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The 2015 and 2016 terrorist attacks in France: was there a short-term impact on hospitalizations for cardiovascular disease?

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Background: The terrorist attacks in Paris and Nice in 2015 and 2016 generated widespread emotional stress in France. Given that acute emotional stress is a well-known trigger for cardiovascular disease, we investigated whether these attacks had any short-term impact on hospitalizations for acute cardiovascular disease in France.

Methods: Annual hospital discharge data from 2009 to 2016 were extracted from the French Hospital Discharge Database. All hospitalizations with a primary diagnosis of acute coronary syndrome, heart failure, or stroke were selected. Generalized additive Poisson models were used to differentiate "unusual" variations in daily hospitalization numbers in the 15 days following the attacks from the expected background hospitalization rate.

Results: The average daily number of hospitalizations was 396.4 for acute coronary syndrome, 598.6 for heart failure, and 334.6 for stroke. The daily mean number of hospitalizations for heart failure and stroke was higher in the 15 days following each attack compared with the reference periods. However, multivariate analysis showed no significant variation in the risk of hospitalization in the days following the attacks.

Interpretation: Watching events unfold on television, no matter how dramatic, was not a sufficiently potent trigger for cardiovascular disease, although it may have led to an increase in hospitalizations for stress or anxiety. The 2015 and 2016 terrorist attacks do not seem to have had any measurable short-term impact on hospitalizations for cardiovascular disease either in the Paris and Nice regions or in the rest of France.

Keywords: hospitalization, terrorist attacks, cardiovascular disease

Introduction

France has recently faced several terrorist attacks of an unprecedented scale throughout its territory. The various attacks in Paris and its suburbs in January and November 2015 and the attack in Nice in 2016 left 233 dead and hundreds injured (Table 1).

The extent and the violence of the attacks and the continuous and extensive media coverage that followed led to an increased level of anxiety and stress in the French population, including in those not directly affected. In France, in the days that followed the attacks in 2015, a significant increase in the number of stress-related visits was observed in emergency departments throughout the Paris region, but also, although to a lesser extent, in the rest of France.[1] Indeed, terrorist attacks may lead to different levels of exposure to emotional stress in the population.[2] The highest level of exposure is expected in the local population, close to the scene of terrorist attacks, where the inhabitants are more likely to know and to have frequented the places of the attacks

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Table 1 Description of 3 series of terrorist attacks' that occurred in France in 2015 and 2016

Date and time	Sequence of the attacks
January 7, 2015	Two terrorists entered the *Charlie Hebdo* satirical newspaper's headquarters and killed 11 people. On their way out of Paris, they killed a policeman.
January 8, 2015	Early in the morning, a police officer in a Parisian suburb was killed on the street.
January 9, 2015	The 2 terrorists of the *Charlie Hebdo* shooting went to a printing office and took 1 person hostage. They were finally killed by the special gendarmerie forces.
January 9, 2015	At the same time, the same person responsible for the death of a policemen on the 8th entered a kosher supermarket in Paris killing 4 people, wounding 4 people, and taking several hostages.
November 13, 2015; 2120 to 2153 h	Three explosions occurred near the Stade de France (in Saint-Denis near Paris) while a soccer game was being held. Besides, 1 person was killed and several were wounded.
November 13, 2015; 2125 to 2140 h	A second group of 3 terrorists attacked several cafés and restaurants in Paris. Thirty-nine people were killed and several were severely injured.
November 13, 2015; 2140 to 0020 h	A third group of 3 terrorists entered the Bataclan theater while the American band Eagles of Death Metal was playing in front of more than a thousand people. Ninety people were killed and many others injured.
November 18, 2015	Early in the morning of 18 November 2015, the police launched an offensive in a building in Saint-Denis where 2 terrorists (of the cafés and restaurants attacks of the 13th of November) were hidden.
July 14, 2016	On the evening of Bastille day, a lorry deliberately drove into thousands of people celebrating Bastille Day on the Promenade des Anglais in Nice (southeast of France). Eighty six people were killed and more than 400 were injured.

or to know people directly involved. However, indirect stress exposures through media exposure may also result in an increased level of stress in a broader population.[3]

Acute emotional stress is a well-known trigger for cardiovascular diseases.[4] It can cause a cascade of several physiological reactions, which in turn can lead to pathophysiological effects such as plaque disruption, thrombosis formation, myocardial ischemia, and cardiac electrical instability.[5] In some patients, this may result in severe clinical events such as ventricular tachycardia, unstable angina, and myocardial infarction. Incidents generating acute emotional stress (natural disasters, major sporting events, wars, and terrorist attacks) have been linked in the literature to increased incidence of cardiovascular events and related mortality.[4] The relative risks of cardiovascular disease reported in these studies are usually important (eg, from 1.5 to 4 depending on cardiovascular disease, the source of the emotional stress and the level of exposure). In France, a health clinic in Toulouse reported an increase in heart attacks, heart failure (HF), and stroke at a local population level after the attacks in January 2015.[6] An increase in patients experiencing serious arrhythmia after the attacks on September 11, 2001 was also reported in the USA.[7] However, studies of cardiac-related death and short-term hospital admissions in New York City after the 11th September attacks provided discordant results.[8–11]

The objective of our study was to investigate if the emotional stress caused by the 2015 and 2016 attacks led to an increase in hospitalizations for cardiovascular disease within the 15 days following each attack. The analyses were carried out at a local and national level.

Methods

Hospital discharge data from 2009 to 2016 were obtained from the PMSI system ("Programme de médicalisation des systèmes d'information"), the French Hospital Discharge Database. PMSI collects anonymous medical and demographic information by means of a unique anonymous identifier allocated to each individual. The French public health agency is allowed to access these data by the French Commission on Individual Freedom and Data Storage ("Commission Nationale de l'Informatique et des Libertés," CNIL, authorization n°902,167). We included all hospital discharge reports where one of the following codes, from the 10th revision of the *International Classification of Diseases* (ICD-10), was recorded as primary diagnosis:

- Acute coronary syndrome (ACS): I20.0 and I21–23.
- Heart failure (HF): I50, I11.0, I13.0 and I13.2. In addition, patients with a primary diagnosis of I13.9, J81, or K76.1 and an associated or related discharge diagnosis of codes I50, I11.0, I13.0, or I13.2 were also included.
- Stroke: I60–I64.

The daily number of hospitalized patients was computed for each cardiovascular disease and geographical area (Paris region vs rest of France and Nice region vs rest of France).

In a first step, we calculated the crude relative difference between the daily mean number of cardiovascular hospitalizations in the 15 days following each attack and for the same days of the year for the other years of the study (referred to later as the reference periods). Confidence intervals were calculated under the assumption of a Poisson distribution.

In a second step, multivariate models were used to evaluate if crude observed variations were related to the attacks (ie, different from the background rate). Generalized additive Poisson models were used to estimate background rate of cardiovascular hospitalizations, ie "usual" 2009–2016 short-term, seasonal, and long-term trends in daily cardiovascular hospitalizations (Wood[12]). Splines of the days surrounding the attacks were introduced to measure any additional "unusual" variations in daily cardiovascular hospitalizations occurring in the short term (within the 15 days following each attack).

In each geographical area, the number of hospitalized patients Y_j for a given cardiovascular event at day t was hypothesized to follow a Poisson distribution with autocorrelation and overdispersion being accounted for. The expected daily number of hospitalized patients μ_t was modeled in a generalized additive model framework (gam) as:

$$\log(\mu_t) = X_t \beta + s(\text{day.of.year}_t) + T(t) + A(\text{day.of.attack}_t) \quad [1]$$

X_t is the matrix of dummies for the day of the week, bank holidays and school holidays for day t, β is a vector of associated coefficients, s is a cyclic penalized regression spline of the day of the year with 30 knots and T a penalized regression spline of the day of the study with 2 knots per year. For each attack, "unusual" variations in daily hospitalization numbers were modeled by introducing a cyclic penalized regression spline of the 15 days following the attack. The cyclic splines were constrained to have a minimum of 3 degrees of freedom.

Moreover, for the 15 days following each attack, we calculated the relative difference between the number of hospitalizations predicted by the model [1] with and without attack effect confidence intervals were estimated using Monte Carlo simulations.

All analyses were performed using the R statistical software; gam models were fit with the mgcv package.

Results

Between 2009 and 2016, 1,145,869 hospitalizations for ACS, 1,730,464 hospitalizations for HF, and 967,329 hospitalizations for stroke were recorded (Table 2). The average daily number of hospitalizations was 396.4 for ACS, 598.6 for HF, and 334.6 for stroke. The Ile-de-France region, which includes Paris and its suburbs, accounted for 13% of hospitalizations for ACS, 15% for HF, and 15% for stroke. The Nice region accounted for 1.4% of hospitalizations for ACS, 1.5% for HF, and 1.8% for stroke. The daily numbers of hospitalization varied markedly with day of the week and season, while a long-term upward trend was apparent for HF and stroke (Figure 1).

The daily mean number of hospitalizations for HF and stroke was higher in the 15 days following each attack compared with the reference periods (up to 24.7% increase for HF in the Paris region after the January 2015 attacks – Table 3). No trend was seen for ACS. After adjustment for usual short-term, seasonal, and long-term variations, maximum adjusted increase was found for HF (+5.9% [–0.6; 13.1]) in the Paris region after the January 2015 attacks. However, none of the "unusual" variations were significant (Figure 2 and Table 3).

Discussion

The increase in acute stress observed in the days following the terrorist attacks in 2015 and 2016 in France did not seem to have any major impact on the short-term onset of cardiovascular events in the Paris region, the Nice region, or in the rest of France. These results, based on large datasets, contrast with those reported at the local level in a clinic in Toulouse, which observed a 75% increase in hospitalizations

Table 2 Total and daily mean number of hospitalizations, mean age of patients, and male-to-female sex ratio of hospitalizations, by reasons for hospitalization and geographical area over the 2009–2016 period

Geographical area	Reasons for hospitalization	Total hospitalizations (n)	Daily mean number of hospitalizations (n)	Mean age (years)	Sex ratio (M/F)
France	ACS	1,145,869	396.4	66.2	2.1
	HF	1,730,464	598.6	77.6	1.0
	Stroke	967,329	334.6	70.7	1.0
Paris region	ACS	145,255	50.2	64.4	2.3
	HF	252,915	87.5	75.9	1.0
	Stroke	146,183	50.6	68.5	1.1
Nice region	ACS	15,838	5.5	67.5	2.0
	HF	26,725	9.2	79.1	1.0
	Stroke	17,509	6.1	73.0	1.0

Abbreviations: ACS, acute coronary syndrome; F, female; HF, heart failure; M, male.

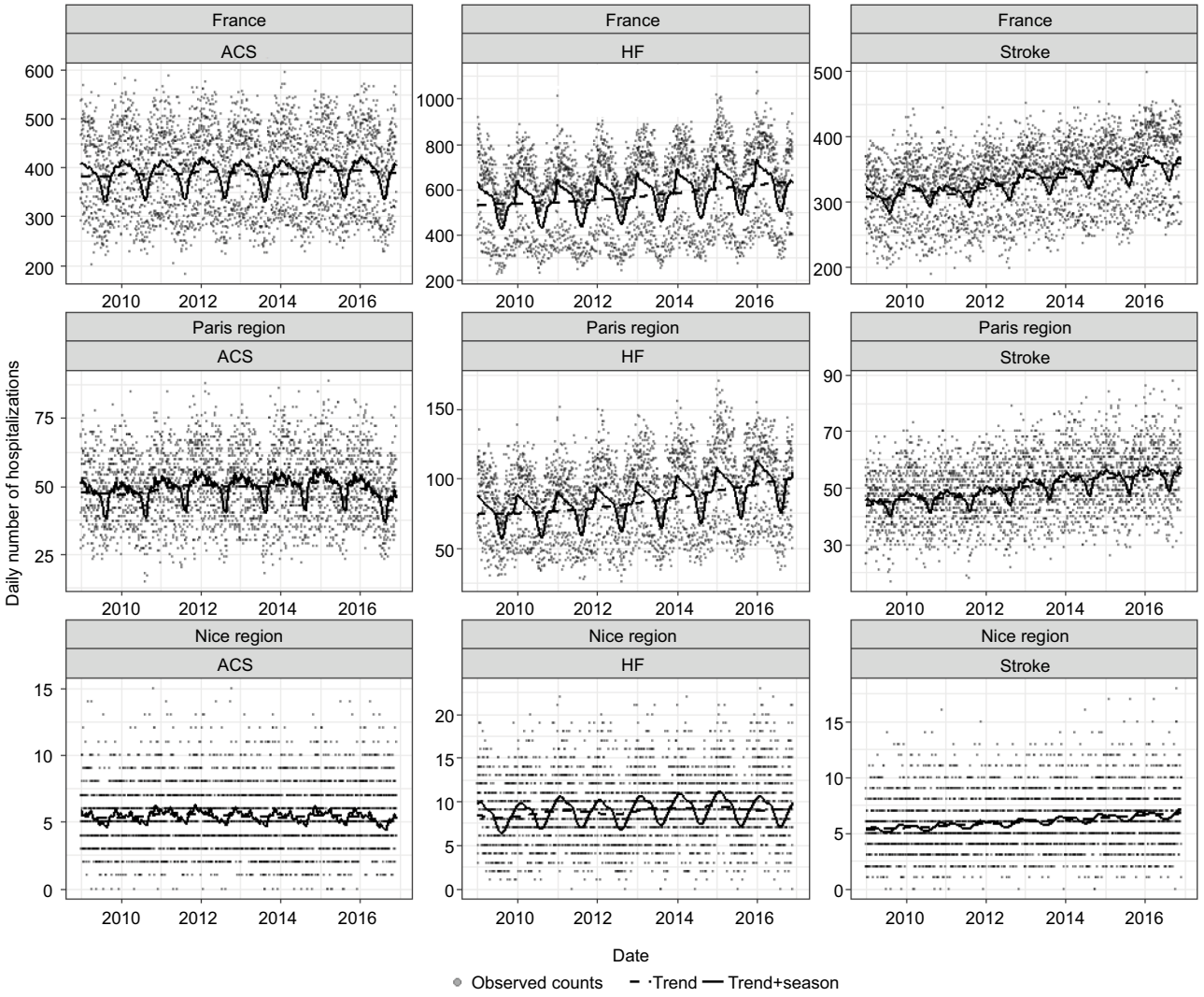

Figure 1 Daily number of hospitalization for ACS, HF, and stroke over 2009–2016 for France, Paris region, and Nice region.
Notes: Dashed and plain black lines represent, respectively, long-term trends, and long-term trends plus seasonal variations, as estimated by the model. Different scales are used for each cardiovascular cause and geographical area.
Abbreviations: ACS, acute coronary syndrome; HF, heart failure.

for cardiovascular disease after the January 2015 attacks.[6] However, the number of patients hospitalized in that health care facility was small, and findings were based on crude comparisons. In our study, crude significant relative differences in daily mean number of hospitalizations in the 15 days following each attack were observed. However, those differences were mainly related to upward long-term trends in hospitalization for those diseases during the 2009–2016 period and disappeared after adjustment for background rate.

Our results are in line with those reported by Chi et al[10] after the September 11, 2001, attacks. In that study, the authors did not find any significant association between hospitalizations for cardiovascular disease and the terrorist attacks. The hypothesis put forward was that watching events unfold on television, no matter how dramatic, was not a sufficiently potent trigger for cardiovascular disease, although it may have led to an increase in hospitalizations for stress or anxiety.

In this study, we used exhaustive data from the French National hospitalization database. The PMSI system is a medico-administrative database used primarily for managing operating costs. Each patient stay comprised both demographic information (age, sex, postcode of the area of residence) and a medical part, indicating diagnosis and medical procedures. PMSI database is widely used to provide relevant information on the burden of hospitalizations in France. The

Table 3 Daily mean number of hospitalizations in the 15 days following the terrorist attacks and for the reference periods, and crude[c] and adjusted[d] overall "unusual" variation in hospitalization rate in the 15 days following the terrorist attacks

Time frame	Cause	Geographical area	Daily mean number of hospitalizations		Overall "unusual" variation in hospitalization rate (in %) [95% CI]	
			Year of the attack[a]	Reference period[b]	Crude variations[c]	Adjusted variations[d]
7th to 21st of January	ACS	Paris region	56.9	55.8	2.0 [–4.7; 9.1]	–3.5 [–9.5; 3.3]
		Rest of France	384.2	377.5	1.8 [–0.8; 4.4]	1.3 [–2.1; 5.0]
	HF	Paris region	123.1	98.7	24.7 [19.1; 30.5]	5.9 [–0.6;13.1]
		Rest of France	664.3	588.9	12.8 [10.6; 15.0]	3.3 [–1.8; 8.7]
	Stroke	Paris region	59.2	52.9	11.9 [4.7; 19.5]	3.8 [–2.3;10.4]
		Rest of France	302.4	293.2	3.1 [0.1; 6.2]	–2.9 [–5.7; 0.1]
13th to 27th November	ACS	Paris region	51.8	55.0	–5.8 [–12.3; 1.1]	–3.5 [–9.7; 3.5]
		Rest of France	357.1	364.7	–2.1 [–4.7; 0.6]	–2.1 [–5.6; 1.7]
	HF	Paris region	96.8	87.9	10.1 [4.5; 15.9]	–4.8 [–11.2; 2.2]
		Rest of France	544.9	512.2	6.4 [4.1; 8.7]	–0.3 [–5.4; 5.2]
	Stroke	Paris region	56.1	52.0	7.9 [0.7; 15.4]	–2.5 [–8.4; 4.0]
		Rest of France	312.1	288.3	8.2 [5.2; 11.4]	0.6 [–2.3; 3.6]
14th to 28th July	ACS	Nice region	5.4	4.9	11.0 [–11.9; 37.9]	2.0 [–15.9; 28.8]
		Rest of France	354.3	349.7	1.3 [–1.4; 4.1]	0.7 [–3.2; 4.4]
	HF	Nice region	8.3	6.8	21.2 [0.8; 44.5]	4.7 [–10.3; 23.2]
		Rest of France	524.7	479.6	9.4 [7.0; 11.8]	–1.0 [–6.6; 4.5]
	Stroke	Nice region	6.4	5.8	10.0 [–10.9; 34.3]	3.8 [–12.7; 31.8]
		Rest of France	340.6	306.2	11.2 [8.2; 14.3]	–1.1 [–3.8; 1.9]

Notes: [a]In 2015, for 7th to 21st of January and 13th to 27th November; for 2016, 14th to 28th July; [b]from the 7th to the 21st of January 2009 to 2014, and 2016, from the 13th to the 27th of November 2009 to 2014, and 2016, from the 14th to the 28th of July 2009 to 2015; [c]relative differences between the daily mean number of hospitalizations in the 15 days following each attack and the daily mean number of hospitalizations for the same days of the year for the other years of the study; [d]relative differences between the number of hospitalizations predicted by the model (1) with and without attack effect.

Abbreviations: ACS, acute coronary syndrome; HF, heart failure.

strengths of this database are its completeness and the reliability of the diagnoses.[13] A French study on ACS coding in those databases was conducted in 2011, and it was found that I20.0 and I121–23 had good positive predictive value.[14] Moreover, a review of validation studies about acute myocardial infarction identification in administrative databases through the use of ICD-10 codes delivered satisfactory conclusions. Finally, according to a recent validation study of the PMSI for stroke, the positive predictive value of a stroke detection algorithm was approximately 90% in 2009–2010.[15] Nevertheless, patients who die before arriving at the hospital are not included in this database. We cannot reject the hypothesis that the number of sudden deaths have increased after the terrorist attacks.

Despite exhaustive nationwide hospitalization data, the daily number of hospitalizations remained relatively low, especially for the Nice region. Therefore, our results may suffer from a lack of power. However, simulation analyses indicated that the model had an 80% power of detecting an increase of 20% in hospitalizations during the 15 days following the attack in the Paris region (data not shown).

A cut-off of 15 days was chosen to define the short-term window used to evaluate the impact of acute emotional stress as a trigger. Actually, according to the literature, stress-related cardiovascular events happen in the immediate short-term period (eg, few minutes to 24 hours) after the stress.[7] The largest part of the population's exposure to acute stress (in intensity and volume of population exposed) has happened the day of the attacks and very few days that followed, as observed, for example, in the study of Vandentorren et al.[1] Thus, we expected that the increase in hospitalization rate, if any, should have happened in the few days following the attacks. However, in order to account for the potentially delayed effects due to sustained acute stress from continued media coverage, we chose to extend the observation time frame to 15 days after the attacks. However, this choice does not appear to be a critical issue.

Conclusion and public health implication

Our study shows that the public health burden of the terrorist attacks in France in 2015 and 2016 is unlikely to have been increased by additional acute hospitalized cardiovascular events in the short term, despite the intense fear and stress generated by the attacks. Therefore, our findings suggest that there is no evidence for specialized cardiovascular management just after terrorist attacks. However, as the threat

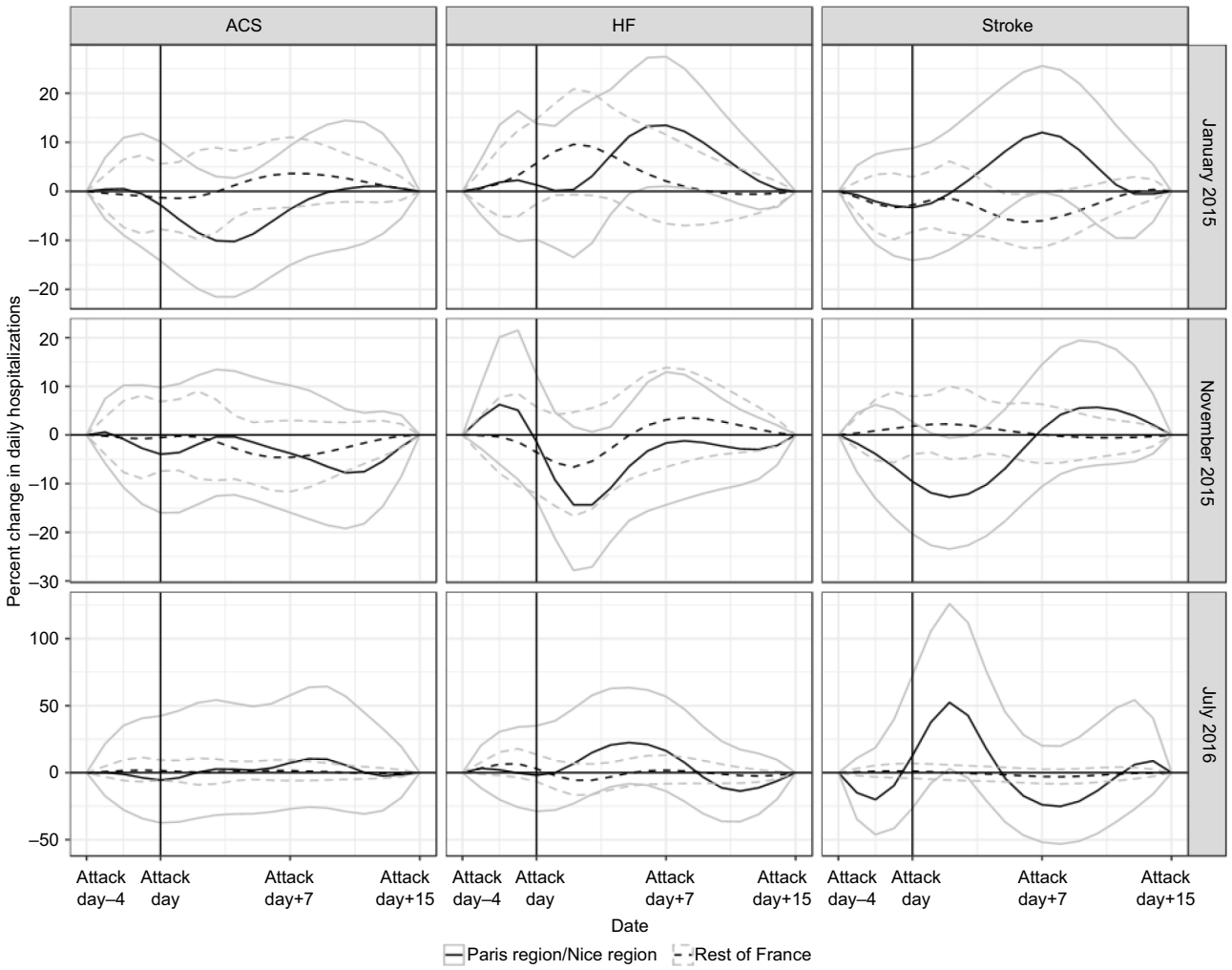

Figure 2 Specific variation in daily hospitalization rates in the 15 days following the terrorist attacks.
Notes: Black lines represent adjusted variations (percentage change between modeled daily counts and background rate, given usual 2009–2016 variations) and gray lines indicate 95% confidence intervals. Different scales are used for each attack.
Abbreviations: ACS, acute coronary syndrome; HF, heart failure.

of terrorism continues in France, the cumulative effects of chronic stress and anxiety may have long-term effects on the risks of cardiovascular disease. These effects could be explored by implementing a large ongoing French cohort. Specific items on a self-administered questionnaire could be added to estimate the level of perceived stress following these attacks and its impact on the occurrence of cardiovascular disease. In light of this, quick implementation of psychological support, and more generally, the development of medical preparedness and long-term management strategies, remain crucial and are still needed to reduce public health impact of terrorist attacks in the long term.

Disclosure

The authors report no conflicts of interest in this work.

References

1. Vandentorren S, Paty AC, Baffert E, Chansard P, Caserio-Schonemann C. Syndromic surveillance during the Paris terrorist attacks. *Lancet*. 2016;387:846–847.
2. Holman EA, Silver RC, Poulin M, Andersen J, Gil-Rivas V, McIntosh DN. Terrorism, acute stress, and cardiovascular health: a 3-year national study following the September 11th attacks. *Arch Gen Psychiatry*. 2008;65:73–80.
3. Bernstein KT, Ahern J, Tracy M, Boscarino JA, Vlahov D, Galea S. Television watching and the risk of incident probable posttraumatic stress disorder: a prospective evaluation. *J Nerv Ment Dis*. 2007;195:41–47.
4. Brotman DJ, Golden SH, Wittstein IS. The cardiovascular toll of stress. *Lancet*. 2007;370:1089–1100.
5. Bhattacharyya MR, Steptoe A. Emotional triggers of acute coronary syndromes: strength of evidence, biological processes, and clinical implications. *Prog Cardiovasc Dis*. 2007;49:353–365.
6. Rosa FD, Van Rothem J, Dongay B, Pathak A. We are CHARLIE: emotional stress from "Charlie Hebdo attack" extensively relayed by media increases the risk of cardiac events. *Clin Res Cardiol*. 2016;105:630–631.

7. Steinberg JS, Arshad A, Kowalski M, et al. Increased incidence of life-threatening ventricular arrhythmias in implantable defibrillator patients after the World Trade Center attack. *J Am College Cardiol*. 2004;44:1261–1264.
8. Feng J, Lenihan DJ, Johnson MM, Karri V, Reddy CV. Cardiac sequelae in Brooklyn after the September 11 terrorist attacks. *Clin Cardiol*. 2006;29:13–17.
9. Chi JS, Poole WK, Kandefer SC, Kloner RA. Cardiovascular mortality in New York City after September 11, 2001. *Am J Cardiol*. 2003;92:857–861.
10. Chi JS, Speakman MT, Poole WK, Kandefer SC, Kloner RA. Hospital admissions for cardiac events in New York City after September 11, 2001. *Am J Cardiol*. 2003;92:61–63.
11. Goldberg RJ, Spencer F, Lessard D, Yarzebski J, Lareau C, Gore JM. Occurrence of acute myocardial infarction in Worcester, Massachusetts, before, during, and after the terrorists attacks in New York City and Washington, DC, on 11 September 2001. *Am J Cardiol*. 2005;95:258–260.
12. Wood SN. *Generalized Additive Models: An Introduction with R*. London: Chapman & Hall; 2006:410.
13. Bezin J, Duong M, Lassalle R, et al. The national healthcare system claims databases in France, SNIIRAM and EGB: powerful tools for pharmacoepidemiology. *Pharmacoepidemiol Drug Saf*. 2017;26:954–962.
14. Bezin J, Girodet PO, Rambelomanana S, et al. Choice of ICD-10 codes for the identification of acute coronary syndrome in the French hospitalization database. *Fundam Clin Pharmacol*. 2015;29:586–591.
15. Giroud M, Hommel M, Benzenine E, et al. Positive predictive value of french hospitalization discharge codes for stroke and transient ischemic attack. *Eur Neurol*. 2015;74:92–99.