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Anatomopathological and Seroepidemiological Surveys of Avian Pseudo-Plague (Newcastle Disease) and Its Socioeconomic Impact on Family Poultry Sector in Abéché, Ouaddaï Province, Eastern Chad

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Abstract

This study investigates the epidemiological and socioeconomic impact of Newcastle disease (ND) on family poultry in Abéché, Chad. Using anatomo pathological surveys, serological testing and stakeholder interview and the authors determined an average serological prevalence of 15.3%. The study identified local perceptions of the disease, its seasonal peak, and significant economic losses for producer, collectors and merchants, which lead to high-risk behaviors like panic selling of sick birds. Newcastle disease is locally recognized forms with distinct clinical presentations. These are different manifestations of the same disease: the peracute form (Nôma) with general symptoms and petechiae, and the acute form with respiratory (Amzirnekh), digestive (Ammisserine), and nervous (Ammarara) tropisms. Salient clinical symptoms characterized by profuse greenish diarrhea (33.5%), high-pitched cry (13.4%), dizziness (11.7%) and serous oronasal serosities (10.5%) and the main lesions dominated by congestions and membrane petechiae of proventriculus. Newcastle disease resurfaces in the cold dry season in the form of a pathological complex often associated with *infectious Coryza* (Ab-iyené) in 10% and with *fowl pox* (djederi ab-rièsse) in 15% of poultry farms as opposed to the hot dry season, when it is linked to external *argas* parasitoses (dalam) and lice (Gamoul). Its annual evolution showed two

epizootic peaks in December and March. The average serological prevalence rate of the province estimated at 15.3%. However, there were observable variations with significant differences ($P < 0.05$) between the peri-urban area of Abeché (15.15%) and rural areas in the rural West area (7.7%) and rural East area of Abéché (23.07%). Furthermore, the average annual direct costs of chicken mortality were 53.371 francs CFA (81.37 €) (n = 19), 317.520 CFA francs (484.09 €) (n = 112) and 184.275 francs CFA (280.94 €) (n = 65) respectively for the production, sales and collection systems with significant differences ($P < 0.05$). The low prevalence rates obtained could likely reflect both a form of adaptation of local chickens to an endemic and less virulent avian viral strain of Newcastle disease. These vulnerability factors can compromise the profitability and sustainable development of the family poultry sector. Promoting comminuted-based biosecurity training or establishing designated safe-slaughter points.

Keywords

Vulnerabilities, Newcastle Disease, Family Poultry Sector, Adaptation of Stakeholders, Economic Performance, Abéché-Eastern Chad

1. Introduction

Global livestock population in Chad is estimated at 113.6 million heads, including 35.6 million heads of poultry [1]. Livestock capital represents more than 3000 billion CFA francs (€4.57 billion), 4% of which come from poultry [2]. Chadian egg production estimated at 2000 to 3600 tons, representing 90 million 40-gram eggs or 14.45 eggs per inhabitant [3]. Direct losses caused by mortality are significant and exacerbated by indirect losses owing to thinning and morbidity, often difficult to quantify. The seasonal Newcastle disease resurgence and the scarcity of breeding management techniques are the key factors limiting local chickens, respectively 86.7% and 50% [4]. In recent years, the Network monitoring of animal diseases surveillance in Chad is no longer functional, which compromises the surveillance Newcastle disease [5] [6]. Newcastle disease virus is mainly spread through people's actions at all levels of production, distribution, processing and of poultry sale and poultry products [7]. This disease strikes through the lack of health monitoring within family farms (78.2%), seriously affects negatively family economy [3]. Furthermore, the growing demand for poultry noticed in recent years Abéché town related to the growing urbanization (nearly 190,000 inhabitants in 2009) and the improvement of purchasing power of a middle-class segment of the population, noted since the massive influx of refugees from Darfur to eastern Chad in 2003. These movements have prompted numerous United Nations humanitarian organizations intervention.

This situation enabling the establishment of banking and financial institutions as well as universities and hotels. Thus, Abéché town has become the largest poultry consumer market in eastern Chad. However, the most disastrous period for

family poultry farming is the cold, dry season (between October and March) [8]. Better knowledge capitalization and perception of Newcastle disease by stakeholders of family poultry sector appeared essential and fully justified, enabling to political and economic decision-makers to make appropriate decisions to improve its health control and good management. Indeed, mass vaccination programs at the provincial level of family poultry population remain a relevant alternative to its eradication. The objective of this study was therefore to clarify the serological and epidemiological status of Newcastle disease and its socio-economic impact on the stakeholders of family poultry sector in Ouaddaï Province in order to establish reasoned health and medical prophylactic methods and health control strategies.

2. Materials and Methods

2.1. Study Area Location

The study took place in Ouaddaï Province in eastern sahelian zone of Chad (approximately 13˚48' of North latitude and 20˚50' East longitude). This study area is under the intertropical climate with a dry season that lasting 9 months (October through June) and a 3-month rainy season (June through September). These seasons are influenced by the fluctuations of the North dry air masses (harmattan) and humid air masses (Mousson). The average annual temperature is 28˚C and the average annual rainfall is around 300 mm [9].

2.2. Sampling

In all, 45 randomly anatomopathological studies involved 12 markets and 33 family farms in periurban zone of Abeché and rural zones in the East and West and 196 blood samplings were randomly carried out in three subzones: 66 samples in periurban area of Abéché, 65 in rural western and eastern-south zones of Abéché and 65 in rural eastern and eastern-north zones of Abéché. Furthermore, 150 poultry autopsies were carried out (50 per zone) (see **Figure 1**).

2.3. Serological Sampling Method

Anatologic and clinical signs alone were insufficient to establish a diagnosis. Serological analyses using the hemagglutination inhibition (HI) technique were required in naturally infected and unvaccinated chickens, followed by an assessment of antibody persistence. Blood samples were collected by bleeding and wing vein punctures from healthy and sick chickens. 0.5 to 2 ml of serum were collected after decantation and clot retraction, after which the serum was removed using a digital pipette (Socorex). The sera were numbered and classified by site, then temporarily stored in an insulated cooler. They were transferred for analysis to the Virology Department of the IRED. The confidence level of results was determined by the sample size and the expected prevalence based on the epidemiological prevalence observed by the PSANG Project (Food Security Project in North Guéra) and IRED. The micro-method was used to determine the sample size as follows: $n = p(1 - p) \times Z^2/i^2$; n = sample size, the constant $Z = 1.96$; i = confidence interval for

a statistical risk of 5% [10]. The final sample size of 196 serum samples was nonetheless adequate for the observed prevalence.

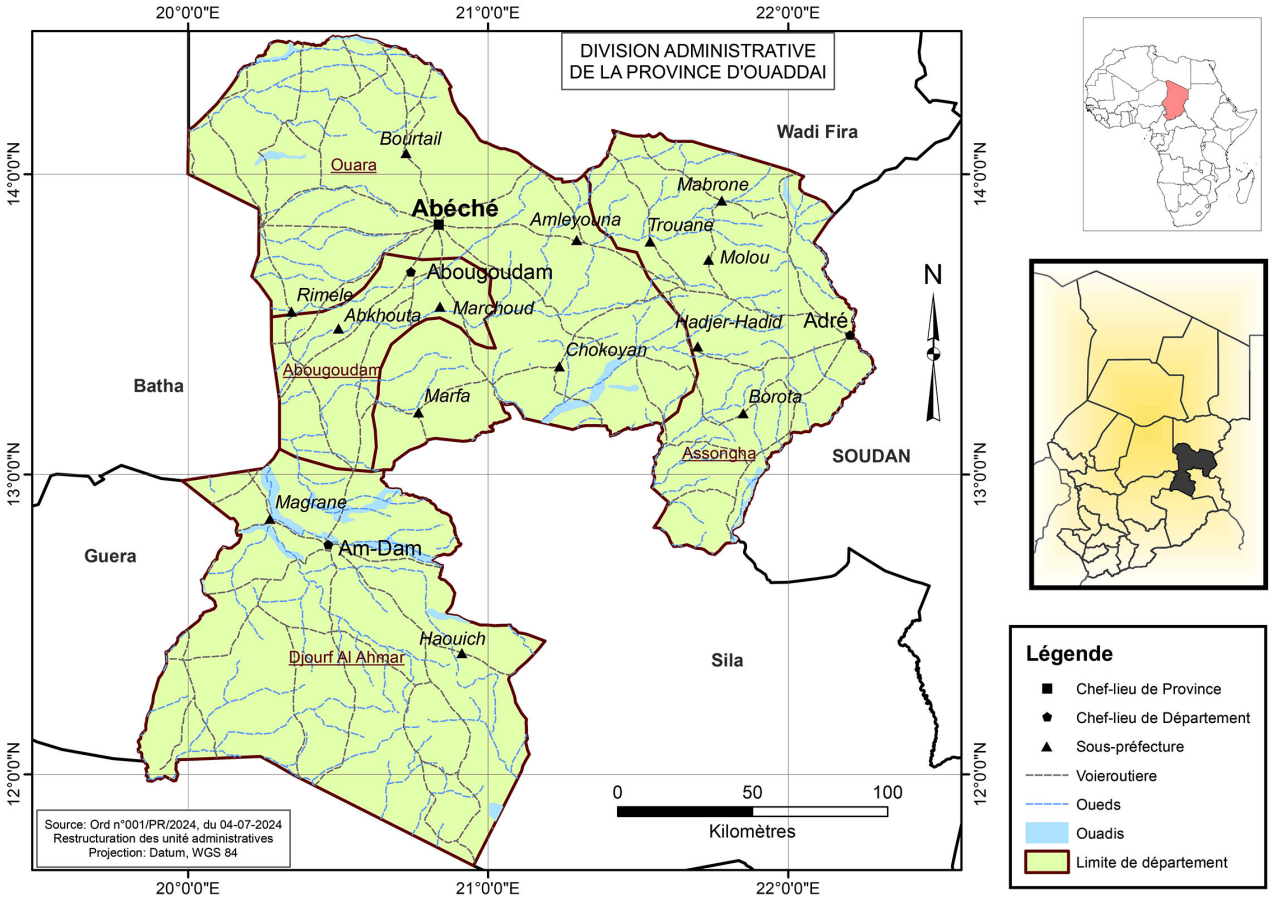

Figure 1. Urban Abéché market and its surrounding markets.

2.4. Serological Analysis Method Using Hemagglutination Inhibition

Serum pools consist of blood samples, and the sera from the same batch constitute a serum pool that is subjected to the HAI test, which is used for serological screening of Newcastle disease due to the hemagglutinating nature of the virus. Indeed, the hemagglutinating power is carried by the lipoprotein spikes of the envelope. The proteins react with the receptors on the surface of erythrocytes to cause agglutination. Viral hemagglutins are specifically inhibited by anti-hemagglutins produced by the body in response to viral infection and this is called hemagglutination inhibition (HI). Newcastle virus hemagglutinins can attach to the neuraminic acid receptors of the hen's red blood cells and cause agglutination. Reaction inhibition makes it possible to quantify the presence of specific antibodies in the hen's serum which results in sedimentation of the blood cells as in the red blood cell control. The highest dilution at which an HI occurs gives the serum titer of hemagglutination-inhibiting antibodies. Each serum titer is given by the inverse of the dilution: in unvaccinated chickens, an antibody titer greater than or equal to 40 is consid-

ered positive, a titer less than 20 is considered negative. In vaccinated birds, a titer greater than or equal to 80 is considered positive with live vaccines (HB1, La Sota). The antibody level peaks at 640 two to three weeks after the booster. Thus, a titer greater than or equal to 1280 indicates the passage of a wild-type virus. Reaction inhibition results in blood cells sedimentation, as in the red blood cell control. The highest dilution where there is HAI gives the serum titer of antibodies inhibiting hemagglutination.

2.5. Processing and Analysis of Survey Data

Data were entered into Excel spreadsheets and analyzed using standard descriptive statistics. Pearson's chi2 test was used to evaluate and compare prevalences [7] in order to compare the observed percentage to a theoretical percentage *u*. $P_{osb} = N_+/N$; N_+ = number of subjects presenting the trait; N = sample size; and P_{th} = theoretical percentage. Conditions: $N^* P_{th} > 5$ and $N^* (1 - P_{th}) > 5$. Critical value: For bilateral alpha 5% C = 1.96; Decision: u > u de la table. We reject H0: there is a significant statistical difference u = 2.886; u of table = 1.96; u > u of table. Therefore, we reject H0: There is a significant statistical difference at 5% risk threshold.

$$u = \frac{P_{osb} - P_{th}}{\sqrt{P_{th} * (I - P_{th})}}{N}$$

3. Results

The results focused on the epidemiological evolution of Newcastle disease and its impact on the economic stakeholders' performance in family poultry sector.

3.1. Stakeholders' Perception of the Sector and Symptomatic-Lesional and Epidemiological Diagnoses

Newcastle disease perceived (100% of respondents) locally by four distinct clinical presentations: hyperacute invasive (Nôma) with general symptoms and petechiae, and acute progressive states with symptoms specific to respiratory tropism (Amzirnekh), digestive (Ammisseriné), and nervous (Ammarara). **Figure 2** shows the salient clinical symptoms of Newcastle disease. It appeared in the form of pathological complexes often associated, in the cold dry season with infectious Coryza (Ab-iyené) in 10% and with fowl pox (djederi, ab-rièsse) in 15% of poultry farms, and in the hot dry season with external parasitoses, lice and argas (gamoul and dalam). Its annual evolution showed two epizootic peaks that are reached in December and March. Additionally, the oberved lesions are mainly congestions and petechiae of the membrane of the proventriculus, the cloaca and under the cuticle of the gizzard and other viscera. Advanced clinical symptoms cannot allow a definitive diagnosis of Newcastle disease, as other diseases can also present the same clinical picture. Thus, serological diagnosis in the laboratory is of paramount importance.

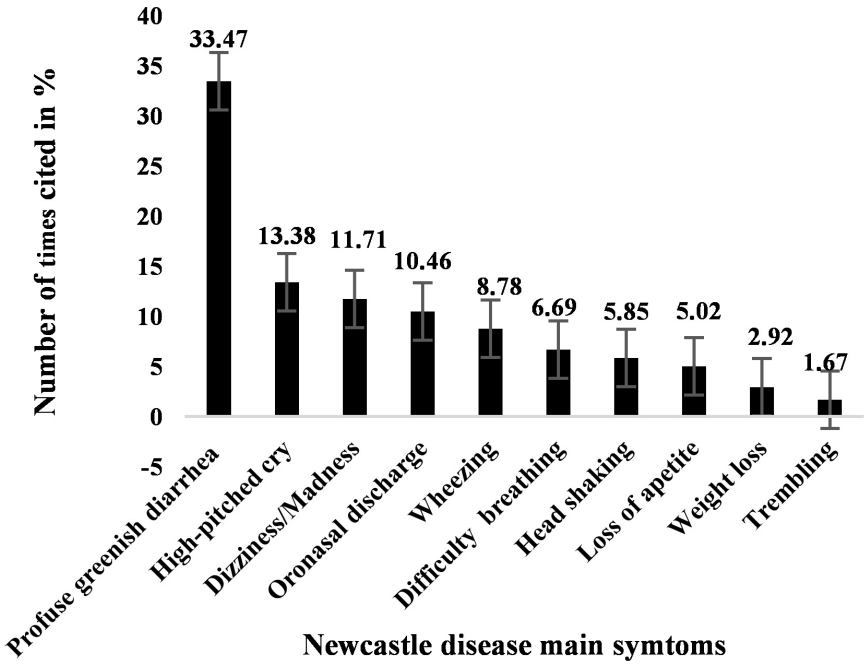

Figure 2. Clinical symptoms of Newcastle disease.

3.2. Newcastle Sero-Epidemiological Prevalence

The average serological prevalence rates observed in the study area was 15.3%, with a variation between 15.15% in peri-urban area of Abéché and 7.7% and 23.07%, respectively, in rural areas located west and east of Abéché, with significant differences ($P < 0.05$).

3.3. Stakeholder Behaviors in Relation to Newcastle Disease

Adapting to the near-endemic situation of Newcastle disease and avoiding significant mortality, required stakeholders in the family poultry sector to adopt disease risk management strategies that are the least harmful and contrary to public health standards. Newcastle disease remains a source of dread for farmers. Its sudden break out, responsible for significant morbidity and mortality among chickens, will trigger panic among breeders. They rush and carry chickens piece by piece to the nearest market for their liquidation, often at ridiculously low prices and without complying with defensive and offensive prophylactic health measures. Since Abéché town does not have an approved poultry slaughterhouse, chickens are slaughtered at the sale point, on the ground, near holes dug for the purpose and sometimes in plastic bags spread out on the ground by ignoring hygiene measures and basic sanitation standards. That can be the source of triggering a vicious contamination cycle among chickens. Young boys are hired to carry out this slaughtering task for a modest amount of 100 CFA francs (€0.15) per unit of slaughtered poultry (Figure 3). The equivalent of dead chickens' price is immediately distributed among live chickens' prices, contributing to the chicken prices soaring up.

Figure 3. Poultry Slaughter at Abéché Central Market sale point.

3.4. New Castle Direct Economic Costs

In Figure 4, consigned are average annual direct economic costs, which are losses due to chicken mortality, for the average producer, the average urban wholesale collector, and the average merchant-reseller in Abéché markets. These costs showed with significant differences ($P < 0.05$).

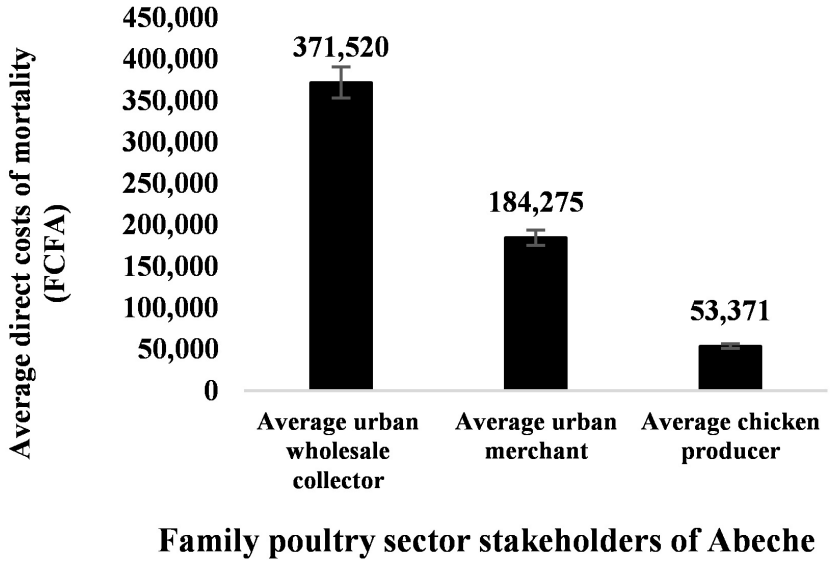

Figure 4. Average direct costs of Newcastle disease mortalities for actors for the family poultry sector in Abéché with significant differences ($P < 0.05$).

4. Discussion

4.1. Sector Stakeholders' Perception and Symptomatic-Lesional and Epidemiological Diagnoses

The profuse greenish diarrhea symptom (34.5%) that characterizes Newcastle disease does not corroborate that of whitish chalky diarrhea described by Mao *et al.* [11] and Ebwa *et al.* [12] (74%) respectively in the villages of Ngoko (90.9%),

Tchanar (57.9%), and Ndjoy (82.4%) in southern Chad and Yangambi in the DRC. On the contrary, these poultry farms in the southern zone did not observe nervous symptoms and dizziness at all. Sylla *et al.* [12] observed an atypical form in Mali with the absence of nervous symptoms and less developed respiratory symptoms. We are observing both respiratory and digestive forms in this region. The disease resurgence, often in the cold dry season in peri-urban and rural livestock farms, may be the direct consequence of a lack of vaccination practices and a near absence of biosecurity. [13] noted precariousness and promiscuity in livestock farming management as well as a failure to comply with biosecurity rules in family poultry farming in Yangambi in the DRC. However, Newcastle disease mortality, which is estimated at between 23.7 and 53% of the average flock size, is lower than that indicated by Ebwa *et al.* [12] (61%), Courtecuisse *et al.* [14] (63%), Branckaert *et al.* [2], Capelle *et al.* [15] and Mourad *et al.* [16]. According to Ebwa *et al.* [12] and FAO [7], Newcastle disease is the leading cause of mortality in chickens in unvaccinated family poultry farms and therefore remains the main obstacle to the development of family poultry farming in Africa. This disease strikes in the cold dry season (mid-November-end of February), often in the form of pathological complexes in association with *infectious coryza* (ab-iyené) in 10% of poultry farms and with *fowl pox* (djederi, ab-rièsse) in 15%. Failure to comply with biosecurity rules and farm hygiene are also factors allowing the break out of argas (Dalam) in poultry in the dry season. According to Maho *et al.* [17], the existence of several different antibodies sometimes present in the same bird shows an association of infections. Newcastle disease reaches its two epizootic peaks in December and March, coinciding with the retreat of the Intertropical Front (ITF), accompanied by harmattan, a hot wind blowing from North to South and which, according to Couacy-Hymann [18], is supposed to spread the germs. Maho *et al.* [8] also reported this disease in poultry farms in southern Chad. Maho *et al.* [8], Ban-Bo *et al.* [19] noted a peak between October and March, whereas Ebwa *et al.* [20] only observed them between June and July in the DRC. Indeed, these periods are times of intense economic and commercial exchanges. Furthermore, Sylla *et al.* [13] reported three epidemiological peaks observed in January, May and November. Thus, the average serological prevalence rate of 15.3% observed in the study area appeared higher than that indicated by Maho *et al.* [17] (7.33%) in northern Guera in Chad and Issa Ibrahim *et al.* [21] (9%) in the commune of Hamdallaye in the Tillaberi region of Niger. However, these rates are almost similar to those indicated by Courtecause *et al.* [14] and Issa Ibrahim *et al.* [21] in the local chiken breeding basin and urban commune of Namari in Niger, 14 and 15% respectively. Seropositivity rates obtained are likely low due to the virulence of the wild virus strains that seem to be attenuated and especially by the great adaptation of local breed chickens to their environment. These low incidence rates are particularly observed in Guéra Province located in the South-west of Abeché (Maho *et al.* [17] and in the Southern provinces of Chad (Maho *et al.* [8]. Newcastle disease thus presents an endemic character, its low incidence could be explained in particular, in the peri-urban zone of Abéché, and in that which is located in the West, by the vaccination that

covered 4% to 10% of poultry farms. Mopate and Awa's work results conclusions [22] showed that research on Newcastle disease is of great interest and deserves to be exploited in family poultry farming development context in the sub-region. In addition, to contain Newcastle disease, poultry producers resorted to the use of some modern medicines, such as oxytetracycline capsules, amprollium and insecticide, although inappropriate and ineffective for viral germs. Many of them recommended ethnoveterinary substances based on decoctions and macerations of Acacia tortilis pods, wild cucumber, salted solutions or chili water, sorrel calyx and camel urine.

4.2. Stakeholder's Behaviors in Relation to Newcastle Disease

In recent years, Newcastle disease has appeared persistent and quasi-endemic. Stakeholders in the family poultry sector have increasingly adapted while adopting disease risk management strategies to stem mortality losses. The disease breakout, with significant morbidity and mortality among chickens, often causes panic among farmers. Therefore, contaminated chickens are rushed to the nearest markets for sale at a ridiculously low price, without complying with defensive and offensive health standards and prophylactic measures. Maho *et al.* [8] notably reported the rise of psychosis during the Newcastle disease epizootic, leading to rushed sales of diseased chickens among poultry sector stakeholders in southern Chad. These new harmful behaviors are contrary to public health standards. Since Abéché town is deprived of an approved poultry slaughterhouse, chickens are slaughtered at a point of sale, on the ground, near holes dug for the purpose and sometimes even in plastic bags spread out without compliance with the most basic hygiene measures and sanitation standards. This situation can trigger a new vicious cycle of chickens contamination. Young boys are hired to carry out this slaughtering task for the modest amount of 100 CFA francs per unit of slaughtered poultry (See **Figure 1**). The stakeholders automatically divide the prices of dead birds among the living ones, which contributes to making chickens even more expensive. Newcastle disease therefore, remains a source of dread for farmers due to considerable damage. When the second epidemic peak occurs in March, family poultry farmers' activities decrease sharply or disappear after 8 months (from July through February). These poultry farms are only revitalized and reinvigorated at the beginning of the rainy season, when transhumant farmers return to the Province from areas located in southern areas of Abéché. Monitoring authors of health status of commercial livestock farms at the Veterinary Medicine Faculty of Ahmadou Bello University in Zaria, Nigeria, cited by [23], consider the inexistence of direct proven link between habitat or climate and pathology. They rather blamed poor farm management that could play a significant role in avian diseases resurgence.

4.3. Direct Costs of Newcastle Disease

Only 36.7% (more than 1/3) of chickens survive Newcastle disease. However, those being in a state of advanced emaciation and economic deprivation are still capable of eliminating the virus within 7 to 60 days. According to Ebwa *et al.* [12],

the disease endemicity can be explained by the avian flock's reconstitution from rescued birds, but those locally considered resistant. Faced with Newcastle disease that can cause up to more than a quarter the average poultry flock losses, poultry farming families adapted relevant strategies against this situation of lesser vulnerability due to stakeholders' multi-activities. In fact, most poultry farmers manage to maintain their poultry farming practice by exhibiting greater resilience. Indeed, for all stakeholders, poultry farming is a secondary practice that complements primary farming activities or truck farming and small businesses, which are largely favored and the basis for acquiring chickens, allowing them to return to a new family poultry farmer's lifestyle. Moreover, this health constraint is often exacerbated by the association of Newcastle disease with infectious coryza and fowl pox in the cold dry season. Absence of a systematic vaccination campaign and poor enforcement of current regulations hinder health policies implementation regarding chickens' transportation and their quarantine. Indeed, quality is considered at all levels as a requirement and an element of competitiveness. Therefore, it would be necessary to establish comprehensive control measures in terms of surveillance strategies and adequate mass vaccination at the interregional level to expect its eradication. This study, focusing on Newcastle disease, attempted to specify the cost of the disease and its real impact on the sustainable management of the segmental economies of the different stakeholders of local poultry sector. These poultry farmers wish to vaccinate their chickens, but the vaccines unavailability and inaccessibility limit their capabilities. In any case, vaccination remains the only effective tool in fighting against Newcastle disease. Its incidence could not be only minimized that the establishment of standards and strict livestock management rules. Finally, developing family poultry farming cannot be only sectoral, as it goes beyond technical considerations and, according to Pagot [24], should be integrated in the global planning issue underpinned by political will.

5. Conclusion

Local family poultry farming certainly contributes to improving rural households' living conditions. Unfortunately, Newcastle disease is undoubtedly the major health constraint affecting family chickens at different level of poultry value chains hindering its sustainable development in Ouaddaï Province. Important poultry mortality linked to this pathology contributes to poverty increase and malnutrition by the reduction of family self-consumption. Establishing an adapted vaccination program against this pathology turns out to be compelling. Poverty and malnutrition increase are attributed to the important poultry mortality linked to this pathology. In fact, risk of break out of epizooties, such as Newcastle disease requires efficient surveillance by setting up a follow up observatory in the field and an active and prompt capability. During the cold dry season, this desease Newcastle seemed to be exacerbated association with the Coryza and poultry pox deseases. Lack of a systematic vaccination campaign and poor enforcement of current regulations hinders health policies implementation regarding chickens' transportation and their quar-

antine. Therefore, quality is required at all levels and has to be considered as an element of competitiveness. It would be necessary to establish comprehensive fighting measures in terms of surveillance strategies and adequate mass vaccination at the interregional level to expect its eradication. This study, focusing on Newcastle disease, attempted to specify the costs of the disease and its real impact on sustainable management of the segmental economies of different stakeholders of local poultry sector. Poultry farmers want to vaccinate their chickens, but the vaccines unavailability and inaccessibility of vaccines limit their capabilities. In any case, vaccination remains the only effective tool for fighting against Newcastle disease. Personnel training, applying strict breeding management, setting up a scheme of reasoned health prophylaxis and an adapted vaccination program, could not minimize this disease incidence. Finally, family poultry farming is crucial in generating family income and food security. Lower costs will enable consumers to obtain chicken meat and eggs at affordable price. Developing family poultry farming cannot be only sectoral, as it goes beyond technical considerations, and should be integrated in the global planning issue underpinned by political will. Promoting comminuted-based biosecurity training or establishing designated safe-slaughter points.

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Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

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