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## **Respiratory infections among pilgrims at the Grand Magal of Touba: A comparative cohort controlled survey**

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**Keywords:** Respiratory infections, Pilgrims, Controls, Grand Magal, Touba

### **Abstract**

Background: The Grand Magal of Touba (GMT) is a large event gathering around 4-5 million participants every year. A pilot study conducted in 2017 among GMT pilgrims showed that 41.8% of participants reported respiratory symptoms, mostly due to rhinovirus (13.0%), coronaviruses (16.0%) and adenovirus (4.6%).

Methods: A PCR-based prospective cohort study was conducted among GMT pilgrims and controls (who did not participate to the event) in two rural villages in South Senegal, in 2019.

Results: 93 pilgrims and 84 controls were included in the study. There were no significant differences between pilgrims and controls regarding demographic characteristics and chronic conditions. 60.2% of pilgrims reported respiratory symptoms during their stay in Touba, or soon after their return. By contrast, only 8.3% of controls reported respiratory symptoms after the GMT. The acquisition of rhinovirus, coronaviruses, *Streptococcus pneumoniae* and *Moraxella catarrhalis* was 22.6%, 6.5%, 17.2% and 6.8% respectively in pilgrims and was significantly higher than in controls (3.6%, 0%, 4.8% and 1.2% respectively). Respiratory symptoms post-GMT were five times more frequent in *S. pneumoniae* carriers (aOR = 5.18, 95%CI = [1.98 – 13.57]).

Conclusion: This study demonstrates that individuals who participated in the GMT were at higher risk of suffering from respiratory symptoms and that this was linked to the acquisition of *S. pneumoniae*.

## 1. Introduction

The Grand Magal of Touba (GMT) takes place in the holy city of Touba in Senegal (755,000 inhabitants) every year on the 18<sup>th</sup> day of Safar month of the Islamic calendar coinciding with the 17 October in 2019 according to the Gregorian calendar. Touba is located 200 km northwest of Dakar, the capital city. The GMT is an act of adoration and communion which celebrates the departure in exile of Cheikh Ahmadou Bamba Mbacke, the founder of the Mouridism, a Sufi Muslim order, who was deported to Gabon by the French colonial authorities in 1895.

Around 4-5 million mourid pilgrims participate in the celebration each year. The event is the largest religious mass gathering in west Africa, with pilgrims coming from all over Senegal as well as from neighbouring countries and countries outside of Africa. The main event of the GMT is the visit of the great mosque of Touba, where pilgrims partially circumambulate around the mosque and visit the mausoleum of Cheikh Ahmadou Bamba. Access to the mosque is allowed to everyone (including tourists), but flows are regulated by security staff. The rituals last one day, however, pilgrims usually stay in Touba for several days. Finally, pilgrims also visit Touba's large temporary market place, one of the biggest in the country, where a wide range of products can be found at a lower price than in other markets in Senegal. In addition to religious celebrations, intense cultural activities take places, including conferences, seminars, and debates between representatives of various Muslim communities from Senegal and beyond. Readings of the Koran, recitals of poems by Cheikh Ahmadou Bamba, and collective hymn-singing sessions are organised in the streets, under large open tents [1].

During the 2016 GMT, of the 20,850 patients who consulted health services in Touba and the surrounding area, the most prevalent symptoms were headaches (28.2%), gastrointestinal symptoms (22.0%), fever (17.2%) and respiratory symptoms (17.1%) and malaria was diagnosed in 2.4% of patients [2].

A pilot cohort study conducted in 2017 among GMT pilgrims from the villages of Dielmo and Ndiop (South Senegal) showed that 41.8% of participants reported respiratory symptoms, mostly due to rhinovirus (13.0%), coronaviruses (16.0%) and adenovirus (4.6%) [3]. However, these studies were only carried out in pilgrims, without a control group, therefore the actual effect of participation in the GMT could not be formally assessed.

The objective of this study was to evaluate respiratory symptoms and pathogen carriage in Dielmo and Ndiop pilgrims participating in the 2019 GMT compared to controls who did not participate in the GMT and stayed in the villages.

## **2. Materials and methods**

### **2.1. Study population**

A longitudinal prospective cohort study was conducted from 2 October to 26 October 2019 among inhabitants of two villages (Ndiop and Dielmo) located in the south of Senegal, in the region of Fatick. Pilgrims were individuals who traveled to Touba and participated in the GMT 2019. Controls were individuals who stayed in the village during the GMT. Both groups were invited to participate in the study on a voluntary basis. Participants, or their parents if minors, were asked to sign a written consent form. Villages are divided into compounds where pilgrims and controls from a same family live in close contact. In Touba, pilgrims were housed in different concrete houses, either in their family's house or in the house of a Marabout (spiritual guides).

### **2.2. Data collection**

Upon inclusion, a standardized pre-Magal questionnaire was administered by nurses to all study participants two weeks prior the GMT that took place on 17 October. The following data were collected: (1) demographic characteristics (age and sex), (2) chronic medical conditions, (3) vaccination status against influenza and invasive pneumococcal disease (IPD) (4) respiratory symptoms. Pilgrims and controls were considered as vaccinated against influenza if they had been vaccinated during the past year and as vaccinated against IPD if they had been vaccinated in the past five years. Influenza like illness (ILI) was defined as the association of cough, sore throat and subjective fever [4].

The post-Magal questionnaire was administered after the GMT took place. Controls were asked whether they experienced respiratory symptoms and used antibiotics since inclusion. Pilgrims were asked about their housing conditions in Touba, their compliance with preventive measures during their stay (use of face mask and disposable handkerchiefs, hand washing practice, hand washing practice with soap), whether they experienced respiratory symptoms and whether they used antibiotics since the pre-Magal questionnaire.

### 2.3. Sample collection (Figure 1)

The procedure included systematic collection of nasopharyngeal samples from 2 October to 6 October 2019 (pre-Magal specimens) from all participants. Systematic sampling was then performed after the GMT took place (post-Magal specimens). Because pilgrims and controls live together in the village, controls were sampled just two days before pilgrims returned to the villages (on 17 and 18 October 2019) and pilgrims were sampled 6-9 days following their return from Touba (from 23 to 25 October), before transmission of pathogens from pilgrims to controls could occur. Nevertheless, 14 controls were sampled at the same time as pilgrims who had returned because they declared themselves as pilgrims at inclusion but finally did not travel to Touba.

Samples were collected using commercial rigid cotton-tipped swab applicators (Medical Wire & Equipment, Wiltshire, UK) which were inserted in the anterior nose or in the oro-pharynx and then placed in viral transport media (Sigma Virocult<sup>®</sup>) [5]. Swabs were kept at 4°C before being transported to Dakar laboratory for storage in a -80 °C freezer within 48 hours of collection and subsequently transferred to Marseille, France, on dry ice for analysis.

### 2.4. Identification of respiratory pathogens by PCR

The respiratory pathogens tested were: influenza A, influenza B, human rhinovirus, respiratory syncytial virus, human metapneumovirus, human non-MERS coronaviruses,

human para-influenza virus, adenovirus, *Streptococcus pneumoniae*, *Staphylococcus aureus*, *Haemophilus influenzae*, *Klebsiella pneumoniae*, *Bordetella pertussis* and *Mycoplasma pneumoniae*.

Pathogens were identified by PCR as described previously [3].

## 2.5. Statistical analysis

STATA software version 11.1 (Copyright 2009 Stata Corp LP, College Station, Texas, USA <http://www.stata.com>) was used for statistical analysis. Differences in proportions were tested by Pearson's chi-square or Fisher's exact tests when appropriate. Mean ages were compared using the student T-test. Associations between age, sex and carriage of respiratory pathogens and prevalence of respiratory symptoms pre- or post-Magal were examined by univariable analysis. The results were presented in odds ratio (OR) with a 95% confidence interval (95%CI). Only the variables with a prevalence  $\geq 5.0\%$  were considered for statistical analysis. Variables with p values  $<0.2$  in univariable analysis were included in multivariable analysis. Logistic regression was used to estimate factor's adjusted odd ratios (aOR) regarding respiratory symptoms. A p value  $<0.05$  was considered as significant.

## 2.6. Ethical approval

The protocol was approved by the National Ethic Committee for Health Research in Senegal (SEN 17/62). It was performed in accordance with the good clinical practices recommended by the Declaration of Helsinki and its amendments.

# 3. Results

## 3.1. Characteristics of study population.

The study included 177 individuals (93 pilgrims and 84 controls) with a sex ratio M/F of 1.3 and a median age of 28 years (IQR 14-41 ranging 0 to 85), with 28.8% participants aged  $\leq 15$  years and 8.5%  $\geq 60$  years. A total of 7.3% participants presented at least one chronic disease, mostly hypertension (3.4%) and hepatitis B (1.1%). No significant differences were observed between pilgrims and controls with regards to demographic characteristics and chronic conditions (Table 1). The mean duration of stay in Touba was four days (min=2; max= 9).

### 3.2.Preventive measures in pilgrims.

None of the pilgrims reported being vaccinated against influenza and around 5% were vaccinated against IPD. Less than 8% reported using face masks during the GMT. About 48% reported washing their hands more often than usual during the GMT and almost 97% reported washing their hands with soap. Finally, around 53% reported using disposable handkerchiefs (Table 2).

### 3.3.Clinical symptoms.

A total of 44/177 (24.9%) participants reported respiratory symptoms before the GMT, with rhinitis and cough as the most frequent symptoms (Table 3). Five percent of individuals were febrile. Among pilgrims 56/93 (60.2%) reported respiratory symptoms during their stay in Touba or soon after returning. Rhinitis, cough and sore throat were the most frequent symptoms. A third were febrile. Of these 39/56 (69.6%) were asymptomatic before travel. By contrast, only 7/84 (8.3%) controls reported respiratory symptoms after the GMT took place. Few participants (1.7%) took antibiotics.

### 3.4.Respiratory pathogens

Among villagers tested before the GMT, 20 (11.3%) were positive for at least one virus, including 15 (8.5%) testing positive for influenza A (Table 4). No villagers were positive for

rhinovirus. An acquisition of rhinovirus (22.6%) and coronaviruses (6.5%) was observed in pilgrims returning from the GMT and was significantly higher than in controls (3.6% and 0% respectively). Of note, the three controls detected positive for rhinovirus were sampled when pilgrims returned to the villages. None of the participants tested positive for influenza after the GMT. When tested before the GMT, 148 (83.6%) participant were positive for at least one bacterium with *S. aureus* (58.2%) and *K. pneumoniae* (40.1%), the most frequent. The acquisition of *S. pneumoniae* (17.2%) and *M. catarrhalis* (8.6%) after the GMT was significantly higher in pilgrims than in controls (4.8% and 1.2%, respectively).

### 3.5. Risk factors for respiratory symptoms

Reporting respiratory symptoms before the GMT was significantly associated with *S. pneumoniae* carriage. Reporting respiratory symptoms after the GMT was significantly associated with older age, participation in the GMT, rhinovirus, *S. aureus*, *S. pneumoniae*, and *M. catarrhalis* carriage (Table 5). In multivariable analysis, reporting respiratory symptoms before the GMT was three times more frequent in *S. pneumoniae* carriers (aOR= 2.68, 95%CI = [1.18-6.06]). Reporting respiratory symptoms post-Magal was seventeen times more frequent in those who participated to the GMT (aOR = 17.31, 95%CI = [6.86 – 43.74] and five times more frequent in *S. pneumoniae* carriers (aOR = 5.18, 95%CI = [1.98 – 13.57]) (Table 6).

## 4. Discussion

In this study we found that one fourth of the villagers had respiratory symptoms before the GMT, with fever and/or dyspnea affecting 4.0% of ill individuals. Interestingly, after the GMT, only 8.3% of those who stayed in the villages were symptomatic compared to 60.2% of those who travelled to Touba for the GMT. Pilgrims had a 17 fold higher risk of acquiring

respiratory symptoms than non-pilgrims. Furthermore, 34.4% of ill pilgrims were febrile and 10.7% reported dyspnea.

Although influenza A virus was detected in 8.5% of villagers before the GMT, no case was detected in participants sampled in late October, whether they travelled to Touba or not. Similarly, in the 2017 cohort, less than 1% of GMT pilgrims acquired influenza virus [3]. By contrast, in a pilot study conducted in pilgrims consulting for respiratory tract infection symptoms in a health care centre during the 2018 GMT, 42.3% tested positive for influenza virus A or B [6]. Lower rates were observed in 2019, with 19.8% influenza A detection rate and no influenza B detected in pilgrims with respiratory symptoms [Unpublished data]. The lack of influenza virus acquisition in the 2019 cohort of pilgrims together with a relatively low proportion of ill pilgrims diagnosed with influenza when consulting at a health care centre during the pilgrimage suggest that the 2019 GMT likely took place during the influenza post-epidemic phase. Unfortunately, national and local surveillance data on influenza in Senegal was not available for the year 2019, to challenge this hypothesis.

Acquisition of other viruses, including rhinovirus and coronaviruses, was frequent in the 2019 cohort of GMT pilgrims and is in line with the results obtained in the 2017 cohort of GMT pilgrims [3]. In addition, we demonstrate here that the acquisition of respiratory viruses was much higher in pilgrims than in controls staying in the villages, which confirms that the overcrowding conditions experienced by pilgrims during the GMT make them at higher risk of exposure to viral respiratory infections. Acquisition of respiratory viruses has been well described in Hajj pilgrims who also experience crowding conditions in Saudi Arabia [7].

High rates of bacterial carriage were observed at baseline in villagers before the Magal took place. In addition, a significant acquisition of *S. pneumoniae* and *M. catarrhalis* was documented in GMT pilgrims. Importantly, carriage of *S. pneumoniae* appeared to be an

independent risk factor for having respiratory symptoms both before and after the GMT. In a study conducted during five months in 2015 among 250 adults and children consulting for acute respiratory infection symptoms at an health post in Central Senegal, 74.0% were positive for *S. pneumoniae* by PCR [8]. In an unmatched case-control study conducted in 2018 in children aged less than five years consulting at a primary care clinic in Dakar, a 48.0% rate of *S. pneumoniae* PCR positivity was found in children with febrile respiratory symptoms, comparing to 18.8% in controls (aOR = 3.0 (1.2-7.4, p<0.05) [9]. Given the very low rate of vaccination against IPD among villagers, pneumococcal vaccine should be considered in individuals who plan to participate in the GMT. In Senegal, pneumococcal vaccination was introduced in the national Expanded Program on Immunization in 2013 [10]. Further studies aiming to evaluate the effect of pneumococcal vaccine on *S. pneumoniae* carriage following participation in the GMT should be conducted. Indeed, in a recent study, we showed that Hajj pilgrims vaccinated with conjugate pneumococcal vaccine were seven times less likely to present with *S. pneumoniae* carriage post-Hajj compared to those not vaccinated (3.2% vs. 18.0%, OR = 0.15; 95% CI [0.03–0.74], p = 0.02) [11].

Our survey has several limitations, including its small sample size and the fact that it was conducted in pilgrims and controls from only two villages. Nevertheless, we showed that those who participated in the GMT were at greater risk of presenting with respiratory symptoms and that this was linked to the acquisition of *S. pneumoniae*.

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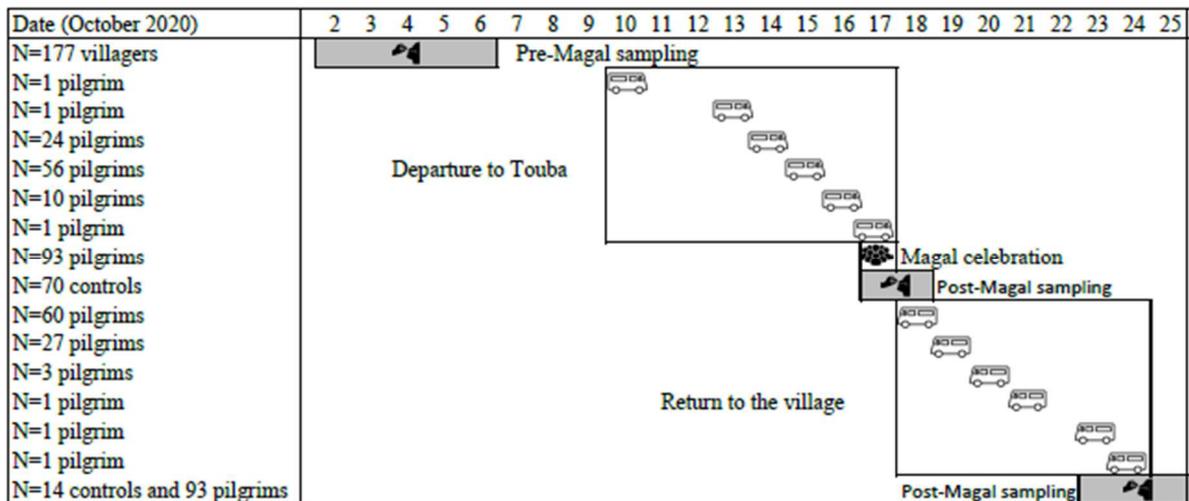


Figure 1: study design.

**Table 1 Characteristics of the study population**

<b>Variables</b>	<b>All participants (N=177) N (%)</b>	<b>Pilgrims (N=93) N (%)</b>	<b>Controls (N=84) N (%)</b>	<b>P-value*  (pilgrims versus controls)</b>
Male	101 (57.1)	54 (58.1)	47 (56.0)	0.77
Female	76 (42.9)	39 (41.9)	37 (44.0)	
<b>Age (years)</b>				
Mean	28	27	29	
IQR	14-40	14-40	14-43	0.63**
Range	0 to 85	0 to 85	1 to 74	
0 to 15 years	51 (28.8)	28 (38.1)	23 (27.4)	0.72
16 to 59 years	111 (62.7)	56 (60.2)	55 (65.5)	
≥ 60 years	15 (8.5)	9 (9.7)	6 (7.1)	
<b>Chronic diseases</b>	13 (7.3%)	4 (4.3)	9 (10.7)	0.10
Hypertension	6 (3.4)	1 (1.1)	5 (5.9)	0.07
Hepatitis B	2 (1.1)	0 (0)	2 (2.4)	0.13
Diabetes	1 (0.6)	1 (1.1)	0 (0)	0.34
Chronic respiratory disease	1 (0.6)	0 (0)	1 (1.2)	0.29
Chronic Renal disease	0 (0)	0 (0)	0 (0)	NA
Chronic heart disease	0 (0)	0 (0)	0 (0)	NA
Chronic immunosuppressant or corticosteroids	0 (0)	0 (0)	0 (0)	NA
Immunodeficiency	0 (0)	0 (0)	0 (0)	NA
Others***	3 (2.3)	2 (2.1)	1 (1.9)	0.91

\*Chi2, \*\* Student test, \*\*\* Rheumatism, cancer and myositis

**Table 2 Prevalence of adherence to preventive measures among pilgrims during their stay in Touba (N=93)**

<b>Preventives measures</b>		<b>N</b>	<b>%</b>
Influenza vaccination		0	0
Invasive pneumococcal disease vaccination		5	5.4%
Face masks	No	86	92.5
	Sometimes	6	6.4
	Often	1	1.1
Hand washing	As usual	48	51.6
	Much more	45	48.4
Hand washing with soap	No	3	3.2
	Sometimes	14	15.1
	Often	76	81.7
Use of disposable handkerchiefs	No	44	47.3
	Sometimes	8	8.6
	Often	41	44.1

**Table 3 Prevalence of clinical symptoms**

Clinical symptoms	Pre-Magal (N=177)		Post-Magal		
	N (%)	Pilgrims (N=93)	Controls (N=84)	P- value <sup>(1)</sup>	P- value <sup>(2)</sup>
		N (%)	N (%)		
At least one respiratory symptom	44 (24.9)	56 (60.2)	7 (8.3)	<0.0001	0.0008
Cough	31 (17.5)	38 (40.9)	7 (8.3)	<0.0001	0.02
Rhinitis	33 (18.6)	39 (41.9)	6 (7.1)	<0.0001	0.007
Dyspnea	7 (3.9)	10 (10.7)	0 (0)	0.03	0.03
Sore throat	3 (1.7)	19 (20.4)	2 (2.4)	<0.0001	0.35
Voice failure	1 (0.6)	10 (10.7)	0 (0)	<0.0001	0.24
Fever	7 (3.9)	32 (34.4)	1 (1.2)	<0.0001	0.11
Influenza like illness	0 (0)	13 (14.0)	1 (1.2)	<0.0001	0.07
Antibiotics	0 (0)	2 (0.2)	1 (1.2)	0.02	0.07

<sup>(1)</sup> Chi2 compared pilgrims post-Magal versus all participants pre-Magal

<sup>(2)</sup> Chi2 compared controls post-Magal versus all participants pre-Magal

**Table 4 Prevalence of respiratory pathogens pre-Magal and acquisition rates in pilgrims (N=93) and controls (N=84) post-Magal.**

Pathogens	Pre-Magal (N=177) N (%)	Acquisition		
		Pilgrims (N=93) N (%)	Controls (N=84) N (%)	P-value <sup>1</sup>
<b>Respiratory virus</b>				
Influenza A	15 (8.5)	0 (0)	0 (0)	NA
Metapneumovirus	1 (0.6)	0 (0)	0 (0)	NA
Virus respiratory Syncytial	3 (1.7)	0 (0)	2 (2.4)	0.14
Human Rhinovirus	0 (0)	21 (22.6)	3 (3.6)	0.0001
Adenovirus	0 (0)	1 (1.1)	0 (0)	0.34
Coronaviruses	1 (0.6)	6 (6.5)	0 (0)	0.02
Coronavirus NL63	1 (0.6)	3 (3.2)	0 (0)	0.09
Coronavirus OC63	0 (0)	3 (3.2)	0 (0)	0.09
At least one virus	20 (11.3)	22 (23.7)	4 (4.8)	<0.0001
<b>Respiratory bacteria</b>				
<i>Staphylococcus aureus</i>	103 (58.2)	12 (12.9)	12 (14.3)	0.79
<i>Streptococcus pneumoniae</i>	31 (17.5)	16 (17.2)	4 (4.8)	0.009
<i>Haemophilus influenzae</i>	46 (26.0)	15 (16.1)	8 (9.5)	0.19
<i>Moraxella catarrhalis</i>	27 (15.2)	8 (8.6)	1 (1.2)	0.03
<i>Klebsiella pneumoniae</i>	71 (40.1)	18 (19.2)	27 (32.1)	0.05
At least one bacterium	148 (83.6)	8 (8.6)	14 (16.7)	0.10

<sup>(1)</sup>: Chi2 compared acquisition rates in pilgrims versus controls

Influenza B, Coronavirus 229E, Coronavirus HKU1, Para influenza viruses, *Bordetella pertussis* and *Mycoplasma pneumoniae* were tested negative.

**Table 5 Risk factors for respiratory symptoms pre- and post-Magal (univariate analysis)**

Variables		At least one symptom pre-Magal (N=77)		At least one symptom post-Magal in pilgrims (N=93) and controls (N=84)	
		N (%)	RR [95% CI] P-value	N (%)	RR [95% CI] P-value
Gender	Male	22 (21.8)	0.68 [0.34-1.35] 0.28	35 (34.6)	0.91 [0.49-1.69] 0.76
	Female	22 (28.9)		28 (36.8)	
Mean age	-	28.9±19.5 (symptoms)	0.55	30.68±18.99 (symptoms)	t = 2.08 p = 0.04
	-	28.0±18.3 (no symptoms)		24.70±17.14 (no symptoms)	
Participating to the GMT	Yes	NA	NA	56 (60.2)	16.65 [6.92-40.06] <0.0001
	No	NA		7 (8.3)	
<b>Virus</b>					
At least one virus	Yes	6 (30.0)	1.34 [0.48-3.73] 0.57	18 (54.5)	2.64 [1.22-5.70] 0.01
	No	38 (24.2)		45 (31.2)	
Influenza A	Yes	5 (33.3)	1.58 [0.51-4.89] 0.43	0 (0)	-
	No	39 (24.1)		63 (36.0)	
Rhinovirus	Yes	0 (0)	-	15 (62.5)	3.64 [1.49-8.91] 0.005
	No	0 (0)		48 (31.4)	
<b>Bacteria</b>					
At least one bacteria	Yes	36 (24.3)	0.84 [0.34-2.07] 0.71	55 (37.6)	1.73 [0.73-4.15] 0.21
	No	8 (27.6)		8 (25.8)	
<i>S. aureus</i>	Yes	21 (20.4)	0.57 [0.28-1.13]	33 (44.0)	1.88 [1.01-3.52]

	No	23 (31.1)	0.11	30 (29.4)	0.04
<i>S. pneumoniae</i>	Yes	13 (41.9)	2.68 [1.18-6.06]	24 (64.9)	4.78 [2.21-10.32]
	No	31 (21.2)	0.02	39 (27.9)	<0.0001
<i>H. influenzae</i>	Yes	9 (19.6)	0.67 [0.29-1.52]	21 (47.7)	1.98 [0.98-3.96]
	No	35 (26.7)	0.34	42 (31.6)	0.06
<i>K. pneumoniae</i>	Yes	16 (22.5)	0.81 [0.40-1.64]	26 (31.3)	0.70 [0.38-1.31]
	No	28 (26.4)	0.56	37 (39.4)	0.27
<i>M. catarrhalis</i>	Yes	9 (19.6)	1.33 [0.53-3.30]	15 (57.7)	2.93 [1.25-6.85]
	No	35 (26.7)	0.53	48 (31.8)	0.01

**Table 6 Risk factors for respiratory symptoms pre- and post-Magal (multivariate analysis)**

<b>Variables</b>	<b>At least one symptoms all participants Pre- Magal aOR [95% CI]</b>	<b>P</b>	<b>At least one symptoms all participants Post- Magal aOR [95% CI]</b>	<b>P</b>
<b>Participating to the GMT</b>	NA		17.31 [6.86 – 43.74]	<0.0001
<i>S. pneumoniae</i>	2.68 [1.84-6.06]	0.002	5.18 [1.98 – 13.57]	0.001