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Geographical disparities of endovascular revascularisations in ambulatory setting in France from 2015 to 2019

Nolwenn Le Meur PhD^{1*}, Cindy Padilla, PhD¹, Narges Ghoroubi², Guillaume Lamirault MD, PhD^{3,4}, Gilles Chatellier Prof, MD⁵, Yann Gouëffic MD, PhD⁶

(1) Univ Rennes, EHESP, CNRS, Inserm, Arènes - UMR 6051, RSMS - U 1309 – F-35000

Rennes, France

(2) Institut national d'études démographiques (INED), F-93322 Aubervilliers, France.

(3) Institut du thorax, INSERM, CNRS, UNIV Nantes, Nantes, France.

(4) Institut du thorax, CHU Nantes, Service de Cardiologie, Nantes, France

(5) Assistance Publique-Hôpitaux de Paris, Hôpital Européen Georges-Pompidou,

Université de Paris, CIC 14-18 INSERM, Paris, France.

(6) Department of vascular and endovascular surgery, Groupe Hospitalier Paris Saint-

Joseph, 185 rue Raymond Losserand, 75014, Paris

* Corresponding author: Nolwenn Le Meur

Mailing address : EHESP, Département METIS, 15 Avenue du Professeur Léon Bernard, CS

74312 35043 Rennes Cedex, FR

Phone: +33 2 99 02 25 14

E-mail : nolwenn.lemeur@ehesp.fr

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1 **What this paper adds**

2 This study is the first to report on the geographical space and time disparities of the
3 development of ambulatory endovascular revascularisation in France. Between 2015 and
4 2019, the ambulatory activity increased slowly but with significant geographical disparities.
5 In 2019, the ambulatory activity in the French departments ranged from 0% to 39%. From
6 both population health and health services perspectives, the clusters of departments with a
7 significant ambulatory activity differed from the others by the burden of lower extremity
8 arterial diseases, some form of social isolation, and the poverty of their elderly population.
9 Therefore, research is needed to improve health care resources and access to ambulatory
10 endovascular revascularisation.

11
12

Abstract

Objectives

Despite evidences of efficiency and safety ambulatory endovascular revascularisation for lower extremity arterial disease (LEAD) concerned only 5% of the interventions in France in 2016. Such low rate suggested temporal and geographical space disparities. The aim of this study was to describe the space-time development of ambulatory endovascular revascularisation for LEAD in France and investigates the contributions of health care services and population characteristics as potential determinants.

Methods

A retrospective study was conducted on discharge data from French hospitals that performed endovascular procedures for LEAD between 2015 and 2019. Space-time analyses with Moran's Index, zero-inflated Poisson regression, and clustering approaches were applied. Spatial clusters were compared on the basis of health care services and population characteristics (including poverty and single-man household as proxies of social isolation).

Results

Between 2015 and 2019, the number of ambulatory interventions has tripled (1104 vs 3130). Out of the 86 French departments, the proportion with > 5% of ambulatory interventions increased from 10.7% to 28.7% over the study period. In 2019, the ambulatory activity in the French departments ranged from 0% to 39%. This evolution was accompanied by a northwest to northeast spatial trend. The clusters of 27 departments with a significant ambulatory activity differed from the others notably by the mortality rate of lower limb arterial thrombo-embolic diseases in male (OR=3.15 95%CI[1.2-8.1]), the proportion of single-man household aged 75 or more (OR=0.37 95%CI [0.2-0.8]), and the poverty rate of people aged 50- to 59-year-old (OR=0.69 95%CI[0.5-0.9]).

Conclusions

1 The development of ambulatory interventions for LEAD in France is encouraging but
2 heterogeneous. Some determinants of this evolution are clearly population based, with a
3 positive impact of needs to take care of the burden of LEAD but negative effects of social
4 isolation and poverty. Research should be conducted to overcome some patients' constraints
5 such as isolation.

1 Introduction

2 Lower extremity arterial disease (LEAD) is the third cause of cardiovascular morbidity after
3 coronary artery disease and stroke. The worldwide prevalence and incidence cases are of 113
4 million and 10 million in 2019, respectively¹. The prevalence increases sharply with age, from
5 3% in those under 60 years to over 20% in those over 79 years². With increasing life
6 expectancy and the rise of risk factors (i.e., tobacco and alcohol consumption , unhealthy
7 diet), a larger burden of LEAD is to be expected in the foreseeable future, including in low-
8 and middle-income countries, and cost-effective treatments are needed³⁻⁵.

9 For more than a decade, technological developments and the expertise of vascular teams have
10 improved the management of LEAD, offering endovascular treatments and outpatient
11 hospitalisation. Although the benefits of outpatients hospitalisations are still debated, notably
12 about the complication rates or the burden of premature discharge on primary health care
13 services⁶⁻⁹, several studies had demonstrated both increased resource efficiency and hospital
14 cost savings, thanks to ambulatory endovascular treatments, while preserving patient safety
15 ¹⁰⁻¹³. Consequently, the development of endovascular interventions in ambulatory setting has
16 accelerated significantly, mainly in the United States^{14,15}. From 2006 to 2011, the rate of
17 peripheral vascular interventions increased from 190.7 to 265.5 per 100 000 Medicare
18 beneficiaries among outpatients while it dropped from 209.7 to 151.6 among inpatients¹⁵.

19 Clearly, LEAD treatment is shifting from conventional hospitalisation and open surgery to
20 ambulatory minimal invasive endovascular surgery, when applicable^{10,16}. In the United States,
21 the latter it concerns more than 60% of the procedures. However in France, only 5% of the
22 endovascular revascularisations for LEAD were performed in ambulatory setting in 2016⁹.

23 However, this average figure may conceal large differences on a smaller individual scale,
24 which can be suspected through the speed of adoption of novelty and the existence of
25 territorial¹⁷. To test this hypothesis, we studied the spatial and temporal evolution of

endovascular interventions in hospital ambulatory setting in France from 2015 to 2019. The main objectives were to assess and decipher any disparity across the French departments and, if any, analyse their evolution over time. In addition, we investigated the contributions of healthcare services and population characteristics in this evolution.

Materials and Methods

In France, endovascular revascularisations in ambulatory setting are performed in hospitals. The ambulatory setting is defined by a hospitalisation of less than 12 hours, without overnight accommodation (same-day discharge); the patient is considered an outpatient¹⁸. The conventional setting includes an overnight stay and the patient, qualified as an inpatient, leaves the hospital the next morning at the earliest.

Study design and data sources

This retrospective study was conducted using hospital data from the French nationwide hospital information system (Supplemental appendix). Since 2015, the French national agency for hospital information publishes yearly consolidated statistics on hospital activities, including medical procedures. The data are open and free to download from the ScanSanté website (<https://www.scansante.fr/opendata/pmsi-mco/ccam>). Our Institutional Review Board approval was not required.

Endovascular activity of all French hospitals (excluding overseas territories) was collected from January 1, 2015, to December 31, 2019. Interventions were identified from the procedure codes issued from the *French common classification of medical procedures* (CCAM) stored in the OpenCCAM files. Twenty-four endovascular procedures were selected, all feasible in both conventional and ambulatory setting (Supplemental Table I).

Measurements

The outcome of interest was the ambulatory endovascular activity compared to overall endovascular activity (for both in- and outpatients) for each year from 2015 to 2019. The measurement was the annual proportion of hospital stays for ambulatory endovascular interventions out of all hospital stays for endovascular interventions in each French department (n=89) and for each year. The outcome and covariates were extracted or computed from the OpenCCAM files. In those files, the variables are grouped by (a) hospital identifier and (b) procedure code. For each hospital and procedure code, the variables are (c) the total number of hospitals stays, (d) the total number of procedures performed over all hospital stays, (e) the total number of hospitals stays for outpatients and (f) the total number of procedures performed in ambulatory setting. At the hospital level, when the total number of hospital entries for outpatients (e) or the total number of procedures in ambulatory setting (f) were less than 11, data were not available to comply with French authorities' privacy regulations. The data available at the hospital level were then aggregated at the department level. Overseas departments were excluded due to an important number of missing values.

Mapping

Mapping was applied to visualise the proportions of hospital stay for ambulatory endovascular interventions from 2015 to 2019 in French departments. The data distribution of 2016 was used as the baseline for the classification scheme aiming to assess the spatial and temporal variations¹⁹. The geographical units and their coordinates were downloaded from the national institute of geographical information (<https://geoservices.ign.fr/>).

Space-time analysis

A global Moran's Index was computed for each year to assess spatial autocorrelation or spatial heterogeneity of the ambulatory activity^{20,21}. The metric varies between -1 and +1, indicating a strong spatial dispersion or a strong spatial concentration, respectively. An index near 0 suggests a random spatial distribution.

Zero-inflated Poisson regression was applied to investigate temporal trend in the number of ambulatory endovascular interventions over the 5-year period. This model combines both Poisson and logit distribution to model the excessive number of zeros (corresponding to no ambulatory intervention) and overdispersion in the data. The logistic part estimated the probability of not receiving ambulatory care. The Poisson part estimated how frequently receiving ambulatory care occurred each year.

Space-time clustering method was applied to identify geographic and time period clusters²² with a high proportion of ambulatory interventions. We used a scan statistics analysis with a zero-inflated Poisson probability model^{23,24}. A p-value threshold of 5% was applied to select the clusters of departments with a higher number of ambulatory endovascular interventions than expected by chance in 2018 and 2019 compared to the 2015-2017 baseline period. The space-time scan statistics can be used for time-periodic surveillance, where the analysis is repeated every year²⁵. The space-time scan statistic creates an infinite number of discrete, cylindrical windows with a circular geographic base and with height corresponding to time. It explicitly considers spatial and temporal data point interconnections using a retrospective space-time permutation model and tests for statistical significance using a Monte Carlo simulation (with 999 simulation runs). Conceptually, a tube with a set kernel moves across the study space, with the body of the tube shrinking or expanding at every location as it identifies clusters of events (in this case ambulatory interventions). Although different kernel sizes were chosen, results reported here are for a maximum of 50 % of the population at risk being included in ambulatory setting.

Statistical analysis

We characterized and compared the clusters of departments with active development of ambulatory interventions to the rest of France using socio-economic data. Socio-economic data were extracted from the French national census. The studied variables relative to the healthcare services were the localized potential accessibility index of general practitioners^{26,27}, a composite measure of the volume of services provided relative to the population's size and the proximity of the services provided relative to the population's location, and the density of health care providers per 100 000 inhabitants in 2019 (general practitioners, vascular surgeons, physiotherapists, nurses, pharmacists, and emergency care units). The population-based variables were the mortality rate for arterial embolism and thrombosis of lower extremities (ICD10 I74.3) in 2016 as a proxy for the burden of LEAD, the proportion of elderly people (> 59 years-old) in 2019 as a proxy for the population in need of health care services, the poverty rate for people aged 50-59 years in 2017 (monthly income < 1 047€), the proportion of the population away from emergency medical services, the proportion of single-man households, and the proportion of households composed of a single man aged 75 or more in 2017, as proxies for limited access to care and social isolation²⁸⁻³⁰. The two latest being critical as 12 hours post-discharge surveillance by a responsible adult is listed among the eligibility criteria for LEAD in ambulatory setting¹⁶ and elderly home-alone men are especially at risk.

Non-parametric Kruskal-Wallis test was performed for univariate comparison. Multivariate logistic regression with a stepwise approach was applied to disentangle the effect of each variable, all other things being equal. The cluster of departments from Paris' area was excluded from those statistical analyses as the population characteristics and the healthcare resources are very specific and different from the rest of France (Supplemental Table II).

All statistical analyses were performed using the R statistical software (version 3.6)³¹. A p-value threshold of 5% was used to assess significance in all tests.

Results

In 2015, 66 389 hospital stays were for endovascular revascularisation in France, of which 104 in ambulatory setting (Table I). This latest value has tripled in 4 years, with 3 144 outpatient stays being reported in 2019. Overall, a subtle but positive trend was observed from 2015 to 2019. Compared to 2015, the expected number of ambulatory endovascular interventions in 2019 increased by 1.21. Whatever the intervention setting, as the number of total endovascular interventions increases, the probability of not receiving care in an ambulatory setting decreases (OR= 0.39; 95%CI:0.33-0.46) (Supplemental Table III). In other words, the higher the number of stays, the less likely zero outpatients will be observed. Nevertheless, the percentage of ambulatory interventions remained low in 2015 and 2019, compared to conventional interventions (1.66% and 4.03%, respectively). Yet, important geographical variations could be observed (Supplemental Table IV).

Spatial and temporal development

Moran's I is a correlation coefficient that measures the overall spatial autocorrelation. In our context it measures whether or not adjacent departments present similar rates of outpatients and thus whether or not the rates are homogeneous across France. The Moran's I decreased from 2015 to 2019, ranging from .45 (p-value = .010) to .11 (p-value = .039), respectively. While a Moran's I of .45 indicated some clusters of departments with similar rates, its decrease over the years brought the hypothesis a heterogeneous diffusion phenomenon i.e., with more but smaller size clusters. Indeed, Figure 1 shows a heterogeneous spatial evolution

of the ambulatory activity. Initially essentially developed in the northwestern part of France, the ambulatory activity extended to the northeast and finally spread in some southern departments.

The space-time analysis allowed identifying groups of departments with similar trend in the development of ambulatory setting. Eight departments with missing data were excluded from the analysis. Compared to the 2015-2017 period, the years 2018 and 2019 presented an identical primary cluster of 9 departments with higher rates of ambulatory interventions than the rest of France (Figure 2). The chance of benefiting from an ambulatory endovascular interventions in those 9 departments is on average 2.51 times higher ($p < .001$) than in the other French departments. Those departments were located in the northwestern part of France. Secondary clusters were identified in the northeast and southern part of France which was coherent with the diffusion phenomenon observed in the descriptive analysis (Moran's I and mapping in Figure 1).

Contribution of healthcare resources and population characteristics

The distribution of healthcare resources is heterogeneous across departments. Although the average densities of healthcare professionals are lower in the active clusters, only the difference in the distribution of the general practitioners is statistically significant in univariate analysis (Table II and Supplemental Table II). Globally, the clusters of significant ambulatory activity have densities of primary healthcare professionals and healthcare services comparable to the other French departments. In the clusters, we observed on average a slightly higher proportion of elderly people, a slightly lower poverty rate of people aged 50-59, slightly higher all causes mortality rates and a slightly higher proportion of the population

away from medical emergency services, but none of these differences was statistically significant in univariate analysis.

The multivariate analysis underlines the importance of the population characteristics. The clusters of departments with increasing ambulatory activity are negatively associated with the proportion of elderly people, elderly single-man household and poverty rate of people aged 50 to 59 years old but positively associated with the burden of all-cause mortality, especially the burden of arterial thromboembolic diseases of lower extremities in the male population (Table III). When the proportion of elderly people increases, the odds for a department to belong to the clusters of significant ambulatory activity is decreased by 50%. Similarly, poverty of people aged 50 to 59 years appears to reduce the odds for a department to belong to the clusters of significant ambulatory activity by 24%. An increase in the proportion of elderly single-man households reduces by 73% the odds for a department to belong to the clusters of significant ambulatory activity. Inversely, when mortality rate for arterial thromboembolic diseases of lower extremity increases in the male population, the odds for a department to belong to the clusters of significant ambulatory activity are 3.15 times higher. Although the odds are lower as women mortality is concerned. This leads to the hypothesis of gender inequality in access to care. Finally, healthcare resources are not significantly associated with active clusters, except for the density of nurses and physiotherapists.

DISCUSSION

This study is the first to report on the space-time disparities of the development of ambulatory endovascular revascularization in France. In 2019, disparities were still striking across and within departments. The proportion of ambulatory endovascular revascularisation for LEAD varied from 0 to more than 20% between departments.

1 The reasons for such disparities in France are complex. First, no financial incentive to develop
2 ambulatory endovascular revascularisation was proposed before 2019. Currently, in France,
3 ambulatory endovascular LEAD interventions are solely performed in hospitals: public,
4 nonprofit hospitals and private hospitals (clinics). Those hospitals may have dedicated
5 healthcare professionals and facilities (i.e., ambulatory wards) but the service remains under
6 the hospital's administration. This configuration is the result of national healthcare policies to
7 control healthcare services and providers for the quality and safety of care. But as a
8 consequence, it may have slowed down the development of ambulatory endovascular
9 treatments in France. In the USA for instance, the current question is no longer whether
10 ambulatory care for LEAD should be developed, but rather whether it is safe to perform these
11 procedures in specialized surgical practices (office-based lab, ambulatory surgery center) and
12 by other health care providers than vascular surgeons.^{11,32,33}

13 Second, the cost effectiveness of ambulatory endovascular revascularisation remains a
14 question. For instance, The AMBUVASC randomised control trial showed that on one month
15 time horizon, ambulatory interventions was not cost effective compared with conventional
16 hospitalisation for a €50 000 per quality adjusted life year threshold⁷. The authors reported
17 that this result was mainly explained by the higher number of re-admissions in the outpatient
18 arm. While previous studies demonstrated patient safety during the intervention, few studies
19 evaluate the rate of early complications and re-interventions^{8,10,34}. Therefore, healthcare
20 services and healthcare professionals may still be hesitant to promote ambulatory setting
21 because of potential side effects. However, using real-life data, we recently demonstrated that
22 in the outpatient setting early complications were rare (<4%) and no more frequent than in the
23 inpatient setting (data not shown)⁸. Thus, complications should not prevent interventionalists
24 to propose ambulatory interventions. Nonetheless, ambulatory surgeries require tighter
25 follow-up prior and post-intervention, increasing nurses' and medical clerks' work in

1 information transmission. In the case of under-staffed or disorganized medical team, the
2 whole hospital management system may be under pressure.
3 In addition, health regulatory agencies may remain cautious for various reasons. Among the
4 principal reasons is the apprehension of shifting the burden of early post-procedural follow-up
5 to ambulatory healthcare services.³⁵ Although we have shown in a former study that
6 ambulatory endovascular interventions for LEAD do not increase the time before resuming
7 work, the coordination between healthcare professionals (hospital and medical offices) is a
8 key element of the postprocedural rehabilitation⁹. In this work, the density of primary
9 healthcare resources are on average lower in the clusters of high ambulatory activity than in
10 the other French departments. Therefore, ambulatory activity does not seem to imply a need
11 for more primary care resources but require optimized coordination between health care
12 services. This result is in favour of a new paradigm for hospital reimbursement with a shift
13 from fee-for-service payment to payment for clinically-defined episodes of care (e.g. bundled
14 payment) that we now observed in Europe³⁶. Another reason is that French health regulatory
15 agencies are the warranter of an equal access to care. Although we showed that disparities are
16 also linked to patients' social characteristics. In particular, poverty and the absence of a helper
17 or a caregiver together result in some form of social isolation²⁸⁻³⁰ that impairs the access to
18 ambulatory interventions and consequently its development.

19
20 Although longitudinal and nationwide, these open data have limitations by construction. No
21 individual information were available to comply with French authorities' privacy regulations.
22 The data did not report age groups, comorbidities, and symptoms. No age standardisation
23 across departments could be computed. This should not impact too much the estimation as
24 age is not an eligibility criterion for an ambulatory intervention. However, the study may
25 under-estimate the proportion of interventions in an ambulatory setting in geographical areas

1 where older patients have more comorbidities. Again, to comply with privacy rules, data were
2 not communicated when the total number of hospital entries or the total number of procedures
3 in an ambulatory setting were less than 11. The study therefore may slightly underestimate the
4 proportion of ambulatory interventions. Finally, no guidelines exist in the United States and in
5 Europe, except in France, for ambulatory interventions for LEAD¹⁶. Consequently, caution
6 should be taken before generalising our findings.

7
8 In conclusion, from 2015 to 2019, the development of ambulatory endovascular
9 revascularization in France is highly heterogeneous across territories. From a health services
10 perspective, these disparities remain complex to explain. In 2019, French vascular surgeons
11 proposed clinical eligibility criteria to guide the development of ambulatory care of lower
12 limb angioplasty procedures¹⁶. In parallel, incentive pricing was introduced to encourage
13 hospitals to develop ambulatory setting for endovascular treatment. However, because of the
14 COVID-19 pandemic and the rescheduling of many surgeries, the effect of such contributions
15 cannot yet be assessed. From a population health perspective, the clusters of departments with
16 a significant ambulatory activity differed from the others by the burden of LEAD, some form
17 of social isolation, and the poverty of their elderly population. Hence, to improve access to
18 ambulatory interventions several issues should be addressed such as clinical issues to reduce
19 complications (*e.g.* use of efficient closure devices), the reimbursement system and the
20 guidelines for outpatient discharge. For the latest, we notably suggest that developing home-
21 based telemedical monitoring tools may help discharge and even overcome some social
22 isolation condition (*i.e.* home-alone) as an exclusion criterion^{37,38}, which could then open
23 access to more patients.

1 CONFLICT OF INTEREST

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REFERENCES

1. Vos T, Lim SS, Abbafati C, Abbas KM, Abbasi M, Abbasifard M, et al. Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *The Lancet*. 2020 Oct;396(10258):1204–22.
2. Song P, Rudan D, Zhu Y, Fowkes FJI, Rahimi K, Fowkes FGR, et al. Global, regional, and national prevalence and risk factors for peripheral artery disease in 2015: an updated systematic review and analysis. *Lancet Glob Health*. 2019 Aug;7(8):e1020–30.
3. Fowkes FG, Forster RB, Levin CE, Naidoo NG, Roy A, Shu C, et al. Prioritization of treatments for lower extremity peripheral artery disease in low- and middle-income countries. *Int Angiol*. 2017 Jun;36(3):203–15.
4. Society for Vascular Surgery Lower Extremity Guidelines Writing Group, Conte MS, Pomposelli FB, Clair DG, Geraghty PJ, McKinsey JF, et al. Society for Vascular Surgery practice guidelines for atherosclerotic occlusive disease of the lower extremities: management of asymptomatic disease and claudication. *J Vasc Surg*. 2015 Mar;61(3 Suppl):2S-41S.
5. Fowkes FGR, Aboyans V, Fowkes FJI, McDermott MM, Sampson UKA, Criqui MH. Peripheral artery disease: epidemiology and global perspectives. *Nat Rev Cardiol*. 2017 Mar;14(3):156–70.
6. Behrendt C-A, Spanos K. Comparing Apples and Oranges? The Possible Impact of Reimbursement and Environmental Factors on Research in Vascular Surgery. *European Journal of Vascular and Endovascular Surgery*. 2021 Mar;61(3):456.
7. Gouëffic Y, Pin JL, Sabatier J, Alimi Y, Steinmetz E, Magnan P-E, et al. A Cost Effectiveness Analysis of Outpatient versus Inpatient Hospitalisation for Lower Extremity Arterial Disease Endovascular Revascularisation in France: A Randomised Controlled Trial. *European Journal of Vascular and Endovascular Surgery*. 2021 Mar 1;61(3):447–55.
8. Jan S, Raux M, Ghoroubi N, Haulon S, Fabre D, Gouëffic Y, et al. Re-hospitalization after the ambulatory endovascular treatment of the arteries of the lower extremities: Data of the SNDS (National System of Health Data) between 2013 and 2016. *Annals of Vascular Surgery*. 2020 Oct;68:112–3.
9. Hamid A, Lamirault G, Gouëffic Y, Le Meur N. Duration of sick leave after same-day discharge for lower extremity arterial disease and varicose vein interventions in active population of French patients, 2013–2016: observational study. *BMJ Open*. 2020 Jun;10(6):e034713.
10. Hauguel A, Maurel B, Bague N, Gouaillier-Vulcain F, Costargent A, Chaillou P, et al. Management of ambulatory (day case) endovascular procedures for peripheral arterial disease. *J Cardiovasc Surg (Torino)*. 2017 Apr;58(2):293–304.
11. Lin PH, Yang K-H, Kollmeyer KR, Uceda PV, Ferrara CA, Feldtman RW, et al. Treatment outcomes and lessons learned from 5134 cases of outpatient office-based

- 1 endovascular procedures in a vascular surgical practice. *Vascular*. 2017 Apr;25(2):115–
2 22.
- 3 12. Mesbah Oskui P, Kloner RA, Burstein S, Zhiroff K, Kartub BR, Economides C, et al.
4 The safety and efficacy of peripheral vascular procedures performed in the outpatient
5 setting. *J Invasive Cardiol*. 2015 May;27(5):243–9.
- 6 13. Aurshina A, Ostrozhynskyy Y, Alsheekh A, Kibrik P, Chait J, Marks N, et al. Safety of
7 Vascular Interventions Performed in an Office-Based Lab in Patients with
8 Low/Moderate Procedural Risk. *Journal of Vascular Surgery*. 2021;73(4):1298–303.
- 9 14. Goodney PP, Beck AW, Nagle J, Welch HG, Zwolak RM. National trends in lower
10 extremity bypass surgery, endovascular interventions, and major amputations. *Journal of*
11 *Vascular Surgery*. 2009 Jul;50(1):54–60.
- 12 15. Jones WS, Mi X, Qualls LG, Vemulapalli S, Peterson ED, Patel MR, et al. Trends in
13 Settings for Peripheral Vascular Intervention and the Effect of Changes in the Outpatient
14 Prospective Payment System. *Journal of the American College of Cardiology*. 2015
15 Mar;65(9):920–7.
- 16 16. Alimi Y, Hauguel A, Casbas L, Magnan P-E, Pin J-L, Sabatier J, et al. French
17 Guidelines for the Management of Ambulatory Endovascular Procedures for Lower
18 Extremity Peripheral Artery Disease. *Annals of Vascular Surgery*. 2019 May 25;59:248–
19 58.
- 20 17. Westert G. Geographical Variations in Surgery: Outpatient versus Inpatient Treatment.
21 *Revue médicale de l'assurance maladie*. 2002 Jan;33(1):45–9.
- 22 18. Lemos P, Jarrett P, Philip BK. Day surgery: development and practice [Internet].
23 International Association for Ambulatory Surgery. British Association of Day Surgery;
24 2006 [cited 2022 Mar 9]. 346 p. Available from: [https://www.iaas-](https://www.iaas-med.com/files/historical/DaySurgery.pdf)
25 [med.com/files/historical/DaySurgery.pdf](https://www.iaas-med.com/files/historical/DaySurgery.pdf)
- 26 19. Rican S. Mapping epidemiological results. The principles behind methods to make
27 continuous data discrete and their importance in cartographic representation. *Sante*. 1998
28 Nov;8(6):461–70.
- 29 20. Wang F, Luo W. Assessing spatial and nonspatial factors for healthcare access: towards
30 an integrated approach to defining health professional shortage areas. *Health Place*. 2005
31 Jun;11(2):131–46.
- 32 21. Feng X, Tan X, Alenzi EO, Rai P, Chang J. Spatial and temporal variations of screening
33 for breast and colorectal cancer in the United States, 2008 to 2012: *Medicine*. 2016
34 Dec;95(51):e5656.
- 35 22. Lefebvre A, Bertrand X, Vanhems P, Lucet J-C, Chavanet P, Astruc K, et al. Detection
36 of Temporal Clusters of Healthcare-Associated Infections or Colonizations with
37 *Pseudomonas aeruginosa* in Two Hospitals: Comparison of SaTScan and WHONET
38 Software Packages. Viboud C, editor. *PLoS ONE*. 2015 Oct 8;10(10):e0139920.
- 39 23. Allévius B. scanstatistics: space-time anomaly detection using scan statistics. *JOSS*.
40 2018 May 9;3(25):515.

24. Allévius B, Höhle, Michael. An expectation-based space-time scan statistic for ZIP-distributed data [Internet]. Stockholm University: Department of Mathematics; 2017 [cited 2022 Mar 9] p. 24. Report No.: 8. Available from: <https://doi.org/10.48550/arXiv.1712.09188>
25. Kulldorff M. SaTScan user guide [Internet]. Vol. Version 10.0. SaTScan TM; 2022 [cited 2022 Mar 9]. Available from: <https://www.satscan.org/techdoc.html>
26. Barlet M, Coldefy M, Collin C, Lucas-Gabrielli V. L'accessibilité potentielle localisée (APL):une nouvelle mesure de l'accessibilité aux médecins généralistes libéraux [Internet]. IRDES; 2012 Mar [cited 2022 Mar 9] p. 1–8. (Etudes et résultats). Report No.: 795. Available from: <https://drees.solidarites-sante.gouv.fr/publications/etudes-et-resultats/laccessibilite-potentielle-localisee-apl-une-nouvelle-mesure-de-0>
27. Luo W, Qi Y. An enhanced two-step floating catchment area (E2SFCA) method for measuring spatial accessibility to primary care physicians. *Health & Place*. 2009 Dec;15(4):1100–7.
28. Bishop CE. Living arrangement choices of elderly singles: effects of income and disability. *Health Care Financ Rev*. 1986;7(3):65–73.
29. Cornwell EY, Waite LJ. Measuring Social Isolation Among Older Adults Using Multiple Indicators From the NSHAP Study. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*. 2009 Nov 1;64B(Supplement 1):i38–46.
30. Tissue T, McCoy JL. Income and living arrangements among poor aged singles. *Soc Secur Bull*. 1981 Apr;44(4):3–13.
31. R Core Team. R: A Language and Environment for Statistical Computing [Internet]. Vienna, Austria: R Foundation for Statistical Computing; 2020. Available from: <https://www.R-project.org/>
32. Jain K, Munn J, Rummel MC, Johnston D, Longton C. Office-based endovascular suite is safe for most procedures. *J Vasc Surg*. 2014 Jan;59(1):186–91.
33. Turley RS, Mi X, Qualls LG, Vemulapalli S, Peterson ED, Patel MR, et al. The Effect of Clinical Care Location on Clinical Outcomes After Peripheral Vascular Intervention in Medicare Beneficiaries. *JACC: Cardiovascular Interventions*. 2017 Jun;10(11):1161–71.
34. Oskui PM, Kloner RA, Burstein S, Zhiroff K, Kartub BR, Economides C, et al. The Safety and Efficacy of Peripheral Vascular Procedures Performed in the Outpatient Setting. *The Journal of Invasive Cardiology*. 2015;27(5):7.
35. Knutsen Glette M, Kringeland T, Røise O, Wiig S. Hospital physicians' views on discharge and readmission processes: a qualitative study from Norway. *BMJ Open*. 2019 Aug;9(8):e031297.
36. Tsiachristas A, Dikkers C, Boland MRS, Rutten-van Mölken MPMH. Exploring payment schemes used to promote integrated chronic care in Europe. *Health Policy*. 2013 Dec;113(3):296–304.

- 1 37. Warren-Stomberg M, Jacobsson J, Brattwall M, Jildenstål P. At-home monitoring after
2 surgery/anaesthesia - a challenge: At-home monitoring. J Eval Clin Pract. 2016
3 Dec;22(6):886–90.
- 4 38. Jaensson M, Dahlberg K, Eriksson M, Nilsson U. Evaluation of postoperative recovery
5 in day surgery patients using a mobile phone application: a multicentre randomized trial.
6 British Journal of Anaesthesia. 2017 Nov;119(5):1030–8.

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Table I. Evolution of endovascular revascularization for LEAD in ambulatory setting in France from 2015 to 2019.

Year	2015	2016	2017	2018	2019
Total number of patients	66 389	69 157	73 232	73 561	77 404
Number of ambulatory patients	1 104	1 590	2 224	2 677	3 130
Number (%) of departments without ambulatory interventions	70 (81.4)	65 (74.7)	57 (67.1)	55 (66.3)	50 (59.5)
Number (%) of hospitals without ambulatory intervention ^a	320 (93)	307 (91)	293 (87)	283 (85)	276 (83)

a -To comply with French privacy rules, data were not communicated when the total number of hospital entries or the total number of procedures in an ambulatory setting were less than 11. Those hospitals were considered as hospitals without ambulatory activity.

Table II. Univariate comparison of population characteristics and healthcare resources between departments contributing to the clusters of significant ambulatory activities and the other French departments (Paris area excluded).

	Departments with significant endovascular ambulatory activity ^a (n=27)		Other departments (n= 56)		
Variables	Mean (+/-SD)	Median (IQR)	Mean (+/-SD)	Median (IQR)	p-value ^b
Population characteristics					
Proportion of elderly people (aged 59 years or more)	30.9 (4.3)	29.5 (27.7-33.8)	29.3 (4.2)	29.0 (26.4-33.0)	.18
Poverty rate of people aged 50-59	13.5 (2.3)	13.1 (11.8-15.4)	14.4 (3.2)	13.6 (12.2-16.3)	.40
Proportion of single-man household	15.8 (1.0)	15.9 (15.0-16.4)	15.6 (1.3)	15.7 (15.0-16.4)	.59
Proportion of single-man household aged 75 or more	23.4 (1.7)	23.1 (22.0-24.6)	23.4 (1.3)	23.3 (22.6-24.1)	.81
Proportion of the population away from emergency medical services	5.5 (7.6)	2.2 (.3-7.1)	4.1 (8.9)	1.3 (0.1-4.6)	.32
Mortality rate of patients with lower limb arterial thrombo-embolic diseases ^c					
Total	1.8 (0.8)	1.7 (1.3-2.1)	1.7 (0.7)	1.6 (1.2-2.1)	.87
Female	1.8 (1.0)	1.8 (1.1-2.2)	2.0 (1.0)	1.8 (1.5-2.7)	.48
Male	1.7 (0.8)	1.4 (1.1-2.3)	1.3 (0.7)	1.2 (0.9–1.7)	.088
All causes mortality rate ^c		1029 (903-1201)			
Total	1066 (195)	987 (889-1164)	986 (179)	974 (873-1125)	.17
Female	1038 (193)	1060 (933-1257)	955 (170)	949 (845-1082)	.12
Male	1096 (200)		1019 (190)	1000 (900–1153)	.19
Healthcare resources					
Accessibility to general practioners ^d	3.7 (0.5)	3.7 (3.4-4.1)	3.9 (0.6)	4 (3.5-4.3)	.092
Density of health care professionals and services per 100 000 inhabitants					
Vascular surgeons	0.6 (0.5)	0.5 (0.3-0.7)	0.8 (0.4)	0.8 (0.6-1.1)	.90
Pharmacies	40.2 (18.0)	36.8 (32.3-42.2)	41.0 (22.7)	38.2 (33.4-41.0)	.93

Emergency care units	1.3 (0.7)	1.1 (0.9-1.6)	1.3 (0.6)	1.2 (0.9-1.6)	.89
General practioners	93.9 (51.5)	85.7 (75.6-95.6)	103.3 (63.2)	96.3 (76.6-107.5)	.054
Nurses	145.2 (66.6)	121.8 (100.5-175.4)	182.7 (99.5)	150.4 (111.8-228.1)	.087
Physiotherapists	100.4 (69.6)	85.5 (69.8-105.6)	123.2 (70.1)	112.4 (71.5-152.7)	.083

- 1 a- departments identified by the space-time analysis as part of clusters of significant
- 2 ambulatory activities in 2018-2019 compared to 2015-2017
- 3 b- p-value of Kruskal-Wallis rank sum test for non-parametric comparison of two groups;
- 4 SD: standard deviation; IQR: interquartile range (25%-75%);
- 5 c- mortality rate for per 100 000 inhabitants for ICD10 diagnosis I74.3
- 6 d- localized potentiall index: a composite measure of the volume of services provided relative
- 7 to the population's size and the proximity of the services provided relative to the
- 8 population's location

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Table III. Population characteristics and healthcare resources associated with departments in clusters of significant ambulatory activities versus the other French departments (Paris area excluded). Only the factors significantly associated with a significant ambulatory activity in the multivariate logistic regression were kept.

	OR ^a [95%CI]	p-value
Population characteristics		
Proportion of elderly people (>59 years-old)	0.50 [0.2-0.8]	.044
Proportion of single-man household aged 75 or more	0.37 [0.2-0.8]	.011
Poverty rate of people aged 50- to 59-year-old	0.69 [0.5-0.9]	.020
Mortality rate of lower limb arterial thromboembolic diseases ^b		
Female	0.36 [0.1-0.8]	.021
Male	3.15 [1.2-8.1]	.018
All causes mortality rate	1.03[1.0-1.1]	.004
Healthcare resources		
Density of health-care personnels per 100 000 inhabitants:		
Physiotherapists	1.02 [1.0-1.1]	.017
Nurses	0.98 [0.9-1.0]	.023

a- OR : odds ratio of the multivariate stepwise logistic regression with 95% confidence interval (CI). b - mortality rate for per 100 000 inhabitants for ICD10 diagnosis I74.3

FIGURE LEGENDS

FIGURE 1. Proportions of ambulatory endovascular revascularization for LEAD

compared to hospitalizations for in ambulatory setting over endovascular

revascularizations, in French departments from 2015 to 2019. From top left (A) to bottom

right (E) the maps represent the years 2015 to 2019. The data distribution of 2016 was used as

the baseline for the classification scheme to assess the spatial and temporal variations. Colors

from dark to light brown indicate high to low proportions of ambulatory interventions,

respectively. White coloring indicates no data, i.e., department where hospitals altogether

performed less than 11 entries in total.

FIGURE 2. Departements with a significant activity of ambulatory endovascular

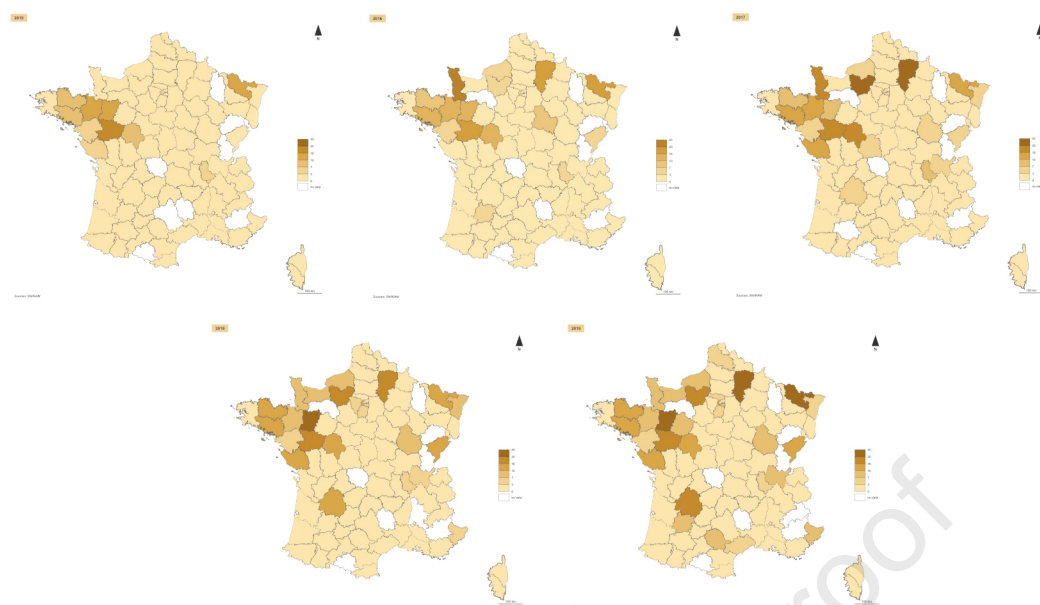
revascularisation for LEAD from 2018-2019 compared to the previous period of 2015-

2017. Cluster issued from the scan statistics analysis with a zero-inflated Poisson probability

model. Those clusters of departments present a higher number of LEAD ambulatory

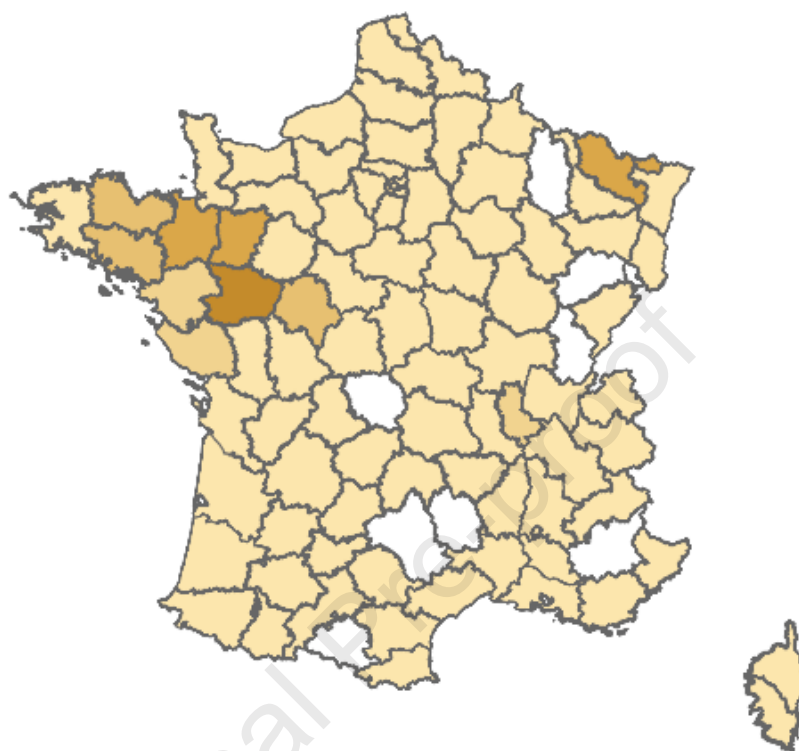
interventions than expected by chance in 2018 and 2019 compared to the 2015-2017 baseline

period. The primary cluster is the oldest in time.



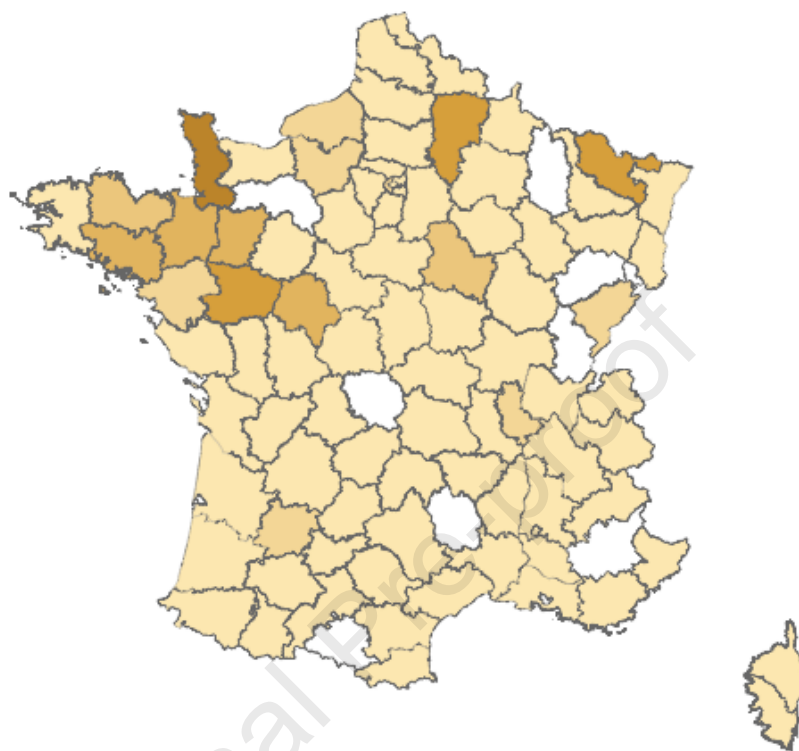
A

2015



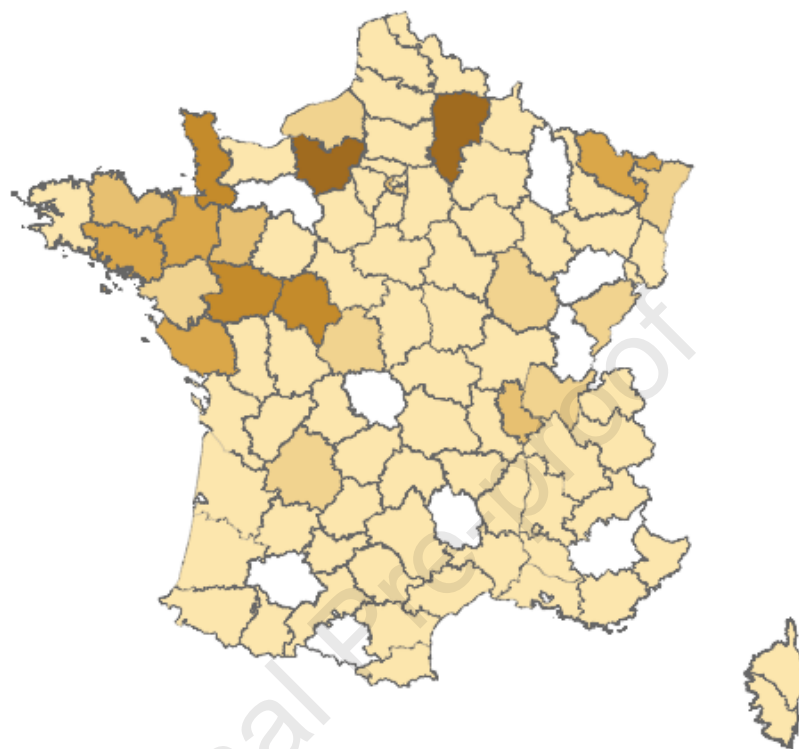
B

2016



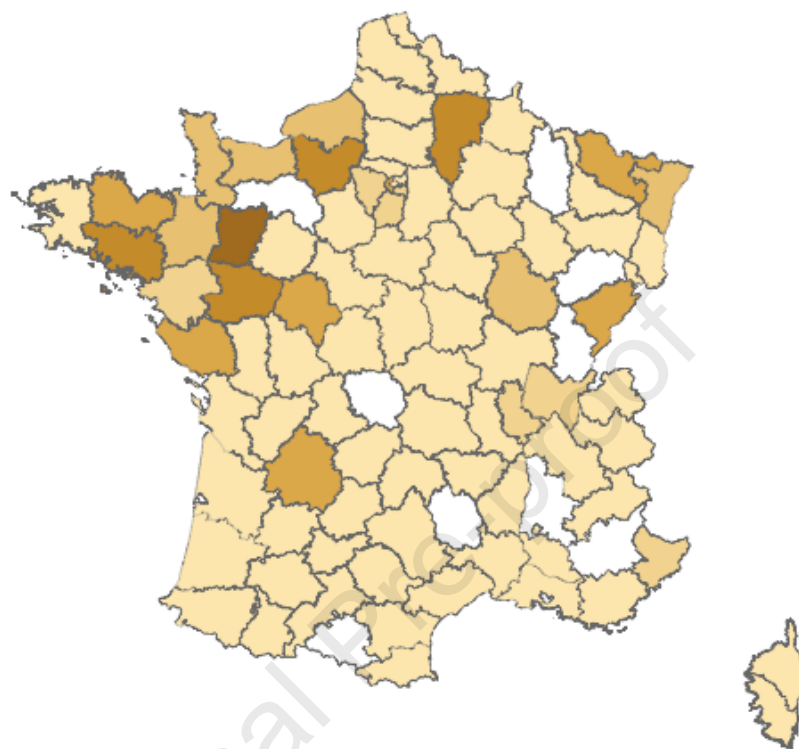
C

2017



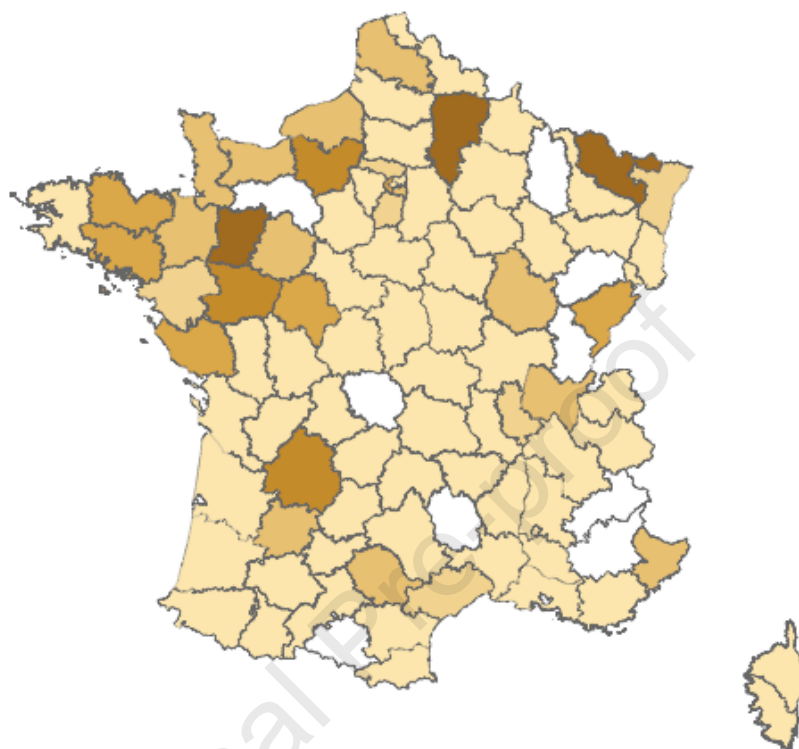
D

2018



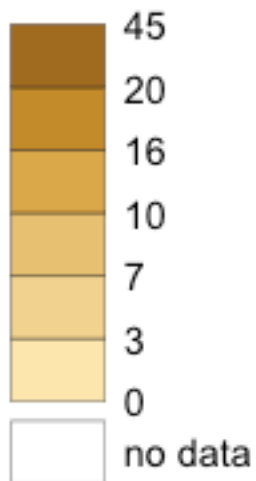
E

2019





Proportions (%) of
ambulatory interventions



100 km

