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Spatio-temporal Prevalence of Foot and Mouth Disease (FMD) in Zimbabwe from the Year 2006-2016

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ABSTRACT

Foot and mouth disease (FMD) is a highly contagious viral disease that primarily affects cloven-hooved livestock and wildlife, with cattle as the main hosts. The disease is endemic to Zimbabwe, Southern Africa and other parts of the world. FMD increases production losses and has resulted in the loss of the lucrative local and international beef markets. This study determined farmer perceptions on FMD and investigated the spatio-temporal distribution of the disease over a 10-year period in Zimbabwe. Farmer perceptions on FMD were determined through a semi-structured questionnaire that was administered to a purposive sample of 99 farmers who delivered cattle to Grills Abattoir in Bulawayo Province. Spatio-temporal distribution and incidence of FMD were mapped with QGIS using 2020 records obtained from the Department of Veterinary Services. Odds ratio estimates indicated the likelihood of occurrence of FMD in a given district. Eighty-seven percent of the respondents had some knowledge about FMD most of which was obtained from the government veterinary officers (42.2%). Farmers identified cattle (68.6%) and buffalos (41.2%) as the species most vulnerable to FMD. About 81% of the farmers acknowledged the negative impacts of FMD on cattle productivity. Farmer perceptions on FMD prevention and control varied widely and were largely inaccurate. Most farmers believed FMD could be cured with common antibiotics such as oxytetracycline. Foot and Mouth Disease had spread from districts from the south of the country to the north western parts of Zimbabwe although some districts had not experienced any outbreaks at the time of the study. Given the spread and prevalence of FMD, there was an urgent need for the Government to invest in the identification of more effective FMD control approaches to prevent nation-wide spread and recurrence.

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INTRODUCTION

Foot and Mouth Disease is a viral panzootic disease caused by a virus (FMDV) of the genus *Aphthovirus* in the family *Picornaviridae* (Aftosa, 2015). The disease has seven major viral serotypes namely O, A, C, Asian 1 and Southern African Territories (SAT 1, 2 and 3; Aftosa, 2015). The disease manifests itself as painful blisters and sores on the feet, tongue and teats of infected cloven-hooved livestock and wildlife (*Oficina Internacional de Epizootias*: OIE, 2011) leading to lameness, hunger and ultimately death. FMD is endemic in Matabeleland North and South, Masvingo, Manicaland and Midlands provinces in Zimbabwe. Active clinical infections have also been reported in Chipinge South, Mwenezi, Chivi, Mvuma, Chiredzi, Chegutu, Marondera, Rushinga and Kwekwe districts (OIE, 2018). Regionally, FMD outbreaks have been reported in Malawi, South Africa and Zambia in Southern Africa, Ethiopia and Kenya in East Africa, as well as Ghana and Nigeria in West Africa between the years 2017-2018.

The first foot and mouth disease (FMD) outbreak in Zimbabwe was recorded in 1931 after which subsequent FMD outbreaks have been recorded albeit with oscillating distribution (Thomson, 1995). Over the years, FMD occurrence has had devastating economic consequences on beef production and beef cattle marketing in Zimbabwe. The FMD prevalence led to loss of trade in beef with the European Union (EU) market in the year 2000 (Mavedzenge et al., 2006). Zimbabwe used to export over 14 000 tonnes/ annum of beef to the European Union, Middle East and Asian markets valued at about US$50 million annually. These exports ceased in the year 2000 following the land redistribution exercise which, unfortunately, resulted in the massive breakdown and disruption of decades of disease control infrastructure (Scoones and Wolmer, 2007). Since then, recurrent Foot Mouth Disease (FMD) outbreaks have been experienced.

The African buffalo (*Syncerus caffer*) has been identified as the major host of FMD virus. Because of the unintended interface between cattle and buffaloes, the latter is historically one of the major drivers of increased infections of the disease in Zimbabwe. The exponential growth of the buffalo population in the Kruger National Park of South Africa in 1980 resulted in buffalos escaping from the park into Zimbabwe thereby increasing the chances of their contact with cattle (Thomson, 1995) and subsequent increases in FMD transmission particularly in southern Zimbabwe which borders the Limpopo province of South Africa in which the Kruger National Park is located (Figure 1).

Figure 1. Map of Zimbabwe, districts, Provinces and major cities [Source: https://commons.wikimedia.org/wiki/File:Zimbabwe.geohive.gif#/media/File:Zimbabwe.geohive.gif]. Accessed: 01/03/23.

In Zimbabwe, FMD is considered a notifiable disease whose control and management is regulated under the Animal Health Act (AHA) (Foot and Mouth) Regulations, (1971) and by the Animal Health (General) Regulations (1994) and its amendments. The Act makes vaccination of exposed animals, controlled movement of animals from infected areas, quarantine of suspected cases and area zoning mandatory for the prevention of the spread of FMD (Perry et al., 2003). Despite all these measures the disease remains a major challenge with recurrent outbreaks severely frustrating attempts to revive beef exports to international markets. The EU requires that a country be FMD-free for at least two years before exports resume. This study was designed to determine farmer perceptions on the importance of FMD in livestock production and marketing, explore its prevalence as well as map the spatial and temporal distribution of this transboundary disease in the country. This would guide and inform the implementation of more robust and effective FMD control measures leading to possible eradication of the disease, which could ensure access to lucrative local and international beef markets in the long run.

MATERIALS and METHODS

Study site

Zimbabwe is a landlocked country in the Southern African region. It has a mean elevation of 961 m and experiences tropical climatic conditions. The rainy season in the country stretches from November to March. Zimbabwe is surrounded by and shares land boundaries with Botswana, Mozambique, South Africa and Zambia amounting to a total of 3 229km (CIA World Factbook, 2018). The country is divided into five agro-ecological regions on the basis of climate, soil and landform characteristics (FAO, 1996). Natural regions I and II are suitable for both crop and livestock production while NR III, IV and V are predominantly ideal for livestock production particularly cattle and goat rearing (Mugandani et al., 2012). Several transfrontier conservation areas (TCA) are located across the borders of Zimbabwe and these hold several herds of buffalo which a reservoir of this transboundary disease. These include the Great Limpopo Transfrontier Park shared by Mozambique, Zimbabwe and South Africa, the Greater Mapungubwe Transfrontier Park to the south west shared by Botswana, South Africa and Zimbabwe, the Lower

Zambezi-Mana Pools TCA to the North West, Zimbabwe-Mozambique-Zambia (ZIMOZA) TCA, the Kavango-Zambezi TCA shared by Zambia and Zimbabwe and the Chimanimani TCA to the east shared by Mozambique and Zimbabwe.

Key

Treaty Signed

1. /Ai/Ais – Richtersveld TP* (Namibia/South Africa)

2. Great Limpopo TP and TFCA* (Mozambique/South Africa/Zimbabwe)

3. Kavango Zambezi TFCA* Angola/Botswana/Namibia/Zambia/Zimbabwe)

4. Kgalagadi TP* (Botswana/South Africa)

5. Lubombo TFCA* (Mozambique/South Africa/Swaziland)

6. Malawi-Zambia TFCA* (Malawi-Zambia)

7. Maloti-Drakensberg TFCA* (Lesotho/South Africa)

MOU signed:

8. Chimanimani TFCA (Mozambique/Zimbabwe)

9. Greater Mapungubwe TFCA* (Botswana/South Africa/Zimbabwe)

10. Iona-Skeleton Coast TFCA (Angola/Namibia)

11. Mayombe Forest TPA (Angola/Congo/DRC/Gabon)

12. Niassa-Selous TFCA (Mozambique/Tanzania)

13. Kagera TFCA (Rwanda/Tanzania/Uganda)

14. Liuwa Plains-Mussuma TFCA* (Angola/Zambia)

15. Lower Zambezi-Mana Pools TFCA* (Zambia/Zimbabwe)

16. Mnazi Bay-Quirimbas TFCMA (Mozambique/Tanzania)

17. Western Indian Ocean TMP (Comoros/Kenya/Reunion (France)/ Madagascar/Mauritius/Mozambique/ Seychelles/Somalia/South Africa/ Tanzania)

18. ZIMOZA TFCA (Mozambique/Zambia/Zimbabwe)

Figure 2. The Southern African Development Community (SADC) Transfrontier Conservation Areas (TCA) (Adapted from SADC Transfrontier Conservation Areas (TFCA) bronchure (2017).

In the year 2013, Zimbabwe had 700586 farms and a total cattle population of 4 857 702. This increased to 4 868 358 in 2014 (ZimStats, 2014). Masvingo, Bulawayo, Mashonaland West and Matabeleland South have the highest slaughters across the country (LMAC, 2018). Zimbabwe produces about five million metric tonnes of beef annually, 90% of which is from smallholder farms.

Sampling and data collection

Secondary and survey data were used in this study. The survey was conducted to determine farmer perceptions on the importance of FMD in livestock production. Ninety-nine farmers delivering their cattle to Grills Abattoir in Bulawayo were randomly selected and interviewed using a semi-structured questionnaire. Grills abattoir was purposively selected to take advantage of its very diverse catchment. Its location in Matabeleland Province is also strategic since FMD outbreaks have traditionally been experienced here. It was, therefore, hypothesised that respondents would provide useful knowledge about FMD and therefore meaningfully contribute to the study. Demographic details, socio-economic household characteristics, general livestock rearing, knowledge, farmer experiences and perceptions on FMD, impact and FMD control measures were some of the details captured through the survey.

The secondary data on FMD cases were obtained from the Division of Livestock Production and Veterinary Services of Zimbabwe. The data collected included date, district, area, location and census on cattle that had FMD.

Statistical analysis

Surveys were entered and analysed using IBM SPSS Statistics ver. 25 (2017). Descriptive statistics were generated and a Chi-square test was done to test for association between variables. Secondary data were edited by removing unrealistic values such as negative and infinite incidences, duplicate and missing records on different variables. Disease incidences were then classified into 4 categories on the basis of quartiles. Logistic ordinal regression analysis was performed in SAS ver. 9.4 (2015) to determine the effect of the district on FMD incidence. The following model was used;

$$\ln\left[\frac{P}{1-P}\right]=\beta_0+\beta_1X_1+\varepsilon$$

Where;

P is the probability of low FMD incidence being category 1

$\left[\frac{P}{1-P}\right]$ represents the odds of FMD incidence

β_0 is the intercept

β_1 is the partial regression coefficient linking district to the odds of the FMD occurrence

ε the random residual error term

Quantum Geographic Information Systems (QGIS) version 3.0.3 Girona (2018) was used to map the spatial and temporal distribution of FMD on a geo-referenced Zimbabwe boundary shape file. The data on FMD cases were converted to Comma Separated Values (CSV) delimited data using Microsoft excel (2010). The boundary shape file was loaded into QGIS, after-which the CSV data were added as a layer. A map was then created and the necessary attributes of a standard map incorporated. The same concept in QGIS was used in ArcGIS ver. 10.5 (2017) to relate odds ratios obtained from SAS analyses with districts. Similarly, a map was created based on the relationships between district and the probability of FMD occurrence to distinguish areas that were more susceptible to FMD occurrence from those that have never experienced FMD.

RESULTS AND DISCUSSION

Household demographics and socio-economic status

The study drew respondents from 22 districts across Matabeleland North and South, Midlands and Masvingo provinces. The average age of the household head was 53.1±15.99 compared to 52.4±16.20 years recorded in a previous study (Mhlanga et al., 2018). The youngest and oldest respondents in this study were 20 and 90 years old, respectively. Ninety one percent of the interviewed respondents were males. Eighty-two percent of the respondents were married, 7.1% widowed, 2.0% divorced and 9.1% single. This is contrary to ZimStats (2017) where 36% of the country's marriageable population were married and 14% were either divorced or widowed. The majority of the respondents were literate where 56.6% attained secondary education, 12% - tertiary level with the remainder (31.3%) having dropped out of primary school. This is in contrast with the report by Mhlanga et al. (2018). The average household size was 6.7 ± 5.26 members, similar to of 6.7 ± 2.68 observed in a separate study (Mhlanga et al., 2018) in Nyanga north district of Zimbabwe. Contrary to this, ZimStats (2017) reported average household size as 4.2 with a spread of 4 to 6 members per household. In the current study, 64.3% obtained income from either crop or livestock farming of which 94.6% highlighted cattle sales as a major source of income. An FMD outbreak would thus have damaging consequences on their livelihoods. That cattle play a major role in the lives of farmers has been demonstrated before (Maburutse et al., 2012).

Livestock production

Cattle (20.16± 26.012) and chicken (30.74±36.018) were the most common species kept by farmers while donkeys (4.95±2.408) and sheep (5.90±4.408) were the least common species kept by farmers (Table 1).

Table 1. Descriptive statistics of the livestock species kept by respondents (N≥9)

Species	N	Min.	Max.	Mean	Std. Dev.
Chickens	91	2	300	30.74	36.018
Cattle	93	1	150	20.16	26.012
Goats	87	1	75	15.15	13.822
Turkeys	9	2	70	14.67	21.909
Sheep	10	2	15	5.90	4.408
Donkeys	56	1	12	4.95	2.408

Of the respondents that kept cattle, 35% used them for draught power, meat and milk. Communal cattle have multiple-purposes such as milk, manure (Shava and Masuku 2019; Masikati, 2010; Ndlovu et al., 2004), draught power, wealth status, socio-cultural ceremonies including lobola and the appeasement of the ancestral spirits (Mmbengwa et al., 2015; Maburutse et al., 2012). There was no relationship between cattle herd size and district nor district and use ($\chi^2 = 823.432$, df = 828, $P > 0.538$).

Ninety percent of the respondents used natural grazing as a source of cattle feed. The land is usually inadequate and herding is common. All the cattle from the entire village may be considered as single interbreeding herd which results in high disease and parasite prevalence (Mavedzenge et al., 2006). The major water sources for livestock were dams (46.4%) while the least commonly used was the water well (5.1%).

Veterinary services were mainly sourced from private Veterinary drug suppliers (27%) and Government veterinary officers (14%). Most farmers (65%) stored medicinal drugs for future use and the most common was oxytetracycline (23.3%).

Twenty-seven cattle diseases were reported in this study with black leg being the most common (55.6%) affecting cattle. Lumpy skin disease (46.7%) and Foot and Mouth Disease (33.3%) were also mentioned by respondents. Elsewhere, black leg, heart water, babesiosis, anthrax and anaplasmosis were the most common diseases

(Masikati, 2010; Mavedzenge et al., 2006). Some respondents also reported using the black leg vaccine to vaccinate cattle (30%) at least once a year (65.8%). Oxytetracycline (3.9%) was used for the control of various disease conditions and the lumpy skin vaccine (12.7%) was used to control of lumpy skin disease. Vaccination was done once a year (74%). For FMD control, the FMD vaccine was used (7.9%). FMD vaccination was done once a year (69.2%).

Farmer perceptions on foot and mouth disease

Eighty-seven percent of the respondents had some knowledge about FMD. Knowledge on FMD was obtained from the community (16.7%), personal experience (2%), extension workers (5.9%), government veterinary officers (42.2%) and the media (3.9%). In this study, animal species known to be affected by FMD were cattle, buffalo, kudu and impala and this is in agreement with the OIE (2005; 2008) and Coetzer et al. (1994). That farmers had some knowledge about FMD was reported previously in Kenya (Nyaguthii et al. 2019). In Ethiopia, 82.4% of the farmers surveyed knew about FMD (Mesfine et al. 2019). According to the respondents, the most affected animals were cattle (68.6%) and buffalos (41.2%). Literature reports cattle as susceptible to FMD (FAO, 1996). The respondents noted that the signs and symptoms of FMD were excessive salivation as also observed by Nyaguthii et al. (2019), lameness and sores on the mouth, tongue and hooves. This observation agrees with Aftosa (2015) and Alexanderson et al. (2003). Respondents, however, believed that FMD is caused by buffalos (18.6%) and wildlife in general (15.7%). While the researcher did not expect farmers to demonstrate accurate knowledge of the causative agent, that FMD was caused by a virus and transmitted by buffalos was thought to be common knowledge. Such knowledge is vital for effective control and management of the disease. For instance, the administration of antibiotics such as oxytetracyclines should not be expected to cure FMD, a viral disease. Buffaloes are the major host of SAT 2, in particular, although a single animal can be infected with 3 serotypes namely SAT1, 2 and 3. Generally, African buffalo are regarded as the major host of these viruses (Volsoo et al., 2004). The majority of the respondents (58.1%) believed that FMD could not be transmitted to humans, a common misconception that has been witnessed in separate work (Aftosa, 2015).

Farmer experiences on FMD

Most of the respondents (59%) had no prior experience with FMD outbreaks. In Ethiopia, 85% of respondents had experienced the disease (Mesfine et al., 2019) while in Sri Lanka, more than 60% had experienced FMD outbreaks in their livestock herds (Gunarathne et al., 2016). The study showed that the period 2015-2017 had more (17%) FMD outbreaks than previously known. There has been increased FMD incidence between the years 1999 and 2017 (Figure 3). In the event of an outbreak, farmers reported the cases to government veterinary officers (8%) for vaccination while others (10%), inappropriately, used oxytetracycline to treat affected and non-infected animals. It emerged from the study that this was done without confirmation or positive identification by the responsible experts. Such activities constitute malpractices that are detrimental to the eradication and effective control of FMD. Those who reported cases of FMD to Government Veterinary officers (20%) purposed to get their herds vaccinated. Some of the respondents noted that they did not report suspected cases of FMD. Similar reports have been made before (CFU, 2014). According to the CFU (2014), 33% of farmers procrastinate reporting any suspected cases. Such farmers simply lack motivation since they are expected to purchase vaccines in the event of an outbreak (CFU, 2014). The cost of vaccination is also a hindrance with each dose costing US$2. Follow-ups are done by the Government Veterinary staff where they vaccinate cattle with either FMD vaccine or administer oxytetracyclines, if available. Forty-nine percent of the respondents think that meat from FMD-infected animals could kill the consumer.

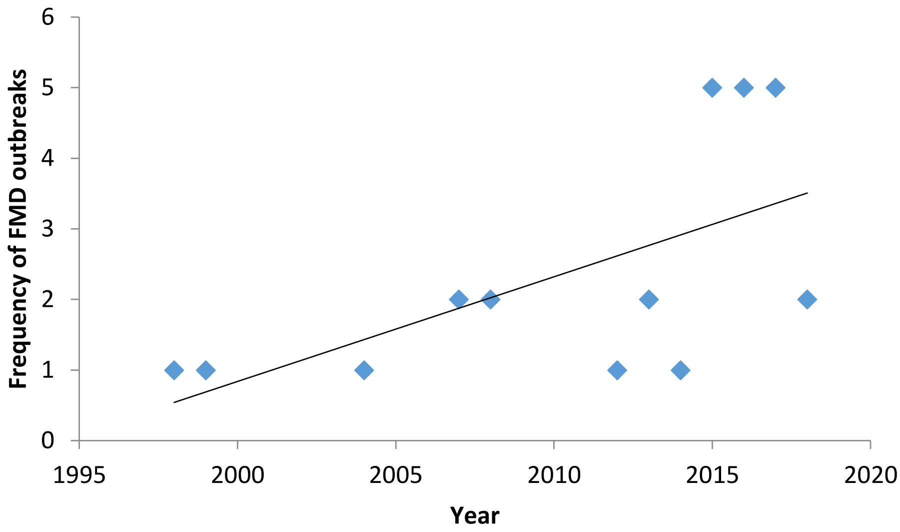

Figure 3. FMD occurrence by year based on farmer interviews

Fencing

Fencing was used for paddocking, protection of crops and livestock (20.2%) and for marking boundaries. Forty one percent of the respondents had fencing around their farms. A few (24%) of the respondents are close to a game park. Chi-Square analyses, however, showed that there was no association ($\chi^2 = 0.185$, df = 1, $P > 0.667$) between proximity to the game park and FMD occurrence. This is contrary to the report by CFU (2014) that FMD is limited to areas close to wildlife sanctuaries with resident buffalos including Gonarezhou, Chimanimani, Hwange and Chizarira National Parks (Figure 1). This probably confirms that FMD has invaded areas that have traditionally been regarded as green zones in Zimbabwe. The importance of game parks has been underscored before (Kivaria, 2003). Weaver and co-workers (2013) noted that there are several wildlife sanctuaries in Southern and Eastern Africa holding large wildlife populations and this creates extensive wildlife/livestock interfaces and thus, complicates FMD control. The wildlife serve as hosts and circulate SAT strains of the FMD virus (Jori and Etter, 2016). These workers concur that most outbreaks occur during and immediately after the dry season where wildlife and livestock meet at the water points and on pastures.

Impact of FMD and its control measures

All respondents felt that knowledge of FMD was important and 81.4% confirmed that FMD significantly affected livestock, particularly, cattle production. Of note was the restriction on the marketing of cattle. This was worsened by unscrupulous market players who valued monetary returns more than FMD control (LMAC, 2018; CFU, 2014). Affected cattle become unproductive as they cannot be used for draught power. They become anorexic, shiver and drool from the mouth with smacked lips. Pregnant cows cannot sustain pregnancy due to lameness. In addition to lethargy, affected animals lose condition rapidly and may exhibit a gradual or sudden, severe decline in milk production (Aftosa, 2021). Forty percent of the respondents reported that FMD killed animals. This agreed with previous reports (MFNP, 2012; CSO, 2010-11; Doel, 2003) although farmers needed to be aware that mortality resulted from secondary infections rather than FMD *per se*. It was encouraging to note that farmers would not sell affected animals or meat from the same which would hasten FMD spread. Farmers were, however, not clear of the need to properly dispose of infected animals or their carcasses since disposal was by coercion. Twenty-one percent of the respondents had not done anything to prevent FMD because the cost of the vaccine was prohibitive. Rather, they waited upon State-driven vaccination programmes while others only injected oxytetracyclines as a control measure.

The role of Government Veterinary Officers in controlling FMD was acknowledged by the respondents. They showed that disease control was mainly through vaccinations and awareness campaigns spearheaded by the State. Fifty percent of the respondents, however, felt that the State could do more if FMD was to be eradicated. In previous work, failure to vaccinate small ruminants was cited as a problem where these became reservoirs of the FMDV (Anderson et al., 1976). Gunarathne et al.

(2016) cited the lack of regular vaccination programs as one of the key drivers of FMD outbreaks. In Korea in 2011, animals located in outbreak areas were stamped out as a way of containing the spread of the FMDV (Yoon et al., 2016). In the current study, respondents felt that the current FMD control measures were fairly effective (59.3%).

Eighty percent of the farmers thought FMD was curable by the use of vaccines, caustic soda, penicillin, salt and oxytetracyclines available at various veterinary drug suppliers (63%). Such gross misconceptions warrant training and awareness campaigns. Sixty-four percent of the respondents had heard about zoning pertaining to FMD control. They defined zoning as the grouping of animals into FMD positive and negative categories to enable movement restriction in affected areas. Zimbabwe has been divided, based on FMD prevalence, into 5 zones namely; wildlife (W), the vaccinated zone adjacent to the wildlife zone (red zone), non-vaccinated buffer zone (green zone) and the clear zone which consists of zones C and E from where exports would be drawn (Anderson et al., 1993).

In this study, respondents defined Foot and Mouth Disease red zones as areas with affected animals and those that have buffaloes close-by while green zones were described as unaffected areas. They reported that they were located in the green zone. The reason for zoning was to restrict the movement of affected cattle to prevent FMD spread. Zoning was meant to eradicate buffalo from farming areas to establish FMD-free zones to allow exports of beef to Europe (Anderson et al., 1993). Forty-five percent of the respondents consider zoning an effective control strategy with about 53% of the farmers having been suspended from moving their cattle at least once. Elsewhere, Zambia affected different FMD control measures since 1933. Such measures as movement restrictions have not been satisfactory and collapsed because in 1980 when they could not be sustained (Perry and Hedger, 1984). The effectiveness of fencing in controlling FMD is questionable given the persistent outbreaks (Muuka et al., 2012). Vaccinations have also been conducted as an immediate response to outbreaks (NDPZ, 2011; DLVD, 2009). Surveys were also done to understand the farmers' knowledge, attitudes and perceptions and how they adapt to FMD outbreaks (Perry and Rich, 2007).

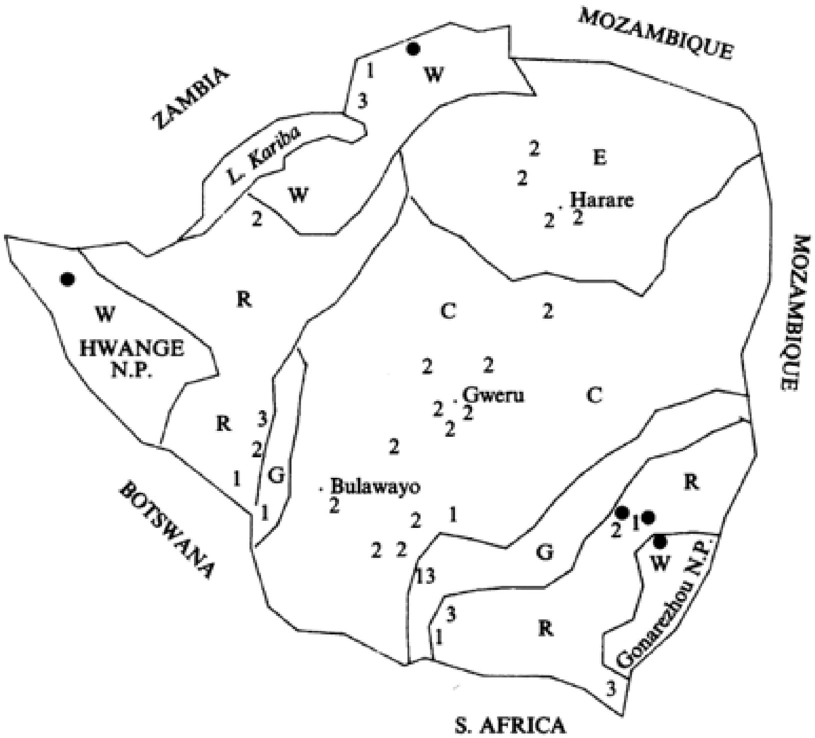

Figure 4. Outbreaks of foot and mouth disease in Zimbabwe between 1980 and 1992, zones and FMD serotypes.
Zones - W: wildlife zone, R: vaccinated zone, G: non-vaccinated buffer zone, C: FMD free zone, E: FMD free zone from which exports were drawn

FMD virus serotypes - 1: type SAT 1, 2: type SAT 2, 3: type SAT 3, 0: places where seropositive animals have been found (Adapted from Anderson et al., 1993).

Spatial and temporal distribution of FMD in Zimbabwe

In the year 2006, FMD outbreaks were sparsely spread in the south eastern part of Zimbabwe in the Masvingo province. Figure 5A shows that the outbreaks then spread to the south-western parts of the country covering small portions of Matabeleland North and South and the Midlands provinces. In the year 2015, even more outbreaks were recorded spreading to the north western side of Zimbabwe in part of the Midlands, Mashonaland West and Matebeleland North provinces. Similar spread continued in 2016 covering most of the northern part of the country. Figures 5 (A-D) show the spatio-temporal distribution of FMD over the 10 years studied. The recurrence of FMD in the Chisumbanje and Chipinge districts (Figure 1) as a result of the escape of buffalos from conservancies was highlighted by FAO (2013). Foot and Mouth Disease is known to be endemic in other parts of Africa including Tanzania, Burundi, Congo and Egypt. In Tanzania, very little had been done by the year 2003, to eradicate FMD (Kivaria, 2003). In Southern Africa, Zimbabwe, Zambia and South Africa have been affected. Botswana, however, has managed to run a more aggressive vaccination program that has reasonably contained FMD spread (FAO, 2013). In July year 2021, two FMD outbreaks were reported in cattle in Gweru, Midlands (FAO, 2021). Elsewhere in Korea, of the seven outbreaks that occurred since 2000, pig and cattle were the main species affected by FMD (Yoon et al., 2016). In their study, the researchers further noted that the Republic of Korea had been FMD-free and without vaccination for almost 7 decades, until the outbreak of March 2000 was recorded.

The odds ratios of FMD incidence were estimated by district and Figure 6 represents the likelihood of FMD occurring by district. Hwange, Mangwe, Chipinge, Bikita, Gutu and Marondera showed a very high probability of FMD occurring (Figures 1 and 6).

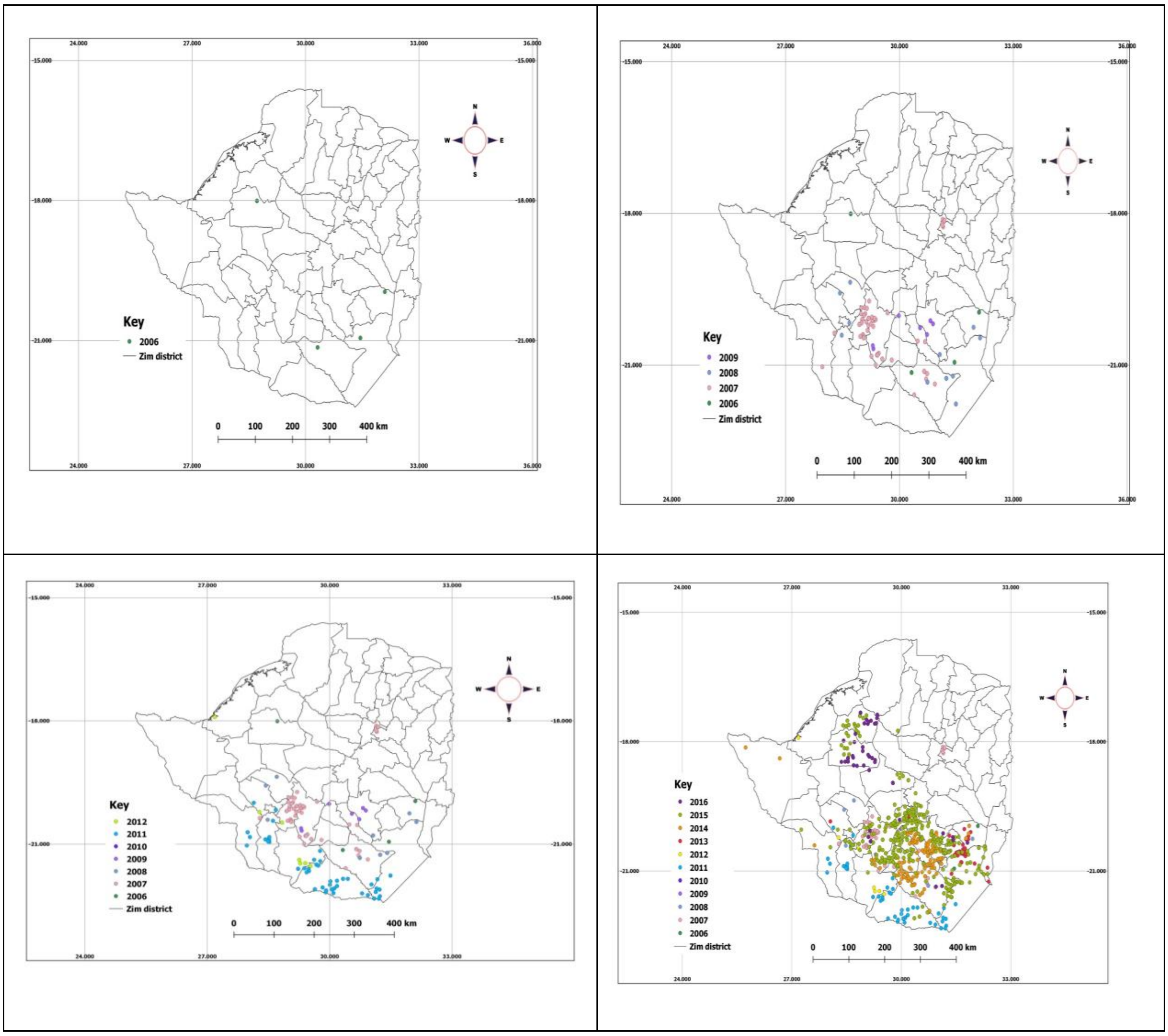

Figure 5. The distribution and spread of Foot and Mouth Disease from the year 2006 to 2016.

The high likelihood of FMD outbreaks is perhaps a consequence of the presence of large herd of buffaloes in the Hwange National Park. Chipinge, Bikita and Gutu possibly get infections from Gonarezhou and Chimanimani TCA which are home to buffaloes as well. Binga, Matopo and Chiredzi (Figure 2) showed a high probability of FMD occurrence perhaps as a result of their adjacency to protected wildlife areas. Such areas are vaccinated zones that should ideally be FMD-free. This was probably because these towns were along the main connecting highway and therefore received infected animals and or products. Districts such as Hwange, Bulilima and Chipinge had the lowest probabilities of FMD occurrence while Guruve, Mazowe and Tsholotsho had not had FMD in the 10 years before 2016.

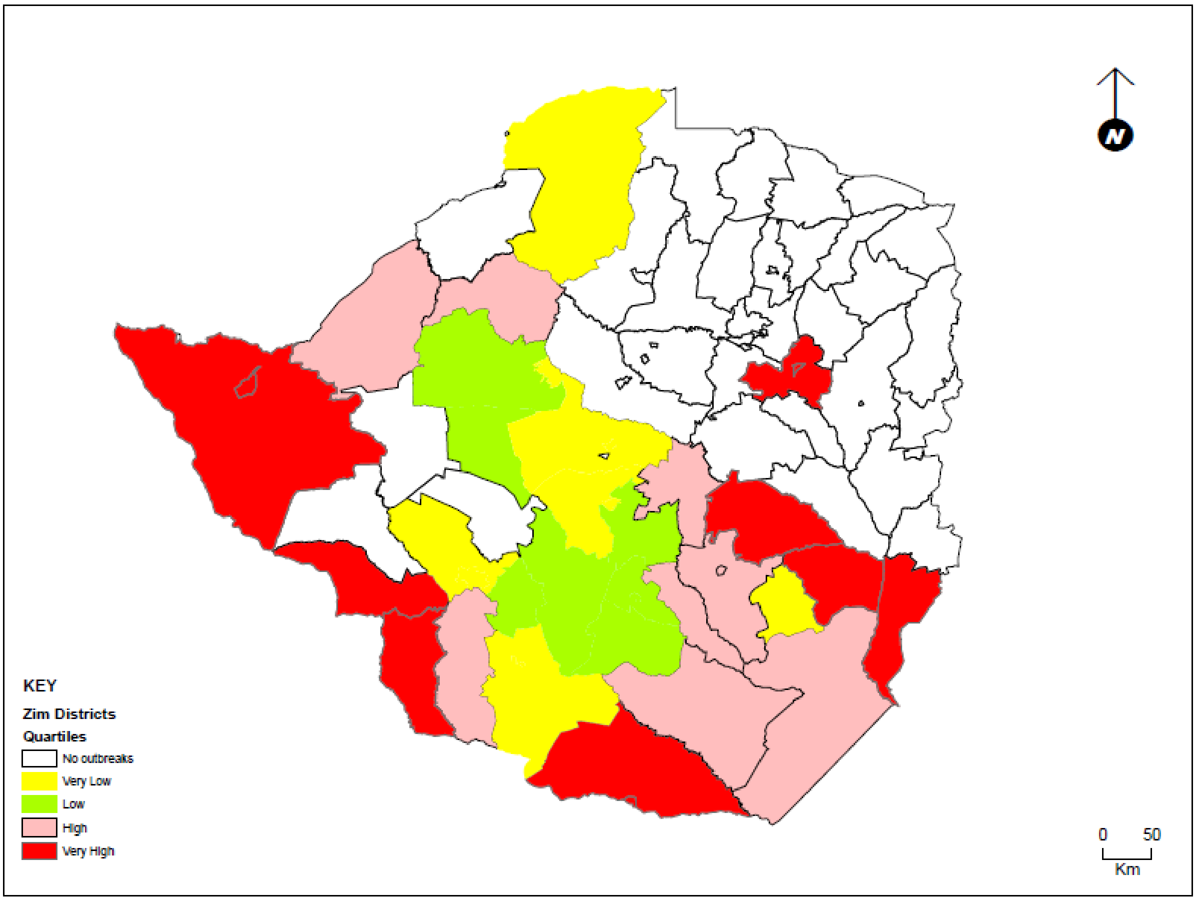

Figure 6. Incidence ratios of the likelihood of occurrence of FMD in Zimbabwe districts.

Logically, areas surrounding Hwange (Figure 1) were expected to show high likelihood of FMD occurrence because of high buffalo populations in the area. Any cattle production in most of the area is under intensive management which entails very close monitoring. The high probability of FMD occurring in Marondera (Figures 1 and 4) comes as a surprise. Marondera and surrounding areas are predominantly crop production areas and cattle production is mainly on an intensive basis. The outbreaks recorded in that area were possibly due to one or a few reckless farmers who might have illegally transported infected animals. Out of the 10 provinces of Zimbabwe, Mashonaland Central, Manicaland with the exception of Chipinge district, which is at the border between Masvingo and Manicaland provinces, had not had any FMD outbreaks in the 10 years before 2016 (Figures 1 and 5).

It is, however, disconcerting to note that new outbreaks have emerged in traditionally FMD-clear zones such as Rushinga in North eastern Zimbabwe. Rushinga lies adjacent to the Umfurudzi Safari area which holds several buffalos. Far West of Rushinga is the Mzarabani wilderness as well. Rushinga also lies right at the border with Mozambique whose influence cannot be ruled out.

Areas that have been previously regarded as clear of FMD are thus showing signs of encroachment of the diseases. This signifies emerging challenges in dealing with FMD in a country that is already plagued with numerous economic challenges. New ways of dealing with FMD spread have to be explored before the whole country becomes a red zone.

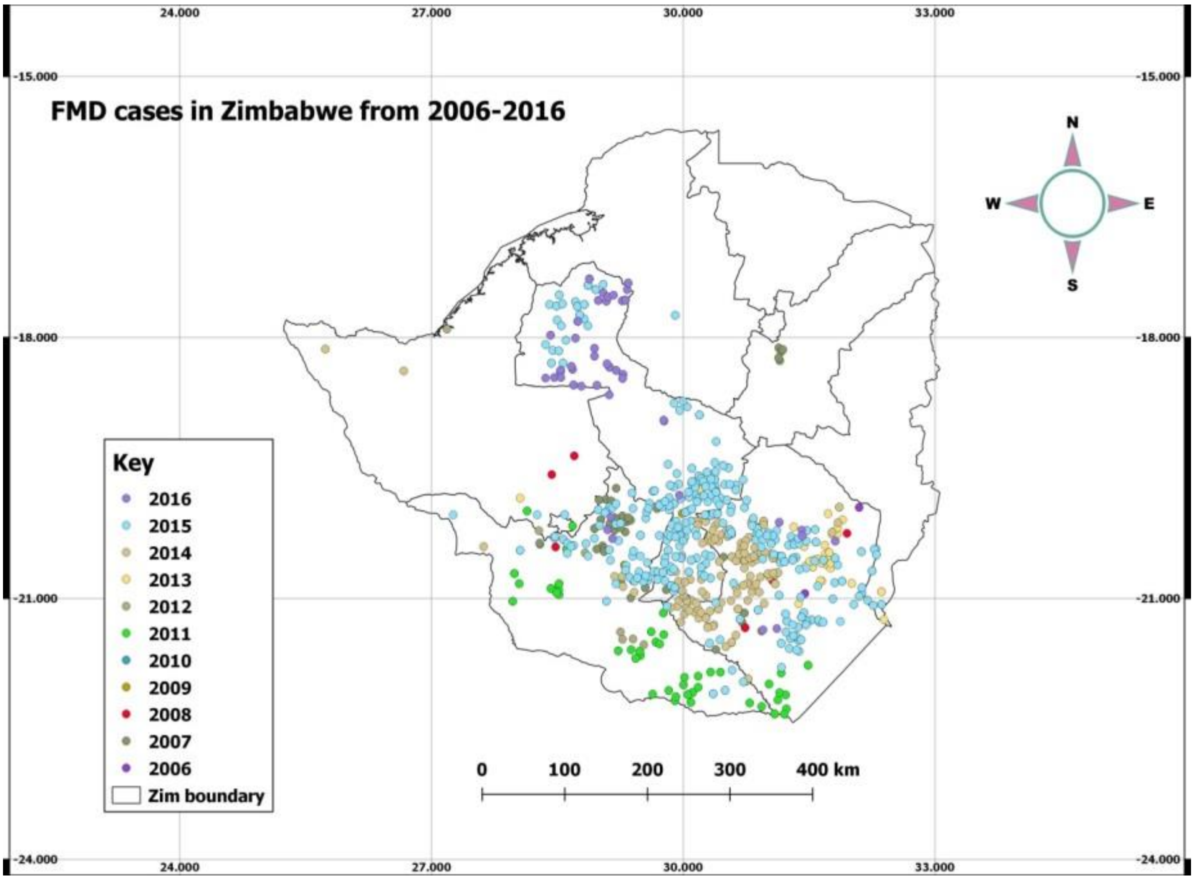

Figure 7. Combined spatio-temporal distribution of FMD across Zimbabwe from the year 2006-2016.

CONCLUSION

While FMD has been persistent since the year 2006 in areas endemic to the disease including Matabeleland South and Masvingo Provinces, the disease is migrating northwards. New outbreaks were recorded in the north western parts of Zimbabwe in the year 2015, with a notable increase in FMD cases in year 2016. Although awareness campaigns have been conducted by the Department of Veterinary and Livestock Services, farmers demonstrated limited knowledge about FMD, species affected and appropriate disease control measures. There is need to invest in the identification or adoption of more effective FMD control measures if new outbreaks are to be prevented.

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Conflict of interest:

The authors declare no competing interest.

Authors Contribution

The authors contributed equally to the article.

REFERENCES

Aftosa F., 2021. Foot and mouth disease. (The center for Food Security & Public Health, IOWA State University): www.cfsph.iastate.edu.

Alexanderson S, Zhang Z, Donaldson AI., 2003. The pathogenesis and diagnosis of Foot and Mouth Disease. Journal of Pathology, 3-7.

Anderson EC, Foggin C, Atkinson M, Sorensen KJ, Madekurozva RL, Nqindi J., 1993. The role of wild animals, other than buffalo in the current epidemiology of FMD in Zimbabwe. Epidemiology and Infection, 111: 559-563.

Central Statistical Office (CSO)., 2011. Past Harvest Survey for the period 2010-2011, Ministry of Finance and National Planning, Lusaka, Zambia.

CIA., 2018. WorldFactbok, https://www.indexmundi.com/zimbabwe/geography_profile.html.

Coetzer JAW, Thomsen GR, Tustin RC, Kriek NP., 1994. Foot and mouth disease: Infectious Disease of the Livestock with Special Reference to Southern Africa, Oxford University Press, Cape Town.

Commercial Farmers Union (CFU)., 2014. Animal health: Disease Monitoring, Veterinary Department, Zimbabwe.

Doel TR., 2003. Foot and mouth disease vaccines, Virus Research, 91: 81-99.

FAO., 1996. Soils Bulletin 73, Soil Resources, Management and Conservation Service:Agro-ecology Zoning Guidelines, Rome.

FAO., 2021. Foot and mouth disease quarterly report, July - September 2021.

Gunarathne A, Kubota S, Kumarawadu P, Karunagoda K, Kono H., 2019. Is hiding foot and mouth disease sensitive behavior for farmers? A survey study in Sri Lanka. Asian Australasian Journal of Animal Science, 29: 280-287.

Jori F, Etter E., 2016. Transmission of foot and mouth disease at the wildlife/ livestock interface of the Kruger National Park, South Africa: Can the risk be mitigated? Preventive Veterinary Medicine, 126: 19–29. https://doi.org/10.1016/j. prevetmed.2016.01.016.

Kivaria FM., 2003. Foot and mouth disease in Tanzania: an overview of its national status. Veterinary Quarterly, 25: 72–78.

LMAC., 2018. Livestock and Meat Advisory Council, Belvedere, Harare.

Maburutse BE, Mutibvu T, Mbiriri DT, Kashangura M., 2012. Communal livestock production in Simbe, Gokwe South district of Zimbabwe. Online Journal of Animal and Feed Research, 2: 301-60 http://www.science-live.com/index/http//www.ojafri.ir.

Masikati P., 2010. Improving the water productivity of integrated crop livestock system in the semi-arid tropics of Zimbabwe http://www.zef.de/fileadmin/webfiles/downloads/zefc-ecology-development/78masikatitextpdf.

Mavedzenge BZ, Mahenehene J, Murimbarimba F, Scoones I, Wolmer W., 2006. Changes in the Livestock Sector in Zimbabwe Following Land Reform: The Case of Masvingo Province. A Report of a Discussion Workshop. IDS. 2006, Brighton. Retrieved May 14, 2012, from http://www.ids.ac.uk/files/Masvingo_workshop_report.pdf.

Mesfine M, Nigatu S, Belayneh N, Jemberu WT., 2019. Sero-epidemiology of foot and mouth disease in domestic ruminants in Amhara Region, Ethiopia. Frontiers in Veterinary Science, 6: 130. doi: 10.3389/fvets.2019.00130.

Mhlanga TT, Mutibvu T, Mbiriri DT., 2018. Goat flock productivity under smallholder farmer management in Zimbabwe. Small Ruminant Research, 164: 105-109.

Ministry of Finance and National Planning (MFNP)., 2012. Estimate of Revenue and Expenditure (Activity Based Budget) for the year 2012. Government of the Republic of Zambia. Lusaka, Zambia.

Mugandani R, Wuta M, Makarauand A, Chipindu B., 2012. Re-classification of agro-ecological regions of Zimbabwe in conformity with climate variability and change. African Crop Science Journal, 20: 361–369.

Muuka G, Songolo N, Kabilika S, Hang'ombe BM, Nalubamba KS, Muma JB., 2012. Challenges of controlling contagious bovine pleuropneumonia in sub-Saharan Africa: A Zambian perspective. Tropical Animal Health and Production, 45(1): 9–15.

Ndlovu RL, Bwakura T, Toops JH., 2004. Donkeys, people and development: A resource for Agricultural and Rural Cooperation CTA, Wageningen, Nertherlands pp. 244.

Nyaguthii DM, Armson B, Kitala PM, Sanz-Bernardo B, Di Nardo A, Lyons NA., 2019. Knowledge and risk factors for foot-and-mouth disease among small-scale dairy farmers in an endemic setting. Veterinary Research, 50: 33. https://doi.org/10.1186/s13567-019-0652-0

OIE., 2014-15. Livestock sector overview. Ministry of Agriculture and Mechanisation and Irrigation Development.

OIE., 2011. https://www.oie.int/en/animal-health-in-the-world/fmd-portal/.

Perry BD, Randolph TF, Ashley S, Chimedza RC, Morrison J, Poulton C, Sibanda L, Stevens C, Tebele N, Yngstrom N., 2003. The impact and poverty reduction implications of foot and mouth disease control in Southern Africa with special reference to Zimbabwe. (International livestock Research institute, Nairobi, Kenya) 12-19.

SADC., 2018. Transfrontier conservation areas bronchure: Accessed 27 December 2018 at: Zimparks.org/wp-content/uploads/2017/09/SADC- TFCA BRONCHURE.pdf.

Scoones I, Wolmer W., 2007. Land, landscapes and disease: the case of FMD in Southern Zimbabwe, 58: 42-64.

Thomson GR., 1995. Overview of foot and mouth disease in Southern Africa. Revue Scientifique et, Office International des Epizooties, 503-520.

UNDP., 2004. The human development Reports, New York, http://hdr.undp.org.statistics.

Vosloo W, Dwarka RM, Bastos ADS, Esterhuysen JJ, Sahle M, Sangare O., 2004. Molecular epidemiological studies of foot-and-mouth disease virus in Sub-Saharan Africa indicate the presence of large numbers of topotypes: Implications for local and international control. Session of the Research Group of the Standing Technical Committee of the European Commission for the Control of Foot-and-Mouth Disease (EUFMD), Chania, Crete, Greece, 12–15 October 2004. Appendix 22: 149–158.

Weaver GV, Domenech J, Thiermann AR, Karesh WB., 2013. Foot and mouth disease: a look from the wild side. Journal of Wildlife Diseases, 49: 759–785.

Yoon H, Jeong W, Choi J, Myung KY, Park HS., 2016. Epidemiology and Investigation of Foot-and-Mouth Disease (FMD) in the Republic of Korea. InTech open. http://dx.doi.org/10.5772/63975

ZimStats, 2012. National Census Report, Causeway, Harare, Zimbabwe.

ZimStats, 2014-15. National Census Report, Causeway, Harare, Zimba