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Determinants of Canine Rabies in Morocco: How to Make Pertinent Deductions for Control?

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ABSTRACT

Objective
This case control study aims to highlight risk factors to contract canine rabies, taking into account several factors like geographical affiliation, sex, age, season, socio-economic and demographic characteristics of the environment in which the canine population evolves.

Design
Case-control study at national level in Morocco included non-randomized comparison groups. This approach was chosen to address practical considerations and the data used correspond to a five years period. A group of 215 cases and 215 controls were needed for an odds ratio (OR) of 2.2 and the sample size was calculated for a 1:1 match, with a power of 80% and a risk of the first species at 5% (95% confidence interval).

Setting
Data collection is retrospective and the collection of information on the exposure of cases and controls was conducted in the same way.

Subjects
Target population was the general canine population of Morocco. Criteria related to age group (puppies, young, adult) and gender (female, male) have been considered in the selection of the target population.

Results
The Moroccan rural context characterized by a lack of basic infrastructures (education, health) makes that there are practices and cultural habits that favor the endemicity of rabies in some regions. Thus, the disease is associated with the presence of rural slaughterhouses and animal markets and landfills which appears offering unlimited food sources for stray dogs and then indirectly promotes their reproduction accordingly.

Conclusion
These findings support advocacy efforts for strengthening a global prevention system. In addition, socio-ecological surveys should be carried out to build understanding in depth for a better adaptation of the ongoing prophylactic programs.

Keywords
Rabies; Dogs; Case control study; Risk factors; Rural habitat; Municipal development index; Rural slaughterhouses; Weekly livestock markets.

Abbreviations
CDI: Communal Development Index; CHB: Communal Hygiene Bureau; LRAR: Regional Laboratory of Analysis and Research.

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INTRODUCTION

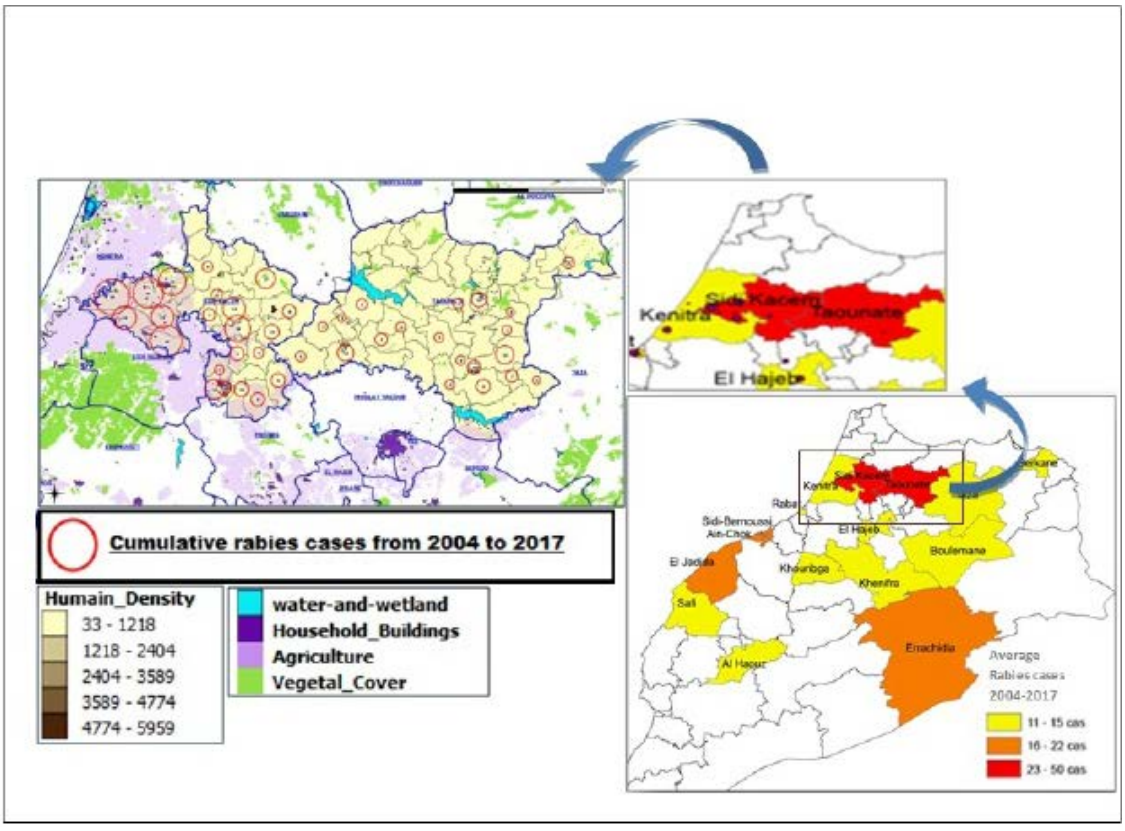
Rabies is a fatal viral infection that can infect all mammals, but domestic dogs cause over 99% of all human deaths from rabies among the world,[1] so the vast majority of human cases (>90%) result from the bites of rabid domestic dogs.[2] Although rabies can infect and be transmitted by a wide range of mammals, reservoirs comprise only mammalian species within the orders Carnivora (e.g. dogs, raccoons, skunks, foxes, jackals) and Chiroptera (bats). After a century of rabies control, Morocco registered an average of 301 animal cases and 21 human cases annually for the last decade (2005-2015).[3]

The reporting of the National Epidemiology Service[4] indicates that animal rabies is spread over almost the entire Morrocan territory and has been enzootic for several decades, all provinces are affected, but to varying degrees from 50 to a few cases per year with highest cases number in rich rural areas and around cities. It is unevenly distributed but in any case the dog is the vehicle and the main reservoir of the virus. Since 1986 in Morocco, an average of 384 domestic animal rabies cases are reported annually (1986 to 2016).[4] It has a high prevalence in rural areas with a percentage of 80% of the declarations. As a result of this prevalence, rabies causes a major public health problem: an average of 22 cases of human rabies is reported each year during the same period both in rural and urban areas.[4]

The prophylaxis carried out for a few decades (since the eighties) have not been able to achieve the expected objectives and animal rabies continues to spread consequently. The strategy adopted was based on elimination of the stray dogs and the vaccination of 70% to 80% of dogs belonging to owners. For logistic reasons, those actions took place in five successive phases corresponding to different geographical areas from 1986 to 1992 and became widespread in all country's provinces from 1993. Public awareness, staff training technical assistance and the provision of appropriate facilities and equipment have been the necessary means to achieve the objectives. Aware of the importance of this disease, the Ministry of Agriculture in collaboration with the Ministries of Health and the interior, developed a new strategy that was launched in 2003 in 2009 pilot areas which have been generalized in 2004. Despite several years of increased fighting, rabies continues enzootically in Morocco and causes a serious public health problem. The averages recorded each year remain high in relation to the efforts made in to control rabies. The success of any rabies control strategy is dependent on a good knowledge of the risk factors associated with the occurrence of the disease and the rigorous application of the proposed control measures and taking into account the epidemiological situation of the disease.[4]

From the foregoing, it appears that the descriptive study of the epidemiological situation of animal rabies in Morocco is characterized by very general indicators which therefore do not allow drawing up a very specific epidemiological analysis of the observed trends of the disease. Similarly, it should be noted that the geographical and temporal situation is very mixed in general.

Figure 1. *Geographic analysis of canine rabies cases by administrative levels (Provinces "Hot spots" and communes "clusters")*



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From this descriptive spatial analysis, it appeared the fact that within the same province "hot spot", there is a tendency to observe-for several years-aggregations of canine rabies cases in some specific localities rather than others. From this finding that our assumptions was initiated on the conditions or determinants that make a dog more likely to inoculate the rabies virus in one specific place than in another like showed in Figure 1.

In parallel, the geographic analysis of the epidemiological data at the communal level made it possible to spatialize the communes which recorded each year more than two cases of animal rabies (Figure 1). These definitions of geographic «clusters» of animal rabies is the prelude of reflection on the determinant factors of canine rabies in Morocco and try to build understanding in depth on why the disease is more likely to be implanted in some given areas rather than others.

This led us to propose a case-control study aimed at highlighting risk factors for the canine population that predispose it to become enraged, according to geographical affiliation, season, sex, environment or age. Finally, we also studied the factors related to the socio-economic and demographic characteristics of the environment in which the canine population of the country evolves.

We attempt to describe rabies disease outside the classical purely sanitary paths and we have tried to introduce other explanatory factors (geographical and socio-economic) according to the fact that dogs-which are a reservoir of this disease-live according to a conditioned-based environment and rabies epidemiological trends are mainly influenced by the communities' behaviors in Morocco.

This study is the first conducted in Morocco for a sustained scrutiny on rabies analytic knowledge of the disease. The upshot is to employ statistics procedures for robust outputs, both to verify assumptions and attempt to make pertinent deductions on the reasons for failures of multiple national control plans during de last decades. The gathered data will help to build a new strategy with a focus on a "One Health" approach.[3]

This study is the first to clarify the risk factors for rabies in Morocco with the aim of improving prevention and adapting disease control recommendations based so far on vaccination measures and culling stray dogs.

METHODS

Choice of Method

The criteria that guided the choice for a case-control survey focused on the characteristics of the disease and the retrospective survey describing its annual variability. In general, the annual incidence of rabies in Morocco shows fluctuations that would be attributed, on one hand, to the cyclical phenomenon of rabies: period of recrudescence and lull, and on the other hand to the status of the different components of the national rabies control plan, including medical and control measures. Within these annual fluctuations, there are seasonal variations closely related to the cycle of reproduction of the canine species coinciding with the fall and spring period of the female's sexual activity. Indeed, the periods of recrudescence and calm observed of rabies trends explain the peaks observed between February-May and August-January. Given the difficulties in obtaining information on the numbers of the canine population and its structure, and moreover due to a possible spatial autocorrelation the case-control approach seemed a better possibility of quantifying the importance various risk factors for dog exposure to rabies virus. The characteristics of the determining factors studied (nature, number and frequency) but also logistical considerations in terms of cost and time lead us to propose the study plan below.

This case-control study included non-randomized comparison groups. This approach was chosen to address practical considerations (in terms of time and availability of retrospective data).

Retrospective studies are often referred to as "experimental batch/control group studies." The normal procedure here is to retrieve records of observed disease events in a population, to determine the presence or absence of the factor. The experimental batch can then be compared to a group of healthy individuals in which the frequency of the determining factor has been determined.[5]

It should be noted that the studies on experimental batch/control lot, in fact boil down to a comparison of the frequency of the determining factor in the two groups: that of the sick animals (cases) and that of the uninfected animals (controls).[5]

Type of Study and Period

There are several types of explanatory epidemiology surveys, but they all have the same objective and the same principles: the objective is to test the hypothesis of a causal relationship between exposure to a risk factor and an illness. The principle is to compare groups of subjects with different characteristics on two levels, the disease and the risk factor studied.[6] Compared with prospective studies, case-control studies have various advantages. The main reason is that the required data are already available, which saves time. There is also the fact that they relate to individuals already identified, which is in fact a privileged instrument for the study of low incidence diseases.[5]

The presence of two groups, both sick and non-sick or exposed and unexposed, is essential in order to draw an explanatory conclusion.[6] It is impossible to attribute a causal role to a factor by working only on a sick population, that is to say by not having witnesses. Indeed, a given factor can be frequently encountered in a healthy population, one cannot draw any conclusions of causality. This same factor can be also frequently encountered in the healthy population and therefore nothing can be concluded without this information in healthy subjects.[6]

Our case-control study included non-randomized comparison groups. This approach was chosen to address practical considerations (in terms of time and availability of retrospective

data) and the data used correspond to a five years period.

Population

The target population was the general canine population of Morocco. The population source is defined as any dog undergone with a laboratory diagnosis or veterinary observation for rabies-related reasons during the five years period from different regions.

The sample size was calculated for a case-control survey for a 1:1 match, with a power of 80% and a risk of the first species at 5% (95% confidence interval). To highlight an odds ratio (OR) of 2.2.

Sample Size

The sample size was calculated for a case-control survey for a 1:1 match, with a power of 80% and a risk of the first species at 5% (95% confidence interval). To highlight an OR of 2.2, a staff of 215 cases and 215 controls were needed.

Case Definition

The definition used for the case (rabid dog) was mainly based on laboratory diagnosis (biological tests and/or clinical criteria issued from 2007 regional laboratories in the whole country. In the study, only dogs that were diagnosed as rabies in the period (2003-2008: period of the pilot control plan) were included as cases. The validity of the choice of cases in this study is based on a definition that includes laboratory criteria associated with suggestive-based symptoms of rabies (based on the laboratory submission form).

We have accepted that the use of registers of regional veterinary laboratories will not ensure (even if they are exhaustive) representativeness of selected cases in relation to the general population (regional laboratory records generally only identified owned dogs whose heads or cadavers have been transferred to laboratories by official veterinary services. For stray dogs, the fatal outcome happen usually in the wild with loss of information and we cannot advance an estimate of this undiagnosed proportion accordingly)

- For a "certain case": dog for which the result of laboratory diagnosis was positive
- For a "probable case": dead dog with suggestive clinical signs of rabies

Excluded cases were those for which veterinary laboratory registrations or veterinary records were incomplete.

The cases are recruited in 53 different provinces of Morocco: Among the 817 confirmed cases of rabies during the last five years: 324 cases were excluded from the study due to lack of information on (commune) locality, age and sex. Five hundred and seven cases were included in the case-control study.

All 507 eligible cases were included in the descriptive study, an inclusion rate of 100%. The majority of cases were males (76%) and the median age was 18 months (between 1.5 months and 168 months).

Two hundred and forty-eight eligible cases (49%) were from urban areas and 259 cases were recruited from rural areas.

The different geographical areas listed in table below were divided into 3 groups: arid zone (11%), plain zone (69%) and mountain area (20%).

Sixty-seven percent of the cases are recorded during the estrous season of the bitch. Rutting period during which, there is a crowd of dogs that predisposes to contamination between individuals (proximity, fights). Only 33% of cases are reported outside this period.

Selection of Control Group

The constitution of the control group is a key element in this survey because of the risk of selection bias. The definition of the controls was also based on biological criteria revealed by the laboratory or clinics. Thus our control group is constituted from the dogs whose result of laboratory or a setting in veterinary observation reveal a negative result. Our control group consists of dogs listed from the registers of the laboratories or official veterinary services by respecting the fact that those animals must come from the same general dog population of the cases group.

The control group was matched for each case on the following criteria:

- The administrative unit (same province)
- Age according to the following age ranges (<1 year, 1 to 3 years, >3 years)
- The time unit (same quarter): given the seasonal variations of rabies reporting as indicated in the bibliographic section.

The selection of the control group was made from the lists of veterinary laboratories. The first two controls on the veterinary laboratory list where the case was diagnosed positive, meeting the matching criteria, were included. If none of the dogs on this list met all the criteria, the control group was searched successively in the registers of the veterinary service which covers the nearest area of case origin then failing in the lists of veterinary inspections.

Data Collection

Data collected was from each study dog was: i) Province of origin, diagnosis period (clinical or laboratory), sex, age, laboratory results or veterinary observation; ii) socio-demographic information: number of human population by province and commune, area of each commune, density of human population per km^2, communal development index (CDI); and iii) information on communal infrastructure: presence of slaughterhouses, landfills, municipal hygiene bureau, impoundment, weekly rural markets, and distance to an asphalt track in a commune.

As in our study, the collection of data is retrospective and the collection of information on the exposure of cases and controls was conducted in the same way, data on the following factors was not possible to obtain: Canine population density, the erratic fringe of dogs compared to the population of dogs owned, vaccine status of dogs (absence of records).

We are referred to data from national animal disease surveillance system (for health data which are compiled regularly from the local veterinary services *via* SIPS's information system). Also, we used data from the planning authority (HCP) that provided us with the data on socio-economic factors (source: national census).

Data Entry

The data has been entered on access tables and their processing is performed on the EPIINFO 3.5.1 software.

Data Analysis Method

Factorial methods establish synthetic representations of large data tables, usually in the form of graphical representations. The purpose of these methods is to reduce the dimensions of the data tables to represent associations between individuals and between variables in small spaces. In this study, this analysis made it possible to guide the choice of exposure to the different risk factors tested.

The complete data analysis must include an univariate analysis and then a multivariate analysis. Univariate analysis consists of evaluating the gross relationship between rabies and each of the exposure factors, without adjusting for potential confounding factors.

Relative risk was estimated by the matched odds ratio (OR). The proportions were compared by chi2 test or Ficher's exact test.

The analysis was performed using the Microsoft Office Access software and EPIINFO version 3.5.1.

RESULTS

Description of Cases

The cases are recruited in 53 different provinces from all official regional laboratories and veterinary services registrations (National Office of Food Safety, ONSSA, Rabat, Morocco). Private veterinarians are also enrolled in this surveillance database by providing 13% of cases. We identified 831 cases for which rabies diagnosis (clinical and tests confirmed) was made between 2003 and 2008; 817 (98%) were confirmed cases and 14 (2%) were probable cases. Nearly half of the cases (54%) were diagnosed between December and April of this period.

Among the 817 confirmed cases of rabies: 324 cases were excluded from the study due to lack of information on (commune) locality, age and sex. Five hundred and seven (confirmed and probable) cases were included in the case-control study.

All 507 eligible cases were included in the descriptive study, an inclusion rate of 100%. The majority of cases were males (76%) and the median age was 18 months (between 1.5 months and 168 months) (Table 1A).

Table 1A. *Cases Distribution by Age*

Age Group	Males		Females		Total	
	N	(%)	N	(%)	N	(%)
<1 Year	135	(35)	43	(35)	178	(35)
1-3 Years	149	(39)	52	(42)	201	(40)
>3 Years	100	(26)	28	(23)	128	(25)
Total	384	(100)	123	(100)	507	(100)

A total of 248 eligible cases (49%) were from urban areas and 259 cases were recruited from rural areas. Distribution by habitat shows that 51% of cases come from rural areas and 49% from urban areas. The different geographical areas were divided into 3 groups: arid zone (11%), plain zone (69%) and mountain area (20%) (Table 1B).

Table 1B. *Casess Distribution by Geographica Areas*

Habitat	Nbr of Cases	(%)
Urban	248	(49)
Rural	259	(51)
Total	507	(100)

A proportion of 67% of cases are recorded during the estralous season of the female dogs. Rutting period during which, there is a crowd of dogs that predisposes to individual contamination between (proximity, fights). Only 33% of cases are reported outside this period (Table 1C).

Table 1C. *Cases Distribution by Habitat*

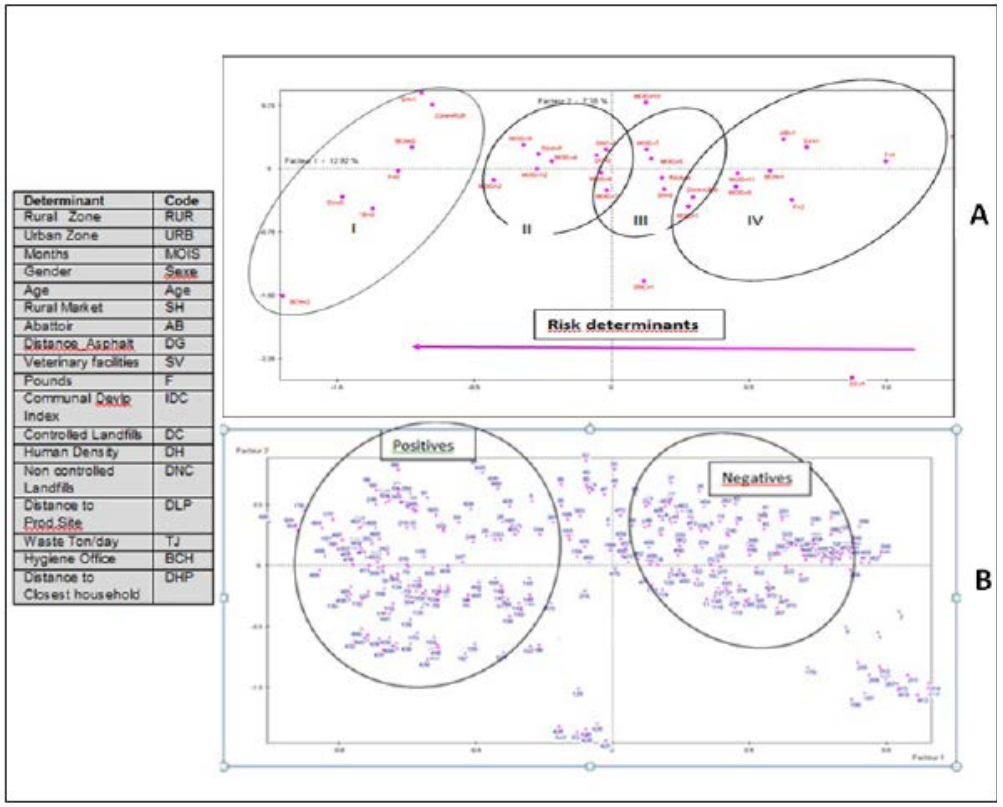
Geographic Areas	Nbr of Cases	(%)
Desert zone	53	(11)
Plain zone	349	(69)
Montanious zone	105	(20)
Total	507	(100)

Result of the Case-Control Analysis

Factorial methods establish synthetic representations of large data tables, usually in the form of graphical representations. The purpose of these methods is to reduce the dimensions of the data tables to represent associations between individuals and between variables in small spaces. In this study, this analysis made it possible to guide the choice of exposure to the different risk factors tested.

The two axes of the domain (factor 1 and factor 2) depend on the projection model used. In our study, the choice is made on factorial axis 2, which best explains the direction of exposure between cases and controls and the determining factors (Figure 2). Thus, we observed that it is more likely to have cases if one operates in an environment characterized by the absence of health and medical management structures (veterinary services,

Figure 2. *Projection of Factors (A) and Eligible Cases-Controls (B) on the Factorial Axes*



BCH, pound), belonging to the rural environment (Group I) and corresponding to a given season (Group II).

On the opposite side, we note that the controls group belongs much more to an environment with presence of veterinary structures and a well management of the wandering fringe of the canine population. This environment is in a generally developed in urban areas (absence of rural markets and dumps) and corresponding to a season which is outside the estrus period (Groups III and IV).

Comparison according to the intrinsic characteristics of dogs: Rabies is a disease that would be contracted regardless of the range age of dogs. There was no evidence of an association between a specific age group and the occurrence of rabies in dogs.

There was no evidence of a link between the sex of the dog (male/female) and the occurrence of rabies (OR=0.99 [95% CI: 0.65-1.51]). However, in rural areas, female dogs appear to be more prone to rabies than males in the same medium (OR=1.2) (but this risk was not statistically significant ([95% CI 0.51 -2.82], p=0.20). The estrus period, which favors dog gatherings in comparison with the anestrus period, seems to predispose dogs to the risk of contracting rabies (OR=1.42, p=0.04), but not significantly since the confidence interval contains 1 (95% CI 0.99-2.04).

Comparison according to spatial characteristics: The geographic area including a mountainous area is associated with rabies occurrence in dogs (OR=1.99 [95% CI: 1.02-3.91]). A dog's membership in the rural setting is associated with the occurrence of rabies (OR=1.92 [95% CI: 1.30-2.84]).

Comparison according to socio-economic aspects: Rabies Cases are notified by the veterinary services and are reported in the databases in relation to municipalities. Our purpose has been to evaluate the infrastructure of these communities and see for instance, if the presence of uncontrolled landfills or rural killings makes it more likely that dogs living in these communities will have rabies.

The risk is conceived for all the territory of the commune because the dogs move on all the geographical space which allows them the survival. Dogs are not static and do not have a fixed address in their geographical space. They move for their foods: one time on dump spots, another time in a rural slaughter or at any other food sources.

To evaluate the socio-economic aspects., we used the municipal development index (MDI) calculated from the data of the Office of the high commissioner for planning (HCP) and measured by three elements from the results of the national general census (GG) of September 2004 (Morocco). This is a composite index comprising three elements that report on the budgetary resources of municipalities, the state of equipment and collective infrastructure, and their level of access to basic public services (water, electricity and road network).

The interactive data corporation (IDC) is the result of the simple arithmetic mean of the rates of the three components.

Any weighting of the latter cannot be the same for all municipalities. Dogs in a territory with an IDC<35% are highly susceptible to rabies (OR=3.90 [95% CI: 1.47-10.72]). For dogs belonging to a communal area with an IDC between 35% and 70%, the association between this factor and the risk of occurrence of the disease is not statistically significant (p=0.06).

The presence of a weekly livestock market is associated with the occurrence of rabies (OR=1.95 [95% CI: 1.25-3.05], Table 2). However, this association between the souk and the disease is more common in urban areas than in rural areas even though the confidence interval contains 1 (OR=1.87 [95% CI: 0.93-3.77] p=0.05).

Table 2. *Risk and Protective Factors for Canine Rabies*

Risk Factors	Cases	(%)	ORmatched	IC95 %	p Value
Mountain	24	(11)	1.99	1.30-2.84	0.02
Rural Habitat	82	(38)	1.92	1.30-2.84	<0.001
IDC<35%	16	(7)	3.90	1.47-10.72	0.006
Rural Markets	59	(28)	1.95	1.25-3.05	0.001
Slaughterhouse	40	(35)	1.92	1.12-3.29	0.01
Distance/ Asphalt	70	(33)	1.76	1.17-2.65	0.004
Distance (rural)	64	(78)	4.40	2.27-8.59	<0.001
Distance (Plain)	62	(31)	1.82	1.18-2.80	0.004
N.controled Landfills	42	(20)	1.70	1.03-2.81	0.02
Not closured Landfills	16	(76)	4.27	1.16-16.49	0.01
Daily waste<100t/d	22	(76)	4.19	1.32-13.76	0.006
Distance/production	12	(46)	4.63	1.18-19.11	0.01
Low H.Density	42	(20)	2.05	1.22-3.44	0.003
Densité/IDC	17	(9)	4.71	1.71-13.65	0.03
Protective Factors	**Cases**	**(%)**	**ORmatched**	**IC95 %**	**p Value**
Abattoir (IDC>70%)	86	(56)	0.63	0.41-0.96	0.02
Veterinary facilities	114	(53)	0.64	0.44-0.93	0.01
Pounds	81	(38)	0.57	0.39-0.82	0.001
Hygiene Office	124	(58)	0.65	0.44-0.94	0.01

Weekly markets are defined as markets for livestock which opens one day per week. The link with rabies problem is due to the fact that on the spot of these markets are organized activities of restoration and butchery (grills). For dogs, it's an ideal place to find food resources and therefore to gather dogs (where they fight for food and thus the possibility of rabies contamination between them). We have included livestock markets as factor to study because we have observed that communities hosting such kind of facilities are often subject to the presence of several cases of rabies (reported by local veterinary services).

The presence of a slaughterhouse appears to be protective against the occurrence of rabies (OR=0.67 [95% CI: 0.47-0.97] p=0.027). Slaughterhouses have been classified according to their condition into two types: municipal slaughterhouses (satisfactory sanitary state of the establishment) and killings (generally deplorable sanitary state of the establishment). It appears from this classification that rabies is significantly associated with the presence of slaughter (OR=1.92 [95% CI: 1.12-3.29] p=0.01).

The difference between the municipal abattoir and the rural killings is the volume of the meat preparation and processing activities. In general, the municipal abattoir that serves the urban population is by far the most functioning structure.

The second important point is that the municipal slaughterhouse is a structure that is managed by a technical service and that responds to a construction plan that meets sanitary standards (Fences around the facilities to prevent the introduction of dogs, cats and rodents, presence of a room specifically dedicated to the seizure of carcasses and offal which are unfit for consumption, presence of incinerator to burn the seizures and also septic zone for the burial of the remains). In this way, the municipal slaughterhouse is designed and operated in such a way that it does not allow stray dogs' access to food resources and therefore cannot contribute to their survival and reproduction.

Rural killing, however, is quite the opposite: no fence, mismanagement, unqualified staff, no standing operating procedure (SOP's) or procedures for denaturing seizures of carcasses and offal that are generally thrown out and are therefore available for feeding stray dogs.

For all these reasons that we have found that the presence of a rural killing in a commune is a predisposing factor for the presence of rabies in this place and therefore a high risk of rabies for the humans and the animals belonging to this area.

Considering that the level of clinical documentation improvement (CDI) can have a strong significance for the occurrence of rabies, the study of the exposure to the slaughterhouse factor according to the IDC did not allow to reveal an associa-

tion between the slaughterhouse determinant factor and disease (OR=2.93 [95% CI: 0.34-27.68] $p1$=0.23); (OR=0.78 [95% CI: 0.32-1.93] $p2$=0.56). The presence of a slaughter establishment at a communal area with an IDC>70% seems to allow protection against rabies (OR=0.63 [95% CI: 0.41-0.96] p=0.02).

The presence in the communal area of public veterinary services is considered a protective factor against the risk of occurrence of rabies (OR = 0.64 [95% CI: 0.44-0.93], p=0.01).

The existence of an important distance separating the communal periphery from an asphalt track is associated with rabies (OR=1.76 [95% CI: 1.77-2.65], p=0.004). This finding is strongly associated with the risk of rabies occurring in rural areas (OR=4.40 [95% CI: 2.27-8.59]), Table 3) and a geographical area mostly represented by plains (OR=1.82 [95% CI: 1.18-2.80]).

Table 3. *Results of the Modeling of Risk Factors Associated with a Canine Rabies*

	ORMat	P	OR	p
Weekly Rural Markets	1.95	0.001	7.50	0.006
Rural Habitat	1.92	<0.001	9.07	0.003
Human Density	2.05	0.003	8.76	0.003
Slaughterhouse	1.92	0.01	2.58	0.04

Distance has been proposed in order to see the accessibility of veterinary teams to these communes during vaccination campaigns of dog-to-owner. Municipalities that are far from a road or paved track are with a difficult access for veterinary teams and therefore dogs in this area are less likely to be vaccinated and protect against rabies. We agreed with the HCP experts to define two range: less than 5 km and greater than 5 km.

Pounds are defined as public facilities where abandoned dogs are temporarily kept until a fine is paid by the owner. The presence of municipal pounds is a protective factor against the risk of occurrence of the disease (OR=0.50 [95% CI: 0.34-0.75], $p1$=0.0004). A statistically significant association between the occurrence of rabies and the number of existing pounds in the communal area ($p2$=0.7 and $p3$=0.24) was not found.

Communal Hygiene Bureau (Hygiene communal office) which is a public facility in charge of common space management in terms of the fight against pests, capture of stray dogs, medical care of bitten people by feral dogs and the management of places where we keep stray dogs. The presence of Communal Hygiene Bureau (Hygiene communal office) is also demonstrated as a protective factor against rabies (OR=0.65 [95% CI: 0.44-0.94], p=0.01). Controlled landfills tend to be considered protective factors against the risk of rabies occurring. However, this association is not statistically significant since the numbers were very small (OR = 0.62 [95% CI: 0.26-1.47], p=0.24).

On the other hand, the presence of an uncontrolled garbage discharge increases the risk of contracting rabies in dogs belonging to a communal area containing this type of landfill (OR=1.70 [95% CI: 1.03-2 , 81], p=0.02).

The absence of closure for uncontrolled landfills appears to be the most important risk factor in the occurrence of rabies (OR=4.27 [95% CI: 1.16-16.49], p=0.01). Landfills with a daily tonnage of less than 100 T/day seem to be more associated with the occurrence of the disease than landfills with a large storage capacity (OR=4.19, 95% CI: 1.32-13), 76], p=0.006). The origin of this waste is generally provided by houses located around these sites-mainly on the outskirts of urban agglomerations - which explains why the existence of a reduced distance (less than 5 km) separating the landfill compared to production sites is more associated with the occurrence of the disease in dogs from this communal area (OR=4.63 [95% CI: 1.18-19.11], p=0.01).

Socio-Demography of the Environment

Human density: Low human density is considered associated with the occurrence of rabies (OR=2.05 [95% CI: 1.22-3.44], p=0.003) which confirms the rural character of rabies canine in Morocco.

Human density and CDI: Taking into account the human density factor according to the IDC, shows a strong association between a low density and the occurrence of rabies in a communal area with an IDC>50% (OR=4.71 [95% CI: 1.71-13.65], $p1$ (Ficher exact)=0.57 and $p2$= 0.03), which is particularly characteristic of human agglomerations at the edges of cities or the so-called semi-urban environment.

From the Univariate analysis of this study, several risk factors that contribute to the occurrence of rabies have been identified. In general, the occurrence of rabies remains globally dependent on the level of development of the environment as well as the state of the hygienic and sanitary infrastructures. Protective factors indicate a certain degree of availability in terms of health structures for management and the fight against the stray dog population, as well as the increased interest in upgrades to hygienic establishments of public interest (slaughterhouses). All those factors are summarized in summary Table2.

Multivariated Analysis

Multiple regressions are complicated by the presence of multicollinearity. Indeed, this study, like the majority of similar studies, involves explanatory variables that are correlated. A simple method for detecting too much correlation between independent variables is to make collinearity tests.

We investigate whether these risk factors influence the likelihood of rabies occurring. We want to determine, among these explanatory variables, the one that best explains this condition of occurrence. A multiple linear regression is realized and we notice that among the variables introduced: the variable distance with respect to the tar, uncontrolled discharges and IDC were particularly affected by this problem and do not contribute significantly to the regression as they present bad collinearity statistics (tolerance and VIF are far from 1 and outside the recommended limits (tolerance>0.3 and VIF<3.3) and therefore are highly correlated with each other. Only 4 of the 12 variables included in multi-varietal

Epidemiol Open J. 2019; 4(1): 1-11. doi: 10.17140/EPOJ-4-113

modeling were independently associated with rabies: Weekly Rural Markets, Rural Habitat, Human Density, and Killing (Table 3).

DISCUSSION

Canine rabies was considered a major zoonosis studied as a priority in terms of public health in Morocco and actions were proposed in the areas of prevention, control and information for doctors, veterinarians and the general public. To our knowledge, this study is the first to specify the risk factors for dog exposure to rabies in Morocco with the aim of improving prevention and adapting the disease control recommendations so far based on measures of vaccination of dogs to owners and slaughter of stray dogs.

Of the exposures independently investigated for possible association with rabies and with the exception of the estrous season which favors dog assemblages predisposing to rabies contamination, none was an exclusively intrinsic exposure (age groups, sex). This situation allows us to conclude that the age group most prone to develop rabies, is represented practically by all the dogs having more than one year that they are of male sex or female. The fact that we have not found here an association between intrinsic factors and rabies in Morocco could be interpreted by the fact that there is an under declaration of cases of canine rabies as it has been recorded in recent years in favor of cases of ruminant rabies, to which can be added the cases of canine rabies stray dogs whose fatal outcome is usually in the wild and which in turn escape the current health monitoring system.

The close relationship between the density of the human population and that of the dog population is also highlighted as a risk factor, because the denser the human population, the denser the dog population too and the higher the risk of exposure to rabies.[3] The incidence of canine rabies in Morocco varies according to the geographical area and habitat environment. As has been highlighted in epidemiological studies and in our study, canine rabies is most often reported in rural areas. Canine rabies remains linked in Morocco to an essentially rural way of life of the population, which does not support the constraints of prophylaxis.[7] This situation is due to the existence of a large canine population that is inadequately vaccinated and whose movements are uncontrolled. For these reasons, especially in rural areas, this canine population has long been mistaken for a wandering population. They are in fact dogs owned by owners and subject to estimation.[8]

It is particularly prevalent in low-density urban areas and also in communal areas with a relatively satisfactory level of equipment, which confirms both the rural character of this disease highlighted by previous epidemiological studies and existence of new endemic areas of the disease especially around the urban centers. This situation is due to the fact that female dogs without landowners do not reproduce much and are not able to breed puppies.[9] These semi-urban agglomerations are generally the result of the rural exodus to the cities and thus preserve all the sociocultural practices related to the dog in rural areas. Stray dogs generally appear to be more numerous than they actually are both in urban and rural areas.[10,11] It seems that stray dogs can not constitute stable populations. The duration of the wandering period seems to correspond to a survival time.[12] This finding is reinforced by the study of the exposure linked to communal facilities such as weekly rural markets and uncontrolled landfills, which by their locations; generally on the outskirts of urban centers, offer inexhaustible food resources for this fringe of dogs. In the absence of existing data on the state of communal infrastructures that may be related to the risk of developing rabies. We have opted for a CDI. This approach seemed to us the most appropriate to evaluate, at the communal level, the situation of equipment and infrastructures (slaughterhouse, slaughter, furrow, controlled dumps, and communal hygiene office).

In this study, it was found that the presence of structures providing veterinary services (particularly focused on vaccination), management of the canine population in terms of collection and culling of stray dogs (pounds and Hygiene Office) constitutes a guarantee for the communal space against the risks of occurrence of rabies. The absence of these facilities at the level of a given communal area can lead to a decrease in the epidemiological observation thanks to an under-declaration at the level of the monitoring device, as well as a decrease in the level of realization of sanitary prophylaxis measures (vaccination and culling stray dogs). Epidemiological surveillance makes it possible to judge the effectiveness of the measures taken.[13,14] It also appears from this study that the presence of a huge distance separating the communal area from a practicable track limits the accessibility of vaccination, collection and slaughter teams to this place and is therefore a factor risk for rabies.

The study also concerned infrastructures that are presupposed to be indicators of rabies-related exposures, either directly (presence, absence), or through the relative variable of the level of development of the communal space in which these structures are located. Slaughterhouse exposure analysis indicates that the type of these establishments is a determinant of risk. Poorly equipped rural slaughterhouses (or slaughterhouses) (lack of fencing, lack of seizure management or denaturation pits) provide dogs with an easily accessible and sustainable food resource given the frequency of slaughter at these establishments. On the other hand, a high CDI regardless of the type of slaughterhouse (Urban slaughterhouse or Abattoir) is a guarantee against the occurrence of rabies. The index reflects the state of equipment and maintenance of the slaughter establishment, which is characterized by the presence of fencing around the establishment which limits the accessibility of the dogs inside the premises. Specific observations show that dogs without owners settle where the quantity and accessibility of the main resources are sufficient both in urban areas[9] and in rural areas.[15]

Weekly rural markets are also a risk factor for rabies because of the fact that these places are involved in slaughtering and marketing of carnivals, which are generally carried out in uncontrolled establishments, which, like killings subsistence resources for dogs. This situation is personalized by a state of rurality adjacent to the city and characterized by the abundance of stray dogs that provide dog populations that can be recruited as rabid in urban centers.

Indeed, unsupervised dogs looking for food are direct competitors of stray dogs.[15] They are not subject to any prophylaxis. They intervene in the transmission of infectious agents responsible for zoonoses such as rabies and hydatidosis.[16] Their promiscuity with humans and domestic animals makes them particularly dangerous.

The study of exposure to landfills that meet international design standards, storage and handling garbage is a protective factor in the risk of rabies occurrence. Uncontrolled and generally unfenced landfills appear to be particularly pre-disposing at the risk of contracting the disease. In urban areas, for example, the home range always has "feeding areas", usually made up of piles of garbage.[9] In rural areas, stray dogs settle around garbage dumps, groups of fixed and open bins. They seem to be forced to avoid their direct competitors of food: stray-owner dogs.[15]

In this study, it was shown that the risk of rabies is greater if the distance between the landfill and the garbage production sites is less than 5 km. This is particularly true of the semi-urban environment. urban area, which hosts most garbage dumpsites and whose resident human population does not benefit from a public waste management service, it seems obvious that the destination of most of the household waste produced in these conurbations made to these sites. This provides accessible and sufficient food resources for dogs belonging to these peri-urban agglomerations. In fact, the poorly guarded dog has a shelter in the home of his master but must obtain some or all of his food by his own means and has a refuge to raise the young.[17] The diet consists mainly of various kitchen waste recovered from residents or dumps.[9,17]

Like most zoonoses, rabies is often underdiagnosed, particularly in underprivileged areas, a state of affairs that reflects the limited capacity and coverage of health services. On the one hand, the subdiagnosis of zoonoses is further aggravated by the unequal geographical distribution of these conditions as well as by the difficulties inherent in the diagnosis of some of them.[18]

CONCLUSION

To limit the incidence of rabies, defined as a major zoonosis in Morocco, the prevention system must be strengthened. The results of this study revealed a shift in risk factors towards slaughter infrastructure, weekly rural markets and road networks.

It is also recommended to review the current regulations on the acquisition of dogs in rural and semi-urban areas to make owners aware of the obligation to keep their dogs tied at the farm level, to prohibit the release of puppies in the wild from numerous litters and to make the acquisition of sanitary documents mandatory for every dog in the household.

In such an epidemiological and socio-economic context, continuous and regular medical prophylaxis by the veterinary services existing in rural areas must be able to stop the deterioration of the epidemiological situation. A culling policy is less likely to interrupt transmission (particularly for owned dogs) as compared to a mass-vaccination strategy, and socially not acceptable. A much higher transmission rate, as suggested above, would affect the threshold coverage of vaccination. Among the compared intervention strategies, mass vaccination of 70% of the dog population is the most profitable and cost-effective intervention, sufficient to interrupt rabies virus transmission for at least 6 years.[19]

Socio-ecological surveys in different regions should allow a better estimate of the dog populations to be vaccinated and the adaptation of ongoing prophylactic programs.

All these measures, combined with a more rigorous application of the legal policy, should allow a significant improvement in the epidemiological situation of canine rabies in Morocco.

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CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES

1. World Health Organization (WHO). Expert Consultation on Rabies Second Report. Geneva: WHO, 2013.

2. Coetzee P, Nel LH. Emerging epidemic dog rabies in coastal South Africa: A molecular epidemiological analysis. *Virus Res*. 2007; 126(1-2): 186-195. doi: 10.1016/j.virusres.2007.02.020

3. Darkaoui S, Cliquet F, Wasniewski M, et al. A century spent combating rabies in Morocco (1911-2015): How much longer?. *Front Vet Sci*. 2017; 4: 78. doi: 10.3389/fvets.2017.00078

4. Reporting Epidemiology Service (SEVS), National office of food safety. Rabat, Morocco. 2015.

5. Putt SNH, Shaw APM, Woods AJ, Tayler L, James AD. Veterinary epidemiology and economics in africa, handbook for animal health planners. 1987; 31: 66-68. University of reading, Berkshire, England.

6. Toma B, Dufour B, Sanaa M, Benet JJ, Ellis P, Moutou F, et Louza A. Epidemiology Applied to the collective fight against major transmissible animal diseases. *AEEMA*. 1996; 394-395.

7. Fassi-Fehri N, Bikour MH, Id Sidi Yahia K, Berrada J. Bovine rabies in morocco through a series of 30 cases. Epidemiological and clinical data. Differential diagnosis elements. *Maghreb Veterinary*. 1987; 3: 12,45-49.

8. Fassi-Fehri N. *Contribution to the Epidemiological Study of Canine Rabies in Morocco*. [PHD thesis]. Villeurbanne, France: Claude Bernard Lyon University; 1993.

9. Beck AM. *The Ecology of Stray Dogs: A Study of Free-Ranging Urban Animals*. Baltimore: York Press. 1973.

10. Artois M, Benosman F. The dog and rabies in Tunisia, Scientific publication of the museum-anthropozoologica. 1986; 4: 33-37.

11. Beck AM. Ecological aspects of urban stray dogs. The compendium on continuing education for the practicing veterinarian, 1980; 2: 721-724.

12. Lecomte J. Eco-ethology of stray dogs. *Position of the problem Ecol Rev (Earth and Life)*. 1985; 40: 193-195.

13. Cayolla da Motta L.The mediterraneen zoonoses control program and its center (MZCC) in Athens, Greece. In: Kuwert E, Merieux C, Koprowsky H, Bogel K, eds. *Rabies in the Tropics*. Berlin, Heidelberg, New York, Tokyo: Springer-Verlag. 1985. 629-643.

14. Bogel K, Meslin FX. Economics oh human and canine rabies elimination. In : Report of the Workshop on Rabies Control in Asian Countries. Samarkand, 1989; 19-21.

15. Matter HC.Ecological study of a canine population. *Maghreb Veterinary*. 1987; 3(12): 65-68.

16. Ben Osman F. The stray dog in Tunisia. *Ecol Rev (Earth and Life)*. 1985; 40: 197-201.

17. Rosset R. Pasteur and rabies, communications, bull. *Acad Vet of france*. 1985; 58: 425-447.

18. World Health Orginization (WHO). Guidelines for dog rabies control. Documents à diffusion restreinte reproduits du document VPH/83-43, Geneva, 2006.

19. Zinsstag J, Dürr S, Penny MA, et al. Transmission dynamics and economics of rabies control in dogs and humans in an African city. *Proc Natl Acad Sci U S A*. 2009; 106(35): 14996-15001. doi: 10.1073/pnas.0904740106