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Original Research

Out-of-hospital Times Using Helicopters Versus Ground Services for Emergency Patients

Andrew Stowell, MD [1], Xavier Bobbia, MD [1,2*], Julien Cheret, MD [1], Romain Genre Grandpierre, MD [1], Alexandre Moreau, MD [1], Stéphane Pommet, MD [1], Jean-Yves Lefrant, MD, PhD [1], Jean Emmanuel de La Coussaye, MD, PhD [1], Thibaut Markarian, MD, PhD [2], Pierre-Géraud Claret, MD, PhD [1]

[1] *Department of Anesthesiology, Emergency and Critical Care Medicine, Intensive Care Unit, Nimes University Hospital, Nimes, France*
[2] *Emergency Department, Timone 2 Hospital, Aix-Marseille University, Marseille, France*

A B S T R A C T

Objective: Minimizing out-of-hospital time reduces morbidity and mortality in patients with severe trauma, acute coronary syndrome, or acute stroke. Our objective was to compare out-of-hospital times by helicopter versus ground services when the estimated time of arrival on the scene was over 20 minutes.
Methods: We proposed a retrospective observational monocentric study following 2 cohorts. The helicopter group and the ground group included patients with severe trauma, acute coronary syndrome, or acute stroke transported by helicopter or ground services.
Results: Two hundred thirty-nine patients were included; 118 were in the ground group, and 121 were in the helicopter group. Distances for the helicopter group were higher (62.1 ± 22.5 km vs. 27.6 ± 10.4 km, $P <$ .001). When distances were over 35 km, the helicopter group was faster. We identified distance, need for surgery, and intensive care hospitalization as 3 predicting factors for choosing helicopters over ground modes of transport.
Conclusion: In cases of severe trauma, acute coronary syndrome, or acute stroke, emergency medical helicopter transport can be chosen over ground transport when patients are in a severe state and when the distance is further than 35 km from the hospital.

Minimizing out-of-hospital times reduces morbidity and mortality in patients with acute coronary syndrome,[1-4] severe trauma, or acute strokes.[2,5-7] Choosing the right mode of transport is important in reducing out-of-hospital times.[8] Analyzing the literature is complicated because prehospital management differs between medical systems throughout the world. Some medical systems exclusively use paramedics, whereas others can use physicians for out-of-hospital emergencies. Nevertheless, many articles concur that helicopters reduce out-of-hospital times[9] and improve survival.[6,8,10-12] In France, out-of-hospital emergencies are taken care of by the Service d'Aide Medicale Urgente (SAMU, French emergency call center). Distress calls are dialed to the SAMU's "15" hotline, corresponding to 911 in the United States. An emergency physician then responds to the call by sending out a service mobile d'urgence et de réanimation (SMUR), which is a prehospital mobile emergency unit with an emergency physician, a nurse, and an ambulance driver or a helicopter pilot depending on which mode of transport is chosen. Our objective was to compare out-of-hospital times by helicopter emergency medical services (HEMS) versus ground transport for patients with severe trauma, acute coronary syndrome, or strokes when the estimated time of arrival at the scene of the event exceeded 20 minutes.

Materials and Methods

Materials

We conducted this observational monocentric study during 2015 in the emergency department of a university hospital, with an average annual census of 65,000 visits and 6,500 out-of-hospital responses. We informed all patients that they might be contacted by telephone for follow-up. The local institutional review board approved our study.

* Address for correspondence: Xavier Bobbia, MD, Department of Anesthesiology, Emergency and Critical Care Medicine, Intensive Care Unit, Place du Pr Robert Debré, Nimes, France
E-mail address: xavier.bobbia@gmail.com (X. Bobbia).

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According to French law (Law 88-1138 relative to Biomedical Research of December 20, 1988, modified on August 9, 2004), this noninterventional study did not require approval by an ethics committee or informed signed consent from patients. We declared our study to the National Commission for Data Processing and Civil Liberties (registration number: 1875857 v 0).

We enrolled patients with severe trauma, acute coronary syndrome, or strokes from January 1 to December 31, 2014, with an estimated arrival time at the scene of at least 20 minutes. Patients refusing to participate, under 18 years old, under guardianship, or under curatorship were not included. We did not include patients transported by ground services during the days and hours the helicopter could not fly.

We examined data from the distress call to SAMU's "15" hotline during hospitalization and then up to 28 days. We collected data from the prehospital medical files such as demographic characteristics, vital signs, invasive procedures, and medication as well as the scene of the event GPS coordinates, the estimated time of arrival at the scene of the event (Appli-SAMU Application; Appligos-Opendev, Strasbourg, France), and the different time periods from the distress call up to arrival at the hospital. We collected data from the hospitalization medical files such as vital signs, surgical procedures, coronarography, invasive procedures, therapeutics, laboratory results, and outcomes up to 28 days. When necessary, patients were contacted by telephone to acknowledge their outcome up to 28 days after.

Aims and End Points

Our main objective was to compare out-of-hospital times by HEMS versus ground transport when the estimated time of arrival on the scene was more than 20 minutes. We defined the primary end point as the out-of-hospital time, which was defined as the period between the distress call to the SAMU "15" hotline and arrival time at the emergency department or the receiving ward. We divided our study population into 2 groups: the helicopter (H) group and the ground (G) group.

Our secondary outcomes were 1) to compare the time of the first medical contact between the 2 groups (the time of the first medical contact was defined as the period of time between the distress call and arrival on the scene of the event), 2) to determine a cutoff distance from the hospital to the scene of the event where out-of-hospital HEMS times are shorter than ground transport, and 3) to identify variables that predict sending HEMSs.

Statistical Analysis

We described patient characteristics using sample size and percentages for qualitative variables and mean and standard deviation or median with interquartile range depending on the type of distribution for quantitative variables. We compared qualitative variables in each group using the Fisher exact test and quantitative variables using the Student test. We conducted logistic regression with backward stepwise selection for variables associated with distance to the on-scene event on univariate analysis. For the different models, identification of each covariate was adjudicated by the empiric association with the primary outcome using the Akaike information criterion. We assessed the correlations between the time of the distress call and the time of arrival at the hospital using locally weighted scatterplot smoothing regression. We considered P values < .05 significant. We performed analysis using R version 3.1.2 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Participants

In total, 239 patients consented to inclusion in the cohort study from January 1 to December 31, 2014. The median (interquartile range) age of patients was 60 years (46.5-74 years). Table 1 shows variables according to each mode of transport. The H group consisted of 121 patients and the G group of 118 patients. The distance from the hospital to the scene of the event was significantly longer in the H group (62.1 ± 22.5 km vs. 27.6 ± 10.4 km, $P < .001$). Patients from the H group were more frequently intubated ($P < .001$), needed more surgical procedures ($P = .037$), and required more frequent hospitalizations in intensive care units ($P < .001$).

We conducted a multivariate analysis of the overall out-of-hospital care period adjusted to the scene of the event transport distance. Out-of-hospital care was not significantly different between groups ($\beta = 0.299$; odds ratio [OR] = 1.005; 95% confidence interval [CI], 0.993-1.017; $P = .449$) (Table 2).

Aims

We performed a multivariate analysis of different out-of-hospital times adjusted to transport distance. Periods between the distress call and the SMUR departure times were not significantly different between groups ($\beta = -0.016$; OR = 1; 95% CI, 0.971-1.030; $P = .982$). Periods between the SMUR departure times and arrival on the scene of the event times were significantly shorter in the H group ($\beta = 8.714$; OR =1.683; 95% CI, 1.421-2.128; $P < .001$). The period between arrival times on the scene of the event and arrival times in the hospital was significantly longer in the H group ($\beta = -2.016$; OR = 0.956; 95% CI, 0.904-0.988; $P = .045$) (Table 2).

Multiple linear regression was calculated to predict when HEMS should be sent based on the transport distance to the scene, the need for surgery, the need for intensive care hospitalization, peripheral capillary oxygen saturation, heart rate, Glasgow Coma Scale score, and prehospital care by a local SMUR. We developed this model on a data set of 224 cases without missing values (15 observations deleted because of missing data). A significant regression equation was found ($F_{7,216} = 40.49$, $P < .001$) with R^2 of 0.553. The transport distance (OR = 1,173; 95% CI, 1.123-1.124; $P < .001$), the need for intensive care hospitalization (OR = 6,703; 95% CI, 1.386-34.950; $P = 0.018$), and the need for surgery (OR = 3,927; 95% CI, 1.079-14.865; $P = .039$) were significant predictors for sending HEMS. This model has a nonsignificant Hosmer-Lemeshow chi-square goodness-of-fit statistic (Table 2).

Linear regression was calculated to assess the correlation between out-of-hospital times and transport distance in both modes of transport. In the H group, transport distance and out-of-hospital times were not correlated ($r_{121} = 0.13$, $P = .159$). The equation for this first regression line was $y = 0.214^*x + 96.935$. In the G group, transport distance and out-of-hospital times were correlated ($r_{118} = 0.49$, $P < .001$). The equation of this second regression line was $y = 1.094^*x + 65.434$. The 2 regression lines intersected at a transport distance of 35 km. Figure 1 shows the local regressions (locally weighted scatterplot smoothing regression) of transport distance and out-of-hospital times according to each mode of transport. Both curves and CIs diverge permanently at a transport distance of 58 km.

Figure 2 shows a map analysis representing out-of-hospital times according to each mode of transport. It shows a geographic spread of interventions for each group. The H group interventions are far away from the hospital and located in areas that are isolated from ground facilities (mountains, seacoast, and rural areas). Out-of-hospital times far from the hospital are similar to others much closer. The G group interventions are located around the hospital and along the main roads and highways. Out-of-hospital times in the G group are longer when the transportation distance is greater.

Discussion

The primary objective of our study was to compare out-of-hospital times using HEMS versus ground transport for patients with severe trauma, acute coronary syndrome, or strokes when the estimated time of arrival on the scene was more than 20 minutes. Our study

Table 1
Variables According to Each Mode of Transport

Variables	Helicopter (n = 121)	Ground (n = 118)	*P* Value
Male sex, n (%)	93 (77)	68 (58)	.002
Age (years), median (IQR)	57 (17.1)	58.8 (21.6)	.485
Reasons for SMUR intervention at SAMU distress call, n (%)			<.001
Suspicion of an acute coronary syndrome	21 (17)	5 (4)	
Suspicion of a stroke	57 (47)	92 (78)	
Suspicion of a severe trauma	43 (36)	21 (18)	
Transport distance to the scene of event (km), median (IQR)	62.1 (22.5)	27.6 (10.4)	<.001
Out of hospital times (min), median (IQR)			
Estimated arrival time by ground services (Apple Maps application)	66.7 (28)	30.9 (8.4)	<.001
Estimated arrival time by ground services (Appli-SAMU application) (5)	57.1 (22.9)	23.6 (9.2)	<.001
Estimated arrival time by helicopter (Appli-SAMU) (5)	23.8 (5.5)	16.4 (3.1)	<.001
Distress call/SMUR departure time	41.4 (25.4)	15.6 (20.3)	<.001
Distress call/arrival at the scene of the event time	57.7 (26.1)	41 (21.5)	<.001
SMUR departure/arrival at the scene time	16.3 (7.4)	25.4 (6.7)	<.001
Transport times	33.8 (10.2)	52.6 (13.3)	<.001
First medical contact time (25)	42.6 (21.2)	37.1 (14.1)	.031
Arrival at the scene/arrival at the hospital time	52.5 (27.6)	54.7 (15)	.448
Time spent at the scene of the event	34.4 (26.5)	27.6 (13.7)	.013
Overall out-of-hospital time	110.2 (37.3)	95.7 (23.2)	<.001
Prehospital Glasgow Coma Scale, median (IQR)	13.2 (3.7)	14.6 (2)	<.001
Prehospital SBP (mm Hg), median (IQR)	135.1 (33.5)	137.2 (23.7)	.567
Prehospital DBP (mm Hg), median (IQR)	77.2 (20)	80.2 (16.6)	.202
Prehospital SpO_2 (%), median (IQR)	95.4 (10.1)	97.3 (4.1)	.051
Prehospital heart rate (/min), median (IQR)	77.5 (20.4)	82.1 (27.9)	0.141
Prehospital capillary glucose measurements (g/L), median (IQR) (47)	1.3 (0.4)	1.2 (0.4)	.792
Prehospital life support procedures, n (%)			
Electric shock	3 (2)	2 (2)	1
Intubation	23 (19)	4 (3)	<.001
Transport to hospital, n (%)	99 (82)	89 (75)	.27
In-hospital medical care, n (%)			
Intensive care unit (2 and 9)	32 (27)	6 (6)	<.001
Monitoring (2 and 9)	55 (46)	46 (42)	.594
Coronarography (2 and 9)	44 (37)	38 (35)	.681
Angiography (3 and 9)	34 (29)	24 (22)	.287
Thrombolysis (3 and 10)	5 (4)	0 (0)	.061
Surgery (4 and 9)	23 (20)	10 (9)	.037
Length of stay (days), median (IQR) (6 and 9)	10.2 (13.7)	6.8 (14.8)	.07
24-hour outcome, n (%) (11)			<.001
Discharge	5 (4)	35 (32)	
Hospitalization	110 (93)	74 (67)	
Deceased	3 (3)	1 (1)	
7-day outcome, n (%) (14)			<.001
Discharge	52 (44)	80 (74)	
Hospitalization	55 (47)	26 (24)	
Deceased	10 (9)	2 (2)	
28-day outcome, n (%) (19)			.022
Discharge	73 (65)	87 (81)	
Hospitalization	17 (15)	14 (13)	
Deceased	13 (12)	3 (3)	
Rehabilitation	9 (8)	4 (3)	

DBP = diastolic blood pressure; IQR = interquartile range; SAMU = Service d'Aide Medicale Urgente; SBP = systolic blood pressure; SMUR = service mobile d'urgence et de reanimation; SpO_2 = peripheral capillary oxygen saturation.
Numbers in parentheses indicate the n for which values were missing.

Table 2
Multivariate Analyses

Variables	β Coefficient	OR	95 % CI	*P* Value
Comparison of patients according to the mode of transport and overall out-of-hospital time adjusted to distance				<.001
Transport distance to the scene of event (km)	−7.238	0.863	0.827-0.894	
Overall out-of-hospital time (min)	0.299	1.005	0.993-1.017	.449
Comparison of patients according to the mode of transport and out-of-hospital periods adjusted to distance				
Transport distance to the scene of event (km)	−8.187	0.847	0.784-0.891	<.001
Distress call/SMUR departure time (min)	−0.016	1	0.971-1.030	.982
Distress call/arrival at scene of event time (min)	8.714	1.683	1.421-2.128	<.001
Arrival at scene/arrival at hospital time (min)	−2.016	0.956	0.904-0.988	.045
Variables associated with HEMS sending				
Transport distance to the scene of event (per km)	7.858	1.173	1.123-1.239	<.001
Requiring an intensive care unit (yes)	1.414	6.703	1.386-34.950	.018
Requiring surgery (yes)	0.958	3.927	1.079-14.865	.039
Prehospital SpO_2 (per %)	-0.500	0.968	0.875-1.020	.387
Prehospital heart rate (per min)	0.370	1.008	[0.986-1.026	.435
Prehospital Glasgow Coma Scale (per unit)	-0.222	0.965	0.808-1.135	.673

CI = confidence interval; HEMS = helicopter emergency medical services; OR = odds ratio; SMUR = service mobile d'urgence et de reanimation; SpO_2 = peripheral capillary oxygen saturation.

shows that when the distance to the scene of the event exceeded 35 km, the H group was faster. Furthermore, the H group treated more severe patients far from the hospital and isolated from ground facilities.

Out-of-hospital times and transport distance were independent in the H group. There was no correlation between these 2 variables as shown in linear regression. The map analysis illustrated this showing interventions in the H group far away from the hospital with equivalent out-of-hospital times to other closer interventions. On the contrary, distance and out-of-hospital times were correlated in the G group. Therefore, out-of-hospital times increase when the transport distance increases. Linear regression analysis showed that when transportation distance exceeded 35 km, out-of-hospital times in the H group became shorter than in the G group. Furthermore, the CIs diverge permanently when distance exceeds 58 km. This increases the benefit of using HEMS over ground services for longer distances.

Transport distance to the scene of the event was significantly higher in the H group. The map analysis showed that interventions in the H group were located far away from the hospital in areas that are difficult to access with ground services, such as the Cevennes (a rural mountainous area northwest of the Gard department), the South Rhône Valley, and the Mediterranean Coast. These areas have very few road facilities. On the contrary, the G group interventions were mainly located around the hospital and along main roads and highways.

Patients' conditions were more severe in the H group. The Glasgow Coma Scale score was significantly lower, and patients were at higher risk of prehospital intubations, needing admissions in intensive care units, or needing surgical procedures.

Out-of-hospital times were not significantly different between groups when adjusted to transport distance. Even though transport

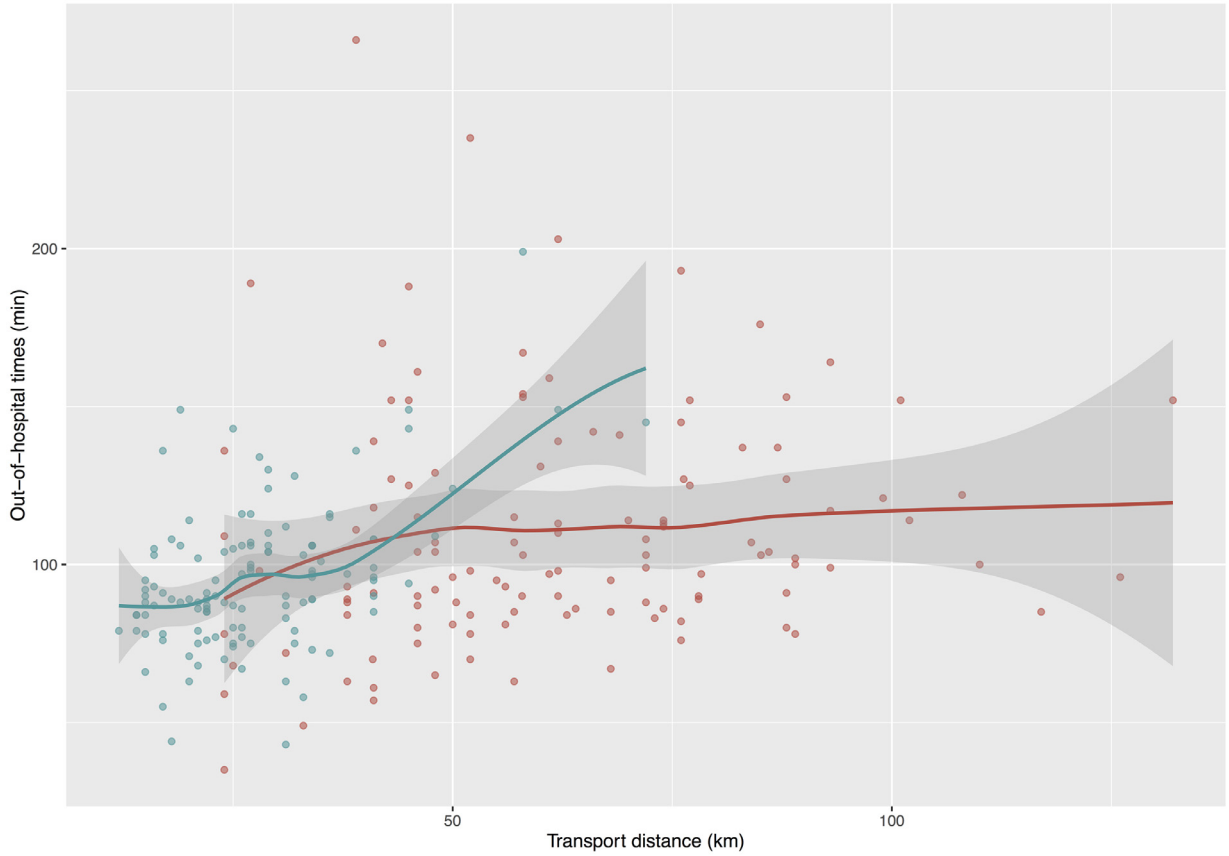

Figure 1. Local regressions (locally weighted scatterplot smoothing regressions) of transport distance and out-of-hospital times according to each mode of transport.

distances were higher in the H group, out-of-hospital times were similar to the G group. When analyzing the different periods in an out-of-hospital intervention, we observed several issues. First of all, periods between the distress call and the SMUR departure times were not significantly different between groups. On the other hand, the H group was fastest to arrive on the scene of the event once on their way. Consequently, the first medical contact was established faster in the H group. Secondly, periods between the arrival time on the scene of the event and the hospital arrival time were longer in the H group. This is probably because of the fact that patients in the H group were more severe and needed more prehospital medical treatment. In order to minimize out-of-hospital times, we identified, through multivariate analysis, that transport distance as well as the need for surgery or admission in an intensive care unit were predictive variables for sending HEMS in immediate response to the distress call.

Our finding that when transport distance exceeded 35 km, out-of-hospital times were shorter when using HEMS replicates those of several previous studies. Responses in the H group were mostly located far away from the hospital and in isolated areas that are difficult to access with ground services. Access to these isolated areas is 1 of the major tasks entrusted to HEMS in France. An American study by Lerner et al[13] showed that out-of-hospital times in severe trauma patients were shorter with ground services when the incident was located near major roads or highways.

Patients in the H group had more severe medical conditions. Several previous studies reported similar findings. A French study by Desmettre et al[6] reported that trauma patients in their helicopter group had significantly lower blood pressure. Ringburg et al[14] reported that patients in their helicopter group had a lower Glasgow Coma Score (10.3 vs. 13.8, $P < .001$) and a higher Injury Severity Score (23.6 vs. 9.1, $P < .001$). An American study by Bulger et al[15] reported that trauma patients transported by helicopter were more severely injured (Injury Severity Score = 30.3 vs. 22.8, $P < .001$) and were at a higher risk of prehospital intubation (81% vs 36%, $P < .001$).

Periods between on the scene of the event arrival time and at hospital arrival times were significantly longer in the H group. This finding replicates the findings of previous studies.[16,17] Desmettre et al[6] and Ringburg et al[8] reported that this was because patients had more severe medical conditions and required more advanced life support procedures and longer prehospital time.

Very few studies relate to the first medical contact[6,16] because they are mostly based on the emergency medical system, which does not require physicians onboard out-of-hospital emergency units. There is also no international score for choosing HEMS or ground services. There are some criteria lists in the United Kingdom[18] and the United States.[19] Taking into account our main results, we suggest that HEMS could be sent in response to a distress call when transport distance to the scene exceeds 35 km, the incident location is remotely isolated from road facilities, or patients have severe clinical conditions. These criteria added to a reference mapping system could be the key to building a decision-making score for choosing the appropriate mode of transport.

Limitations

First, our study was conducted in a single institution and may not be representative of other institutions. We chose to study 3 different illnesses that require different medical treatments. They were significantly unequally represented in both groups ($P < .001$). This might have biased the results in our study. It could have been interesting to study separately each of these illnesses, but our sample size did not

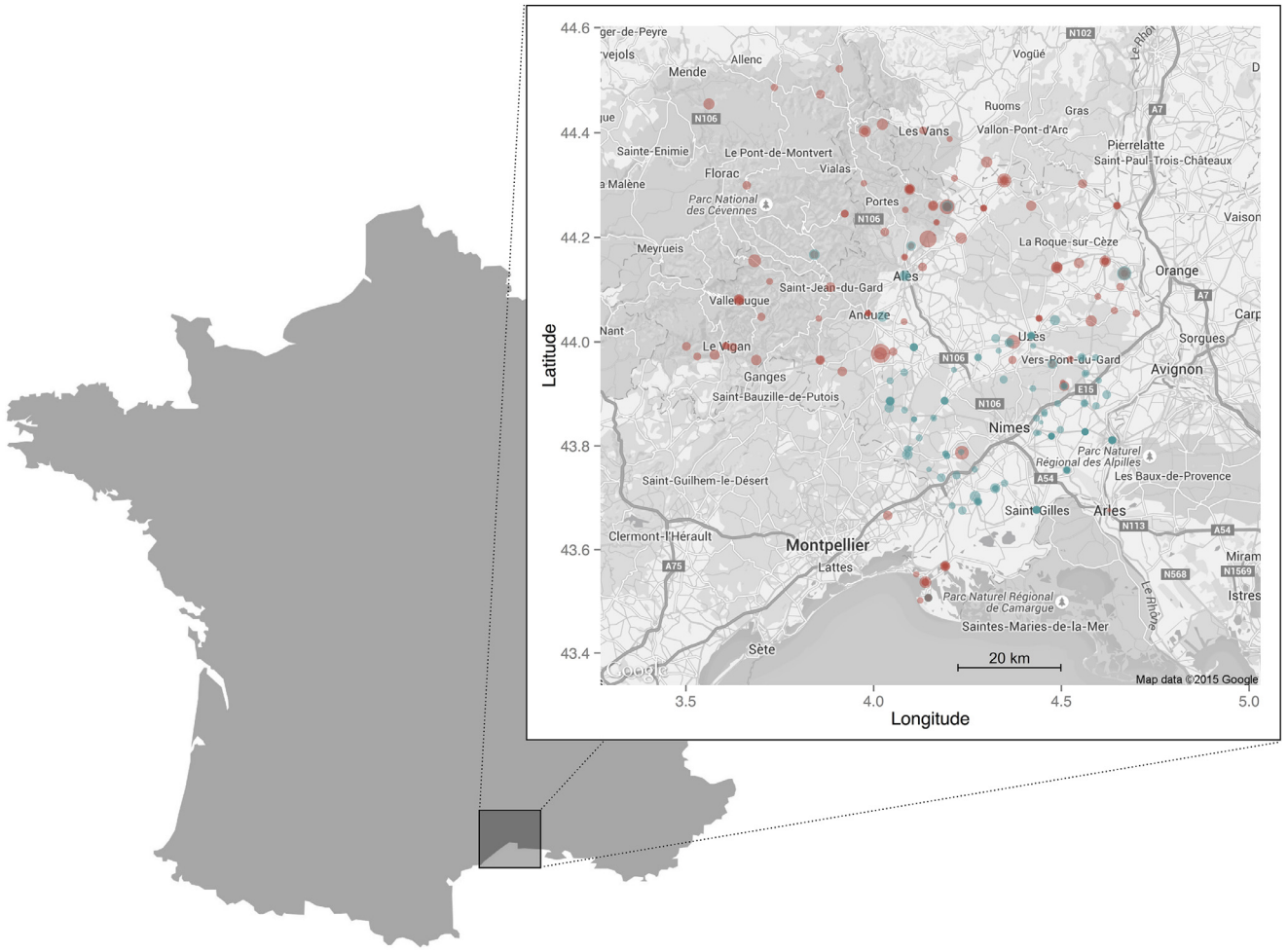

Figure 2. Map analysis representing out-of-hospital times according to each mode of transport.

allow us to perform a subgroup analysis. Second, we chose the criteria "distance to arrival on the scene of 20 minutes or more" to include our study population. Other criteria could have given different results, especially because the Appli-Samu application in the SAMU's call center tends to underestimate estimated transport times compared with the Apple Maps application (Apple, Cupertino, CA). This criterion might not be fully reliable. Third, our study was conducted retrospectively so we could not take into account the helicopters unavailability because, for example, of bad weather conditions. This led us to exclude ground interventions on days the helicopter did not fly. Finally, our study did not take into account differences in the driving skills of all ambulance drivers and helicopter pilots.

Conclusion

Our study shows that in cases of patients with trauma, acute coronary syndrome, or strokes, prehospital transportation by HEMS can be used if the distance to the scene of the event exceeds 35 km, the scene of the event is located in an area isolated from road facilities, or patients have a severe medical condition.

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