MOLECULAR EPIDEMIOLOGY

Pneumococcal infections and homelessness

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Keywords

Homelessness • Invasive pneumococcal diseases • *Streptococcus pneumoniae* • Pneumococcal vaccination • Real-time polymerase chain reaction

Summary

Objective. *To assess the prevalence of pneumococcal nasopharyngeal carriage, the role of potential risk factors, and the pneumococcal vaccination coverage among sheltered homeless people in Marseille, France.*
Methods. *During the winters 2015-2018, we enrolled 571 sheltered homeless males and 54 non-homeless controls. Streptococcus pneumoniae was directly searched from nasal/pharyngeal samples using real-time polymerase chain reaction.*
Results. *The homeless people were mostly migrants from African countries, with a mean age of 43 years. Pneumococcal vaccination coverage was low (3.1%). The overall pneumococcal carriage rate was 13.0% and was significantly higher in homeless people (15.3% in 2018) than in controls (3.7%), with p = 0.033. Among homeless people, being aged ≥ 65 years (1.97, 95% CI; 1.01-3.87), living in a specific shelter (OR = 1.80, 95% CI: 1.06-3.05), and having respiratory signs and symptoms at the time of enrolment (OR = 2.55, 95% CI: 1.54-4.21) were independently associated with pneumococcal carriage.*
Conclusion. *Pneumococcal nasopharyngeal carriage, which is a precursor for pneumococcal disease in at-risk individuals, is frequent among French homeless people. Studies conducted in other countries have also reported outbreaks of pneumococcal infections in homeless people. Pneumococcal vaccination should be systematically considered for sheltered homeless people in France, as is being done in Canada since 2008.*

Introduction

Invasive pneumococcal disease (IPD) is caused by *Streptococcus pneumoniae* and has been associated with several outbreaks among homeless people [1-4]. In several studies conducted in Canada between 2000 and 2016, many patients with IPD were homeless (7.4-18.8%) and experienced high mortality rates (6.9-15.6%) [1-4]. Serotype 4, 5, 8 and 12F IPD outbreaks were associated with homelessness in Canada [3, 5]. Serotype 4 outbreaks were also associated with homelessness in New Mexico, USA [6]. A study investigating the baseline risk of invasive streptococcal infections in Alaska, USA, estimated that the prevalence of IPD among homeless people between 2002 and 2015 was 8.7%, 36 times higher than the prevalence in non-homeless people [7]. A serotype 1 IPD outbreak was reported among sheltered homeless individuals in Paris, France in 1988 and 1989 [8].
Studies have found that homeless individuals with IDP were typically younger [1, 7], more often male [1], smokers [1, 9, 10], alcohol abusers [1, 7, 9], illegal drug users [1, 9], and had a primary diagnosis of pneumonia [1], HIV infection, or liver disease [10] compared to non-homeless individuals.
In this article, we share our research experience in Marseille, south of France, as part of a global surveillance and research project that started in 2000 on the diagnosis, prevention and treatment of infectious diseases among homeless people living in Marseille. We aimed to assess the prevalence of pneumococcal nasopharyngeal carriage and pneumococcal vaccination coverage among sheltered homeless people. We also investigated the role of potential risk factors on pneumococcal nasopharyngeal carriage.

Methods and materials

Ethics

Ethical approval was obtained from our institute's Institutional Review Board and Ethics Committee (2010-A01406-33). Informed consent was dated and signed by all individuals.

Setting, study design and population

Cross-sectional one-day surveys were conducted on February 17th 2015, March 7th and 10th 2016, February 6th and 8th 2017 and February 6th and 8th 2018, among adults living in two municipal emergency shelters for homeless men (A and B) in Marseille. The two shelters have a total capacity of 300 beds each and include emergency units (overnight stays) with a quick turnover (7-14 nights). Shelter A has a special unit (day-night) with a capacity of 35 beds, dedicated to high-risk sedentary homeless people (high level of poverty, poor hygiene, alcoholism, and mental illness). Rooms can accommodate 3-8 people for shelter A and 2-3 people for shelter B.

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Participants were asked to complete a questionnaire including information on their demographic characteristics, personal history, addictions, chronic disease status, respiratory signs and symptoms (including IPD symptoms), and fever at enrolment. In addition, information on personal hygiene habits and pneumococcal vaccination status that was not part of the standard questionnaire used in 2015-2017 was investigated during the 2018 survey. A pair of swabs (nasal and pharyngeal) was systematically collected from each participant on transport media using Sigma-Virocult® (Medical Wire, Corsham, United Kingdom), and stored at -80°C in our laboratory until processing. The homeless people who were screened were offered treatment, or further evaluation based on the assessment of their symptoms. Indeed, quantitative PCR results were obtained several weeks after the surveys were performed.

During the 2018 survey, a non-homeless group (controls) was also enrolled, including administrative staff, medical staff, medical students and PhD students from our research institute who agreed to provide nasal and pharyngeal samples. Data collected included demographic characteristics, chronic medical conditions, addictions, vaccination status, and respiratory signs and symptoms at enrolment. Age, gender and ethnic origin were considered as selection criteria for controls in order to avoid marked demographic differences between the two groups. Enrolment took place only five days after the recruitment of homeless people.

PCR assay for identification of *Streptococcus pneumoniae*

The automated DNA extraction was performed on 200 µL of each swab using a BioRobot® EZ1 Advanced XL instrument (QIAGEN, Hilden, Germany) and DNeasy® Blood & Tissue according to the manufacturer's instructions.

Real-time PCR based on *lytA* gene was carried out using in-house protocol. The amplification was performed in 20 µL volume including the 5 µL extracted DNA, 10 µL ready-to-use Hot Start reaction mix (Light-Cycler® 480 Probes Master kit, Roche Diagnostics, Meylan, France), 0.5 µL Uracil-DNA glycosylases (Thermo Fisher Scientific, Strasbourg, France), 0.5 µL sense primer (5′-ACGCAATCTAGCAGATGAAGCA-3′) at 20 µM, 0.5 µL antisense primer (5′-TCGTGCGTTTTAATTCCAGCT-3′) at 20 µM, 0.5 µL probe (6-FAM-TGCCGAAAACGCTTGATACAGGGAG-TAMRA) at 5 µM, and 3 µL distilled water. The PCR cycling conditions were 50°C for 2 min, 95°C for 5 min, followed by 39 cycles at 95°C for 5 sec, and 60°C for 30 sec. Results were considered positive when the cycle threshold value of the real-time PCR was ≤ 35. Individuals with at least a nasal or a pharyngeal positive sample were considered positive cases.

Statistical analysis

Statistical procedures were performed using Stata 11.1 software (StataCorp LLC, USA). We used Pearson's chi-square or Fisher's exact tests to compare percentage differences between the two groups of individuals, where appropriate. The theoretical normal distribution of quantitative data was assessed using Shapiro-Wilks test and means of quantitative data were compared using the Wilcoxon signed-rank test when samples were not normally distributed. A two-sided p-value of less than 0.05 was considered as statistically significant. A multivariate logistic regression analysis was applied to identify factors (demographic, chronic medical condition) associated with pneumococcal nasopharyngeal carriage in homeless people between 2015 and 2018. The results were presented as percentage and odds ratio (OR) with a 95% confidence interval (95% CI). Variables with p-values of < 0.2 in univariate analyses were included in the initial multivariate multinomial model. The stepwise regression procedure and likelihood-ratio tests were applied to determine the final model.

Results

Participant characteristics

During the 2015-2018 period, 571 subjects [265 from shelter A (46.4%), 306 from shelter B (53.5%)] volunteered to participate in this study, accounting for an estimated 40% of homeless people present in the shelters at the time of enrolment. The homeless individuals had a mean age ± SD (range) of 42.9 years ± 16.3 (18-83), and 62 of them (10.9%) were aged ≥ 65 years. They were mostly migrants from African countries who had settled in France approximately 10 years before the survey was performed (Tab. I). The mean duration of homelessness was about 2.6 years. Tobacco use and frequent alcohol consumption were reported by 244 (39.4%) and 64 (11.3%) individuals, respectively. Current cannabis use was reported by 100 individuals (17.6%). Drug addiction, defined as using injected or nasally inhaled illicit substances or being under opioid agonist treatments (methadone or buprenorphine), was uncommon, being reported by 26 individuals (4.6%). A proportion of 16.9% (n = 96) of homeless people had an indication for vaccination against IPD (chronic diseases) according to French guidelines [12]. 4.1% (n = 22) were underweight, 37.1% (n = 200) were overweight or obese. About 36.4% (n = 208) reported suffering from at least one respiratory symptom, notably a cough (n= 142, 24.8%) and expectoration (n = 69, 12.1%) at enrolment. About 2% (n = 13) were febrile (Tab. I).

In 2018, the pneumococcal vaccination coverage was less than 4% (3 of 98) among homeless individuals (Tab. II). More than a quarter reported taking a shower less than twice a week, more than a third reported changing their underwear less than twice a week, about a third reported brushing their teeth less than once a day. Compared to controls, homeless individuals were significantly more likely to report tobacco use and chronic diseases (Tab. II), and to present with respiratory signs and symptoms at enrolment (Fig. 1).

Tab. I. Characteristics and associations between multiple factors and pneumococcal nasopharyngeal carriage among 571 homeless individuals in a survey conducted between 2015 and 2018 (univariate and multivariate analysis).

Characteristics	Total	Positive	Negative	Univariate		Multivariate	
				OR (95%CI)	P-value	aOR (95%CI)	P-value
Total, n (%)	571 (100)	74 (13)	497 (87)				
Year of study[1] (571) [2]							
2015, n (%)	123 (21.5)	29 (23.6)	94 (76.4)				
2016, n (%)	154 (27.0)	9 (5.8)	145 (94.2)				
2017, n (%)	196 (34.3)	21 (10.7)	175 (89.3)				
2018, n (%)	98 (17.2)	15 (15.3)	83 (84.7)				
Housing facility (571)							
Shelter A, n (%)	306 (53.6)	49 (16.0)	257 (84.0)	**1.83 (1.09-3.05)**	**0.021**	**1.80 (1.06-3.05)**	**0.028**
Shelter B, n (%)	265 (46.4)	25 (9.4)	240 (90.6)	Ref		Ref	
Age (years) (569)							
Mean ± SD	42.9 ± 16.3						
Median, interquartile	42, 29-55						
Range (min-max)	18-83						
≥ 65, n (%)	62 (10.9)	14 (22.6)	48 (77.4)	**2.17 (1.13-4.17)**	**0.02**	**1.97 (1.01-3.87)**	**0.048**
18-65, n (%)	507 (89.1)	60 (11.8)	447 (88.2)	Ref		Ref	
Birthplace (571)							
Africa, n (%)	413 (72.3)	48 (11.6)	365 (88.4)	0.71 (0.41-1.24)	0.233		
Asia, n (%)	23 (4.0)	5 (21.7)	18 (78.3)	1.50 (0.50-4.50)	0.462		
Europe, n (%)	135 (23.6)	21 (15.6)	114 (84.4)	Ref			
Mean duration of residence in France for migrants (SD), range (min, max) (years) (480)	9.6 ± 15.7, 0-66						
Range of duration of residence in France for migrants							
> 1.5 years	255 (53.1)	35 (13.7)	220 (86.3)	1.27 (0.73-2.20)	0.38		
≤ 1.5 years[3]	225 (46.9)	25 (11.1)	200 (88.9)	Ref			
Mean duration of homelessness (SD), range (min, max) (years) (557)	2.6 ± 5.5, 0-63						
Range of duration of homelessness							
> 9 months	260 (46.7)	30 (11.5)	230 (88.5)	0.8 (0.49-1.34)	0.424		
≤ 9 months[3]	297 (53.3)	41 (13.8)	256 (86.2)	Ref			
Tobacco use (569)							
Yes, n (%)	345 (60.6)	50 (14.5)	295 (85.5)	**1.41 (0.84-2.37)**	**0.192**	--	
No, n (%)	224 (39.4)	24 (10.7)	200 (89.3)	Ref			
Frequent alcohol consumption (568)							
Yes, n (%)	64 (11.3)	9 (14.1)	55 (85.9)	1.10 (0.52-2.34)			
No, n (%)	504 (88.7)	65 (12.9)	439 (87.1)	Ref			
Cannabis (marijuana) (569)							
Yes, n (%)	100 (17.6)	14 (14.0)	86 (86.0)	1.10 (0.59-2.07)	0.745		
No, n (%)	469 (82.4)	60 (12.8)	409 (87.2)	Ref			
Drug addiction (569)							
Yes, n (%)	26 (4.6)	5 (19.2)	21 (80.8)	1.65 (0.59-4.47)	0.34		
Injecting illicit substances	2 (0.4)	0 (0)	2 (100)	NA			
Snorting illicit substances	20 (3.5)	4 (20.0)	16 (80.0)	NA			
Using opioid agonist treatment	9 (1.6)	2 (22.2)	7 (77.8)	NA			
No, n (%)	543 (95.4)	69 (12.7)	474 (87.3)	Ref			

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Tab. I. Characteristics and associations between multiple factors and pneumococcal nasopharyngeal carriage among 571 homeless individuals in a survey conducted between 2015 and 2018 (univariate and multivariate analysis).

Characteristics	Total	Positive	Negative	Univariate		Multivariate	
				OR (95%CI)	P-value	aOR (95%CI)	P-value
Total, n (%)	571 (100)	74 (13.0)	497 (87.0)				
Yes, n (%)	111 (19.6)	22 (19.8)	89 (80.2)	**1.92 (1.10-3.32)**	**0.02**	-	-
HIV infection	2 (0.4)	0 (0)	2 (100)				
Cancer	6 (1.1)	2 (33.3)	4 (66.7)				
Heart failure	3 (0.6)	1 (33.3)	2 (66.7)				
Chronic respiratory failure[4]	49 (8.7)	10 (20.4)	39 (79.6)				
Severe asthma	27 (4.8)	7 (25.9)	20 (74.1)				
Hepatitis	23 (4.1)	7 (30.4)	16 (69.6)				
Renal failure	2 (0.4)	0 (0)	2 (100)				
Diabetes mellitus	41 (7.2)	6 (14.6)	35 (85.4)				
No, n (%)	456 (80.4)	52 (11.4)	404 (88.6)	Ref			
Body mass index (542)							
Mean BMI (SD) (kg/m^2)	24.2 ± 4.0						
Range of BMI (kg/m^2)	14.7-38.8						
Underweight, n (%)	22 (4.1)	6 (27.3)	16 (72.7)	**2.80 (1.06-7.45)**	**0.038**		
Others	518 (95.9)	61 (11.8)	457 (88.2)	Ref			
Normal weight, n (%)	318 (58.9)	35 (11.0)	283 (89.0)				
Overweight, n (%)	150 (27.8)	20 (13.3)	130 (86.7)	1.24 (0.69-2.23)	0.47		
Obesity, n (%)	50 (9.3)	6 (12.0)	44 (88.0)	1.10 (0.43-2.77)	0.83		
Seasonal vaccination against influenza (562)							
Yes, n (%)	83 (14.8)	10 (12.0)	73 (88.0)	0.92 (0.45-1.87)	0.82		
No, n (%)	479 (85.2)	62 (12.9)	417 (87.1)	Ref			
Clinical symptomsand signs (568)							
At least one respiratory symptom and sig							
Yes, n (%)	206 (36.3)	41 (19.9)	165 (80.1)	**2.47 (1.51-4.06)**	**< 10^{-4}**	**2.55 (1.54-4.21)**	**< 10^{-4}**
Cough, n (%)	142 (24.8)	33 (23.2)	109 (76.8)				
Expectoration, n (%)	69 (12.1)	14 (20.3)	55 (79.7)				
Rhinorrhoea, n (%)	48 (8.4)	6 (12.5)	42 (87.5)				
Dyspnoea, n (%)	47 (8.2)	7 (14.9)	40 (85.1)				
Sore throat, n (%)	44 (7.7)	7 (15.9)	37 (84.1)				
Sibilants, n (%)	23 (4.0)	9 (39.1)	14 (60.9)				
Ronchi, n (%)	20 (3.5)	4 (20.0)	16 (80)				
Crackles, n (%)	1 (0.2)	0 (0)	100 (0)				
No, n (%)	362 (63.7)	33 (9.1)	329 (90.9)	Ref		Ref	
Fever (≥ 37.8%)							
Yes, n (%)	13 (2.8)	1 (7.7)	12 (92.3)	0.61 (0.07-4.85)	0.65		
No, n (%)	455 (97.2)	54 (11.9)	401 (88.1)	Ref			

Ref: reference; NA: not applicable; OR: odds-ratio; aOR: adjusted odds-ratio.
[1] The variable was not included in the analysis, given that no intervention could be performed based on this criterion; [2] Number of individuals for whom data was available; [3] Median of the variable was used for analysis; [4] including chronic bronchitis, chronic obstructive pulmonary disease, emphysema; bold lines indicate the variables recruited in initial multivariate mode.

Tab. II. Characteristics of homeless participants and non-homeless participants in a survey conducted in 2018, Marseille, France.

Characteristics	Homeless group	Non-homeless group	P-value
Total	**98**	**54**	
Gender: male, n (%) (98, 54) [1]	98 (100)	54 (100)	1.0
Age (years): mean ± SD, range (98, 54)	39.3 ± 17.6	34.4 ± 17.6	0.48
18-34, n (%)	51 (50.0)	33 (61.1)	0.12
35-49, n (%)	16 (16.3)	13 (24.1)	
50-65, n (%)	23 (23.5)	7 (13.0)	
> 65, n (%)	8 (8.2)	1 (1.8)	

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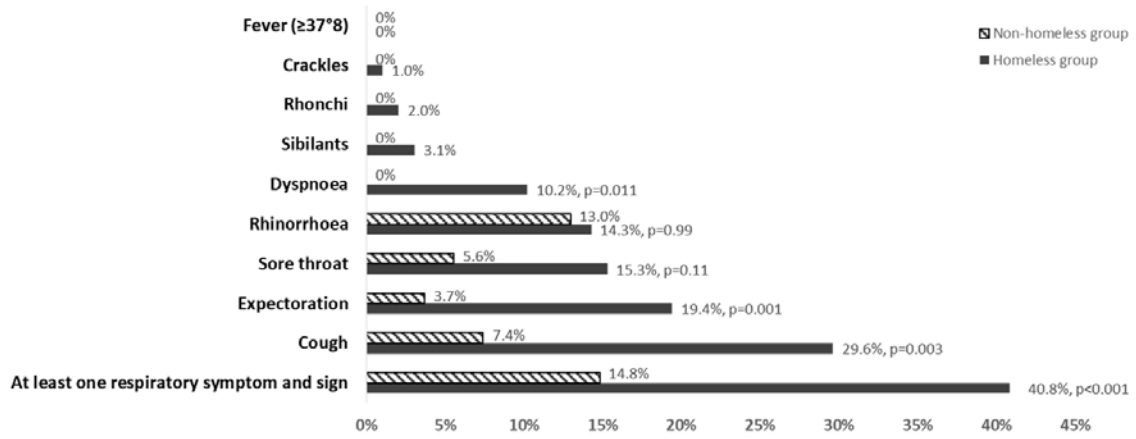
Tab. II. Characteristics of homeless participants and non-homeless participants in a survey conducted in 2018, Marseille, France.

Characteristics	Homeless group	Non-homeless group	P-value
Total	**98**	**54**	
Origin, n (%) (98, 54)			0.06
Europe	22 (22.4)	19 (35.2)	
North Africa	45 (45.9)	18 (33.3)	
Sub-Saharan Africa	28 (28.6)	10 (18.5)	
Eastern Mediterranean	1 (1.0)	2 (3.7)	
Asia	2 (2.0)	4 (7.4)	
America	0 (0)	1 (1.9)	
Mean duration of homelessness (years) (SD) (96, NA)	2.68 (0-7.2)	NA	NA
Mean duration of residence in France (years) (SD) for migrants (min-max) (85, 35)	8.2 ± 16.1 (1 week-63 years)	3.8 ± 3.9 (5 months-17 years)	0.053
Addiction, n (%) (97, NA)			
Tobacco use	58 (59.2)	13 (24.1)	$< 10^{-4}$
Alcohol consumption	13 (13.3)	6 (11.1)	0.89
Cannabis (marijuana)	25 (25.8)	0 (0)	$< 10^{-4}$
Drug addiction	12 (12.2)	0 (0)	0.018
Injecting illicit substances	8 (8.2)	0 (0)	
Snorting illicit substances	7 (7.1)	0 (0)	
Using opioid agonist treatment	0 (0)	0 (0)	
Chronic diseases[2], n (%) (97, NA)	22 (22.4)	0 (0)	$< 10^{-4}$
HIV infection	1 (1.0)	0 (0)	
Cancer	1 (1.0)	0 (0)	
Heart failure	1 (1.0)	0 (0)	
Chronic respiratory failure[2]	7 (7.1)	0 (0)	
Severe asthma	4 (4.1)	0 (0)	
Hepatitis	6 (6.1)	0 (0)	
Renal failure	1 (1.0)	0 (0)	
Diabetes mellitus	5 (5.1)	0 (0)	
Body mass index (95, NA)		NA	
Mean BMI (SD) (kg/m2)	23.1 ± 4.0		
Range of BMI (kg/m2)	14.7-38.8		
Normal weight	5 (5.3)		
Underweight	70 (73.7)		
Overweight	12 (12.6)		
Obesity	8 (8.2)		
Personal hygiene habits		NA	
Taking a shower (96, NA)			
Less than once a week	4 (4.2)		
1-2 times a week	22 (22.9)		
3-4 times a week	21 (21.9)		
Every day	49 (51.0)		
Changing underwear (95, NA)			
Less than once a week	5 (5.2)		
1-2 times a week	30 (31.6)		
3-4 times a week	23 (24.2)		
Every day	37 (39.0)		
Tooth brushing (92, NA)			
Less than once a day	29 (31.5)		
Equal or more than once a day	63 (68.5)		
Vaccination against pneumococcus, n (%) (98, 54)	3 (3.1)	4 (7.4)	0.24
Pneumococcal nasopharyngeal carriage, n (%) (98, 54)	**15 (15.3)**	**2 (3.7)**	**0.033**

N: number; NA: not applicable; SD: standard deviation; HIV: human immunodeficiency virus; BMI: body mass index.
[1]Number of individuals for whom data was available (homeless group, non-homeless group); [2]indication for pneumococcal vaccination according to French guidelines: Ministère des Solidarités et de la Santé. Calendrier des vaccinations et recommandations vaccinales 2019 - available at: https://solidarites-sante.gouv.fr/IMG/pdf/calendrier_vaccinal_mars_2019.pdf (accessed 08 September 2020); [3]including chronic bronchitis, chronic obstructive pulmonary disease, and emphysema; [4] including cough, expectoration, rhinorrhoea, dyspnoea, sore throat, sibilants, rhonchi, crackles.

Fig. 1. Prevalence of clinical signs and symptoms in 2018 (homeless group versus non-homeless group).



Pneumococcal nasopharyngeal carriage

All participants underwent both nasal and pharyngeal sampling. During the 2015-2018 period, 74 homeless individuals (13.0%) tested positive for pneumococcal carriage. The prevalence of pneumococcal carriage varied significantly according to the study years ($p < 0.001$), with the highest prevalence (23.6%, 29 of 123) found in 2015. We found that pneumococcal carriage in 2018 was significantly higher among people living in shelters (15 of 98, 15.3%) than among the non-homeless group of controls (two of 54, 3.7%), with $p = 0.033$.

Table I shows pneumococcal carriage rates among homeless people according to demographic characteristics, housing facility, chronic medical condition, and clinical findings. In univariate analyses, living in shelter A, being aged ≥ 65 years, having chronic diseases, being underweight and suffering from at least one respiratory sign or symptom at enrolment were significantly associated with pneumococcal carriage. In multivariate analyses, pneumococcal carriage was associated with living in shelter A [16.0% *vs* shelter B (9.4%), OR = 1.80, 95% CI: 1.06-3.05], being aged ≥ 65 years [22.6% *vs* being aged < 65 years (11.8%), OR = 1.97, 95% CI: 1.01-3.87], and presenting with at least one respiratory sign or symptom at enrolment [27.3% *vs* no respiratory symptoms (9.1%), OR = 2.55, 95% CI: 1.54-4.21].

Discussion

This is the first epidemiological study aiming to directly assess the carriage of pneumococcal DNA in nasal/pharyngeal samples from sheltered homeless population. We found a high (13.0%) prevalence of pneumococcal nasopharyngeal carriage among sheltered homeless people in Marseille, France, and the prevalence was higher than in non-homeless people. Using the same molecular method, the prevalence of *S. pneumoniae* carriage was 3.6% among Hajj pilgrims in summer 2014-2018 before their departure from Marseille (unpublished data), and 2.5% among medical students sampled before travelling abroad in summer 2018 [11]. A retrospective survey conducted among homeless people hospitalised in infectious disease units in our hospital between 2017 and 2018 revealed that *S. pneumoniae* was responsible for two (among 98, 2.0%) cases of community-acquired pneumonia or acute exacerbation of chronic obstructive pulmonary disease [12].

In this study, a low rate (3.1%) of homeless people reported had been vaccinated against IPD prior to recruitment. However, according to French guidelines, 23.5% of these individuals should have been vaccinated because they had chronic conditions, whilst according to American guidelines, which include being ≥ 65 years as a risk factor, 26.5% should have been vaccinated [13, 14]. In other studies, vaccination coverage among homeless populations ranged from 9.0 to 37.0% [3, 5, 8, 10].

In our study, being aged ≥ 65 years and having respiratory symptoms at enrolment were potential risk factors for pneumococcal carriage among homeless people. This bacterium was possibly responsible for the respiratory symptoms observed. Indeed, such an association was also observed in medical students from Marseille taking part in an elective abroad [15].

In addition, pneumococcal carriage was associated with the type of housing (shelter A). A significantly higher transmission of SARS-CoV-2 and infestation with body lice in people living in shelter A has also been found in previous studies conducted during the same period [16, 17]. This may be a result of the higher number of individuals per room in this shelter, as compared with shelter B, which may have facilitated the transmission of infectious agents. A sub-population of homeless people with a high level of precariousness was housed in a special sector of shelter A, which may partially explain our results. Unfortunately, being housed in the special unit was not recorded on a regular basis in our surveys.

Our study has several limitations. The population was not randomly and homogenously recruited. Only

homeless people present in the shelters were enrolled on a voluntary basis leading to a 40% participation rate. Furthermore, we cannot exclude the possibility that those with respiratory symptoms might have been more likely to enrol in the survey. Moreover, our study took place in winter, so we could not have an overview of seasonal variations of pneumococcal carriage among homeless people, whereas these impact the airway microbial community in adults and children [18, 19]. Future studies will be conducted at least twice a year (in winter and in summer).

Conclusions

Pneumococcal nasopharyngeal carriage, which is a precursor for pneumococcal disease in at-risk individuals, is frequently found among French homeless people. Studies conducted in other countries have also reported outbreaks of pneumococcal infections in this population. Although a quarter of homeless people present risk factors for IPD, vaccination against IPD is clearly suboptimal [3, 5]. We therefore suggest that pneumococcal vaccination should be systematically considered for residents of homeless shelters in France, as is being done in Canada since 2008 [5].

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Conflict of interest statement

The authors declare no conflict of interest.

Authors' contributions

TDAL, and PG contributed to the experimental design, data analysis, statistics, interpretation and writing. LP contributed to the writing. TDAL, VTH, TLD administered questionnaires, examined patients, collected samples and provided technical assistance. PG coordinated the work.

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