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ABSTRACT

Accurate demographic knowledge of the equine population is needed to assess and model equine health events. France is one of the few European countries with an operational centralized database (SIRE) recording individual data on all declared equines living in France and on their owners and keepers. Our study aimed to assess SIRE database quality concerning the updating of information by equine owners and keepers with a view to its improvement and use in surveillance and research. Two online surveys were conducted with the participation of 6244 registered keepers and 13,869 owners. Results showed some inconsistencies between SIRE records and survey responses. The inconsistency rate for equines whose castration and death were not registered in the database was 28.7% and 5.9% respectively. Concerning owners, 11% of respondents did not own the reference equine selected considered by the survey, 33% had changed address without updating it in the SIRE. Concerning premises hosting equines, the keeper survey's inconsistency rate was 7.3%, of which 57 respondents had closed and 32 had opened premises without reporting it. Comparatively, the owner survey's inconsistency rate was 40.7% including respondents who owned and hosted an equine without reporting these equine premises, and owners who did not keep any equines on their premises. In conclusion, the SIRE database proved to be a valuable and reliable source for epidemiological research as long as some bias is taken into account. On the contrary, its use in surveillance is currently limited due some shortcomings in updating and/or reporting by owners and keepers.

1. Introduction

The absence of reliable and complete data on the equine population can have significant economic and health consequences, especially in the event of a rapidly-spreading epizootic. The example of the equine influenza epidemic in Australia in 2007, when nearly 4,500 premises hosting equines were infected in less than two months (Brendan et al., 2009; Callinan, 2007) has shown the importance of knowing the location of equines in order to control disease (Garner et al., 2010). Demographic data are also needed for research, in particular for modeling the spread of diseases, evaluating control measures and quantifying economic consequences (Lo Iacono et al., 2013; Robin et al., 2012). However, in most countries, demographic knowledge of the equine population is limited. In fact, the equine sector is divided into several sub-sectors managed by different organizations with multiple separate databases. It also includes various types of equines (for sport, work, leisure, hire, etc.) and mixes individuals and professionals with a different status (owner/keeper/owner-keeper). This leads to difficulties in comprehension but also in complying with regulations on the traceability of equines, especially since the legal liabilities of keepers and owners differ according to whether the regulations are European or national. European regulations define the "keeper" as any natural or

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legal person who is in possession of an equine or is responsible for providing for its maintenance, whether or not for a fee, and whether it is under their responsibility on a permanent or temporary basis. This includes during its transport, at a market or during competitions, races or cultural events. The "owner" is the natural legal person(s) who owns the equine (Regulation, 262/2015). European regulations impose all traceability obligations on the keeper, whereas French regulations place the onus of traceability on the owner. European keepers are thus responsible for applying to the competent authorities to identify an equine, while in France, owners can also apply. Similarly, when the equine dies (except at slaughter), European keepers must return the identification document (passport) to the competent authorities within 30 days of the animal's death, while French owners are asked to return it, the important point being that the passport is invalidated by the competent authority to avoid any fraudulent use and update traceability database. To complete the traceability system, European regulations (Regulation, 262/2015) made it compulsory to set up a central database in each European state by June 30, 2016 at the latest. France is one of the few European countries with a centralized database that has been operational for many years (Engelsen, 2017).

The French central database is known as "SIRE" from the French acronym for equine-related information system. It was created in 1976 and is managed by the French horse and riding institute (IFCE). The SIRE database records information on equines in France (unique SIRE identification number, microchip number, date of birth, sex and breed, date of death) whose owners (95%) have complied with regulations (Dornier, 2010; Ifce, 2015). This declarative collection of information is mandatory. It also records information on "equine premises", where equines are kept, because French regulations require keepers to notify the authorities of the opening and/or closing of such premises (Article R215-14 of the French Rural Code). The SIRE database also records contact information for both owners and keepers (address, email, etc.). The IFCE must be notified of any change in information concerning equines (such as castration or a change in ownership), owners or keepers (contact information) so it can update the SIRE database. However, owners and keepers do not systematically comply with these regulations, or take a long time to do so, which means that some of the information in the database is incomplete or not up to date. The IFCE carries out annual communication campaigns targeting owners and keepers in order to encourage them to update information (through emails to all keepers in the database, web news, Facebook posts, phone calls (Reinforced-health-protection), but their impact is known to be limited.

Until now, no major survey has ever been carried out to evaluate the global quality of the SIRE database. The aim of our study was to assess the quality of information of potential interest for surveillance and epidemiological research by comparing the information obtained from two online surveys—one targeting owners and the other, keepers—with that registered in the SIRE database.

2. Materials and methods

2.1. Data sources and sample selection

The SIRE database was consulted in December, 2018 to select owners and keepers having filled in their email address and specified their agreement to be contacted in this way.

The 6404 keepers meeting these criteria were included in the keeper survey. This corresponded to 8.4% of the 76,501 keepers who had declared one or more equine premises, regardless of the premises' status (open or closed) or the date of registration. Similarly, the owner survey included the 13,869 contactable owners, representing 1.9% of the 737,789 owners known as the last owner of at least one equine recorded in the SIRE database. The 4,400 people registered as both owner and keeper received both questionnaires.

As an owner could have several equines in the database, we selected a single equine for each owner (subsequently referred to as the "reference equine"). This simplified the questionnaire, thus encouraging responses, while providing us with additional information on one specific equine. The reference equine was selected as follows:

- If the owner had only one equine registered in the SIRE database, this was the reference equine, regardless of its status (dead or alive);
- If the owner had several equines, all of which were alive, the reference equine was randomly selected among them;
- If the owner had several equines all registered as dead, the equine that had died most recently was selected to limit memory bias;
- If the owner had several equines of different statuses (alive or dead), the reference equine was randomly selected among the live equines.

Two SIRE datasets were used to evaluate the quality of data:

- the "equine premises" dataset that has been used since 2006 to register the identification number of the keeper, the location(s) of the equine premises including the *commune* (smallest French administrative unit), the *commune*'s INSEE code (unique identification number) and the date the premises were opened and closed (if applicable).
- The "equine owner" dataset that contains the information on equines registered in the SIRE database since 1977 (SIRE number, sex, breed, date of birth, date of death declaration (if relevant)), in addition to information concerning the last known owner (SIRE identifying number, INSEE *commune* code for the owner's residence, date on which the equine owner became its owner, and date on which information was last updated).

2.2. Data collection and analysis

The questionnaires were designed with Sphinx iQ2® software to collect information needed to evaluate how up-to-date the information on owners and keepers recorded in the SIRE database actually was, and the degree of compliance of declarations of changes in the status of equines (castration, death) which must be declared by owners or keepers. The owner survey focused on information on the owner (*commune* of residence, equine ownership and whether the owner was also a keeper) and on the reference equine (dead/alive, gender, date of death if relevant). The keeper survey aimed to characterize the keeper and the premises on which the equine was kept, including whether or not these premises had been declared.

The emails were sent by the IFCE. Each recipient was given a unique identification code that was used to link survey responses to SIRE information. This code was the first item to be filled in on the questionnaires. For owners, the email also specified the name and identification number of the reference equine in order to facilitate its identification by the owner. Owners who were also registered as keepers were surveyed twice independently. The surveys were initiated in March 2019 and ended in August 2019 with two follow-ups in May and July. The surveys fully complied with the General Data Protection Regulations.

The responses were extracted, processed and analyzed with R software version 3.6.1 (Rstudio, 2019).

Associations between two qualitative variables were tested using the Pearson's Chi squared test. The Wilcoxon test was used to compare the means of two distributions, with an error threshold set at 0.05.

3. Results and discussion

We based our selection on the availability of an email address and contact agreement, and only 1.9% of owners and 8.2% of keepers registered in the SIRE database were reachable. This was the main limitation of our study, as we had little explanation for the lack of an email address and none for the lack of agreement. It also revealed an significant problem, namely that it is not possible to contact quickly all owners and keepers individually in the event of an outbreak.

3.1. Response rates

By the survey closing date, we had received 2925 owner and 1243 keeper questionnaires (Table 1). Of these, 34 keeper and 159 owner questionnaires were excluded due to an erroneous identification code incomplete answers by email. Of the 4,400 people to whom we sent both questionnaires, 923 answered only the owner survey, 826 answered only the keeper survey, and 495 answered both. After exclusion and deduplication, there were 1217 exploitable keeper questionnaires and 2788 owner questionnaires (Table 1). These figures correspond to a response rate of 19.5% and 20.1% for keeper and owner surveys respectively. These response rates appear satisfactory for this type of survey. Response rates for such surveys are usually around 10–15% even though higher rates are sometimes observed (Bachmann and Stauffacher, 2002; Hartig et al., 2013; Hotchkiss et al., 2007; Knubben et al., 2008; McGowan et al., 2010; Merlin et al., 2020). Compared to these studies, the lower response rates obtained in our study could be linked to the differences in survey procedures (email rather than direct contact). Additionally, we were not able to check the validity of the email address, and some of the owners and keepers selected probably never received the email, especially those that had not updated their personal information in the SIRE database for a long time. Indeed, respondents had updated their information on average more recently than non-respondents (2.2 years vs. 2.7 years, Wilcoxon Test, $p < 0.05$).

3.2. Estimation of sampling and response biases

People having recently updated information in the SIRE database were more likely to have provided an email address and a contact agreement, so were selected more often (Wilcoxon test, p-value <0.05). Nevertheless, the proportion of owners and keepers selected was almost identical in each *département* (a French administrative unit), with an average of 1.2% for owner and 8.4% for keeper surveys (Fig. 1).

In contrast, the response rates of both surveys varied greatly depending on the *département*. They ranged from 0 to 32% for the keeper survey (Fig. 1C) and from 0 to 50% for the owner survey (Fig. 1D). Any recent updating of information in the SIRE database had a positive influence on the probability of response (Wilcoxon test, p-value <0.05, see above).

The sex and age distributions of the reference equine for the selected and respondent owner subpopulations were close to those of the declared equine population, with a slight over-representation of equines between 10 and 15 years old and geldings in these two subpopulations (Table 2). We also had an over-representation of saddle horses and under-representation of donkeys and draft horses (Table 2). This could be linked to differences in use (leisure vs. sports and racing) and to the fact that saddle horses represent a particularly active subpopulation for which up-to-date information is checked during horse competitions and meetings. Concerning the equine's status (dead or alive), we expected an under-representation of dead equines due to our sample selection method, as we selected a live equine as the reference equine for owners having both dead and live equines (cf. section 2.1). Dead equines were also strongly under-represented in the responses (Table 2). Owners with only dead equines were considered less likely to have an updated email address and were probably less motivated to participate in the survey. It is also possible that some people did not answer for emotional reasons related to the death of their equine.

Table 1
Number of questionnaires sent, received, and included, with the response rate for each survey.

Survey	Number of emails sent	Number of questionnaires received	Number of questionnaires included in the analysis	Response rate (%)
Owners	13,869	2925	2788	20.1
Keepers	6244	1243	1217	19.5

3.3. Consistency between the SIRE information and the survey data

In order to evaluate how up-to-date the information on owners and keepers recorded in the SIRE database was, and the degree of compliance with the mandatory declaration of changes in the status of equines, we compared SIRE information with the survey data.

3.3.1. Updates of castration and death of equines

Out of 1041 geldings belonging to owner survey respondents, only 690 (66.3%) were registered as castrated in the SIRE database. This suggests that about 1/3 of castrations are not declared by owners. This high percentage of non-compliance with notification regulations is probably due to the absence of any checks on castration except for equines participating in official events (jumping, dressage, races, etc.), and to the fact that castration cannot be notified online. The owner has to send to the IFCE, by email or ordinary mail, a copy of the identification page from the equine's passport modified either by the veterinarian who performed the castration or by another veterinarian who certifies it.

Concerning the 2613 reference equines for which the owners knew the life status (dead or alive), the information given by 2450 (93.8%) of them was consistent with that in the SIRE database. For the 162 for which inconsistencies were observed (Fig. 2a), either the death had not been declared to the IFCE, or the death occurred between the date we extracted datasets and the date the questionnaire was returned. The rate of non-declaration of an equine's death in our survey (6.2%) was much lower than that estimated by the IFCE. Indeed, only some 30 to 40% of owners return the passport of their animal (IFCE, personal communication). It has been estimated that 40% of equines that died between 2011 and 2017 were still alive according to SIRE information. In the United Kingdom, it has been estimated that only 27% of owners complied with the mandatory process of returning the passport either to the issuing authorities (the Department for Environment, Food and Rural Affairs) directly or indirectly via the fallen stock disposal representative (Defra, 2018).

Concerning delays in notifications of death, the difference between the date of death indicated by the owner and the date of death recorded in the database (most of the time this was the date on which the passport was returned) was calculated for 41 equines. The delay was under one year for the majority of equines (68.3%, $n = 28$) and it was between one and four years for 24.4% ($n = 10$). A recent French survey (Merlin et al., 2020) had noted various reasons for the non-return or late return of the passport after death. These included the fact that the keepers do not necessarily return the passport themselves to the IFCE but entrust it to the rendering company; secondly, the keeper rarely has the original passport, which is kept by the owner; and thirdly, some owners want to keep the passport in memory of their animal. In fact, owners can ask for the passport to be returned once invalidated as long as they enclose a stamped addressed envelope, but many people are not aware of this procedure, despite regular IFCE communication campaigns. This explains part of the under-notification and the long delay sometimes observed between the animal's death and its notification. This could also explain why surveyed owners whose reference equine was dead were less likely to respond to our survey, leading to an underestimation of the proportion of dead equines recorded as still being alive in the SIRE database.

The under-declaration of equine deaths and the long delays in notifications of deaths severely limit knowledge of the size of the equine population living in France. Different multi-stakeholders working groups are underway in order to improve the updating of deaths in the SIRE database: improvement of the collection of the microchip number during the cadaver removal, interconnection of regulatory traceability databases (fallen stock database, slaughterhouse database) (Tapprest

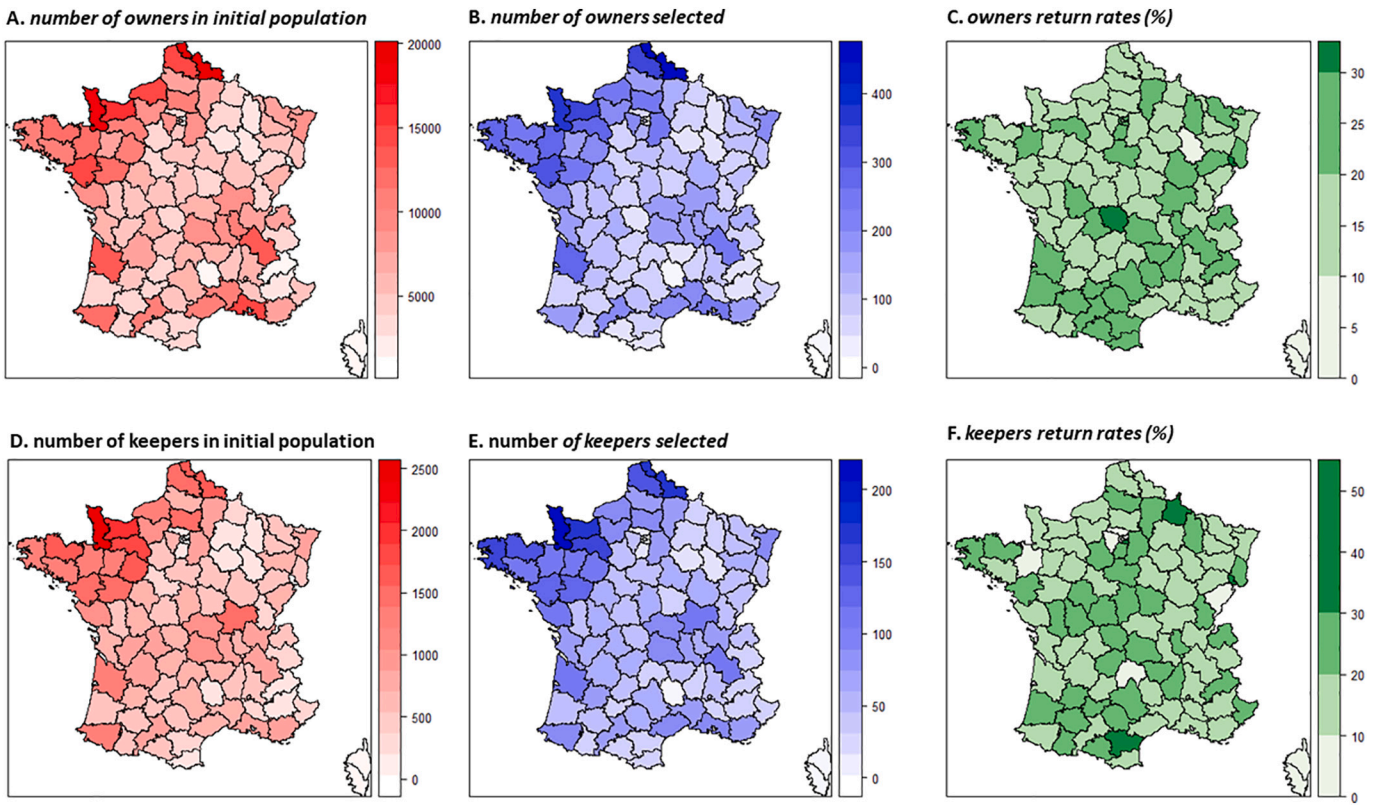

Fig. 1. Spatial distribution by département of the number of owners (1st line) and keepers (2nd line) of the population registered in the SIRE database (left), in the selected sample (middle), and in the respondent population (right).

Table 2
Distribution (percentage) of the group of breeds, sex, age, and status of the equines registered in the SIRE database for the initial population, the selected sample and the respondents.

Variables	SIRE modalities	Population	Sample	Respondents
Group of breeds	Donkey	7.0	3.1	3.0
	Racehorse	19.5	17.2	16.3
	Pony	18.5	20.1	19.1
	Saddle horse	37.1	54.7	57.1
	Draft horse	17.9	4.9	4.6
Sex	Female	53.2	52.2	52
	Gelding	20.7	25.7	27.7
	Male	26.1	22.1	20.4
Age	≤2	6.0	7.0	7.2
	]2–5]	11.5	11.5	12.0
	]5–10]	21.6	21.3	21.4
	]10–15]	19.7	27.7	27.8
	]15–20]	17.9	16.4	16.6
	>20	23.3	16	15.1
Equine's status	Dead	16.8	2.4	1.8
	Alive	83.2	97.7	98.2

et al., 2015) and possibility of exchanging information between the SIRE database and private databases (cremation companies, insurers, etc.).

3.3.2. Quality of ownership status data

We checked not only whether the ownership of the reference equine was up to date but also the ownership of other equines potentially owned by the respondents. Concerning the reference equine, 11% (n = 307) of the 2788 respondents stated that they no longer owned this equine (Table 3). Concerning ownership in general, of the 50 owners that were not linked to any living equine in the SIRE records (but only dead ones), 16 indicated that they currently owned at least one equine (Fig. 2b). On the other hand, of the 2738 respondents linked to at least one living equine registered in the SIRE database, 3.6% (n = 99) reported that they no longer owned any equines (Fig. 2b). These inconsistencies are mainly due to the lack of or late notification to the IFCE by owners of a change in ownership, leading to a delay in the ownership records being updated. While the seller can tell the IFCE that the animal has been sold, it is the new owner's declaration that prevails legally for the updating of the equine's ownership. We also estimated that a number of inconsistencies could be due to owners having more than one SIRE ID number or the equine being registered under the name of another family member.

The lack of updating evidenced in our survey is probably underestimated. Indeed, saddle horses—known to have the best compliance rate—were strongly over-represented in our selected and respondent populations. Conversely, ponies and donkeys were under-represented even though they are mainly used for leisure by individuals who are often less familiar with regulations and less controlled.

Finally, we asked the owners whether they had declared all their equines to the IFCE. The vast majority (91.2%, n = 1835) answered that they declare all their equines, but 2.6% (n = 52) answered that they do not declare all of them, and 5.0% (n = 100) that they do not know whether all their equines were declared. Surprisingly, some owners (0.8%, 17/2,004) answered that they did not declare any equines. This last point was surprising because surveyed owners have necessarily declared at least one equine (Table 3). The high number of declarations by equine owners is in accordance with a very low level of underdeclaration (3%) estimated by the IFCE's economic observatory (Dornier, 2010).

3.3.3. Quality of personal information on owners

We evaluated the updating of the address of residence of owners through a question on the *commune* of residence (open question, not compulsory). Among the 2303 respondents concerned (current owner), 64.7% (n = 1490) had the same postcode in the survey and the SIRE

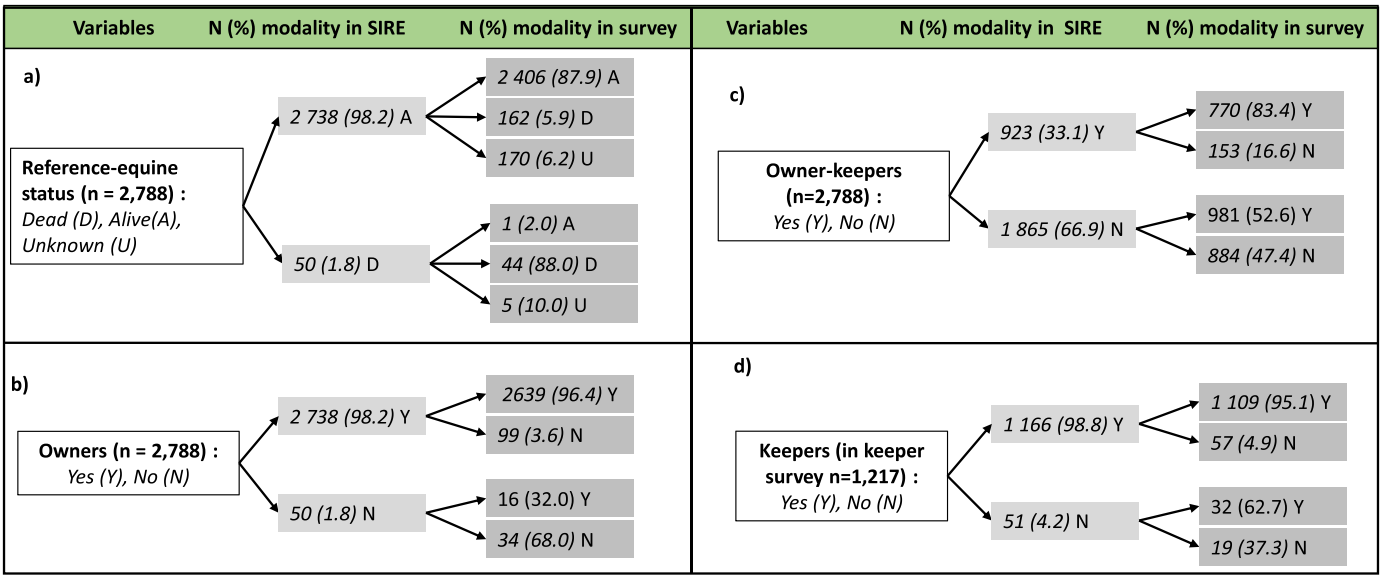

Fig. 2. Consistency between SIRE information and survey data.

Table 3
Owner survey data regarding the updating of ownership and address.

Variables	Modality	N	%
Last owner of the reference equine	Yes	2481	89.0
	No	307	11.0
Other equines owned	Yes	2004	28.1
	No	784	71,9
Owners' *commune* of residence	Not found	54	2.3
	Consistent	1490	64.7
	Inconsistency	759	33.0
Declaration of equines to the IFCE	All equines	1835	91.6
	Some equines	52	2.6
	No equines	17	0.8
	Unknown	100	5.0

database. For 2.3%, the *commune* was either not registered in either the database or in the survey ($n = 33$), or erroneous in the survey ($n = 21$) (Table 3). The inconsistency rate for the location of the owner highlighted in our study is high (33%), and suggests that the knowledge of equine owners' location in France is noticeably incomplete. In the absence of a valid email or postal address, it is questionable as to whether the IFCE could contact an owner if necessary.

3.3.4. Notification and updating of equine premises

We combined the two surveys to obtain a more complete view of the premises where equines are kept. The keeper survey was essentially used to check information on premises recorded in the SIRE database, while the owner survey aimed to identify premises that had not been declared to the IFCE and to characterize these premises. Among the 1166 respondent keepers who had one or more open equine premises recorded in the SIRE database, 4.9% ($n = 57$) did not still have one at the time of the survey, and 32 of the 51 respondents having premises that were closed according to SIRE records, actually had open premises at the time of the survey (Fig. 2d).

The owner survey indicated that, out of the 1865 respondents not recorded as being keepers in the SIRE database, in fact 52.6% ($n = 981$) hosted equines, so these equine premises should have been recorded (Fig. 2c). Only 37.1% ($n = 364$) of them kept equines not owned by them. The majority ($n = 617$) kept only their own equines: of these, 21.6% ($n = 133$) of them owned only the reference equine and 78.4% (484) also owned one or more other equine(s).

Finally, the global inconsistency rate concerning equine premises in the keeper survey was 7.5% (92/1217) and the combination of the two questionnaires indicated a global inconsistency rate for notifications concerning equine premises of around 40.7%.

Our results confirm the massive under-declaration of premises to the IFCE by keepers. The reasons for non-declaration are not all known, but could include a limited knowledge of regulations, and incomprehension about when to open or close premises: some of the equine premises in the database are marked open yet have zero equines associated with them (perhaps because they do not host equines on a permanent basis), while others are opened then closed the same day, for example. Additionally, for professionals, under-declaration could be linked to the fact that many of them already notified their professional databases (such as those of farmers or equestrian centers) and do not know that it is also mandatory (and free) to declare information to the IFCE for inclusion in the SIRE database, or consider this complementary declaration as redundant and useless. A sociological approach could shed light on the obstacles and identify the levers to be used to promote compliance - especially of non-professionals - with mandatory regulations.

To sum up, the lack or poor quality of owner contact information and the under-declaration of equine premises slow down the management of health events (information, surveillance of restricted movement area, epidemiological investigation…). For example in the case of an equine infectious anemia outbreak, epidemiological investigations are needed to identify the contact cases and limit the spread of the disease. In the absence of reliable contact details of owners and keepers, and comprehensive identification of premises, time consuming and cost intensive field investigations are carried out (Gaudaire et al., 2018).

Conclusion and prospects

We estimated that the SIRE data are of good quality and a valuable and reliable source for epidemiological research and studies as soon as the identified biases are taken into account. The main limits were the lack of updating of deaths, the under-reporting of equine premises, and the lack of availability of a valid contact of owners and keepers as well as a contact agreement.

Our work evidenced the complexity of the management of a declarative database in a complex context with i) the particular status of equines in animal regulation, ii) a majority of non-professional owners and keepers, iii) a lack of interoperability of complementary databases and iv) the opposition between the protection of personal data regulation (European regulation 2016/679) and the needs of epidemiological

surveillance.

Despite the obligation to set up a central database in each European country, a great disparity currently exists between the different European states (for example, the United Kingdom, Sweden and the Netherlands do not yet have operational centralized databases (Engelsen, 2017). Our work could help other European countries to develop or improve their mandatory database. This work also contributes to the reflections to be carried out in terms of regulation within the framework of the identification and traceability of equines in Europe.

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