National point prevalence survey of healthcare-associated infections and antimicrobial use in French home care settings, May to June 2012

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In May and June 2012, a national point prevalence survey (PPS) of healthcare-associated infections (HAIs) and antimicrobial use was conducted among French patients under home-based hospital care (HBHC). Data from 5,954 patients in 179 volunteer HBHC providers were collected. Prevalence of patients with at least one active HAI was 6.8% (95% confidence interval (CI): 6.1–7.4). Prevalence of those receiving at least one antimicrobial agent was 15.2% (95% CI: 14.3–16.1). More than a third (35.5%) of HAIs were HBHC-associated, 56% were imported from a healthcare facility and 8.5% of indeterminate origin. The main infection sites were urinary tract (26.6%), skin and soft tissue (17.6%), surgical site (15%), and pneumonia or other respiratory tract infections (13.5%). In multivariate analysis, three risk factors were associated with HBHC-associated infections: urinary catheter, at least one vascular catheter and a McCabe score 1 or 2. The most frequently isolated microorganism was *Staphylococcus aureus* (20.7%), 28.1% of them meticillin-resistant. Non-susceptibility to third-generation cephalosporins was reported in 25.3% of *Enterobacteriaceae*, of which 16.1% were extended spectrum beta-lactamase-producing strains. The most prescribed antimicrobials were fluoroquinolones (16.1%), and third-generation cephalosporins (14.5%). PPS may be a good start in HBHC to obtain information on epidemiology of HAIs and antimicrobial use.

Introduction

Nowadays, healthcare-associated infections (HAIs) may occur at different steps of the care pathway from hospital to home care. Besides the fact that more and more patients receive high-tech home care, including home infusion therapy, tracheostomy care and ventilator support, dialysis and other highly invasive procedures, home care patients may have substantial host risk factors, including advanced age, chronic illness or immunosuppression [1,2]. Surveillance of HAIs is thus important in order to identify patients who are at risk of infection and to develop effective infection control prevention measures [1,2]. In the last decades, the importance of surveillance of HAI in the home care setting has been recognised but literature remains sparse [1-7].

In France, a national point prevalence survey (PPS) of HAIs has been organised in healthcare facilities (HCFs) every five years since 1996 as part of the HAI prevention strategy [8]. However, data are lacking concerning care delivered to patients under home-based hospital care (HBHC). This system is becoming an important part of the French healthcare system: in 2011, ca 300 HBHC have provided home healthcare to 12,000 patients each day, accounting for almost 4 million patient days [9].

The objectives of this paper were to describe the major characteristics of HAIs and antibiotic consumption in HBHC and to identify risk factors associated with HBHC-associated infections, based on the first national PPS conducted on patients under HBHC in 2012.

Methods

Setting

This study was conducted in HBHC providers which were invited to participate in the national 2012 PPS survey. This system is part of hospital care that provides

complex medical and paramedical care to individuals in their home. In France, HBHC has to meet the same requirements as hospitals in terms of accreditation, quality and safety of care and prevention of HAIs [10]. They are general and versatile, public or private. Nevertheless, certain HBHC providers can specialise in a particular area of care (e.g. rehabilitation, obstetric or paediatric). Patients of any age, if covered by the national health insurance system, can be admitted with a family doctor's or hospital prescription [10,11]

The home care system is complex and involves a particular context of cooperation and coordination. Various participants are necessary for continuity of care, including the persons involved in the logistic implementations, the HBHC team (physicians in charge of the coordination, nurses, assistant nurses, midwives, physiotherapists, nutritionists etc.) and the team involved in the patient's wellbeing (e.g. family, home help, psychologist). The HBHC providers operate around the clock. The frequency of visits by a nurse varies according to the type of illness and the medical prescription but all patients receive at least one medical visit a week [10,11].

Study design and data collection

This study used the French national PPS protocol [12], which takes into account the European requirements for PPS [13]. However, the French PPS covered not only acute care hospitals, but also rehabilitation centres, long-term care facilities and HBHC providers. The latter had a specific protocol [14] involving a two-step methodology for data collection. All HBHC providers in France were invited to participate in the study between 14 May and 29 June 2012. Regional coordinating centres for nosocomial infection control (CClin) organised training courses on the use of the study protocol and on data collection, and provided technical assistance to local teams. All participating HBHC providers had up to one week during the study period to collect data from their patients in order to account for the extent of the geographical area they cover. A local coordinator, preferably a member of the hygiene team, was responsible for training and managing an investigation team including infection control practitioners or nurses. A senior nurse was responsible for organising visits to patients at home and for assigning a registered nurse or a midwife to help investigators collect data. Data collection was carried out in two steps. Firstly, at the patient's home, the registered nurse or midwife collected clinical data after informing the patient or their guardian about the study and obtaining verbal consent. Secondly, at the HBHC headquarters, the medical investigator completed the patient's questionnaire and confirmed the HAIs and the antimicrobial treatments by examining the patient's medical records.

Data collected included: date of PPS, date of patient admission to HBHC (starting date of home care), age, sex, clinical condition (whether the patient was immunocompromised or had active/advanced cancer and a McCabe score [13] that classifies the severity of underlying medical conditions, specialty area of the patient's care, presence of invasive devices on the day of the survey and whether the patient had one or more active HAIs and/or received antimicrobial treatment. For HAIs, date of onset, infection site, pathogens, origin of HAI (HBHC-associated, imported from a HCF or with an indeterminate origin) were included. Up to three different HAIs per patient and up to two pathogens per HAI could be recorded. Antimicrobial resistance data were collected for selected bug–drug combinations. For antimicrobial use, the type, number (up to five), route of administration and indication (when listed in the patient's medical record) were collected.

The European Centre for Disease Prevention and Control (ECDC) case definitions were used for most HAIs [13] and the McGeer criteria [15] for the diagnosis of pneumonia and respiratory tract infections. An HAI was considered active when signs and symptoms of the infection were present on the date of the survey or when signs and symptoms were no longer present but the patient was still on antimicrobial treatment for this infection on the survey date. HBHC-associated infections were those occurring in a patient during the process of care, neither present nor incubating at the time of starting home care (Day 1), for which the signs and symptoms became apparent after Day 2 and were not associated with a previous discharge from an HCF. Imported HAIs were those that were already present on Day 1 of starting home care or that developed in a patient before Day 3 and for which a discharge from an HCF had preceded the HBHC services (e.g. surgical site infections that met the case definition of an active HAI and occurred within 30 days of the date of surgery or within a year of the surgery in the case of an infection related to a surgically implanted device). For antimicrobial use, the Anatomical Therapeutic Chemical (ATC) classification system established by the World Health Organization (WHO) was used [16].

Data analysis

Data analysis was performed using Stata 11.2 (StataCorp Texas, US). The prevalence of HAIs was reported as the percentage of patients with at least one active HAI among the total number of patients. Analogously, the prevalence of antimicrobial use was reported as the percentage of patients receiving at least one antimicrobial agent among the total number of patients. Antimicrobial resistance was reported as the percentage of non-susceptible (intermediate or resistant) bacteria among the total number of isolates for which antimicrobial susceptibility testing (AST) results were available. Univariate and multivariate analyses were carried out in order to identify factors independently associated with HBHC-associated infections. Thus, patients with HAIs exclusively imported from an HCF or with an indeterminate origin were excluded from these analyses. In the univariate analysis, comparisons

Table 1

Prevalence of infected patients according to clinical characteristics, national point prevalence survey in home care settings, France, May–June 2012 (n = 5,954)

	Patients	With HAIs	Prevalence ratio (95% CI)	P [a]	Patients[b]	With HBHC-associated infections	Prevalence ratio (95% CI)	P [a]
	n (%$_{column}$)	n (%$_{row}$)			n (%$_{column}$)	n (%$_{row}$)		
Age group (years)								
<1	149 (2.5)	1 (0.7)	0.1 (0.14–0.80)		148 (2.6)	0 (0.0)	NA	
1–17	127 (2.1)	4 (3.1)	0.5 (0.18–1.49)		125 (2.2)	2 (1.6)	0.7 (0.16–3.17)	
18–44	650 (10.9)	38 (5.8)	Reference	<0.01	626 (11.0)	14 (2.2)	Reference	0.35
45–74	2,665 (44.8)	207 (7.8)	1.4 (0.95–1.94)		2,525 (44.3)	67 (2.7)	1.2 (0.67–2.13)	
75–84	1,412 (23.7)	94 (6.7)	1.1 (0.78–1.69)		1,353 (23.7)	35 (2.6)	1.2 (0.62–2.17)	
≥85	951 (16.0)	59 (6.2)	1.1 (0.70–1.62)		920 (16.1)	28 (3.0)	1.4 (0.72–2.63)	
Specialty area of patient's care								
Medical or paediatric	5,476 (92.0)	393 (7.2)	3.6 (1.91–6.83)	<0.0001	5,226 (91.7)	143 (2.7)	4.4 (1.4–13.82)	<0.01
Other area of care[c]	478 (8.0)	10 (2.1)	Reference		471 (8.3)	3 (0.6)	Reference	
Sex								
Female	2,995 (50.3)	194 (6.5)	Reference	0.37	2,880 (50.6)	79 (2.7)	Reference	0.38
Male	2,959 (49.7)	209 (7.1)	1.1 (0.90–1.34)		2,817 (49.4)	67 (2.4)	0.9 (0.62–1.20)	
McCabe score								
0 Non-fatal disease	1,664 (28.0)	88 (5.3)	Reference		1,596 (28.0)	20 (1.3)	Reference	
1 Ultimately fatal disease	1,573 (26.4)	114 (7.2)	1.4 (1.05–1.86)	0.02	1,510 (26.5)	51 (3.4)	2.8 (1.63–4.64)	<0.0001
2 Rapidly fatal disease	1,342 (22.5)	108 (8.0)	1.6 (1.17–2.10)		1,283 (22.5)	49 (3.8)	3.1 (1.85–5.29)	
Missing/unknown	1,375 (23.1)	93 (6.8)	NA		1,308 (23.0)	26 (2.0)	NA	
Immunocompromised patients								
No	3,870 (65.0)	244 (6.3)	Reference		3,707 (65.1)	81 (2.2)	Reference	
Yes	1,512 (25.4)	127 (8.4)	1.4 (1.09–1.70)	0.01	1,437 (25.2)	52 (3.6)	1.7 (1.18–2.39)	0.01
Missing/unknown	572 (9.6)	32 (5.6)	NA		553 (9.7)	13 (2.4)	NA	
Active/advanced cancer								
No	3,483 (58.5)	236 (6.8)	Reference		3,319 (58.3)	72 (2.2)	Reference	
Yes	2,005 (33.7)	148 (7.4)	1.1 (0.89–1.35)	0.04	1,926 (33.8)	69 (3.6)	1.7 (1.20–2.34)	0.001
Missing/unknown	466 (7.8)	19 (4.1)	NA		452 (7.9)	5 (1.1)	NA	
At least one invasive device								
No	3,457 (58.1)	140 (4.0)	Reference	<0.0001	3,365 (59.1)	48 (1.4)	Reference	<0.0001
Yes	2,497 (41.9)	263 (10.5)	2.8 (2.26–3.45)		2,332 (40.9)	98 (4.2)	3.0 (2.14–4.30)	
Urinary catheter								
No	5,188 (87.1)	328 (6.3)	Reference	<0.0001	4,965 (87.2)	105 (2.1)	Reference	<0.01
Yes	766 (12.9)	75 (9.8)	1.6 (1.23–2.09)		732 (12.8)	41 (5.6)	2.8 (1.90–3.98)	
Tracheal intubation or tracheotomy								
No	5,748 (96.5)	384 (6.7)	Reference	0.15	5,505 (96.6)	141 (2.6)	Reference	0.97
Yes	206 (3.5)	19 (9.2)	1.4 (0.88–2.30)		192 (3.4)	5 (2.6)	1.0 (0.41–2.51)	
At least one catheter								
No	4,077 (68.5)	190 (4.7)	Reference	<0.0001	3,963 (69.6)	76 (1.9)	Reference	<0.0001
Yes	1,877 (31.5)	213 (11.3)	2.6 (2.14–3.21)		1,734 (30.4)	70 (4.0)	2.2 (1.55–2.99)	
Peripheral vascular catheter								
No	5,792 (97.3)	364 (6.3)	Reference	<0.0001	5,562 (97.6)	133 (2.4)	Reference	<0.0001
Yes	162 (2.7)	39 (24.1)	0.2 (0.14–0.31)		135 (2.4)	13 (9.6)	0.2 (0.13–0.42)	
Central vascular catheter								
No	5,812 (97.6)	380 (6.5)	Reference	<0.0001	5,572 (97.8)	139 (2.5)	Reference	0.03
Yes	142 (2.4)	23 (16.2)	0.4 (0.23–0.57)		125 (2.2)	7 (5.6)	0.4 (0.20–0.94)	
Peripherally inserted central catheter								
No	5,795 (97.3)	368 (6.4)	Reference	<0.0001	5,568 (97.7)	141 (2.5)	Reference	0.34
Yes	159 (2.7)	35 (22.0)	4.2 (2.82–6.15)		129 (2.3)	5 (3.9)	1.6 (0.63–3.85)	
Implantable venous access device								
No	4,823 (81.0)	300 (6.2)	Reference	0.001	4,630 (81.3)	107 (2.3)	Reference	0.01
Yes	1,131 (19.0)	103 (9.1)	1.5 (1.20–1.91)		1,067 (18.7)	39 (3.7)	1.6 (1.10–2.33)	
Subcutaneous catheter								
No	5,624 (94.5)	380 (6.8)	Reference	0.88	5,378 (94.4)	134 (2.5)	Reference	0.16
Yes	330 (5.5)	23 (7.0)	1.0 (0.67–1.60)		319 (5.6)	12 (3.8)	1.5 (0.84–2.79)	
Total	**5,954**	**403 (6.8)**			**5,697**	**146 (2.6)**		

CI: confidence interval; HAI: healthcare-associated infection; HBHC: home-based hospital care; NA: not applicable.

[a] P value of Pearson's chi-squared test. Significant values are highlighted in bold.

[b] Patients with HAI exclusively imported from a healthcare facility or with an indeterminate origin were excluded from this analysis (n = 257 patients).

[c] This category covers patients receiving psychiatric/mental healthcare, antepartum or post-partum care, rehabilitation and physical therapy and other care. Among the patients who received psychiatric/mental healthcare or antepartum care, none presented an infection.

Relative percentage (site-specific) of healthcare-associated infections by origin of infection, national point prevalence survey in home care settings, France, May-June 2012 (n = 420)
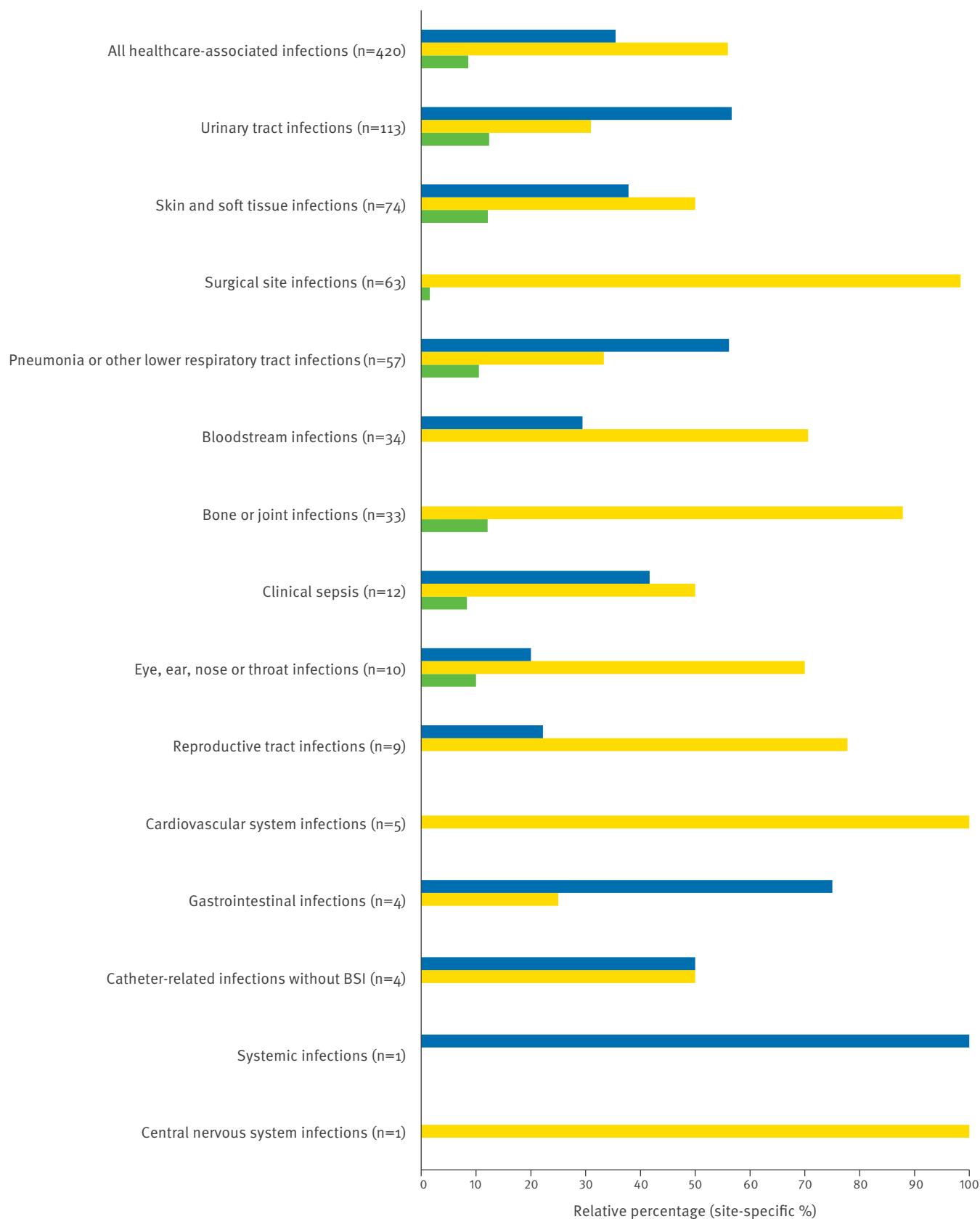
BSI: bloodstream infection; HAI: healthcare-associated infection; HBHC: home-based hospital care.

TABLE 2

Independent risk factors of infections associated with home-based hospital care, national point prevalence survey in home care settings, France May–June 2012 (n = 5,656)

Variables	Two-level random intercept model [a]			
	Full model		Final model	
	OR (95% CI)	p	OR (95% CI)	p
Active/advanced cancer	1.15 (0.69–1.89)	0.18	NA	NA
Immunocompromised patients	0.91 (0.11–1.20)	0.32	NA	NA
Receiving medical or paediatric care	2.10 (0.58–7.52)	0.26	NA	NA
McCabe score 1 or 2	1.61 (0.91–2.87)	0.10	1.82 (1.07–3.08)	0.03
Urinary catheter	2.35 (1.58–3.49)	<0.0001	2.38 (1.61–3.52)	<0.0001
At least one vascular catheter	1.82 (1.24–2.66)	0.002	1.89 (1.33–2.70)	<0.0001
	Model validation results			
	Full model		Final model	
Log likelihood	−626.99		−629.91	
Level 2 intercept variance (uoj)	0.73; SE (0.27)		0.74; SE (0.27)	
Intra-class correlation	0.18; SE (0.05)		0.18; SE (0.05)	
Likelihood-ratio test of rho (p)	<0.0001		<0.0001	
Akaike information criterion (AIC)	1,275.97		1,271.81	
Bayesian information criterion (BIC)	1,349.02		1,311.65	
Total number of patients	5,656		5,656	
Number of home care providers	160		160	
Number of patients with HBHC-associated infections	145		145	

CI: confidence interval; HBHC: home-based hospital care; NA: not applicable; OR: odds ratio; SE: standard error.

[a] Output model obtained by retaining the significant variables (p<0.05).

Patients with healthcare-associated infections exclusively imported from a healthcare facility or with an indeterminate origin were excluded from this analysis, as were HBHC that included fewer than five patients (nine HBHC and 41 patients).

between infected and non-infected patients were performed using the chi-squared test and expressed as prevalence ratios. Multivariate analysis was conducted using logistic regression with all variables that had p<0.2 in the univariate analysis. Multivariate analysis was completed by a two-level random intercept logistic model, considering patients clustered in their respective HBHC. The Stata command *xtmelogit* was used to run analyses and data from HBHC that included more than five patients. The final model was computed with a manual stepwise backward elimination. All tests were considered as significant at p<0.05 in the whole analysis. The −2 log likelihood ratio test and lowest Akaike information criterion score were evaluated in order to determine the model with the best fit.

Results

Data from 5,954 patients in 179 HBHC providers were collected. More than half (55%) of participating providers were public, 35% were private for-profit and 10% were private non-profit. Private for-profit providers included most patients (45.6%). The median number of patients per HBHC was 19 (interquartile range (IQR): 10–35). Most patients (88.4%) received medical care, 3.6% paediatric care, 3.3% psychiatric or mental healthcare, 3.2% antepartum or post-partum care, 1.2% rehabilitation and physical therapy and 0.3% received other care. The median length of home healthcare was

35 days (IQR: 12−96) and only 4.3% had received home healthcare for less than two days on the day of survey.

The median patient age was 69 years (IQR: 55−81) and the male-to-female sex ratio was 1. A quarter of patients were immunocompromised, a third presented an active or advanced cancer and nearly a half (48.9%) were classified as having fatal prognosis (McCabe score 1 or 2). On the day of the survey, 42% of patients presented at least one invasive device, 31.5% at least one vascular or subcutaneous catheter (mostly an implantable venous access device in 19% of patients), 13% a urinary catheter and 3.5% a tracheal intubation or tracheostomy (Table 1).

Healthcare-associated infections

A total of 420 HAIs in 403 patients were reported. The prevalence of patients with at least one active HAI was 6.8% (95% confidence interval (CI): 6.1–7.4). Most of the infected patients (n=387, 96.0%) had only one HAI, 15 (3.7%) had two HAIs and one patient (0.3%) had three HAIs on the day of the survey. The prevalence of patients with at least one HAI was not significantly different for HBHC with different ownership status. Among the patients who received psychiatric/mental healthcare or antepartum care, none presented an infection. The HAI prevalence was significantly lower (p<0.001)

Distribution of microorganisms isolated from healthcare-associated infections, national point prevalence survey in home care, France, May-June 2012 (n = 324)
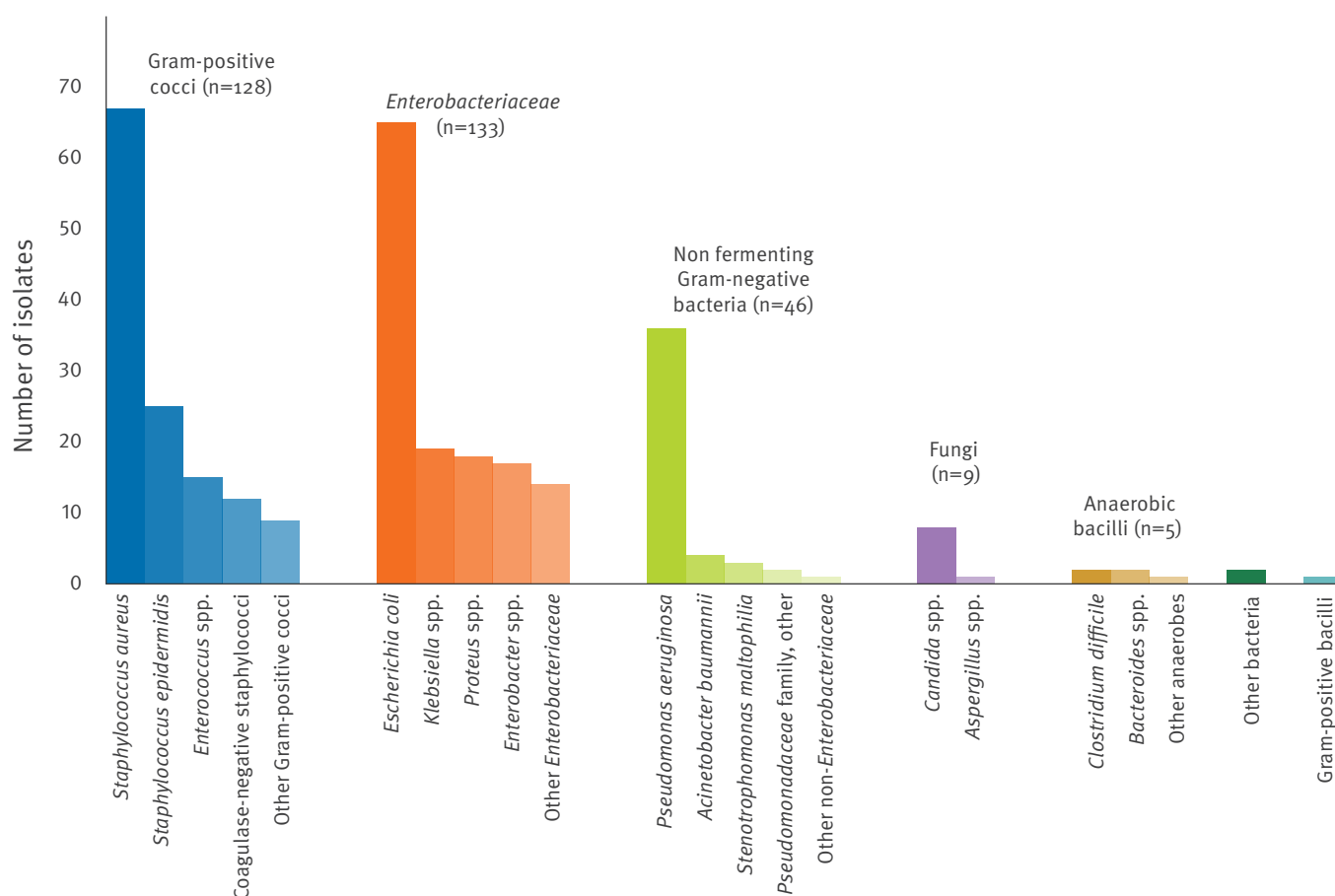
in patients younger than 18 years (1.8%) than in patients 18 years and older (7%). Overall, 149 (35.5%) infections in 146 patients were HBHC-associated infections (prevalence: 2.5%; 95% CI: 2.1–2.9), 235 (56%) infections in 228 patients were imported from a healthcare setting (mainly from acute care facilities) and 36 infections (8.5%) in 34 patients had an indeterminate origin. The most common HAIs were urinary tract infections (UTIs), followed by skin and soft tissue infections (SSTIs), surgical site infections (SSI) and pneumonia or other lower respiratory tract infections (LRTIs). UTIs and pneumonia or other LRTIs were the most frequent infections reported as HBHC-associated (Figure 1). Surgical site infections accounted for 26.4% of the 235 infections reported as imported from an HCF.

Risk factors for HBHC-associated infection

Several patient characteristics were associated with higher risk in the univariate analysis: patients who received medical or paediatric care, McCabe score > 0, immunocompromised patients, active/advanced cancer, at least one invasive device, a urinary catheter or at least one vascular catheter (Table 1). When these factors were analysed using a two-level random effect logistic model, the presence of a urinary catheter (odds ratio (OR) = 2.38; 95% CI: 1.61–3.52), the

presence of at least one vascular catheter (OR = 1.89; 95% CI: 1.33–2.70) and McCabe score 1 or 2 (OR = 1.82; 95% CI: 1.07–3.08) were the independent factors associated with HBHC-associated infections (Table 2).

Isolated microorganisms and antimicrobial susceptibility

A positive microbiology result was available for 274 (65.2%) HAIs (any origin): a single microorganism was reported for 224 HAIs (53.3%); two or more were reported for 50 (11.9%). Among the 324 microorganisms isolated, the most common were *Enterobacteriaceae* (41%) followed by Gram-positive cocci (40%). *Staphylococcus aureus* was the most frequently isolated microorganism (21%), mainly in skin and soft tissue infections, followed by *Escherichia coli* (20%), mostly in urinary tract infections (Figure 2).

Among the 257 isolates concerned by selected bug–drug combinations, 181 (70%) had available AST results. Listing only strains with at least 20 isolates tested, the available results were: 57 of 67 S. aureus isolates, 23 of 36 *Pseudomonas aeruginosa* isolates and 87 of 133 *Enterobacteriaceae* isolates, mainly *E. coli* isolates (46 of 87 with known AST results). Meticillin resistance was reported in 16 of 57 S. aureus isolates with known AST results, including two vancomycin non-susceptible

Antimicrobial use: prevalence, indication, route of administration and reason in patient charts/notes, national point prevalence survey in home care settings, France, May–June 2012 (n = 179 home-based hospital care providers, n = 5,954 patients)

	Patients under antimicrobial treatment[a]		Antimicrobial agents	
	n	Prevalence (95% CI)[b]	n	Relative %[c]
Total	**906**	**15.2 (14.3–16.1)**	**1,163**	**100**
Indication of antimicrobial treatment				
Treatment intended for community infection	346	5.8 (5.2–6.4)	462	39.7
Treatment intended for healthcare-associated infection	343	5.8 (5.2–6.4)	446	38.3
Medical prophylaxis	115	1.9 (1.6–2.3)	129	11.1
Other indications[d]	48	0.8 (0.6–1.0)	53	4.6
Surgical prophylaxis[e]	17	0.3 (0.1–0.4)	20	1.7
Unknown indication	47	0.8 (0.6–1.0)	53	4.6
Route of administration				
Oral	605	10.2 (9.4–10.9)	718	61.7
Intravenous	302	5.1 (4.5–5.6)	387	33.3
Intramuscular	23	0.4 (0.2–0.6)	23	2.0
Subcutaneous	26	0.4 (0.3–0.6)	27	2.3
Unknown	7	0.1 (0.0–0.2)	8	0.7
Reason in patient's medical record				
Yes	743	12.5 (11.6-13.3)	973	83.7
No	150	2.5 (2.1-2.9)	164	14.1
Missing data in the questionnaire	21	0.4 (0.2-0.5)	26	2.2

CI: confidence interval.

[a] Patients receiving a least one antimicrobial agent.

[b] Prevalence of antimicrobial use in each category.

[c] Percentage among total number of antimicrobials (relative percentage).

[d] This category included antimicrobials used for other indications: e.g. erythromycin as prokinetic agent or when the same antimicrobial agent was prescribed for more than one indication.

[e] Surgical intervention does not occur in home-based hospital care, however, surgical prophylaxis was reported for 17 patients of whom 16 received surgical prophylaxis for longer than two days.

The sum of patients treated, by indication, route of administration or reason of antimicrobial treatment, may not be equal to the total number of patients treated with at least one antimicrobial, as the same patient could have had more than one antimicrobial treatments.

(intermediate) isolates. Resistance to third-generation cephalosporins was reported in eight of 23 P. aeruginosa isolates and in 22 of 87 *Enterobacteriaceae*, 14 of them were extended spectrum beta-lactamase (ESBL)-producing strains. Non-susceptibility to carbapenems was reported in six of 23 *P. aeruginosa* isolates and in two of 87 *Enterobacteriaceae* (which were *E. coli* strains).

Antimicrobial use

A total of 906 patients received at least one antimicrobial agent (prevalence: 15.2%; 95% CI: 14.3–16.1). Among them, 687 (75.9%) patients received one antimicrobial agent, 187 (20.6%) received two antimicrobials and 32 (3.5%) received three or more antimicrobial agents. A total of 1,163 antimicrobial prescriptions were reported (68 different molecules), which corresponds to an average of 1.3 antimicrobial agents per patient receiving an antimicrobial treatment. On the day of the survey, 85% of patients with an HAI received at least one antimicrobial. The prevalence of patients receiving at least one

antimicrobial agent was highest in patients between 1 and 17 years of age (32.3%) and lowest among patients younger than 1 year (4.0%). It was also significantly higher (p<0.0001) among men than among women (17.3% vs 13.2%) and highest among immunocompromised patients (20.8%). Furthermore, patients were more likely to receive at least one antimicrobial agent when they had at least one invasive device (23.3% with invasive device vs 9.4% without) or at least one catheter (26.6% with catheter vs 10% without) or a urinary catheter (18.7% with urinary catheter vs 14.7% without).

Antimicrobials were most frequently prescribed for treatment of an infection (78.1%): community-acquired infection (39.7%) or HAI (38.3%). Medical prophylaxis was the indication in 11.1% of prescriptions (Table 3). The most common infections treated were: SSTI (23.8%), pneumonia and LRTI (20.3%), bone or joint infections (17.3%) and UTI (14.6%). The route of administration was mostly oral (61.7%) and the reason for antimicrobial use was documented in the patient's medical records for 83.7% (Table 3).

Distribution of antimicrobial agents by main indication, national point prevalence survey in home-care settings, France May–June 2012 (n = 1,163)

Top antimicrobial agents (accounting for 95.2% of use) n (%)	All indications n (%)	Treatment for community infections n (%)	Treatment for healthcare-associated infections n (%)	Medical prophylaxis n (%)	Other[a] indications
Antimicrobial agents, total	**1,163 (100)**	**462 (39.7)**	**446 (38.3)**	**129 (11.1)**	**53 (4.6)**
Fluoroquinolones (J01MA)	187 (16.1)	77 (16.7)	80 (17.9)	10 (7.8)	7 (13.2)
Ciprofloxacin (J01MA02)	72 (6.2)	29 (6.3)	36 (8.1)	3 (2.3)	2 (3.8)
Ofloxacin (J01MA01)	61 (5.2)	25 (5.4)	23 (5.2)	3 (2.3)	2 (3.8)
Levofloxacin (J01MA12)	40 (3.4)	16 (3.5)	17 (3.8)	2 (1.6)	3 (5.7)
Third-generation cephalosporins (J01DD)	169 (14.5)	72 (15.6)	67 (15.0)	11 (8.5)	11 (20.8)
Ceftriaxone (J01DD04)	109 (9.4)	47 (10.2)	40 (9.0)	7 (5.4)	9 (17.0)
Cefixime (J01DD08)	26 (2.2)	10 (2.2)	12 (2.7)	1 (0.8)	2 (3.8)
Ceftazidime (J01DD02)	18 (1.5)	8 (1.7)	9 (2.0)	1 (0.8)	NA
Combinations of penicillins, incl. beta-lactamase inhibitors (J01CR)	153 (13.2)	74 (16.0)	48 (10.8)	14 (10.9)	6 (11.3)
Amoxicillin and enzyme inhibitor (J01CR02)	127 (10.9)	61 (13.2)	35 (7.8)	14 (10.9)	6 (11.3)
Piperacillin and enzyme inhibitor (J01CR05)	25 (2.1)	13 (2.8)	12 (2.7)	NA	NA
Combinations of sulfonamides and trimethoprim, incl. derivatives (J01EE)	95 (8.2)	22 (4.8)	20 (4.5)	42 (32.6)	7 (13.2)
Sulfamethoxazole and trimethoprim (J01EE01)	95 (8.2)	22 (4.8)	20 (4.5)	42 (32.6)	7 (13.2)
Penicillins with extended spectrum (J01CA)	83 (7.1)	37 (8.0)	29 (6.5)	8 (6.2)	2 (3.8)
Amoxicillin (J01CA04)	81 (7.0)	37 (8.0)	27 (6.1)	8 (6.2)	2 (3.8)
Streptogramins (J01FG)	51 (4.4)	15 (3.2)	30 (6.7)	1 (0.8)	2 (3.8)
Pristinamycin (J01FG01)	51 (4.4)	15 (3.2)	30 (6.7)	1 (0.8)	2 (3.8)
Carbapenems (J01DH)	49 (4.2)	20 (4.3)	26 (5.8)	NA	1 (1.9)
Imipenem and enzyme inhibitor (J01DH51)	36 (3.1)	16 (3.5)	17 (3.8)	NA	1 (1.9)
Antibiotics for treatment of tuberculosis (J04AB)	42 (3.6)	12 (2.6)	27 (6.1)	NA	2 (3.8)
Rifampicin (J04AB02)	41 (3.5)	12 (2.6)	26 (5.8)	NA	2 (3.8)
Triazole derivatives (J02AC)	35 (3.0)	16 (3.5)	10 (2.2)	3 (2.3)	1 (1.9)
Fluconazole (J02AC01)	30 (2.6)	14 (3.0)	9 (2.0)	2 (1.6)	NA
Other antibacterials (J01XX)	35 (3.0)	12 (2.6)	22 (4.9)	NA	NA
Daptomycin (J01XX09)	19 (1.6)	4 (0.9)	15 (3.4)	NA	NA
Imidazole derivatives (J01XD)	33 (2.8)	19 (4.1)	4 (0.9)	6 (4.7)	2 (3.8)
Metronidazole (J01XD01)	33 (2.8)	19 (4.1)	4 (0.9)	6 (4.7)	2 (3.8)
Glycopeptide antibacterials (J01XA)	31 (2.7)	13 (2.8)	18 (4.0)	NA	NA
Vancomycin (J01XA01)	21 (1.8)	8 (1.7)	13 (2.9)	NA	NA
Other aminoglycosides (J01GB)	31 (2.7)	14 (3.0)	12 (2.7)	2 (1.6)	2 (3.8)
Macrolides (J01FA)	30 (2.6)	11 (2.4)	7 (1.6)	8 (6.2)	3 (5.7)
Beta-lactamase-resistant penicillins (J01CF)	23 (2.0)	8 (1.7)	10 (2.2)	1 (0.8)	1 (1.9)
Lincosamides (J01FF)	23 (2.0)	10 (2.2)	11 (2.5)	1 (0.8)	NA
Beta-lactamase-sensitive penicillins (J01CE)	20 (1.7)	3 (0.6)	NA	13 (10.1)	1 (1.9)
Tetracyclines (J01AA)	17 (1.5)	7 (1.5)	2 (0.4)	3 (2.3)	4 (7.5)

NA: not applicable.

[a] This category included antimicrobials used for other indications: e.g. erythromycin as prokinetic agent or prescription of a same antimicrobial agent for more than one indication.

Only levels 4 and 5 of the Anatomical Therapeutic Chemical classification system [16] are shown. Individual sums may not add up to the totals because only the most frequent antimicrobials are shown here.

The categories 'unknown indication' and 'surgical prophylaxis' represented 4.6% and 1.7% of the total, respectively, and are included in the first column.

Antibacterials for systemic use (ATC group J01) accounted for 91.6% of all reported antimicrobials. Antimycotics for systemic use (ATC group J02) accounted for 4.0% of the total reported antimicrobials. The most widely used antimicrobial agents at ATC level 4 [16] were fluoroquinolones (16.1%), followed by third generation cephalosporins (14.5%) and combinations of penicillins with beta-lactamase inhibitors (13.2%), mainly prescribed for the treatment of infections. For medical prophylaxis, combinations of sulphonamides and trimethoprim were the most common group (32.6%). At ATC level 5, the most frequently prescribed antimicrobial agent was amoxicillin, with enzyme inhibitor representing 10.9% of all antimicrobials. It was the most frequently used drug in treatment of community infections, followed by ceftriaxone (9.4%) and sulfamethoxazole with trimethoprim (8.2%), mainly prescribed for medical prophylaxis (Table 4).

Discussion

To our knowledge, our study is the first to provide estimates of HAIs and antimicrobial use in HBHC in a European country based on a large multicentre patient-based sample. The prevalence of patients with at least one HAI was slightly higher in our study than those found in the PPS conducted in HCFs [17], however only a third of the total were HBHC-associated infections. Our home care population was at high risk for HAIs with heavy underlying conditions, including diseases with poor prognosis, and with frequent exposure to invasive procedures (especially urinary and vascular catheters) and to antimicrobial agents for either community infection or HAI (mainly fluoroquinolones and third-generation cephalosporins). In addition, our study provides critical data on antimicrobial susceptibility, especially MRSA and ESBL-producing strains.

Our study covered almost 60% of HBHC providers registered in France by the National Agency for Information on Hospital Care (ATIH) [9]. To date, few HAI prevalence studies in HBHC settings have been published despite the growing use of home care services in the recent years [1,4,9]. This could be partly explained by the fact that data collection in the home care setting is more difficult than in HCFs owing to the geographical dispersion of homes, difficulty in tracking clinical and laboratory data, and the multiple healthcare workers. In our study, data collection was facilitated by a two-step methodology, previously tested in 2007 in a French pilot HBHC [18] and by the technical and methodological support provided by regional reference centres. Dwyer et al. [19], in a recently published study in the United States on a national sample representative of people receiving home care, reported that 11.5% of individuals had an infection at the time of the survey, which is higher than the rate found in our study. However, the most common infections including UTIs, pneumonia and cellulitis were the same as ours. However, in the study by Dwyer et al., the study design did not allow determining whether infections were resolved or ongoing or whether infections were associated with the community or with a previous healthcare exposure or with the current home care. In our study, the origin of HAIs was recorded: HBHC-associated infections were defined as those occurring in a patient during the process of care, neither present nor incubating at the time of starting home care (Day 1), for which the signs and symptoms became apparent after Day 2 and were not associated with a previous discharge from an HCF. In another American study, Manangan et al. [4] reported that 16% of home care patients had infections during the study period; 8% of these infections were reported as being acquired at home, which differs significantly from our study. Compared with the *Healthcare Associated infections and antimicrobial use in Long-Term care facilities* (HALT) study conducted in Europe in LTCFs and nursing homes (NHs) [20], the prevalence of infected residents in French NHs was similar to our prevalence of HBHC-associated infections.

Compared with included patients from HCFs [17], our studied patients were older, more likely to have been exposed to at least one invasive device, more frequently immunocompromised or suffering from an active cancer and more likely to have a diagnosis that was rapidly or ultimately fatal than patients included from HCFs. In our study, many individual patient characteristics were associated in the univariate analysis with a HBHC-associated infection, but only the presence of invasive devices and underlying conditions was associated with HAI in the multivariate analysis. This result was obtained using a two-level random intercept logistic model allowing adjustment of the risk estimates for random variations among HBHC, meaning that the results were not influenced by differences between HBHC providers.

In our study, a microbiological diagnosis was made in two thirds of HAIs, as most of the case definitions of HAIs were mainly based on clinical criteria. In addition, AST results were available for the majority of selected bug–drug combinations. Among the few published prevalence studies in home care, only two French pilot studies [5,18] reported microbiological data on HAIs. *S. aureus* was the main pathogen isolated in our study, in contrast to results found in PPS in HCFs where *E. coli* was most frequently isolated [17]. The rates of ESBL-producing strains as well as carbapenemase-producing *P. aeruginosa* were as high in HBHC as in HCF. Emerging ESBL-producing strains and carbapenemase-producing bacteria remain a rare but scrutinised phenomenon in France. The higher antimicrobial non-susceptibility estimated in our study should therefore be interpreted with caution because the number of isolated microorganisms with information on AST was small.

With regard to antimicrobial use, our study is, to our knowledge, the first published study which presents data about antimicrobial use in the HBHC setting. Some studies reported data on antimicrobial use in nursing home residents [20-24] and others focused only on outpatient parenteral antimicrobial therapy.

Most of these studies are not directly comparable with our study because of different patient populations and different antimicrobial classification. For instance, in the 2010 HALT study [20], the prevalence of residents in French NHs receiving at least one antimicrobial agent was lower than the prevalence of patients who received at least one antimicrobial agent in our study. Penicillins, quinolones and other beta-lactams were the most frequently prescribed antimicrobials in the HALT study [20]. In addition, the prevalence of patients receiving at least one antimicrobial agent was slightly lower in our study when compared with those in HCFs [17]. More guidance on the use of antimicrobials for infection or prophylaxis is needed. Overuse and misuse of antimicrobials have resulted in the emergence of multidrug-resistant organisms; monitoring the use of antimicrobials has become a concern in all HCFs, and home care settings should not be an exception.

As is usual in prevalence study designs, some methodological issues have to be raised. Firstly, this study does not allow assessment of the temporal relationship between exposure and outcome, as in other point-prevalence studies, resulting in a possible over-representation of infections of long duration (e.g. skin and soft tissue infections) and underestimation of more time-limited infections (e.g. infectious diarrhoea) [25,26]. Secondly, there was a potential risk of selection bias because the HBHC participating were not a random sample of HBHC settings in France. Finally, due to the large-scale patient-based approach, we could only investigate certain risk factors and may have missed some confounding factors (e.g. parenteral nutrition, comorbidities, some patient characteristics or potential health and safety hazards in the home) [1,2,27,28]. On the other hand, data quality of the survey was controlled by training investigators, searching for missing data, validation of clinical diagnosis by a supervisor and support from regional reference centres. Standardised criteria for infection diagnosis were based on ECDC case definitions for most HAIs and on the McGeer criteria [15] for the diagnosis of pneumonia and respiratory tract infections. Indeed, radiological diagnosis for the latter infections may not be available in HBHC settings. In addition, variability due to HBHC differences was taken into account using a two-level random logistic regression analysis. One additional benefit of this study is that it reinforced awareness about infection control among the large number of participating home care staff and that the impact of this study could encourage more staff to participate in future PPS.

In conclusion, PPS may be a good start in HBHC to obtain information on the epidemiology of HAIs and to quantify the burden of HAIs and antimicrobial use. Programme initiatives in such settings should include surveillance of the more critical HAIs, staff training and awareness, allocation of sufficient resources for infection control teams, fostering the safety culture of healthcare staff, patient empowerment and definitions of priorities at the national level.

Ethical considerations

According to the French law for biomedical research and human experimentation, an individual written consent from the patients or their relatives was not required for data collection. However, all patients were informed about the study by the nurse before their inclusion.

Conflict of interest

None declared.

Authors' contributions

All authors have contributed directly to the intellectual content of the paper and have agreed to have their name listed as an author on the final, revised version. Their own substantive contribution to the paper is as follows: Katiuska Miliani developed the concept of the manuscript, managed the national database, analysed the data and wrote the first draft of the manuscript. Brigitte Migueres contributed to the concept of the manuscript, interpreted the results critically and revised the article to ensure important intellectual content. Delphine Verjat-Trannoy critically reviewed the article and provided important feedback on the article. Sophie Vaux provided critical revision of the article for important content. Jean-Michel Thiolet reviewed the article and contributed to the final version. Pascal Astagneau, is the head of the research team, he provided epidemiological expertise and also contributed to final revision.
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