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APPLICATION OF DISCRETE CHOICE EXPERIMENT TO ANALYZE THE DEMAND FOR VILLAGE CHICKEN PAID VACCINATION SERVICE AGAINST NEWCASTLE DISEASE IN DR CONGO.

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KEYWORDS: Discrete choice experiment -- Paid vaccination -- Newcastle disease -- Rural poultry -- Willingness to pay

ABSTRACT

Newcastle disease (ND) is a highly contagious viral disease that can affect a large number of avian species and cause severe economic loss in many countries. This disease is a major constraint for rural chicken production in most developing countries. In this country, ND is known since the 1940s. It exists in enzootic form in almost all provinces of the country. No systematic long-term control measures have been taken against this devastating disease in village poultry. A discrete choice experiment was carried out to analyze the demand for paid vaccination services, by first identifying the preferences of 320 village chicken keepers from eight sites, four of which had benefitted from such a paid chicken vaccination program against ND and four of which did not. The preference was for a vaccination service carried out following imposed calendar. The public veterinarian was the most preferred professional to ensure the paid vaccination of village chickens. The results led to the design of a profile of paid vaccination service tailored to chicken keepers' expectations. The public veterinarian would supervise vaccination activities, which would be implemented by trained community-based health workers, through collective campaigns at fixed periods in the year. The acceptable price (equivalent to 0.10 US dollar per dose) would allow the service to be set in a sustainable way and might be increased if trust in the delivered service may be built further.

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1. Introduction

In developing countries, chicken farming contributes to the food and financial security in rural and urban households (Alders et al., 2010; Bagnol et al., 2013; Padhi, 2016). It provides animal protein in the form of meat and eggs for home-consumption and is a reliable source of cash (Bett et al., 2013; Terfa et al., 2015). In the Democratic Republic of Congo (DRC), the share of rural households owning a chicken nucleus is estimated at 80 %. Terfa et al. (2015) argue that village chicken farming does not require large investments and is therefore accessible to the poorest households. Avian diseases are the main cause for the low productivity of village chicken farming and are a constant threat to these crucial livelihoods. As a result, there is wide potential for poverty alleviation through the control of these infectious diseases in village chicken farming (Moula et al., 2012; Terfa et al., 2015). Newcastle disease (ND) is considered in this context as the main constraint for the development of village chicken farming (Alders and Spradbrow, 2000; Van Boven et al., 2008; Bagnol et al., 2013).

In DRC, this disease has been known since the 1940s and occurs in an enzootic form in almost all provinces. However, the country has no viable control and monitoring program for this devastating disease (Huart and Bisimwa, 2004). In this country, ND epidemics are reported to occur two to three times a year (Mugumaarhahama et al., 2016; Lwapa et al., 2019). Widespread vaccination programs appear as the sole viable strategy to solve this problem (Alders and Spradbrow, 2000). However, despite an established biological efficacy, the effectiveness of a vaccine in the field will be determined by its availability, accessibility and affordability (Zinsstag et al., 2011). Also, these features of a vaccine do not necessarily guarantee its use by farmers. Farmers will use several selection criteria before deciding to adhere or not to a vaccination program. It seems important to understand farmers' preferences in this decision of vaccine adoption (Newman et al., 2006).

Animal vaccination campaigns must achieve the widest possible vaccination coverage to enable the control or eradication of the disease. As introduced here above, this requires a good vaccine, sufficient funds and appropriate policies and practices for vaccine delivery and farmer cooperation (McLeod and Rushton, 2007). Yet, in the developing world, veterinary services display important weaknesses and are under constant adaptation of their functioning, funding and management in a context of highly constrained public budgets (Haan, 2004). Hence, in these countries, livestock vaccination remains irregular with a low coverage (Kairu-Wanyoike et al., 2014). The organization of paid animal vaccination campaigns, ensuring the recovery of costs incurred, appears as a way to ensure the sustainability of the intervention.

In order to find a model of a paid vaccination service for village chicken against the disease in DRC, we applied stated preference methods to measure the farmers' appreciation of different modalities for organizing vaccination and assess their willingness to pay for this service. Among stated preference methods, the discrete choice experiment (DCE) has become increasingly popular (Kairu-Wanyoike et al., 2014). This method analyses the trade-offs made by respondents when choosing between propositions of goods or services characterized by a set of attributes displaying different values. As long as the price is one of these attributes, the trade-off between various characteristics and price of the good or service will be analysed in

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the form of a willingness to pay for each appreciated characteristic. Hence, DCE has the advantage of being able to estimate the value of each characteristic (attribute) separately and not just the value of the whole good or service (Bennett and Balcombe, 2012).

2. Materials and methods

2.1. STUDY AREA

This study was conducted at eight sites. In four of these sites, the *Centre Agronomique et Vétérinaire Tropical de Kinshasa* (CAVTK) had organized vaccination campaigns for village chickens against ND from 2011 to 2015. The other sites did not benefit from a similar program. Sites choice was based on three criteria: the accessibility of the site by road, the cultural diversity and the fact of having benefited or not from this program. Interviewed farmers did not share the same cultural or geographical space. The populations of all selected belong to different ethnic groups with different habits and customs.

The eight sites were distributed in the four following provinces (Table1): Kongo Central, Kinshasa, Kwango and Kwilu. The sites which benefited from the program were Kasangulu, Madimba, Boko and Kwilu-Ngongo (Boko and Kwilu-Ngongo are two cities of the territory of Mbanza-Ngungu). The sites which never benefited from the program, were Songololo, Maluku, Kenge and Bulungu. The territories Ka- sangulu, Madimba, Mbanza-Ngungu and Songololo are territories of the Province of Kongo Central. Maluku is a territory of the Province of Kinshasa, Kenge is a territory of the Province of Kwango and finally Bulungu is a territory of the province of Kwilu.

Table 1. Study area description

Site's status	Sites	Territories	Provinces
Benefited from paid vaccination program for village chicken	Boko	Mbanza-Ngungu	Kongo Central
	Kasangulu	Kasangulu	Kongo Central
	Kwilu-Ngongo	Mbanza-Ngungu	Kongo Central
	Madimba	Madimba	Kongo Central
Not benefited from paid vaccination program for village chicken	Bulungu	Bulungu	Kwilu
	Kenge	Kenge	Kwango
	Maluku	Maluku	Kinshasa
	Songololo	Songololo	Kongo Central

2.2. STUDY PERIODS

Data collection was carried out at two different periods. Data collection took place from 1st September to 31st October 2016 in the sites which had benefited from the paid vaccination program for village chickens organized by CAVTK. After the construction of the first data set, the authors found convenient to compare the preferences of chicken keepers who have experience of village chickens paid vaccination and those of chicken keepers not having tried out such vaccination. This second data collection took place from 1st August to 30th September 2017. Considering the time spent between the start of data collection and analyses,

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it was important to consider monetary inflation in order to avoid underestimating or overestimating the values of various parameters during data processing (Lefèvre, 2014).

2.3. OVERALL DESCRIPTION OF METHODS

This study followed the stages of a DCE described by WHO (2012). First, attributes and levels were identified. Then based on these "attribute levels", experimental profiles of paid vaccination service for village chicken and choice sets were constructed. Using this choice set, a questionnaire with 20 questions was developed. The applicability of the questionnaire was tested in the territory of Kasangulu during the period from the 1st to 5th August 2016. After data collection, data matrix were developed and finally data analysis and interpretation were realized.

2.4. IDENTIFICATION OF ATTRIBUTES AND ATTRIBUTE LEVELS

Identification of the attributes of paid vaccination services for village chicken against ND had been made by two focus groups discussions (FGD) in the Kasangulu territory. The first brought together five veterinarians of the public services and the second concerned five village chicken keepers. At the end of these FGDs, it was concluded that these hypothetical vaccination services had four attributes. These attributes were the modality of recourse to vaccination, the route of vaccine administration, the professional status of the vaccinator and the price of one dose of vaccine. The modality of recourse to vaccination refers to the overall organization as campaigns with an imposed calendar or as an on-demand service. The imposed calendar is a compulsory vaccination program drawn up by the public veterinary services. In contrast, on-demand vaccination service is that individually demanded by the farmer. The two types of management were the two levels of this attribute. The route of vaccine administration was related to the efficacy and ease of administration of the vaccine. The vaccine could be given by injection, orally or as ocular drops. The three vaccine forms constituted the three levels of the attribute of route of administration. In order to reach the largest number of chicken keepers, private veterinarians, chicken keepers and members of community and communitybased health workers (CBHW) would support the team of public veterinarians in the territory. Thus, the four levels of vaccinator attributes were "public veterinarian", "private veterinarian", "chicken keeper" and "CBHW". The price of the vaccine dose was established with reference to the price practiced by the CAVTK for its ND vaccination campaigns in Kongo central Province. At first, CAVTK fixed the dose at 50 Congolese francs (FC), and then CAVTK raised it to 100 Congolese francs (FC). Thus for the price attribute, three levels were retained, 50 FC, 100 FC and 150 FC (equivalent respectively of US$ 0.05, US$ 0.10 and US$ 0.15 at the time of the study). The amount of 150 FC was withheld in anticipation of a possible depreciation of the national currency. Table 2 presents the different attributes and their different levels.

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Table 2. Attributes and attribute levels of paid vaccination services for village chicken against ND in Kongo central Province (DR Congo), 2016.

Attribute	Level of attribute			
	1	2	3	4
Modality of vaccination	Imposed calendar	On-demand		
Administration Route	Injection	Oral	Ocular drops (OC)	
Vaccinator status	Public veterinarians	Chicken keepers	Community-Based Health Workers	Private veterinarians
Price	50 FC	100 FC	150 FC	

2.5. DESIGN AND CONSTRUCTION OF CHOICE SETS TO PRESENT TO PARTICIPANTS

With one attribute of two levels, two attributes of three levels and one attribute of four levels, the full factorial model would give (2 × 3 × 3 × 4) or 72 combinations. Following the protocol described by Aizaki and Nishimura (2008), it was possible to generate an acceptable number of combinations that could be used during this stated choice survey. By using the R software (version R 3.3.3, package Alg-Design) 20 pairs of combinations of 20 hypothetical profiles of village chicken paid vaccination services were generated.

2.6. QUESTIONNAIRE DEVELOPMENT

Each pair of combination constituted one question. Each question was presented in the form of a choice card. The choice card constituted a tool aimed at simplifying the communication between the researcher and the interviewee. On the choice card, apart from the price, the other attribute levels were represented in the form of images and the price was expressed in numbers associated with the monetary symbol of the Congolese francs (FC). The drawings used for these illustrations have been adapted from images taken from image banks available online and from the book Newcastle Disease in Village chicken raising: Field Manual (Alders and Spradbrow, 2000). The 20 choice cards constituted the 20 questions in the survey. On each choice card, the chicken keeper had three alternatives: choosing the one or the other profile of the combination pair, and one alternative opt-out. The possibility to opt-out was given to allow the chicken keepers to discard both profiles, and then to express the motives of their decision (Pham et al., 2017). Fig. 1 shows an example of a choice card used for data collection of this study.

2.7. DATA COLLECTION

A sample of 320 chicken keepers was interviewed from eight sites, i.e. 40 per sites. In each site, interviewed chicken keepers were selected through a convenience sampling, i.e. based on their availability and willingness to participate. This number represented 10 % of the smallest number of chicken keepers having participated in chicken vaccination campaigns per

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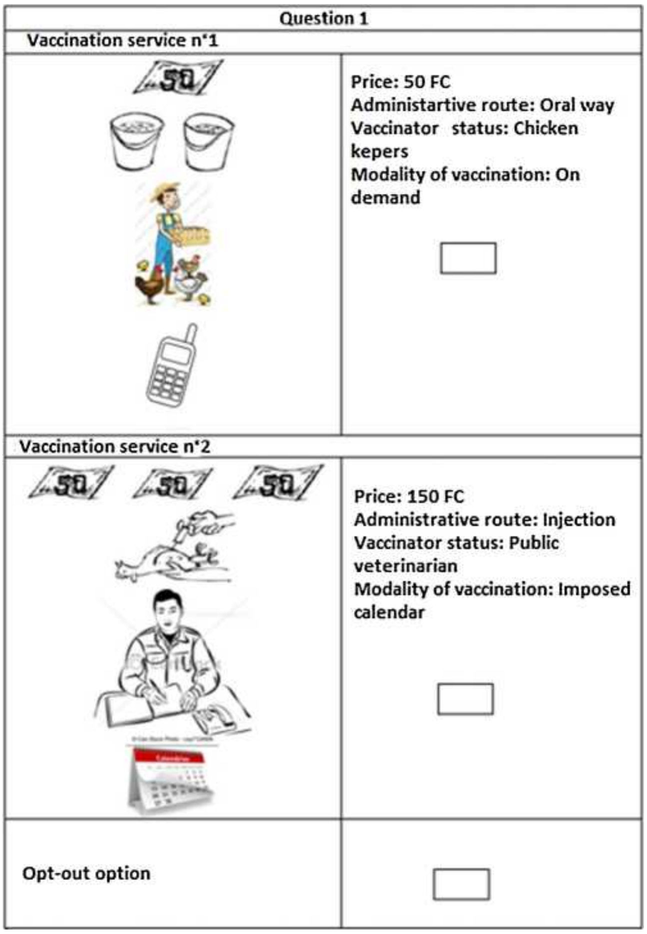
site (Kasangulu). According to the WHO guideline on DCE in public health research, performing an econometric analysis requires that the main sample be formed of subgroups (stratified groups) with a minimum sample size of 30 (WHO, 2012). The 20 choice cards were successively presented to the interviewed chicken keepers who was asked to make a choice. To better understand the choice of chicken keepers, after each choice made, the investigator asked the concerned chicken keeper to explain his choice. Throughout the questionnaire, his answers revealed the importance he gave to each attribute. These answers would contribute to a better understanding of his preferences (Pons, 2011). All attributes and attribute levels of village chicken paid vaccination services against ND and the assessment procedure were described to chicken keepers in detail prior to data collection. Each interviewed chicken keeper had given his oral informed consent to participate in the survey. For personal reasons, chicken keepers were not willing to sign a document confirming their consent.

Figure 1. Example of a choice card used for data collection of this study.



2.8. DATA ANALYSIS

The econometric analysis of chicken keepers' preferences was carried out using R software (version R 3.3.3, package survival). The model considers that the levels taken by the different attributes determine the utility one ascribes to a profile, affecting in turn the probability for this profile to be chosen within the sampled population. The probability (Pi) to choose profile *i* is determined by :

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$$P_i = \exp(Ui)/\Sigma\exp(Uj) \quad (1)$$

Where U_i is the marginal utility of profile *i*. The utility function can be written as:

$$U_i = V_i + \varepsilon_i \quad (2)$$

Where U is a stochastic utility function, V_i is the observable deterministic component of utility and is determined by the vaccination profile attributes, ε_i is the error term, an unobservable stochastic component. The deterministic component of utility may be written as follows:

$$V_i = ASC + \beta_{kl}*X_{kli} + \beta_{Pr}*Pr_i \quad (3)$$

Where ASC represents the alternative specific constant, β_{kl} the utility coefficient of the level l of the categorical attribute Xk, which takes a value X_{kli} in the profile i, and Pr the price that was treated as a continuous variable, expressed in Congolese francs, and ascribed a utility coefficient βPr. Based on farmers' choices, probabilities for scenarios to be chosen are derived and used to estimate the model parameters ASC, βkl, and βPr.

The probit model and the conditional logit model are two of the most widely used statistical models in discrete choice analysis. Probit model is a particular case of a generalized linear model. It is best suited for binary choice analysis. On the other hand, the conditional logit model is better suited for choice analysis involving more than two categories of elements (Hoffman et al., 1988). Considering the number of choices to be analyzed, conditional logit model was used for the present study. This model uses only fixed effects and does not take into account the random effect between individuals (Aizaki and Nishimura, 2008; Aizaki, 2012; WHO, 2012). In this analysis, the measure of utility does not take into account individual differences between respondents and between different profiles to choose from (scale heterogeneity) or unobserved differences in respondents' preferences (preference heterogeneity) (Hauber et al., 2016). The collected data were transcribed on an Excel sheet following the protocol described by Aizaki and Nishimura (2008). The utility coefficients of attribute levels were calculated using the clogit function included in the survival package (Aizaki and Nishimura, 2008). The utility of each attribute level was estimated in relation to a reference attribute level. The reference attribute level were ocular-drop, CBWH and chicken keeper management. To describe and interpret the preference of different attribute levels by chicken keepers, the odds ratios have been exploited (corresponding to the exponential function of the utility coefficient, OR = $\exp(\beta_{kl})$). In this case, the odds ratios represent the strength of the association between the increase (or decrease) of the probability for a profile to be chosen and the presence in that profile of a defined attribute level other than the reference level. Hence, it is interpreted as expressing the extent to which a preference is influenced by a given attribute level compared to its reference level. An appreciated level will show an OR above 1, a disliked level will show an OR below 1.

Willingness to pay (WTP) is a measurement of the amount of money consumers are willing to pay for obtaining a product or a service. It is derived from the utility consumers give to the product or the service (Breidert et al., 2006). The WTP for each attribute level was calculated from the utility coefficients by the formula:

$$WTP_{kl} = -\beta_{kl}/\beta_{Pr} \quad (4)$$

Where WTPkl is the willingness to pay for the attribute level l of the attribute k, β_{kl} is the utility coefficient of the attribute level l of the attribute k and β_{Pr} is the utility coefficient of the price attribute. For this study, willingness to pay values are expressed in Congolese francs (FC). The total WTP of each profile has been obtained by summing the individual WTPs of different attribute levels that characterize them. Their confidence intervals were calculated by Krinsky and Robb method (Cooper, 1994). Krinsky and Robb's method allows the estimation of non-symmetric confidence intervals. This method is performed automatically using the Nlogit package executed on the R software (Hensher et al., 2015).

The analysis was conducted separately on data from sites that had and had not benefited from the CAVTK vaccination program. Results from these two analyses were then compared. The profiles analyzed were all based on the oral route of administration. The other attribute levels were then changed to test the profile's probability of being chosen. The probabilities of the profiles were calculated according to the following model:

$$P_{profile} = \exp(\beta P*Pr+ \Sigma\beta_{kl})/(\exp(\beta Pr*Pr+ \Sigma\beta_{kl})+(\beta_{Pr}*Pr) \quad (5)$$

3. Results

3.1. ODDS RATIOS OF ATTRIBUTES LEVELS

Tables 3 and 4 contain the attribute levels' utility coefficients and odds ratios from sites that had benefited and not benefited from the CAVTK's paid vaccination campaigns, respectively. The imposed calendar was the most appreciated characteristic in all sites, with an odds ratio of 2.31 in CAVTK's beneficiary sites and 2.08 in non-beneficiary sites. The preferred professional status of vaccinators was the public veterinarian, this attribute level obtaining an odds ratio of 1.80 in CAVTK's beneficiary sites and 1.85 in non-beneficiary sites (the reference level being the CBHW). It was the second most appreciated characteristic of these services. Vaccination by private veterinarians was slightly but significantly more preferred to CBHW in all sites, with an odds ratio of 1.15 in CAVTK's beneficiary sites and 1.17 in nonbeneficiary sites.

A divergence between beneficiary and non-beneficiary sites was observed about the appreciation of the possible intervention of chicken keepers as vaccinators. In beneficiary sites, vaccination by other chicken keepers was well accepted, being 1.38 more preferred to CBHW and this was statistically significant ($p < 0.001$), while in non-beneficiary sites no significant difference of preference between these two types of vaccinators could be detected (OR = 0.99). The preferred administration route also differed between the two types of sites. In beneficiary sites, the oral administration route was not significantly preferred (OR = 1.11) to the reference level, i.e. the ocular drops, while such a preference could be observed in non-beneficiary sites (OR = 1.66). Injection was negatively associated with the preference in all sites, with an odds ratio of 0.82 in beneficiary sites and 0.83 in nonbeneficiary sites. However, this was significant only in CAVTK's beneficiary sites ($p = 0.01$ and $p = 0.06$, respectively).

Table 3. Conditional logit model of paid vaccination services for hypothetical village chicken vaccination against Newcastle disease, in sites that had benefited from the paid vaccination program, DR Congo, 2016.

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Attribute	Level	Coefficient	Odds ratio [95 % CI]	p-value
Route of vaccine administration	Oral	0.11	1.11 [0.97–1.28]	0.12
(ref = ocular-drop)	Injection	-0.20	0.82 [0.70-0.96]	0.01
Vaccinator	Chicken keepers	0.32	1.38 [1.17–1.64]	< 0.001
(ref = CBHWs)	Public veterinarians	0.59	1.80 [1.50–2.17]	< 0.001
	Private veterinarians	0.14	1.15 [1.02–1.29]	0.02
Modality of vaccination (ref = on-demand)	Imposed calendar	0.84	2.31 [2.07–2.58]	< 0.001
Price		-0.0033	0.997 [0.995-0.998]	< 0.001

CI: Confidence interval; ref = reference.

Table 4. Conditional logit model of paid vaccination services for hypothetical village chicken against Newcastle disease, in sites that had not benefited from the paid vaccination program, DR Congo, 2017.

Attribute	Level	Coefficient	Odds ratio [95 % CI]	p-value
Route of vaccine administration	Oral	0.51	1.66 [1.35–2.05]	< 0.001
(ref = ocular-drop)	Injection	-0.18	0.83 [0.69–1.00]	0.06
Vaccinator	Chicken keepers	-0.01	0.99 [0.83–1.17]	0.88
(ref = CBHWs)	Public veterinarians	0.61	1.85 [1.56–2.19]	< 0.001
	Private veterinarians	0.16	1.17 [1.00–1.36]	0.04
Modality of vaccination (ref = on-demand)	Imposed calendar	0.73	2.08 [1.85–2.34]	< 0.001
Price		-0.0017	0.998 [0.997-0.999]	0.02

CI: Confidence interval; ref = reference

3.2. CHICKEN KEEPERS WILLINGNESS TO PAY

Table 5 contains the values of willingness to pay (WTP). Being calculated on basis of utility coefficients, the translated appreciation is as described here above. In beneficiary sites, chicken keepers were willing to pay up to 250 FC for a vaccination carried out according to an "imposed calendar" and up to 176 FC for a vaccination administered by a "public veterinarian". They were willing to pay up to 32 FC if the vaccination was administered by "oral way", while a compensation of up to 61 FC would be needed to make them accept a vaccination by "injection". In non-beneficiary sites, WTP reached higher values, i.e. up to 428 FC for a vaccination carried out according to an "imposed calendar", up to 359 FC for a vaccination administered by a "public veterinarian", and up to 296 FC if the vaccination was administered by "oral way". The compensation required to accept the "injection" route was up to 108 FC.

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Table 5. Chicken keepers willingness to pay for vaccination service for vaccination of village chicken against Newcastle disease in sites with or without a history of vaccination (Result of Krinsky and Robb model).

Attribute	Attribute levels	MWTP [95 % CI]	
		Beneficiary sites (FC)	Non-beneficiary sites (FC)
Route of vaccine administration	Oral way	32 [(-)9-82]	296 [122–1456]
	injection	-61 [(-)137 - (-)12]	-108 [(-)604-14]
Vaccinator status	Chicken keeper	98 [45–165]	-8 [(-)216-135]
	Private veterinarian	43 [7–95]	91 [(-)8-528]
	Public veterinarian	176 [109–306]	359 [155–1785]
Modality of vaccination	Imposed calendar	250 [176–406]	428 [212–1985]

MWTP = Mean of willingness to pay; FC = Congolese Francs; (-) = negative number

4. Discussion

4.1. PREFERENCES, WILLINGNESS TO PAY AND THE EFFECT OF SITES' HISTORY

The paid vaccination campaigns for village chickens organized by the CAVTK made use of two vaccination service profiles. In all cases, the vaccine was administered under the form of ocular drops, vaccination was carried out according to an imposed calendar, and the price was set at 100 FC per chicken. Hence, the services differed in the professional status of the vaccinator. In Madimba, private veterinarians who were employed by a non-governmental organization provided the service while public veterinarians were involved in the case of Kasangulu, Boko and Kwilu Ngongo. In general, chicken keepers preferences in sites that had benefited from chicken paid vaccination was not different from those of the other sites. Indeed the main pattern of preference was the same, including the attributes levels "imposed calendar", "public veterinarian", "private veterinarian", "vaccine injection", "oral vaccine" had the same direction in all the sites. In the sites that had benefited from the paid vaccination program, chicken keepers had appreciated ocular drops and would have found oral vaccination to be of little use. They would also have seen that the vaccine was easy to administer and that a trained chicken keeper could administer the vaccine to their chickens, hence they deemed that mobilizing chicken keepers as vaccinators was appreciable. In the sites that had not benefited from this program, the lack of experience of chicken keepers as vaccinators may explain that they considered oral vaccination as useful and did not think of chicken keepers as potential vaccinators. This tends to indicate that, based on a widely shared preference pattern, changes may occur due to an effect of experience and learning. This dynamic of preferences suggests that stated preference methods might be used as a method to objectivate the evolution of a service acceptability throughout its improvement process.

Chicken keepers did not trust their own ability to manage the vaccination program of their flock, therefore requiring unanimously an imposed calendar. This was probably because ND is a major threat to them and their experience of individual control attempts has never been effective. This situation highlights the need of external support of these populations that are left to their own management for almost all aspects of everyday life. Chicken keepers mainly preferred public veterinarian services because they trust their expertise and their stability in the community. They also believed that public veterinarians had control over the epidemiological data on animal diseases and were in a better position to organize vaccinations in a timely manner. Despite their expertise, the private veterinarians did not attract much interest from chicken keepers. The latter thought that private veterinarians would not be easily found when needed. This preference represents an interesting divergence between the present case and the case of PPR vaccination in Mali, where private veterinarians were preferred and increased the WTP (Wane et al., 2020).

The WTP proved higher than the price applied in the field, which was 100 FC. Once multiplied by the number of chickens, this WTP may appear high compared to the economic ability of these households. Due to the use of virtual choices, the methodology may generate overestimated WTP. Indeed, a feature as the fixed calendar for vaccination proved so important to chicken keepers that it appeared as a dominant motive for preference, orienting systematically the choice towards this option when opposed to a vaccination on demand. Such distortions of the estimated WTP and unrealistic prices are common in the application of the method (Siddo et al., 2015). This situation must be understood as a qualitative indication of the important demand rather than as a true pricing of the attribute. The WTP for animal vaccination increases with the risk that the animal disease poses to animal keepers. Most often when the risk is high, the WTP may result higher than the price applied for vaccination (Bennett and Balcombe, 2012; Terfa et al., 2015). Also, regardless of the species to be vaccinated, WTP is strongly influenced by the socio-economic characteristics of livestock farmers (Bennett and Balcombe, 2012; Kairu-Wanyoike et al., 2014; Terfa et al., 2015; Birhane et al., 2016).

The interpretation of the present results should imperatively take into account the monetary inflation between 2016 and 2020, with a dramatic change of the exchange rate between the US Dollar and FC in the period. The local currency depreciated by at least 90 % compared to the US Dollar. Indeed, chicken keepers' revenue could play a determining role in the vaccination decision.

4.2. CHALLENGES AND SOLUTIONS IN THE IMPLEMENTATION

The implementation of paid vaccination service for chicken keepers in DR Congo according to chicken keepers preferences will be confronted with two principal constraints. Those are the insufficient number of public veterinarians and the lack of logistics (in terms of transportation means, cold chain and vaccines). With these weaknesses, it would be difficult to organize a sustainable chicken vaccination in DR Congo responding to chicken keepers' expectations. The assessment of paid vaccination program for village chicken realized in Kongo-Central province identified two major obstacles for the success of such a program in the country, i.e. the lack of vaccinators' motivation and the weak chicken keepers' access to information (Lwapa et al., 2019). Yet, wider vaccination coverage are needed to interrupt the chain of pathogen transmission and to control the animal disease targeted by vaccination (Kairu-Wanyoike et al., 2014).

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The present study tested the acceptability of mobilizing the CBHWs as animal vaccinators in the prospect of taking advantage of their better access to the field. Indeed, CBWHs present a far better distribution across the DRC territory than veterinarians. Being volunteers from the communities who are involved in the implementation of health reforms and policies, one could think of the interest of their involvement in such vaccination campaigns to more rapidly spread the service across the country. This would be in line with the initial rationale for their recruitment, i.e. to compensate the scarcity of civil service in remote areas (Faye, 2012), and with their recognized role in community animation in DRC (MSP, 2006). This strategy, in agreement with the One Health concept, would appear as reverse case of the synergy established between animal health and public health services in Chad to expand the vaccination coverage of children (Schelling et al., 2007). This strategy would reduce the cost of organizing awareness activities, increase access to information for chicken keepers, fill the shortage of vaccinators and logistics, and bring chicken keepers closer to vaccinators. However, in this study, chicken keepers did not express any interest for the involvement of CBHWs in poultry vaccination, due to their lack of expertise in animal health. Thus, such a strategy would need a significant communication effort to increase its acceptability among farmers. Moreover, this innovation could be rendered more acceptable if the mobilization of CBHWs is done under the supervision of public veterinarians.

5. Conclusion

This study provides insights on expectations of Congolese chicken keepers regarding the organization of vaccination services and the impact of these on their willingness to pay. This willingness to pay clearly confirmed the good participation rate in past campaigns of paid vaccination against ND. The preference of chicken keepers for an imposed calendar vaccination by a public veterinarians was also confirmed. In order to address the challenges of vaccinators' mobility, chicken keepers' confidence and vaccinators' motivation, it is recommended to integrate CBHWs who are more stable at village level and community service motivated. Comparisons between sites based on participation in past vaccination campaigns against ND illustrated the dynamic nature of preferences and awareness levels. Therefore, knowing when preferences conflict with field necessities may appear crucial in order to more effectively direct communication efforts throughout vaccination campaigns and to better understand needed elements for trust building.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.prevetmed.2020.105097.

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