in 68% of cases, two in 31.5% and three and more in other cases. The most common microorganism was Klebsiella Pneumoniae. The national prevalence of antimicrobial use was 43.0% (95%CI [42.0%-44.0%]). Antibiotic resistance phenotypes were identified in 82.6% of isolated bacteria. Conclusion: Our results highlighted the need to implement targeted prevention control measures especially an early warning system for HAIs in departments at risk and a national antibiotic stewardship program to fight against emergence and spread of multi-resistant bacteria.

Keywords: Hospital acquired infection; prevalence; risk factors; antibiotic resistance; Tunisia;

Introduction

Hospital Associated Infections (HAIs) still represent a global public health challenge with about 15% of hospitalized patients suffer from these infections according to WHO [1, 2]. These complications are a threat for patient safety with high impact in terms of morbidity and mortality, leading to additional financial burden as a result of longer hospital stay, antibiotic treatments, and high proportion of antibiotic resistance [3].

Continued improvements in patient safety depend on a comprehensive understanding of national epidemiology of HAIs. Reliable data on HAIs is crucial to evaluate national infection prevention and control (IPC) policies and adherence of health professionals to existing HAI guidelines.

In Tunisia, there is no relevant surveillance system providing an accurate estimation of the burden of HAIs. Available data are mainly based on fragmentary and regional surveys [4-7]. The only alternative to address this gap is to conduct regular surveys as a part of the National Strategy of Patients Security (NSPS) to guide the implementation of relevant infection prevention and control measures. The first Tunisian national point prevalence survey was conducted in 2005 “NosoTun 2005” and covered only public hospitals [8].

A second national point prevalence survey was conducted in 2012 to assess the trend of prevalence of HAIs in public and private hospitals, to identify their main risk factors and to estimate the frequency of antimicrobial use and antibiotic resistance in order to guide the implementation of Infection prevention and control measures in Tunisia.

Methods

The national Observatory of New and Emerging Diseases, conducted a point prevalence cross-sectional survey over a period of one month during December 2012 “NosoTun 2012”.

Criteria of Centers for Disease Prevention and Control (CDC) Atlanta USA, as well as criteria of the French National Technical Committee for nosocomial infections and the criteria of the CCLIN Paris-Nord guide, were used and customized to the national context to define HAIs [9-11]. HAIs were defined as infections acquired during hospital care, which are not present, or incubating at the time of admission of patients. An infection was considered to be hospital acquired when the onset of the signs and symptoms occurred more than 48 hours after the current admission, or became apparent within 48 hours of admission but the patient had been discharged from another hospital less than 48 hours before the current admission. For surgical site infections, the definition included infections that occurred up to 30 days after surgical intervention and affected either the incision or deep tissue at the operating site, or infections related to an implant that occurred within one year.

All academic and regional hospitals, and a randomized sample of local hospitals belonging to the public sector besides private clinics were invited to participate to the survey. Medical, surgical, gynecology, polyvalent (Different medical specialties inpatients department), neonatology and intensive care units departments were included. Day hospitals, peripheral maternities, emergency services and hemodialysis units were excluded. All patients present on the day of the survey and hospitalized for at least 48 hours were included.

Selected and trained investigators carried out a single passage by department on each health facility. Training sessions were organized and a standardized survey guideline was developed for investigators.

Data were collected from patient medical records using three different standardized forms (Hospital Form, Department Form, and Patient Form). Data on hospital and department characteristics, included ward type and size, number of beds, and number of patients admitted in each ward at the time of the survey. Data related to patients were age, gender, Predisposing Intrinsic factors of HAI (Underlying Diseases, Medical and Surgical history, McCabe score [12]), Extrinsic factors of HAI (Use of indwelling devices, antimicrobial treatments prescripted, presence of active HAI, results of microbiological tests performed (Identified microorganisms, and results of the Antibiogram).

Clinical specimens were sent for microbiological culture, and organisms were identified using standard methodologies.

Data have been checked by regional coordinators, and have been entered using Epidata 3.2 at regional level in 2013. Afterward, national coordinators team at the ONMNE, proceeded to double data entry, cleaning and validation, during 2014.

Statistical analysis was performed using SPSS 20.0 version. For descriptive statistics, prevalence rates were calculated with 95% confidence intervals (95% CI). The Chi-square test was used to compare different prevalence rates. For the analytical part, we performed crude Odds Ratios (OR) and their 95% confidence intervals followed by a multivariable analysis using binary logistic regression. Variables with p-value 0.20 in univariate analysis were introduced in the multivariable analysis after testing the interaction between the different variables in bivariate analysis based on the homogeneity test. The final model consisted of variables independently associated with the variable of interest with $p\text{-value} \leq 0.05$, and we presented adjusted OR (AOR) with their 95% confidence intervals.

This survey was authorized by the Tunisian Ministry of Health.

Results

Study Population

In total, 132 healthcare facility participated in the survey: all the academic (n=26) and regional (n=32) hospitals and 24 local hospitals from the public sector and 50 private clinics. A total of 8608 patients were enrolled in the survey with a male to female ratio of 1.03 and a Median age of 47.0 years (min 2 days, max 104.5 years). Most patients (88.4%) were from public hospitals and hospitalized in medical wards (45.5%), surgical wards (30.4%) and intensive care units (ICU) (10%). The most common under-lying diseases were diabetes (21.1%) and immunosuppression (11.7%). Peripheral vascular catheter (56.1%) and urinary catheter (12.7%) were the most frequent used invasive devices. (Table 1).

Half of surveyed patients with available data, had at least one intrinsic factor (50%, n=3567) and 60% at least one extrinsic factor (n=5187). Combining extrinsic and intrinsic factors, 76.1% (n=5768) had at least one factor, of which more than 25% had three factors or more.

Variables	Patients	
	N	%
Socio-demographic characteristics		
Gender		
Male	4366	50.7
Female	4242	49.3
Age group		
[0-1[	663	7.7
[1-5[	280	3.3
[5-15[	296	3.4
[15-45[	2830	33.0
[45-65[	2499	29.1
>= 65	2018	23.5
Characteristics of hospitalization site		
Hospital Sector		
Public	7613	88.4
Private	995	11.6
Hospital type		
District Hospital	184	2.1
Regional Hospital	2230	25.9
University-affiliated Hospital	5199	60.4
Private Hospital	995	11.6
Department		
Medical	3917	45.5
Surgical	2625	30.4
Intensive care	885	10.2
Gynecological and obstetric	582	6.8
Polyvalent**	599	7.1
Intrinsic factors		

Diabetes		
Yes	1824	21.2
No	6688	77.7
MD*	96	1.1
Malnutrition		
Yes	356	4.1
No	8061	93.6
MD*	191	2.2
Obesity		
Yes	869	10.1
No	7617	88.5
MD*	122	1.4
Immunosupression		
Yes	1006	11.7
No	7400	86
MD*	202	2.3
Neutropenia		
Yes	289	3.4
No	7889	91.7
MD*	430	5
Mac Cabe Score		
0	6553	76.1
1	1122	13
2	490	5.7
MD*	443	5.2
Cancer		
Solid tumor cancers	634	7.4
Hematological cancers	234	2.7
Solid tumor cancers & Hematological cancers	30	0.3
No	7710	89.6
Extrinsic factors		
Urinary catheter		
Yes	1096	12.7
No	7509	87.2
MD*	3	0.1
Central vascular catheter		
Yes	362	4.2
No	8238	95.7
MD*	8	0.1

Peripheral venous catheter		
Yes	4836	56.1
No	3768	43.7
MD*	4	0.2
Intubation/ Mechanical Ventilation		
Yes	366	4.2
No	8236	95.7
MD*	5	0.1
Suprapubic Aspiration		
Yes	30	0.3
No	8570	99.5
MD*	8	0.2
Parenteral Nutrition		
Yes	265	3.1
No	8336	96.8
MD*	7	0.1
*MD: Missing Data, **Polyvalent: Different medical specialties inpatients department.		

Table 1: Characteristics of study population. NosoTun 2012.

Prevalence and types of HAIs

Among the 8608 patients included in this study, 575 had at least one HAI, which corresponded to a prevalence of 6.7% (CI95%[6.2-7.3]). A total of 664 active HAIs were identified in the 575 patients translating to an overall prevalence of 7.7%(CI95%[7.2-8.3]). Among these patients 503 (87%) had one HAI, 55 (10%) had two HAIs, and 17 (3%) had three concomitants HAIs.

Newborns (0- 27 days) and children under the age of 2 years (28 days-23 months) were more affected by HAIs than other age groups with a prevalence of 13.4% %(CI95%[[10.0-17.5]) and 10.0%(CI95%[[5.6-14.6]) respectively (Figure 1). HAIs prevalence was significantly higher among males (8,2% CI95% [7,4-9,1]) than females (5,1% CI95%[4.2-5.5]). The highest prevalence rates was in the intensive care units 20.8% [18.2-23.5] and neonatology wards 16.4% CI95% [12.2-21.2] (Figure 2). The prevalence was significantly higher in private hospitals 9.8% CI95% [8.1-11.9]), followed by academic hospitals 7.3% CI95% [6.7-8.1].

The most common infection sites were respiratory infections 25.0% [21.3-28.5], urinary tract infections 20.8% [17.8-24.0], followed by bloodstream infections 16.2 % [13.6-19.2] (Table 2).

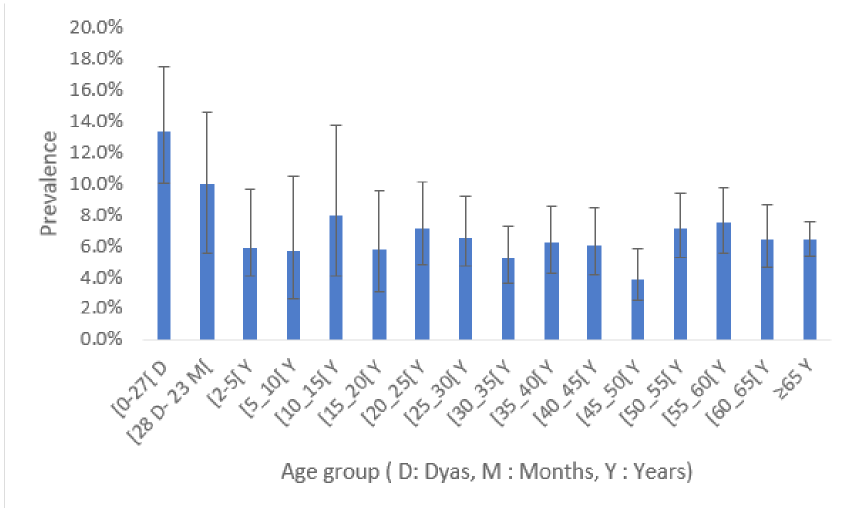

Figure 1: Distribution of HAIs Prevalence by age group. Tunisia, 2012

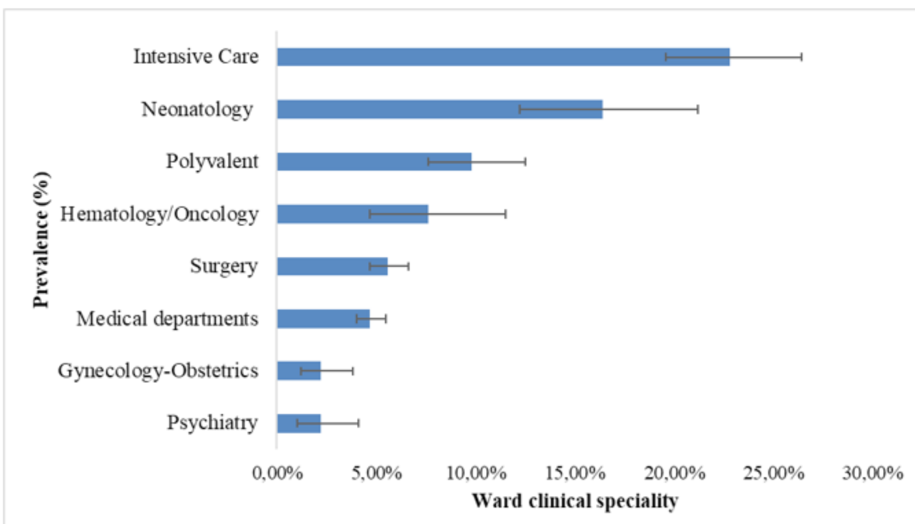

Figure 2: Prevalence of HAIs by ward clinical speciality. Tunisia, 2012

	n	%	CI95%
All specified infections	658	-	
Respiratory tract infections	165	25	21.3-28.5
Bloodstream	107	16.2	13.6-19.2
Skin / Soft Tissue	63	9.5	7.4-12.1
Surgical site infection	51	7.7	5.9 -10.0
Urinary tract infections	137	20.8	17.8- 24.0
Other infections	135	20.5	17.6 -23.7

Table 2: Proportion of site infections among HAIs.

Risk factors for HAIs

In Univariate Analysis, age, gender, hospital type, hospital department, existence of an isolation unit, malnutrition, immunosuppression having a MacCabe score, the use of a central vascular catheter, intubation /mechanical ventilation and suprapubic aspira-tion were significantly associated to HAIs (Table 3).

Variable	N	Prevalence (%)	COR* [CI 95%]	p
Sociodemographic factors				
Gender				
Female	4243	5.1	Ref.	$<10^{-3}$
Male	4365	8.2	1.7 [1.4-2.0]	
Age				
Others	7923	6.2	Ref.	$<10^{-3}$
Newborns & age < 1 year	663	11.3	1.9 [1.5-2.5]	
Hospital related factors				
Hospital department				$<10^{-3}$
Gynecology-Obstetrics	582	2.2	Ref.	
Medical services	3917	4.6	2.1 [1.2-3.8]	0.009
Surgery	2625	5.2	2.4 [1.4-4.3]	0.003
Polyvalent	599	9.8	4.8 [2.6-8.8]	$<10^{-3}$
Intensive care & Neonatology	885	20.8	11.5 [6.5-20.4]	$<10^{-3}$
Hospital type & sector				
District/ Regional Hospital	2414	3.9	Ref.	
University-affiliated Hospital	5199	7.3	1.9 [1.5-2.4]	$<10^{-3}$
Private Hospital	995	9.8	2.7 [2.0-3.6]	$<10^{-3}$
Isolation room				
No	6218	5.7	Ref.	$<10^{-3}$
Yes	2390	9.2	1.7 [1.4-2.0]	
Intrinsic factors				
Diabetes				
No	6688	6.7	Ref.	0.798
Yes	1824	6.9	1.0 [0.8-1.3]	
Malnutrition				
No	8061	6.1	Ref.	$<10^{-3}$
Yes	356	19.9	3.9 [2.9-5.1]	
Obesity				
No	7617	6.8	Ref.	0.713
Yes	869	6.4	0.9 [0.7-1.3]	
Immunosupression				
No	7400	5.8	Ref.	$<10^{-3}$
Yes	1006	13.8	2.6 [2.1-3.2]	

Neutropenia				
No	7899	6.7	Ref.	$<10^{-3}$
Yes	289	12.5	2.0 [1.4-2.8]	
Mac Cabe Score				
0	6239	4.8	Ref.	$<10^{-3}$
1	1027	8.5	1.8 [1.4-2.3]	
2	3810	22.2	5.7 [4.5-7.2]	
Cancer				
No	7710	6.5	Ref.	0.048
Yes	898	8.2	1.3 [1.0-1.7]	
Extrinsic factors				
Urinary catheter				
No	7509	4.6	Ref.	$<10^{-3}$
Yes	1096	20.7	5.4 [4.5-6.4]	
Central vascular catheter				
No	8238	5.3	Ref.	$<10^{-3}$
Yes	362	37.6	10.7 [8.5-13.5]	
Peripheral vascular catheter				
No	3735	4.1	Ref.	$<10^{-3}$
Yes	4869	8.6	2.2 [1.8-2.6]	
Intubation/ mechanical ventilation				
No	8211	5.3	Ref.	$<10^{-3}$
Yes	392	34.9	9.5 [7.6-12.0]	
Suprapubic aspiration				
No	8570	6.6	Ref.	$<10^{-3}$
Yes	30	40	9.5 [4.6-19.8]	
Parenteral nutrition				
No	8336	5.9	Ref.	$<10^{-3}$
Yes	265	32.8	7.9 [6.0-10.3]	
Surgical intervention				
No	6744	5.6	Ref.	$<10^{-3}$
Yes	1864	10.7	2.0 [1.7-2.4]	
N= number of hospitalized patients; COR* Crude OR.				

Table 3: Factors associated with HAIs; univariate analysis.

Multivariable analysis identified the main independent risk factors associated to HAIs (Table 4) : Gender (AOR=1.4,CI95%[1.1-1.7]); Hospital department (Intensive Care unit AOR=3.4 ,CI95% [1.8-6.4]unit , Existence of an isolation room(AOR= 1.3,CI95% [1.0-1.6]), Parenteral nutrition (AOR= 1.4 ,CI95%[1.0-2.1]), Surgical intervention (AOR= 1.7,CI95% [1.3-2.1]), Peripheral vascular catheter (AOR= 1.8, CI95% [1.4-2.2]), Intubation/Mechanical ventilation (AOR= 1.9,CI95% [1.3-2.6]), Urinary Catheter (AOR=1.9,CI95%[1.3-2.6]),Central Vascular Catheter (AOR= 3.8,CI95%[2.7-5.4]) , Suprapubic aspiration(AOR= 5.3 ,CI95%[[2.2-12.5]), immunosuppression (AOR= 1.9 ,CI95%[1.5-2.6]and malnutrition (AOR= 1.9 ,CI95% [1.3-2.6].

Variables	AOR* [CI 95%]	P
Gender (male)	1.4 [1.1-1.7]	0.003
Hospital department		$<10^{-3}$
Medical	2.0 [1.1-3.7]	0.026
Polyvalent*	2.8 [1.5-5.3]	0.002
Intensive care	3.4 [1.8-6.4]	$<10^{-3}$
Isolation room	1.3 [1.0-1.6]	0.021
Extrinsic factors		
Parenteral nutrition	1.4 [1.0-2.1]	0.05
Surgical intervention	1.7 [1.3-2.1]	$<10^{-3}$
Peripheral vascular catheter	1.8 [1.4-2.2]	$<10^{-3}$
Intubation/ mechanical ventilation	1.9 [1.3-2.6]	0.001
Urinary catheter	2.3 [1.8-3.0]	$<10^{-3}$
Central vascular catheter	3.8 [2.7-5.4]	$<10^{-3}$
Suprapubic aspiration	5.3 [2.2-12.5]	$<10^{-3}$
Intrinsic factors		
Immunosuppression	1.9 [1.5-2.6]	$<10^{-3}$
Malnutrition	1.9 [1.3-2.6]	$<10^{-3}$
AOR* : adjusted OR; Polyvalent* : Medical and surgical department.		

Table 4: Factors associated with HAIs; multivariate analysis.

Antibiotic Use

In total, 3702 patients had at least one antibiotic prescribed the day of survey, corresponding to a global prevalence of antibiotic use of 43% (CI95%[41.9-44,0]). Regarding the indications of the 5927 precripted molecules, 52.6% were used as curative treatment of community-acquired infections and 16.7% as curative treatment of HAIs (Table 5).

Indication	*n*	%	$IC_{95\%}$
Curative treatment of community-acquired infections	3117	52.6	51.3 – 53.8
Surgical prophylaxis	1262	21.2	20.2 – 22.3
Curative treatment of nosocomial infection	990	16.7	15.7 – 17.6
Prophylaxis of opportunistic infection	404	6.8	6.2 – 7.4
Other indications	154	2.6	2.2 – 3.1
Total prescribed molecules	**5927**	**100**	**-**

Table 5: Indications of antibiotic treatment prescribed the day of survey.

Microbiological Results

Identified Pathogens

Out of the 575 patients having at least one infection, microbiological tests were per-formed for 199 patients (34.6%). One microorganism was identified in 68% of the cases (n=136), two in 31.5% (n=43) and more in rest of the cases. In total, 282 pathogen were isolated; Klebsiella Pneumoniae was the most frequent (Figure 3)

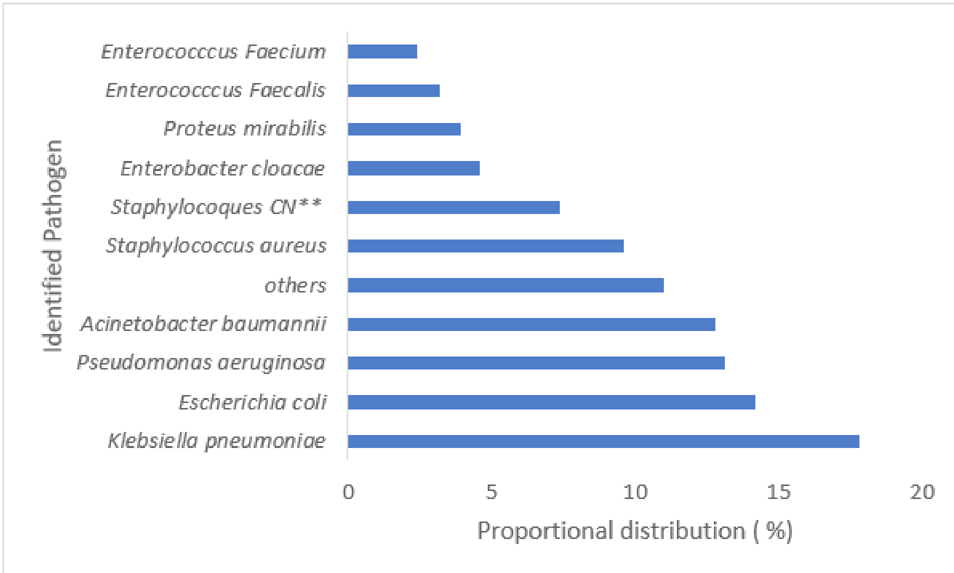

Figure 3: Identified pathogens (n = 282).

Antibiotic-Resistance Phenotypes

The antibiotic- resistance phenotypes were identified for 233 pathogen (82.6% of the isolated bacteria). In total; 4.9% of Staphylococcus aureus were Methicillin-resistant, 15.6% of Enterobacteria were Extended-spectrum beta-lactamases (ESBL) producing; 6.1% of Pseudomonas aeruginosa and 11.7% of Acinetobacter baumannii were Carbapenem-resistant (Table 6).

Microorganism	N	(%)	IC $_{95\%}$
Staphylococcus aureus	27	9.6	6.5 - 13.4
Meticillin-R	14	4.9	2.8 - 7.9
Vancomycine-R	0	-	
Fosfomycine-R	6	2.2	0.9 - 4.4
Quinolones-R	16	5.7	3.4 - 8.9
Pseudomonas aeruginosa	37	13.1	9.5 - 17.4
Ceftazidime-R	12	4.2	2.3 - 7.2
Colistine-R	0	-	
Carbapénème-R	17	6.1	3.7 - 9.3
Acinetobacter baumannii	36	12.8	9.2 - 17.1
Ceftazidime-R	35	12,4	8.9 - 16.7
Colistine-R	0	-	
Carbapénème-R	33	11.7	8.4 - 15.9
Enterobacteria	133	47.2	41.4 - 53.0
E-BLSE (+)	44	15.6	11.7 - 20.2
Carbapeneme-R	19	6.7	4.2 - 10.2
Quinolones-R	59	20.9	16.7 - 25.9
Total isolated	**233**	**100**	
(+): Positive R: Resistant.			

Table 6: Antibiotic - resistance phenotypes (n=233)

Discussion

This study represents the first large prepandemic National point-prevalence study of HAIs including data from patients at different levels of health service delivery in public and private sector in Tunisia.

This study has potential strength: hospitals in this study represent different levels of hospital facilities, and are representative of all healthcare facilities in Tunisia. An-other key strength of this study is that data were actively collected using international standardized tools, and validated by a set of trained experts, leading to a reduction in the variability in case definition and detection.

Our survey revealed that 575 patients had one or more active HAI giving a prevalence of 6.7% (CI95%[6.2-7.3]) and 664 HAIs were identified corresponding to a prevalence of 7.7% (CI95%[7.2-7.3]).

These prevalence's are higher than those found in 2005 survey (6.0%) [8], and are in the range of those reported through the literature, whether in neighboring countries or in some European countries.

In Tunisia, other studies were conducted and focused on specific health care facilities or departments. Surveys conducted in teaching hospitals varied from 9.02% to 17.9% [5,7,13]. A recent study conducted in a Tunisian teaching hospital showed that the prevalence of HAIs increased significantly from 12.3% to 15.5% in 2012 and 2020 respectively [13]. Nosorea 1 is a survey conducted Tunisia in 15 medical intensive units in 2015 showed prevalence of HAI of 25.2% [14].

In Africa, published data are limited. A systematic review of the literature published in 2011 showed that the prevalence of HAIs ranged from 2.5% to 14.8% in Algeria and that it was 19% in Burkina Faso, 15% in Senegal and 14% in Tanzania [15]. A meta-analysis published in 2011 showed that the prevalence ranged from 5.7% to 19.1% [16].

More recently, a study conducted in Ghana in 2019 showed a prevalence of 8.2% and that 161 (93.6%) patients had one HAI [1]. Studies from Sub-saharian countries had demonstrated prevalence rates of HAIs ranging from 6.7% to 28% [17,18]. A study conducted in Ethiopia in 2015 in two teaching hospitals showed a prevalence of 14.9% [19].

The ECDC in 2010 initiated a pilot survey of HAIs in 23 European countries, with an average prevalence rate of 7.1% [20]. Prevalence in other countries ranged between 1.2% and 11.3 [21-25]. In 2010, as part of the NosoMed network, a survey was con-ducted in 27 Public and private institutions belonging to five Mediterranean countries including Tunisia, the prevalence of infected patients ranged from 6.3% in Algeria to 11.9% in Italy [26].

From 2016 to 2017, surveys conducted in 28 countries from the European Union and European Economic Area (EU/EEA), showed a prevalence of 5.9%. This prevalence varied between 4.4% in primary care hospitals to 7.1% in tertiary care hospitals [27].

The widely difference of the design of published studies did not allow a useful comparison as many other studies included different sampling methods, case definition, site infections or patient populations.

First, hospitals surveyed have differences in bed capacity, activities, complexity of patients and the use of invasive procedures [28]. Second, differences in HAI prevalence may be explained by differences in methodology, such as the type and source of data, the qualification of the interviewers, definitions adopted and the period of completion. Last, seasonal fluctuation of HAI prevalence has been reported in the literature [29].

Comparison of HAI site proportions shows similar results with NosoTun 2005 and other studies worldwide but sometimes in different order [21,22,26,27]. This difference could be explained by the difference in ward clinical activities, definitions adopted, and the diagnosis methods of infections.

The prevalence of HAIs is the highest among patients in ICU. This is due to their particular vulnerability and a more frequent use of invasive devices for diagnostic or treatment. Patients in ICU are more exposed to a longer antibiotic treatment resulting in infections with multi-resistant germs and longer hospital stay [30].

Regarding the distribution of HAI prevalence with age, the prevalence in our study was higher among newborns and infants <2 years. This may be explained by complications occurring during hospitalization and also their susceptibility conditions related to prematurity and immune status, use of invasive procedures (such as umbilical vascular catheterization and mechanical ventilation) total parenteral nutrition, antimicrobial use and therapeutic molecules [31,32].

Regarding risk factors, our findings were consistent with other studies [33]. In fact, many authors revealed a higher prevalence among male and patients with mal-nutrition or immunosuppression [21,27,34,35]. Although not identified in our findings, obesity was widely reported as a risk factor for HAIs, as well as diabetes [36]. Besides, it is well established that invasive procedures increase the risk of nosocomial infections [37,38]. Of these, our study showed that the main extrinsic risk factors were suprapubic aspiration, mechanical ventilation, vascular and urinary catheters.

In this one-day survey methodology, the reported HAIs for surgical site infections may be underestimated as a proportion of surgical site infections may occur after hospital discharge and may not have been reported. Recognition of surgical site infections arising after hospital discharge would require setting up a surveillance system that includes active follow-up.

Among the patients surveyed, 43% were actively on antibiotics on the survey date. These high rates of antibiotic use are comparable with findings from other countries and could contribute to the high levels of antibiotic resistance observed [39-41]. In our study, we recorded a low microbiological documentation of HAIs, which may be linked to the high costs associated with performance of these laboratory tests, lab capacities or non-availability of some tests. Lack of information regarding antibiotic susceptibility affects the selection of appropriate agents for therapy, as well as implementation of standard precautions. Nevertheless, the findings are alarming and suggest widespread of antimicrobial resistance in Tunisia, as reported elsewhere.

Both under and over reporting of HAIs may occurred in this type of studies. Underreporting of HAIs is a frequently encountered problem in one day cross sectional surveys related to a difficulty in confirming the case definition of an infection if signs and symptoms were not well documented in the patient's records or if diagnostic tests included in the case definition of a particular HAI type were not done. To avoid this bias, multiple sources of information were verified during data collection, certain elements of a case definition might have been missed in the patient record and revised. Failure to systematically check criteria for all case definitions included in the protocol may also result in incomplete case ascertainment and therefore in under reporting. Finally, lack of diagnostic testing and/or failure to document any signs and symptoms of infections in the patient records may result in low numbers of HAIs.

Overreporting is usually less problematic, and was indeed not a big issue these studies. For example, if certain symptoms are assumed to be present even though they were not documented in any data source.

Another issue is related to the non-respect of the definition of the key term healthcare-associated: even if the case definition of an infection is matched, hospital professional staff may decide not to report the infection as healthcare-associated even though it should according to the definition in the protocol. The recognition of an infection as healthcare-associated still has a negative connotation in our country, be-cause an HAI is perceived as a medical error. Such reporting behavior is possibly influenced by historical or still existing punitive consequences of reporting HAI.

Despite these limitations, this type of surveys allows a rapid estimation of HAI magnitude; generate necessary data in a short time and contribute to the identification of intervention priorities using limited resources. Repeated prevalence surveys at regular intervals provide useful comparative data, revealing secular trends of infections and evaluating control programs [17,18,24]. Point prevalence surveys are generally accepted as a cost-effective strategy of gathering all types of HAI. Hospital-wide surveil-lance of HAIs is very resource-intensive because too few hospitals had sufficient re-sources to perform hospital-wide surveillance using active monitoring and surveil-lance.

Prospective continuous monitoring of HAIs in high-risk departments could help to identify areas that need improvements in terms of prevention and control, and to evaluate the effectiveness of interventions. It is recommended to use prospective continuous surveillance in ICUs, to targeted surgical site infections, or for specific micro-organisms [17].

Given the likelihood for COVID-19 response activities to impact HAI risks and practices, comparing prepandemic prevalence from 2012 to postpandemic prevalence in 2022 is recommended to explore potential changes and implement appropriate infection control measures.

Conclusion

Our study is the first comprehensive HA survey in Tunisia and the findings represent the baseline data that could help to initiate a well-designed HAI prevention and control strategy.

We provided a baseline estimation of the burden of HAI among Tunisian private and public hospitals. Based on our findings, it is recommended to set up an early re-porting system of HAI at hospitals, targeting services at risk. Moreover, a better under-standing of trends in the epidemiology of health care–associated infections and prevention success may be achieved through repeated prevalence surveys in which simi-lar methods are used each time.

This study highlights the need to enhance the NSPS in order to reduce the risk to patients of acquiring preventable infections; effectively manage HAI, prevent and contain antimicrobial resistance; promote appropriate prescribing and use of antimicrobials as part of antimicrobial national strategy; and promote appropriate and sustainable use of infection prevention and control resources.

These results contributed to the development of future control interventions and help practitioners to prioritize strategies.

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All authors declare: We have participated in the conception and design of this work and in the writing of the manuscript and take public responsibility for it. We have reviewed the final version of the manuscript and approve it for publication. We attest to the validity and legitimacy of the data in the manuscript and agree to be named as author of the manuscript. This study was recommended by the Ministry of Health, all-ethical consideration related to confidentiality of data were respected. We have no conflict of interest to declare.

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