

**Risk factors associated with the
outbreaks of African Swine Fever in
Lusaka Province, Zambia**

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*A dissertation submitted to the University of Zambia in partial fulfillment of the
requirements for the award of degree of Master of Science in One Health Analytical
Epidemiology*

The University of Zambia

Lusaka

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DECLARATION

I, **Cynthia M. Siamupa** do hereby declare that the contents of the dissertation being submitted herein are my original work and they have not been previously submitted to any university for the award of a degree or any other qualification.

Signature.....

Date.....

ABSTRACT

African Swine Fever (ASF) is one of the most complex diseases of swine and a worldwide problem with most countries in the sub-Saharan region being endemic. The disease is characterised by widespread hemorrhages and high mortalities and affects trade in pigs and/or pork products both locally and internationally. The aetiological agent for ASF is a DNA virus that does not produce neutralising antibodies in affected animals. Lusaka province of Zambia experienced outbreaks of ASF in 2013. The outbreak was first reported in Lusaka district and later spread to Chilanga and Chongwe districts and a total of 6 471 out of 40 233 pigs were depopulated on 20 farms that were surveyed. The Zambian government incurred a huge cost in terms of loss in trade, cost of control measures and compensation of affected farmers. This study was carried out to identify the risk factors that were associated with these outbreaks in the province. The participants were selected purposively from the four (4) districts of Lusaka province namely; Lusaka, Chilanga, Kafue and Chongwe that had cases of ASF diagnosed by Central Veterinary Research Institute and reported by the Director of Veterinary Services in the 2013-2014 outbreaks. The recruited participants included 3 District Veterinary Officers, 3 Veterinary assistants, 4 police officers and 2 Veterinary staff from veterinary check points, 3 managers from abattoirs and processing plants, 3 meat inspectors from Ministry of Local Government and Housing, 3 market chairpersons, 15 traders and 50 pig farmers. All participants were purposively sampled except for the pig farmers that were included using respondent-driven technique. Apart from managers at abattoirs and processing plants and pig farmers that used semi-structured questionnaires for data collection, all the participants utilized interviews. Interview data and

questionnaire responses from managers at abattoirs and processing plants was analysed using narrations, tables and flow charts. Some key statements or quotations emerging from the interviews were used to illustrate the main ideas. Information from the questionnaire for farmers was coded and entered into Microsoft Excel. The coded data was then transferred to STATA® Version 12 (STATA Corporation, College Station, Texas). The variables that could be associated with spread of ASF such as location, duration of pig keeping, alternative source of income, absence of a boar, type of feed, source of feed/ingredient, ASF screening, market availability, knowledge on ASF transmission, occurrence of ASF outbreak and regulation on pig movement were identified. Univariate analysis using Chi-square to determine the effect of each independent variable on the dependant variable (ASF) and multivariate analysis using logistic regression were performed. A confidence interval of 95% was used to ascertain the effects of the above factors on ASF positivity. The *P*-value for the test was >0.05 meaning that the logistic model used was an adequate fit for the data. The study revealed that farmers bought breeding stock from fellow farmers and live pig markets such as Chibolya market near the Lusaka Central Business District. The farmers (4/50, 8%) that had no boars took their sows to other farms for servicing. Fifty eight per cent (29/50) of the farmers used disinfectants while traders did not disinfect the modes of transport they used. Only 48% (24/50) and 33.3% (5/15) of farmers and traders respectively had knowledge of ASF transmission. Fifty per cent (25/50) of farmers had their animals screened for ASF before sale. All the markets did not have the pork inspected. Further, farmers and traders used alternative routes to avoid check points. The study revealed that the risk factors that were associated with the spread of ASF in Lusaka province were (1) purchase of pigs for replacement and breeding stock from one another and from markets,

(2) poor adherence or absence of biosecurity measures, (3) laxity in enforcing livestock movement control and inadequate police and veterinary staff manning check points, (4) evading pig checks at check points by traders who use alternative routes, (5) low awareness levels on ASF transmission among pig farmers and traders, (6) lack of enforcement of regulations at pig markets and (7) inadequate of ASF screening. Of these factors, only absence of a boar ($P=0.01$, 95% C.I:8.22-68.41) and occurrence of ASF outbreaks in the previous year ($P=0.08$, 95% C.I:0.23-35.54) were significantly associated with the ASF outbreak. Improving biosecurity, sensitizing farmers, traders and all stakeholders in the pig value chain on ASF, reinforcement of staff at check points and regulation of pig markets are some of the ways in which future outbreaks can be prevented since there is no vaccine or treatment for ASF.

DEDICATIONS

This document is dedicated to my parents, Mr. Peter Siamupa and Jennifer Muzyamba Siamupa for their sacrifice in ensuring that I attained the right education from pre-school through to tertiary education; to my husband, Mr. Muketeke Mwalusambo for his love and support. Their sacrifice with regard to contribution to my general achievement in life including completion of this course is immeasurable.

Further, I dedicate this document to my young brother Jay Siamupa so that it acts as an inspiration throughout his academic journey.

ACKNOWLEDGMENTS

I would like to thank the following persons and Institutions for their support during my pursuant of a Master of Science in One Health Epidemiology at the University of Zambia;

- i. Southern African Centre for Infectious Disease Surveillance (SACIDS) for financial support without which it would not have been possible to pursue the course.
- ii. My supervisors, Dr. Ngonda Saasa and Dr. Andrew M. Phiri for the guidance.
- iii. Dr. Geoffrey Zyambo and Mr. David E. Daka from Livestock Services etc for the valuable information linked to this study they provided.
- iv. My employer, Livestock Services Co-operative Society for granting me study leave.
- v. The University of Zambia through the School of Veterinary Medicine and the Directorate of Research and Graduate Studies for according me an opportunity to study Master of Science in One Health Analytical Epidemiology.

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LIST OF ACRONYMS

ASF	African Swine Fever
ASFV	African Swine Fever Virus
CFSPH	Centre for Food Security and Public Health
CVO	Chief Veterinary Officer
CVRI	Central Veterinary Research Institute
DVO	District Veterinary Officer
DVS	Department of Veterinary Services
FAO	Food and Agriculture Organization
MAL	Ministry of Agriculture and Livestock
MLGH	Ministry of Local Government and Housing
SLAZ	Small Livestock Association of Zambia
VA	Veterinary assistant
VCP	Veterinary check point
ZNFU	Zambia National Farmers' Union

DEFINITION OF KEY TERMS

Pig products	Range from primary commodities (e.g. pork) to processed food products (e.g. sausages and smoked hams).
Livestock Market	A place where animals are assembled for the purpose of trade or sale.
Marketing	The organization of the sale of a product, for example, deciding on its price, the areas it should be supplied to, and how it should be advertised.

CHAPTER 1

INTRODUCTION

In Eastern and Southern Africa, livestock production has intensified due to the increase in demand for dietary animal protein (Lekule and Kyvsgaard, 2003). The sharp increase in demand for dietary protein is a result of rapid human population growth and urbanization (Adeshinwa *et al.*, 2003). Unlike other sources of animal protein (such as beef, mutton, chevron, fish and poultry), pork serves as a common source of this protein because of the pig's high prolificacy, good feed conversion and minimal land requirements (Ajala *et al.*, 2007). In addition, pigs also serve as alternative investment in many households through the sale of pigs for basic and emergency needs such as fees for school going children (Ouma *et al.*, 2014).

In Zambia, the pig population increased from 268 599 heads in the year 2003 to 1 098 951 heads in 2013 (FAO Statistical Databases, 2015). During this period, the predominant breeds in Zambia were local, landrace and large whites which are prone to African swine fever (ASF) (Annual Reports, MAL 2013). The pure breeds (landrace and large whites) are common among commercial farmers while their crosses are owned by small-scale farmers. The local pigs are mostly kept as scavengers in the rural and sub urban communities (Ministry of Agriculture and Co-operatives, 2003).

In developing countries such as Zambia, the majority of pigs are kept by small-scale farmers (Mekuriaw and Asmare, 2014). These small-scale pig farmers experience a wide range of productivity and market related constraints such as poor disease management,

lack of infrastructure, low capital investments and poorly organized markets for the sale of their products (Ridel *et al.*, 2012). Owing to poor disease management strategies, these pig producers have continued to lose their pigs to diseases like ASF among many other diseases (Zambia Development Agency, 2011).

African Swine Fever is one of the most severe viral pig diseases (FAO, 2013). African swine fever outbreaks are usually deadly and their devastating effects disrupt the pig industry through the restriction of local and international trade (Swayi and Lyimo, 2014). Further, the disease results in loss of income for farmers, employment and negatively affects food security as pork is an important source of human dietary protein (FAO, 2012).

The spread of ASF from Africa to other parts of the world has been attributed to feeding pigs with infected pig meat or products that came from ASF-endemic areas via ports, airports or travellers from such areas (Sanchez-Vizcaino *et al.*, 2012). African swine fever was able to spread to the Western Hemisphere using transport associated routes where it was successfully eradicated. However, its spread to Southern Europe has resulted in ASF endemicity in the Iberian peninsula and Sardinia (Wilkinson 1986). In the island of Sardinia, the disease is maintained by wild boars and recovered domestic pigs which act as carriers of ASFV (Laddomada *et al.*, 1991). In Russia, ASF was reported in 2008 and since then the virus has been diagnosed in meat processing plants and carcasses that were disposed illegally. The introduction of ASF into Caucasus and the Russian Federation is a threat for the world because the risk of African swine fever virus (ASFV) dissemination to the remaining parts of Europe, China and other countries

with an established pig industry in South-East Asia has increased substantially (FAO, 2008; FAO, 2009a).

In Africa, ASF has become rampant and is spreading into new areas because of the tremendous growth of the pig sector and increased transboundary trade (FAO, 2014). In the recent decades, the virus has become endemic in domestic pigs in some countries in sub-Saharan Africa due to the movement of infected pigs and pig meat despite the presence of the sylvatic cycle in that country (Penrith *et al.*, 2013).

In Zambia, ASF has been present since 1912 during which time the disease had been confined to the Eastern province of Zambia (Plowright *et al.*, 1994; Samui *et al.*, 1996). In the last decade, the disease has spread to other provinces of the country including Lusaka, Southern, Northern and North-western provinces. Although ASF outbreaks have continued to spread in these provinces, Lusaka province has had the highest incidences of cases since its introduction in the province in 1993 (World Organization for Animal Health, 2013a). This could be attributable to the many pork processing plants and large markets for pigs and pig products that attract pig farmers and traders from all parts of the country.

Lusaka Province has experienced several outbreaks of ASF with the latest cases being reported in November 2013 in Lusaka, Chilanga and Chongwe districts (Yabe *et al.*, 2014). In accordance with Sections 12, 22 and 23 of the Animal Health Act of 2010, which stipulates that any notifiable disease outbreak must be officially announced in the Government gazette, the Director of Veterinary Services at the Ministry of Agriculture and Livestock (MAL) announced the outbreak of ASF in Chilanga and Lusaka districts

on the 18th November, 2013 through Gazette Notice number 807 of 2013 (Appendix 8.1). During this outbreak, a total of 187 farms with a pig population of 40, 233 were inspected by the Department of Veterinary Services (DVS) surveillance teams. Twenty (20) farms with a total pig population of 6, 471 were found to be positive and had been depopulated. Most of the infected farms were along three main roads of Mungwi Road (Lusaka West), Mumbwa Road (Lusaka West) and Great East Road (Chelstone and Chongwe). Among the measures imposed on the pig industry during ASF outbreaks in Lusaka province include restriction of pig movement within and out of the province. These measures consequently give rise to tremendous economic losses to the small scale farmers (MAL, Personal communication).

The continued cases of ASF in Lusaka province (2013-2015) despite the government applying immediate control measures in November, 2013 such as quarantine, movement control inside the country, screening, zoning, no vaccination and no treatment of affected animals (World Organization for Animal Health, 2013a) suggests that there could be some factors associated with these outbreaks that must be identified and considered. Despite this reoccurrence and spread of ASF in Lusaka province, little work has been done to investigate the risk factors influencing these outbreaks. It is likely that there are factors which have not been considered, or that the trends in the pig industry have evolved and thus brought forth new aspects that must be considered in the control of the disease.

Besides being a major constraint for pig production, ASF results in high mortality rates in pig herds not only because of the virus lethal power, but also the massive destruction of pigs in order to control the disease (Annual report, MAL 2013). Further, ASF

outbreaks imply severe economic losses in affected countries due to market and trade bans and closure of borders to pigs and pork products. Lusaka Province's location in the south-central part of Zambia puts it at risk of ASF outbreaks. Lusaka Province shares its borders with Central, Southern and Eastern Provinces where most ASF outbreaks have been reported during 2013 (World Organization for Animal Health, 2013b). This study was aimed at establishing risk factors associated with regular ASF outbreaks in Lusaka province and to identify the key stakeholders to engage in order to adequately control the outbreaks. The results of this study will therefore help government policy on ASF control as well as offer adequate information and recommendations. It was envisaged that in addition to the conventional methods of test and slaughter, livestock movement bans and stopping of processing of pigs and pork products, other approaches will be adopted.

The general objective of the study was to identify and assess risk factors that were associated with the outbreaks of ASF in Zambia's Lusaka Province. The specific objectives used to achieve this were;

- i. To establish control measures put in place during ASF outbreaks and associated challenges
- ii. To understand market regulations for pigs and ASF awareness among pig traders and managers at abattoirs and processing plants
- iii. To understand pig production, ASF awareness among pig farmers and interaction with veterinary staff

CHAPTER 2

LITERATURE REVIEW

2.1 Importance of African swine fever

African Swine Fever is an acute, febrile, highly contagious hemorrhagic viral disease of pigs (Costard *et al.*, 2009). The African swine fever virus usually persists in pig products and the environment and spreads quickly in pig populations by direct or indirect contact (Maurer, 1975). African swine fever virus can become endemic in wild Suidae and *Ornithodoros* ticks (Wilkinson, 1988). The isolates of ASFV are variable in their virulence. The highly pathogenic strains result in 100% mortality rates while low-virulent strains are often difficult to diagnose (Centre for Food Security and Public Health, 2010).

African swine fever is a threat to any country with a pig industry because it causes significant losses due to depopulation of infected and exposed swine (Sanchez-Vizcaino, 1992). The disease is endemic in many African countries and it spread to Europe, South America and Caribbean where eradication was at a considerable cost (Costard *et al.*, 2009). The spread of ASF on the European continent and the uncontrolled situation in the Russian Federation places all countries at great risk as a result of intense global trade (Sanchez-Vizcaino *et al.*, 2012).

2.2 Aetiology

African Swine Fever is caused by a large, enveloped, double stranded DNA African swine fever virus (Dixon *et al.*, 2005). African swine fever virus is the sole member of the family *Asfarviridae* and genus *Asfivirus* (Dixon *et al.*, 2005). The genetic and

antigenic properties of ASFV vary considerably and viral genotyping has been achieved using restriction enzyme analysis (Centre for Food Security and Public Health, 2010). In Africa, 22 genotypes whose descriptions are based on the p72 sequences are in circulation (Boshoff *et al.*, 2007).

2.3 Susceptible species

The members of the pig family (*Suidae*) are susceptible to infection with ASF (FAO, 2001). These include domestic pigs, European wild boars, warthogs (*Phacochoerus africanus*), bushpigs (*Potamochoerus larvatus*), red river hogs (*Potamochoerus porcus*), giant forest hog (*Hylochoerus meinertzhageni*) and peccaries (*Tayassu spp.*). However clinical disease only occurs in domestic pigs, feral pigs and the European wild boar (Centre for Food Security and Public Health, 2010). The warthogs are the natural vertebrate hosts of ASF while the role of bush pigs and red river hogs in the epidemiology of the disease is not yet known because their infection is normally sporadic (Dutch wildlife health centre, 2014). Furthermore, the involvement of the giant forest hog in the epidemiology of ASF is negligible as only a single case of ASF was reported (Costard *et al.*, 2013a). The peccaries of America (collared and white lipped peccaries) are asymptomatic carriers of ASFV (Centre for Food Security and Public Health, 2011). The disease has no public health significance because humans are not susceptible to ASFV (Sánchez-Vizcaíno *et al.*, 2009).

2.4 Global distribution of ASF

African Swine Fever was primarily a continental problem in Africa with warthogs, bush pigs and forest hogs serving as reservoirs for ASFV (Jori *et al.*, 2009). Therefore, the history of ASF as a destructive disease of pigs can be traced back to the time when

domestic pigs were initially introduced in an area infected with warthogs and ticks (Penrith, 2013). African swine fever is now a global problem (Figure 1).

African Swine Fever was recognised for the first time in Montgomery, East Africa where the disease outbreaks were associated with interaction between wild pigs and free-range pigs and not due to fomites or movement of domestic swine (Plowright *et al.*, 1994). The initial record of ASF occurred in pigs that belonged to the European settlers in Kenya in 1914. This led to the development of studies that distinguished ASF from CSF (Penrith, 2013).

African Swine Fever in South Africa was recognized in 1928 in the Transvaal bushveld where there was existence of contact between warthogs and domestic swine (Steyn, 1928). The ASF outbreak which was reported in 1933 in Witwatersrand spread to the Cape Province due to movement of infected pigs. ASF survivor pigs caused outbreaks from 1935 to 1939 on a farm in Piketberg district by infecting younger pigs (Plowright *et al.*, 1994, Penrith *et al.*, 2004). South Africa also reported periods when ASF was absent during 1918-1926, 1939-1951 and 1962-1972 (Penrith & Vosloo 2009).

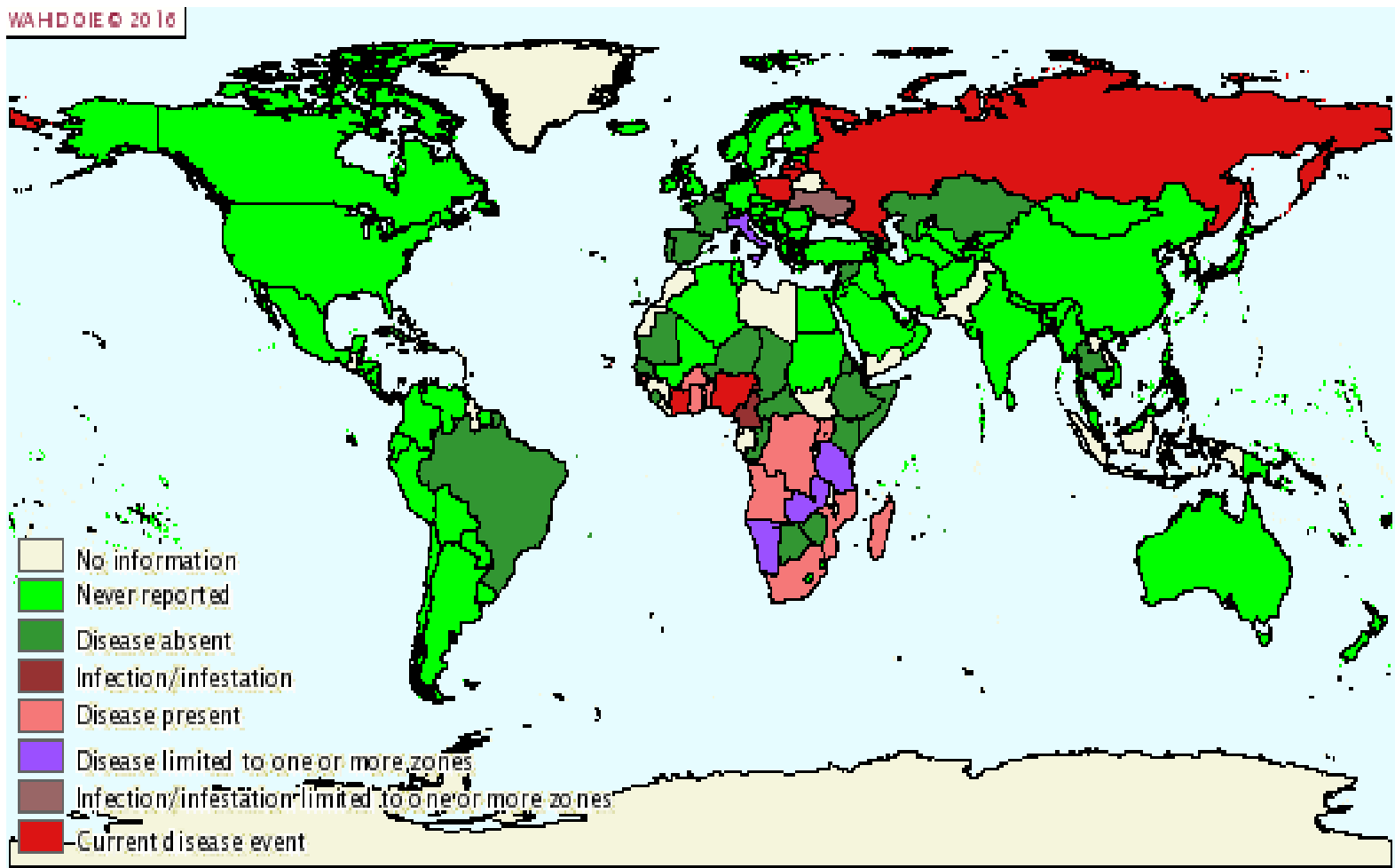


Figure 1: World distribution of ASF for a period of 6 months from January to June 2014 (Source: WAHID)

The potential significance of ASF if it spread to developed countries with a highly developed pig industry was recognized in Kenya (Plowright *et al.*, 1994). African swine fever was reported outside the endemic zone of Africa in 1957 in Lisbon when it had spread from Angola (Figure 2) (FAO, 2001). The ASF outbreak that occurred in Lisbon was acute with almost 100% mortality rate. Further, another ASF outbreak occurred near Lisbon in 1960 and spread to Portugal then later to Spain in the same year resulting in epizootics in both countries. These ASF outbreaks in the Iberian Peninsula were spread to France (1964, 1967, 1977), Madeira (1965, 1974, 1976), Italy (1967, 1980), Malta (1978), Sardinia (1978), Belgium (1985) and Holland (1986) through the illicit movement of infected pigs and pig products (Costard *et al.*, 2013b).



Figure 2: Epidemiology of African swine fever (1957-1967); its spread from Angola to Lisbon and neighbouring countries (Source: <http://sanidadanimal.info/cursos/asf/img/caps/c3i4.jpg>)

Outside Europe, different countries were infected by ASF: Cuba (1971, 1980), Brazil (1978), Dominican Republic (1978) and Haiti (1979). However, it is postulated that the 1982 epidemic of ASF which occurred in the Cameroon Republic was a reverse flow of infection to West Africa from Europe or America because the ASFV isolates from Cameroon, Dominican Republic and Haiti were genetically indistinguishable (Penrith *et al.*, 2004).

An upsurge of ASF between the 1990s and 2000s changed the distribution of the disease (Figure 3). The ASF virus travelled around West Africa causing disease outbreaks in several countries; Ivory Coast (1996), Nigeria (1997), Togo (1997), Ghana (1999), Burkina Faso (2003) and Chad in 2010 (World Organisation for Animal Health, 1996–2002; Penrith *et al.*, 2004; World Organization for Animal Health, 2011a). The islands of Madagascar (1997) and Mauritius (2007) also became infected (World Organisation for Animal Health, 2007).



Figure 3: Countries where different outbreaks have occurred between 1997 and 2002
(Source: <http://sanidadanimal.info/cursos/asf/img/caps/c3i5.jpg>)

African swine fever was confirmed in June 2007 for the very first time in Georgia, Caucasus region (Gogin *et al.*, 2013) (Figure 4). The isolates implicated in the outbreak belonged to genotype II which is present in Mozambique, Madagascar, and Zambia. The outbreak in Georgia was linked to pigs being fed ASFV contaminated pork from ships (FAO, 2008; Rowlands *et al.*, 2008).

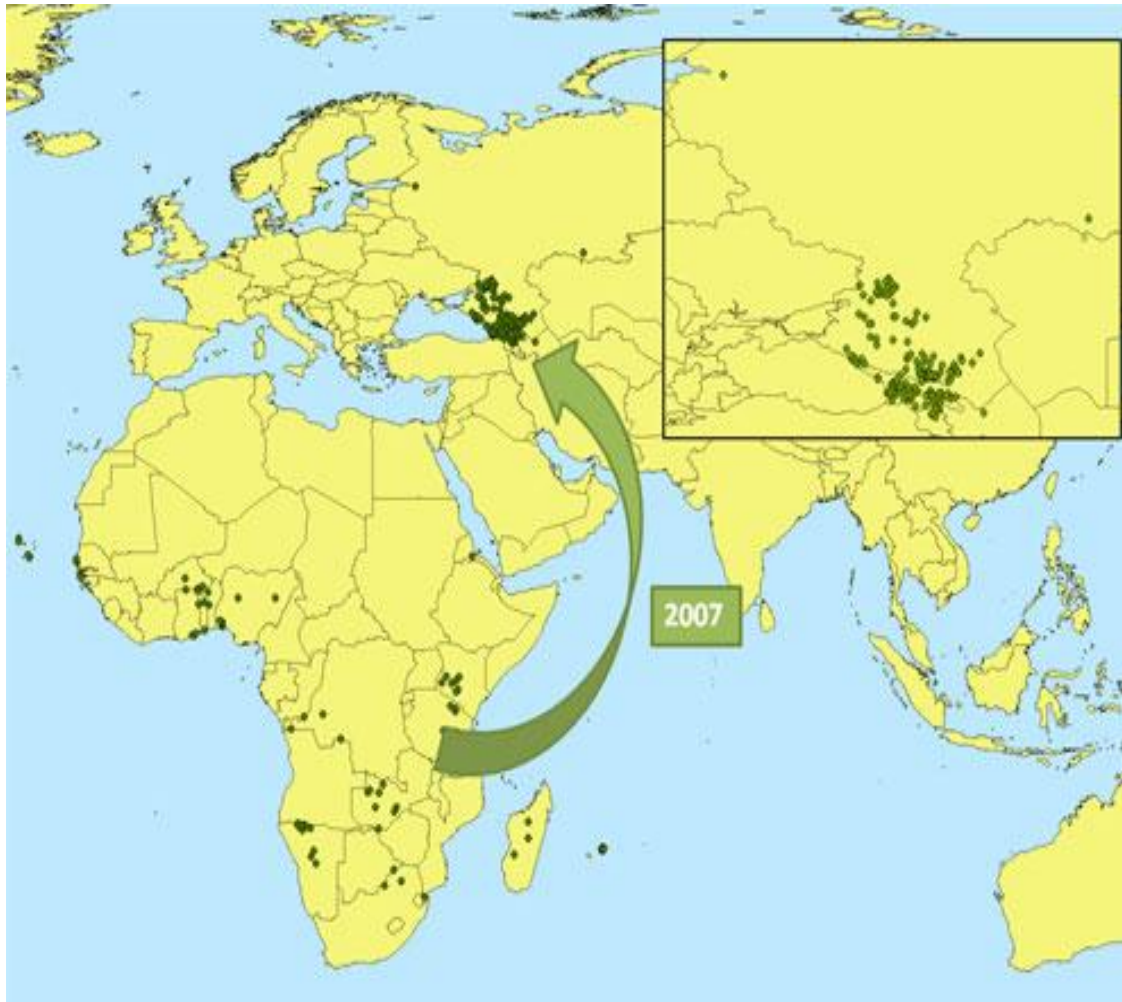


Figure 4: African swine fever outbreaks from 1998-2010; its spread from Africa to Georgia in 2007 (Source: <http://sanidadanimal.info/cursos/asf/img/caps/c3i6B.jpg>)

The extensive type of swine rearing characterised by backyard or traditional ways of pig farming led to the rapid spread of ASF in the Caucasus region as it allowed contact between the infected wild boar and domestic pigs (Emergency Prevention System for Transboundary Animals and Plant Pest Diseases (EMPRES), 2012; Oganesyanyan *et al.*, 2013). Since then, ASFV spread to Western and Southern Russia in 2013 where it is well established and causing destruction in domestic as well as wild pigs. Further incursions to the edges of Europe with outbreaks being recorded in Ukraine and Belarus

in 2013 puts the large pig populations in Eastern Europe at risk of ASF infection (Department of Environment, Food and Rural Affairs Veterinary Science Team International Disease Monitoring, 2012; World Organization for Animal Health, 2012a; FAO, 2013). There is also a risk of ASF encroachment in the Central part of Ukraine because of the densely populated residential areas, increased human and pig product movement into the country and availability of commercial pig farming units (FAO, 2010a).

2.5 History of ASF in Zambia

In Zambia, ASF was first reported in 1912 in free-range indigenous pigs near Chipata, Eastern province with other outbreaks being recorded later in 1974, 1975, 1977, 1978 and 1988 (Plowright *et al.*, 1994). Despite the presence of ticks and warthogs that were infected in game parks and national parks throughout the country, the disease only occurred in Eastern province near Malawi which is endemic to ASF. The disease outbreaks were associated with the transfer of infected pig meat into villages with highly susceptible pigs. Further, the *Ornithodoros* ticks were absent in the pig pens though there was some evidence of their existence some time back (Wilkinson *et al.*, 1986). The disease is maintained by pig to pig transmission though there is an existence of the sylvatic cycle in national parks, game parks and nearby areas. The transmission of ASF from warthogs via ticks to domestic pigs is absent though there is some potential of transmission at the interface (Wilkinson *et al.*, 1988).

The disease has since become endemic in the indigenous pigs in the Eastern province and to prevent the spread of the disease to the rest of the country, an indefinite movement ban on pigs and pig products to other provinces of the country was put in

place through the establishment of a permanent checkpoint on Luangwa bridge (Samui *et al.*, 1996). This resulted in a decrease in the supply of cheap animal dietary protein which was readily produced in the province. African swine fever incursions into other provinces have been reported (Yabe *et al.*, 2014). The map (Figure 5) below highlights the ASF outbreaks that have been reported in Zambia from 1912 to 2014.



Figure 5: Map of Zambia showing the distribution of ASF outbreaks from 1912 to 2014 (Source: NALEIC)

The first outbreak outside the endemic zone of Eastern province was reported in May 1989 in Central province at Mpima seminary in Kabwe. During this outbreak, 30 out of 164 pigs had died before stamping out measures were instituted (Samui *et al.*, 1991). It was suspected that ASF was introduced by priests from the Eastern province during the

pope's visit in Lusaka of the same year (World Animal Health, 1989). Several priests had travelled from the Eastern Province while some flew from Petauke district that had active cases of ASF. These priests were accommodated at the mission. It was suspected that the priests had smuggled pork and/or its products from Petauke which were cooked in the main kitchen and the leftovers fed to pigs therefore causing the outbreak (Samui *et al.*, 1991). The entire urban district of Kabwe was declared as an ASF infected zone by the government. However, MAL eradicated the disease by complete destruction of infected and exposed pigs (134), disinfection and surveillance within a 10km radius from the mission for 3 months. The mission was not allowed to restock the piggeries for a year and only after introduction of sentinel pigs for a period of 2 months was done (Samui *et al.*, 1991).

In 1993, an ASF outbreak was reported in Leopards Hill area in Lusaka district due to the illegal introduction of pigs from Eastern province (MAL, Personal communication)). The Zambian government contained the disease by complete slaughter of pigs within a radius of 5km and compensation of affected pig farmers was done. Further, the area remained depopulated for at least a year. In August 2001, more cases of ASF at a commercial farm in Lusaka were reported and the source of infection was established to be Kasamu village which is located near the Kafue National Park (MAL, Personal communication).

In 2001, ASF spread to the Southern province where it affected 4 districts (Mazabuka, Monze, Namwala & Choma). Penrith (2013) attributed the increase in pig production to one of the predisposing factors for the ASF outbreaks that were experienced in the Southern Province. The increase in pig production was a result of increased cattle

diseases that affected the supply of meat as reported by Phiri *et al.* (2002). The Government of Zambia with the help of the Food and Agriculture Organisation (FAO) under the project (TCP/ZAM/0169-Phase II, TCP/ZAM/3002E) from February 2002 to August 2004 instituted several disease interventions of which strengthening of the surveillance teams and capacity building of the Veterinary Services in response to ASF epidemics was one of them. During this period technical support and regional workshops on ASF containment and epidemiological analysis were provided by an FAO International consultant. The Central Veterinary Research Institute (CVRI) was provided with ASF diagnostic materials and the members of staff were trained at Onderstepoort Veterinary Institute. In addition, workshops on ASF recognition were conducted in Southern Province for the staff (Emergency Prevention System for Transboundary Animals and Plant Pest Diseases, 2004).

African Swine Fever was detected on 19th April 2004 in Livingstone in a backyard pig pen which had 21 pigs. It was established that about 280 pigs had died at a commercial farm located about 7km South East of Livingstone town the previous month. The DVS in Livingstone was not notified of this incidence which was at the border of Zimbabwe and Botswana thus a risk of transboundary spread (Emergency Prevention System for Transboundary Animals and Plant Pest Diseases, 2004).

Several cases of ASF outbreaks were later reported in 2005 in Lusaka, Monze and Mazabuka while in Livingstone in 2006 (MAL, Personal communication). By 2007, Zambia was still experiencing some ASF outbreaks (Penrith and Vosloo, 2009). In North-western Province ASF outbreaks were recorded in 2008 and 2014. Northern

Province was also severely affected by ASF with the disease being experienced from 2011 to 2013 in Nakonde, Isoka and Mbala (MAL, Personal communication).

In November 2013, another ASF outbreak was recorded in Lusaka province and affected 3 districts, namely Lusaka, Chilanga and Chongwe (Yabe *et al.*, 2014). The localities in which ASF positive cases were confirmed including Veterinary check points that were mounted during the outbreak are shown in Figure 6.

The disease was first reported in October 2013 on a farm in Lusaka west, Lusaka district and later spread to three other farms within the district. The disease continued to spread to other farms in Chilanga and Chongwe districts such that more than 500 pigs had died of the disease by the time interventions were instituted by the Zambian authorities in November 2014 (Yabe *et al.*, 2014). In the quest to contain the ASF outbreaks that occurred in Lusaka province in 2013, MAL through the DVS surveillance team quarantined the affected farms and restricted pig and pig product movement through the establishment of Veterinary checkpoints specifically for ASF control in the province. Further, there was slaughter of infected and exposed pig herds within a 2km radius, burning in deep pits, burying and lime applied on top of the burial site (Figure 7). Disinfection of the pig pens was done using an aldehyde-based disinfectant while a 3m perimeter of the surrounding pig pens was sprayed with an amitraz-based acaricide. Further, the DVS banned the slaughter of pigs at abattoirs and processing plants in Lusaka and gave a directive that all the pork in their abattoirs and processing plants be sold off in the shortest possible time. The premises were later closed and disinfected. In addition, the movement of all pigs and sell of pig products in and out of Lusaka province was banned.

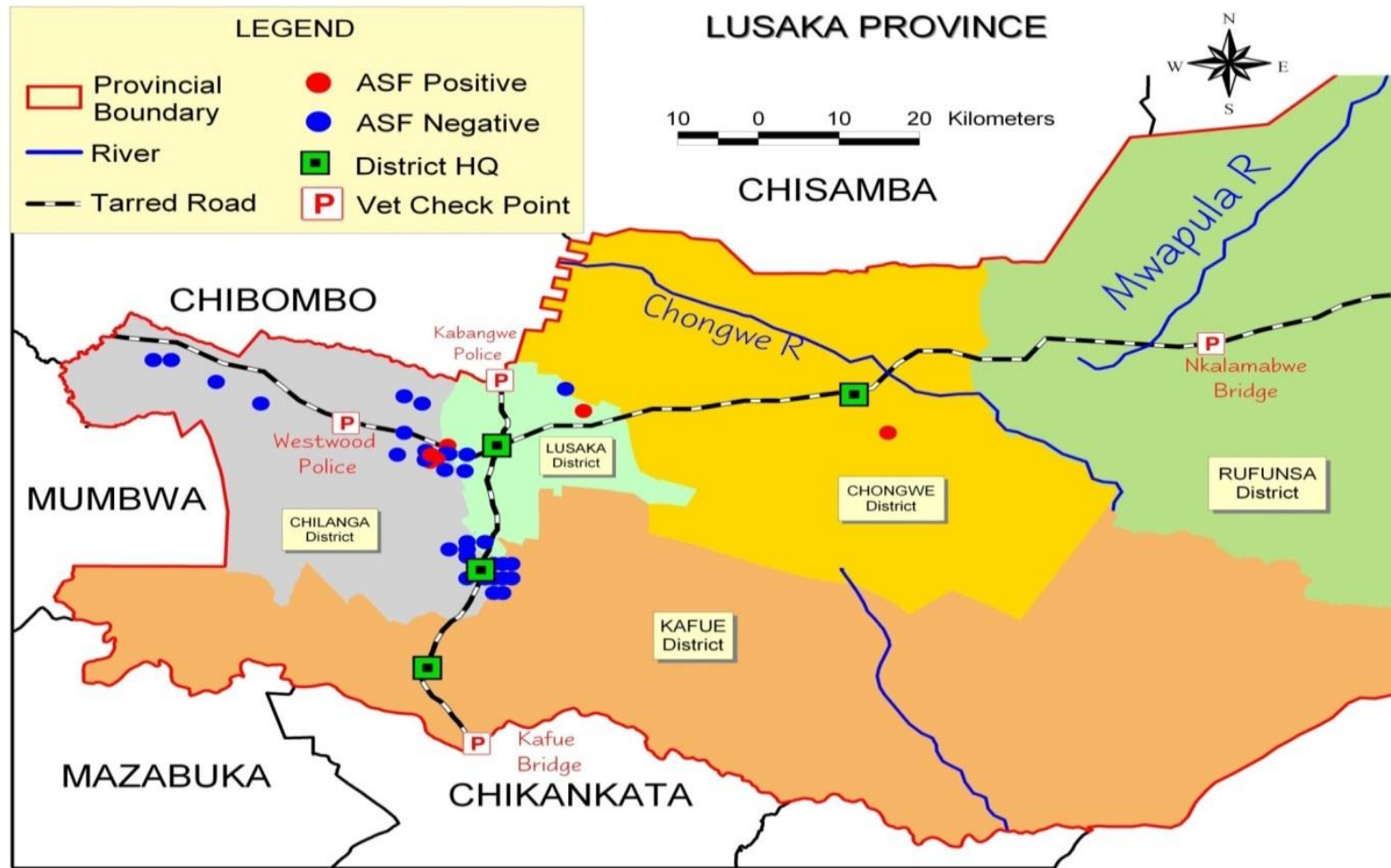


Figure 6: Distribution of the 2013 ASF outbreaks showing both negative and positive cases and veterinary checkpoints that were mounted as a control point (Source NALEIC)



Figure 7: a & b) Pigs that were slaughtered as part of ASF control measures in Lusaka
c) Burning of slaughtered ASF pigs **d)** Limed burial site for burnt pigs (Source: NALEIC)

The livestock movement ban in Lusaka province was lifted by the DVS on 14th January, 2014 when they were satisfied that the disease was under control, i.e. all affected farms and those in the 2km radius had their farms depopulated and disinfected 3 times at 2 weeks intervals. The affected farms were allowed to restock their farms after being given a certificate of freedom from the disease by MAL (MAL, Personal

communication). However, these control measures put in place did not achieve their purpose of eradicating the disease as evidenced by the series of outbreaks recorded in Lusaka province in 2014 to 2015.

2.6 Risk factors for spread

In endemic areas, the spread of ASF is often associated with the presence of free ranging pig husbandry, free movements of pigs locally and lack of biosecurity (Penrith *et al.*, 2007). For instance, the seasonal ASF outbreaks that occurred in the Sardinian pig industry in fall, winter and spring had been associated with the free-range carrier pigs that were usually concentrated in public areas where there was abundant corn thus facilitating ASFV transmission from the permanently infected carriers to susceptible pigs (Manneli *et al.*, 1998).

Several opportunities for spread such as contact occur along the market chain as traders move from one village to the other collecting sick and exposed pigs which are taken or walked to live pig markets and slaughter slabs (Gallardo *et al.*, 2013; Fasina *et al.*, 2012). The presence of poor slaughtering infrastructure to lack of slaughtering facilities has been shown to be a risk factor for ASF spread (Figure 8). The slaughter slabs normally lack proper sewerage and waste disposal mechanisms thus making the waste being accessible to other pigs as a source of food (Muwonge *et al.*, 2012; Muhangi, 2014).

Lack of knowledge on ASF and its transmission is common among small-scale farmers and this has been implicated in the spread of ASF in Madagascar where pigs were sold in the initial stages of an ASF outbreak (Costard *et al.*, 2009). The tendency to share

workers, farm equipment and transport for inputs and movement of animals by pig farmers has also been significantly implicated in the spread of ASF in localities (Saka *et al.*, 2010). Mur *et al.* (2012) reported that returning trucks and waste from ships and planes (swill feeding) poses a high risk of ASF introduction into the European Union.



Figure 8: Risk factors: **a)** Movement of sick and in-contact pigs **b)** Poor or lack of slaughtering infrastructure (Source: Muhangi, 2014)

The presence of infected ticks of the *Ornithodoros* species, wild suids, infected boars for natural mating or artificial insemination, consultation and visits by veterinarian/paraveterinarians when animals were sick, infected pigs present in the farm and infected or in-contact pigs bought into the farm without quarantine have been ascribed as risk factors for the spread of ASF (Fasina *et al.*, 2011; Fasina *et al.*, 2012; Nantima *et al.*, 2015).

2.7 Transmission

In Africa, ASF transmission is linked to the old sylvatic cycle in which maintenance of the disease is largely dependent on asymptomatic warthogs (Figure 9) and the new cycle in which the virus is maintained in domesticated pigs (Penrith, 2013).



Figure 9: Warthog, the natural reservoir for African swine fever virus (Source: FAO, 2000)

The linkage between the sylvatic and domestic cycles led to severe outbreaks which were also self-limiting in free-range domestic pigs (Costard *et al.*, 2013a). This scenario resulted in survivor pigs which were carriers of ASFV with a reduced virulence and changed the disease pattern of transmission. Once the disease gets established in the domesticated pigs, it can be maintained and transmitted to other domestic pigs using other routes that do not require vectors (Plowright *et al.*, 1994). Therefore, transmission of ASFV can occur via bites of an infected tick of the *Ornithodoros spp.*, contact between ASF infected and healthy pigs, ingestion of meat or products infected with ASF and through fomites which include virus contaminated material such as feed, farm equipment, protective clothing, vehicles and bedding (Penrith and Vosloo, 2009). The summary of ASF transmission and maintenance in Africa is shown in Figure 10.

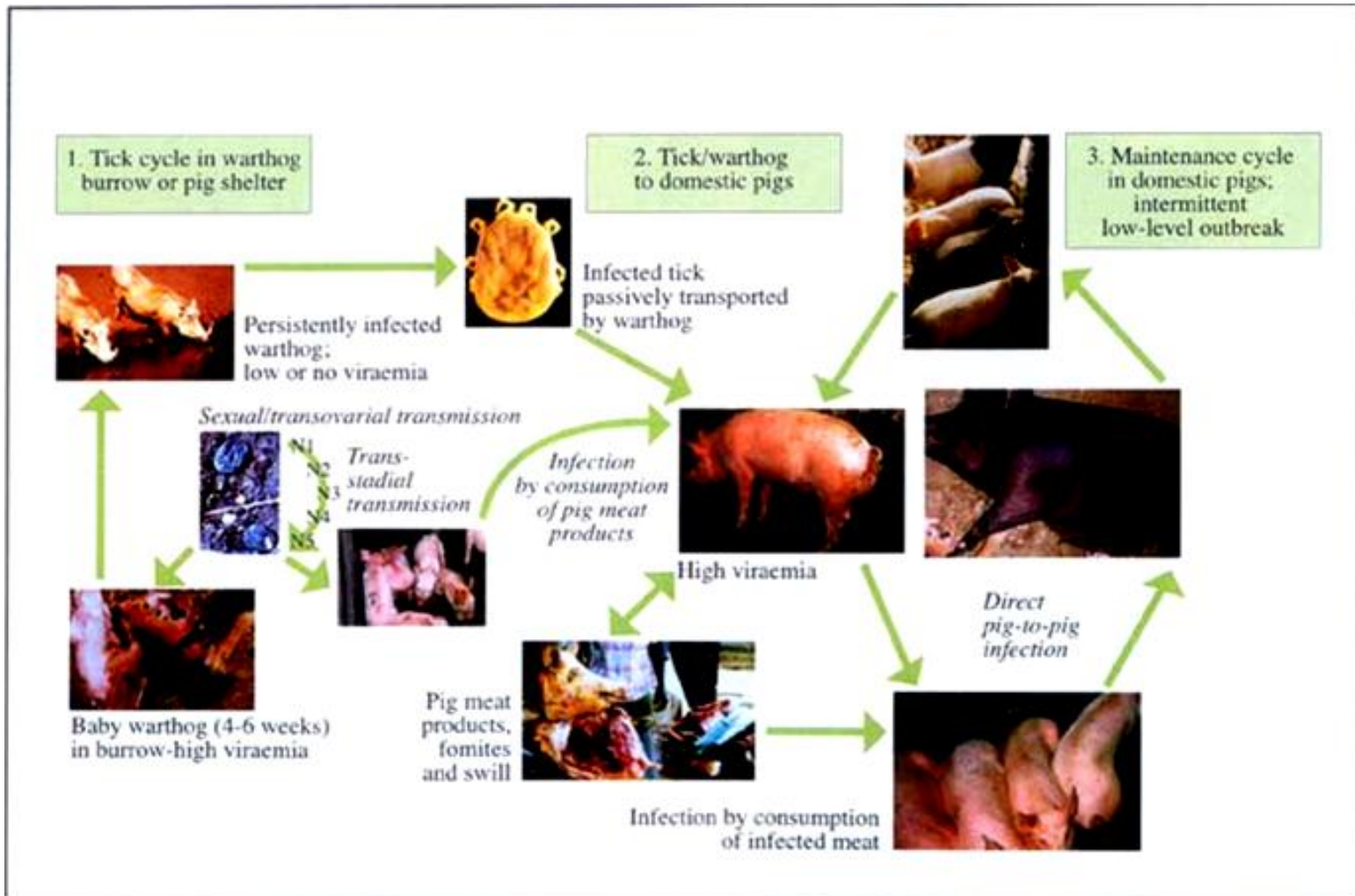


Figure 10: Transmission and maintenance of ASF in Africa (Source: FAO, 2000)

2.7.1 Sylvatic cycle

The transmission of ASF between warthogs and soft ticks of the *Ornithodoros moubata* (argasid ticks) complex is known as the sylvatic cycle (Costard *et al.*, 2013a). The life cycle of some *Ornithodoros spp* may be as long as 15-20 years and during the cycle, they can survive for about 5-6 years at some stages without a blood meal but still be able to maintain and transmit the virus for approximately 2 years (Dutch wildlife health centre, 2014). ASFV transmission among ticks can be transovarial, transstadial and sexual (which only occurs from males to females via the spermotheca and not vice versa) (FAO, 2001).

Warthogs live in burrows (for the first four to six weeks of their life) which are usually infested with soft ticks. The soft ticks transmit the virus when they feed on the young warthog blood as there is no maternal immunity which is passed on (Penrith *et al.*, 2012). The young warthogs develop low viremia which can be detected for up to 3 weeks post infection and remain asymptomatic for the rest of their life therefore facilitating ASFV transmission to susceptible ticks when they take their blood meals (Thomson, 1985; FAO, 2000, Glanville *et al.*, 2014). This implies that only neonatal warthogs can serve as a source of infection for ticks in a limited period of time annually because of the relatively low ASFV titres. Therefore, only the ticks that imbibe blood during periods of peak viremia become infected (Thomson, 1985).

2.7.2 Tick-pig cycle

The transmission of ASFV between ticks of the *Ornithodoros spp.* (Figure 11) and domestic pigs is referred to as the tick-pig cycle (Penrith *et al.*, 2013).



Figure 11: Ticks of the *Ornithodoros spp* (Source: Mohammad, 2008).

Outbreaks of ASF can occur when domestic pigs come into contact with the ticks that had a blood meal on wild pigs (Anderson *et al.*, 1998). The transmission of ASF in Africa from the reservoir wild pigs to domestic pigs via *O. moubata* has raised considerable interest because maintenance of the virus occurs in warthog-associated argasid ticks (Penrith *et al.*, 2004).

The argasid ticks have a restricted habitat therefore prevention of contact between the domestic swine and wild pigs including their burrows would prevent transmission of infection. Virus maintenance in these ticks can occur for prolonged periods in the absence of fresh sources of infection thereby acting as reservoirs in addition to being vectors of infection. Spread of the virus from the infected ticks or warthogs to domestic pigs results in sporadic outbreaks of ASF (FAO, 2000). In the absence of *O. moubata* in an area, *O. savignyi* is usually a field vector of the virus. In endemic areas of Zambia, the distribution and biology of *O. moubata* has been reported (Wilkinson, 1988). Tick

control using acaricides or absence of hosts over a long period has been found to decrease the risk of infection (Costard *et al.*, 2013a).

2.7.3 Domestic pig cycle

African swine fever virus transmission from one domestic pig to another is referred to as the domestic pig cycle. Domestic pigs infected with ASFV shed the virus in saliva, tears, nasal secretions, urine, faeces and secretions from the genital tract during clinical illness and for at least 24 hours before clinical signs develop (FAO, 2000). African swine fever virus persists in tissues and the environment, contributing to its transmission over long distances through swill feeding and fomites such as contaminated material, vehicles or visitors to pig premises (Mur *et al.*, 2012, Atuhaire *et al.*, 2013, Glanville *et al.*, 2014). However, exposure to sunlight and desiccation for prolonged periods renders the ASFV inactive (FAO, 2000). In Sardinia, the low ASF frequency observed in summer was attributed to solar irradiation which reduces ASFV viability on pig pasture (Manneli *et al.*, 1998).

The ASFV is normally stable in excretions of infected pigs, carcasses of the pigs and it is not inactivated by putrefaction (FAO, 2000). For instance, the virus can survive for a year and a half in blood stored at 4°C, 11 days in faeces at room temperature, and at least a month in contaminated pig pens (Maurer, 1975). In addition, the virus remains infectious for 150 days in boned meat stored at 3.8°C and 140 days in salted dried hams (Centre for Food Security and Public Health, 2010). In Sardinia, slaughtering pigs for household consumption and hunting of wild boars were linked to the seasonal ASFV transmission in fall and winter due to feeding pigs with infected pork (Manneli *et al.*, 1998).

2.8 Pathogenesis

Infection occurs via the upper respiratory tract with primary viral replication occurring in the tonsils and lymph nodes that are responsible for draining the head and neck (Blome *et al.*, 2013). Subsequent generalized infection is haematogenous and the virus becomes concentrated in all tissues (Oura *et al.*, 2013). African swine fever virus replication occurs in reticular cells, monocytes and macrophages though the virus has a predilection for the antigen-presenting cells of the macrophage-mononuclear system. Cell surface protein membrane receptors are used as entry points into the antigen-presenting cells of the macrophage-mononuclear system and replication occurs in 'viral factories' in the cytoplasm (Gomez-Villamandos *et al.*, 2013). Other cells where replication takes place include the endothelial cells, pericytes, glomerular mesangial cells, renal collecting duct epithelial cells, hepatocytes, neutrophils and megakaryocytes. However, only replication that occurs in the macrophages contributes significantly to the nature of the disease outcome though presence of the virus in immature neutrophils that are released into the blood increases haematogenous dissemination (Gomez-Villamandos *et al.*, 2013). Lymphopenia and marked destruction of T and B lymphocytes are common features of ASF despite replication not occurring in lymphocytes. This is due to apoptosis (programmed cell death) which is triggered by the release of cytokines such as tumour necrosis factor- α (TNF- α) released from infected macrophages (Blome *et al.*, 2013). African swine fever virus contains a gene that produces p21 which is expressed during the entire infection cycle and inhibits apoptosis thus enabling viral replication in surviving infected macrophages. This may cause the infection to persist (Penrith *et al.*, 2004).

African Swine Fever Virus causes hemorrhages in various organs. A schematic representation of the physiological pathways that are involved in the pathogenesis of shock and haemorrhage in ASF is shown in Figure 12. The factors responsible for these hemorrhagic lesions are not known though there is disruption of the blood clotting factors and the development of thrombocytopenia (Anderson, 1986; Oura, 2013). The severe destruction of macrophages is of great significance in the impaired haemostasis due to the release of active substances including enzymes, cytokines, complement factors and arachidonic acid metabolites (Blome *et al.*, 2013). It is postulated that the wide spread effusion and haemorrhage found in the acute form of ASF is due to the increased vascular permeability and disseminated intravascular coagulation (DIC). The mortalities are attributed to shock and/or excessive fluid exudation in the lungs (Penrith *et al.*, 2004).

The clotting cascade and the disseminated intravascular coagulation that occur in the vascular system have been attributed to the effect of mediators and prostaglandin E₂ (PGE₂), secreted by the infected macrophages on endothelial cells. The endothelial cells are responsible for the impairment of prostacyclin production. Thrombocytopenia results from the immune complexes of ASF antigen and antibody that cause aggregation of platelets, consumption of platelets due to coagulopathy, and the direct effect of virus on megakaryocytes (Penrith *et al.*, 2004).

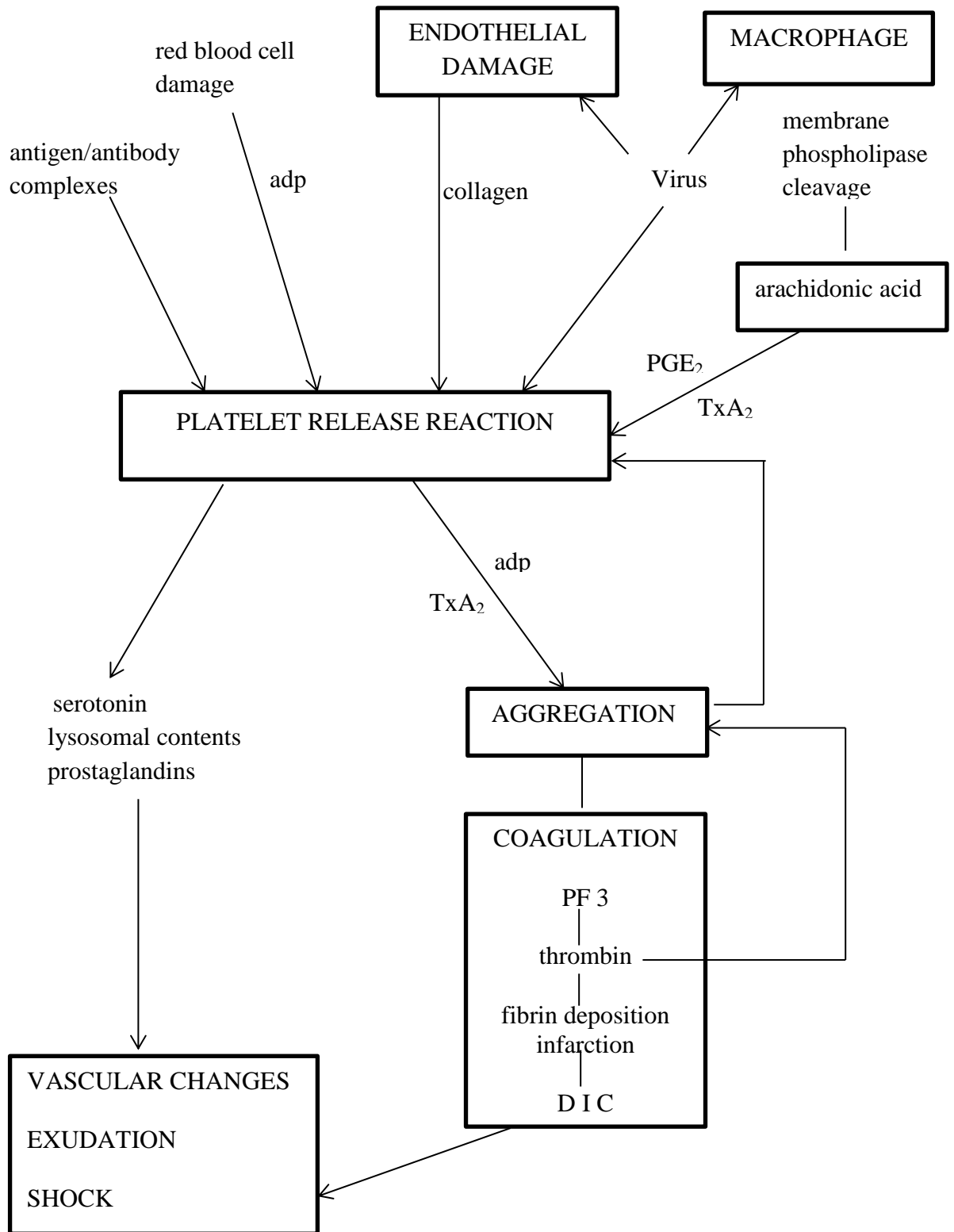


Figure 12: A schematic representation of the physiological pathways that are involved in the pathogenesis of shock and haemorrhage in ASF (Source: Anderson, 1986)

The intravascular coagulation observed in the liver is a response to the TNF- α that is released by virus-infected macrophages (Kupffer cells). The increase in PGE₂ and thromboxane A₂ (TxA₂) and the decrease in prostacyclin have been ascribed to TNF- α (Gomez-Villamandos *et al.*, 1995a). The hemorrhages observed in the kidneys and lymph nodes are a result of phagocyte activation, endothelial destruction in renal interstitial capillaries and DIC (Gomez-Villamandos *et al.*, 1995b). Alveolar oedema in the lungs is due to the activation of pulmonary intravascular macrophages that results in the release of IL-1, TNF- α , LTB₄ and oxygen radicals (Carrasco *et al.*, 1996).

2.9 Immunity

Pigs that survive ASFV infection remain infected for life and develop some level of immunity due to the circulating antibodies (Oura *et al.*, 2005). This implies that the survivor pigs are resistant to disease when exposed to related isolates of high virulence (homologous challenge) and at times even exposure to heterologous strains (Hamdy and Dardiri, 1984). However, the immunity developed was not absolute and/or enduring in some cases (Plowright, 1986). An important point that needs to be borne in mind is that to date, there is no vaccine against ASF. This is because all efforts that were directed towards the production of a vaccine were unsuccessful. All the various immunizations that were attempted did not yield any immunity that would protect the susceptible pigs (Mebus, 1988). Despite the identification of ASFV neutralizing antibodies, incomplete protection is obtained with the proteins p30, p54, and p72 (Gomez-Puertas *et al.*, 1996). On the other hand, CD8 + lymphocytes appear to have a role in the protective immune response to ASFV infection (Oura *et al.*, 2005). Therefore, a combination of humoral

and cellular immunity is required to obtain an efficient protective immune response to ASF (Oura *et al.*, 2013).

2.10 Clinical signs

African Swine Fever can occur as peracute, acute, subacute or chronic in form (Centre for Food Security and Public Health, 2010). Infection of wild pigs with ASFV does not result in clinical disease though infection with virulent strains of ASFV in domestic swine is almost deadly all the time (Thomson, 1985). When ASF was introduced in domestic pigs, it was characterised by high morbidity and case fatality rates which have reduced over the past years because of the decrease in the virulence of the disease (Penrith *et al.*, 2004). The change in ASF disease character occurs whenever the disease becomes endemic in pigs (Plowright *et al.*, 1994). In outbreaks experienced in Africa, ASF disease is mostly presented as an acute or peracute form (Plowright *et al.*, 1994). The incubation period for ASF ranges from 5-10 days though it may be as long as 20 days. For regulatory purposes, the incubation period is 40 days (Australia animal health, 2014).

In peracute ASF, death may ensue with no apparent clinical signs (Maurer, 1975). Acute disease is characterized by high fever (up to 42°C) which occurs within 48 hours post infection. Loss of appetite, weakness, huddling together, swayed gait, incoordination, convulsions, muscle tremors or paralysis later become evident (Plowright *et al.*, 1994). Further, congestion, cyanosis and haemorrhages occur around the skin of the tail (Figure 13a), limbs, abdomen, snout and ears which are very noticeable in white-skinned swine (Yabe *et al.*, 2014). Laboured breathing, mucopurulent ocular and nasal discharge and

frothy blood tinged nasal discharge (Figure 13b) may also be seen (Australia animal health, 2014).

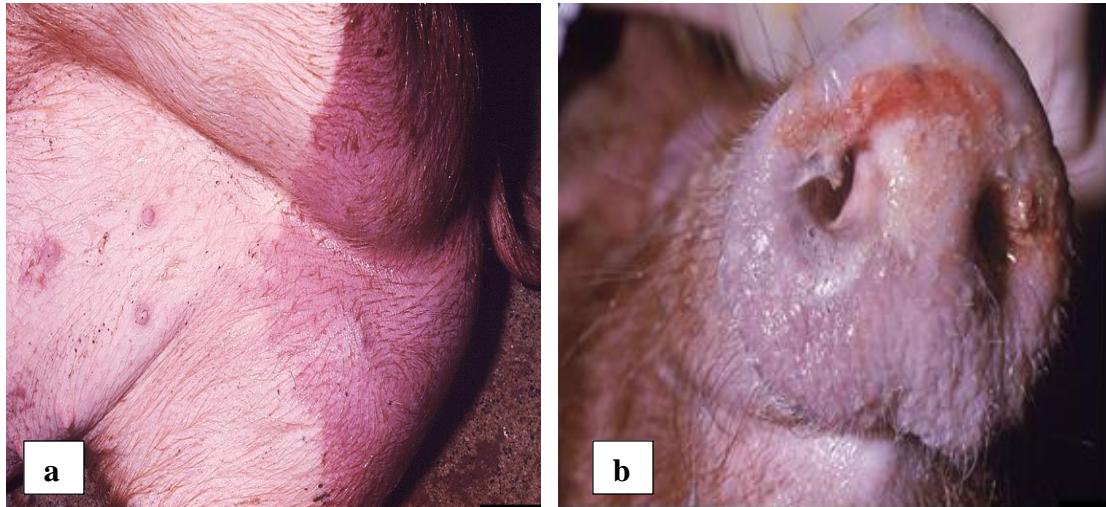


Figure 13: Acute ASF: a) Haemorrhages around the skin of the tail b) Frothy blood tinged nasal discharge (Source: CFSPH, 2010)

Another common sign in ASF infected pigs is vomiting while others may also exhibit constipation with bloody mucus on the faecal matter or watery diarrhoea or dysentery with fresh or blackened blood on the tail or perineum (Sanchez-Vizcaino, 1992). Abortion may also be seen in pregnant sows at any stage of the pregnancy. As the acute stage of ASF comes to an end, a rapid drop in temperature occurs followed by coma and later death (Sanchez-Vizcaino, 1992; Australia animal health, 2014).

Subacute ASF is similar to acute ASF though less severe because it is caused by isolates of moderate virulence. The mortality rate in the subacute form is reduced in adult pigs while it is still high in younger ones. There is transient fever, thrombocytopenia and leukopenia followed by death or recovery in about 4 weeks (Centre for Food Security and Public Health, 2010).

The chronic form of the disease normally develops over a period of 2-15 months. It is characterised by recurrent fever, emaciation, stunted growth, necrosis in areas of skin (Figure 14), chronic skin ulcers, arthritis, pericarditis, adhesions of lungs resulting from pneumonia which leads to serofibrinous pleuritis with pleural effusions, swellings over joints due to joint and tendon sheath effusions. The mortality rates are usually low and chronically infected pigs are normally carriers of the disease (Centre for Food Security and Public Health, 2011).

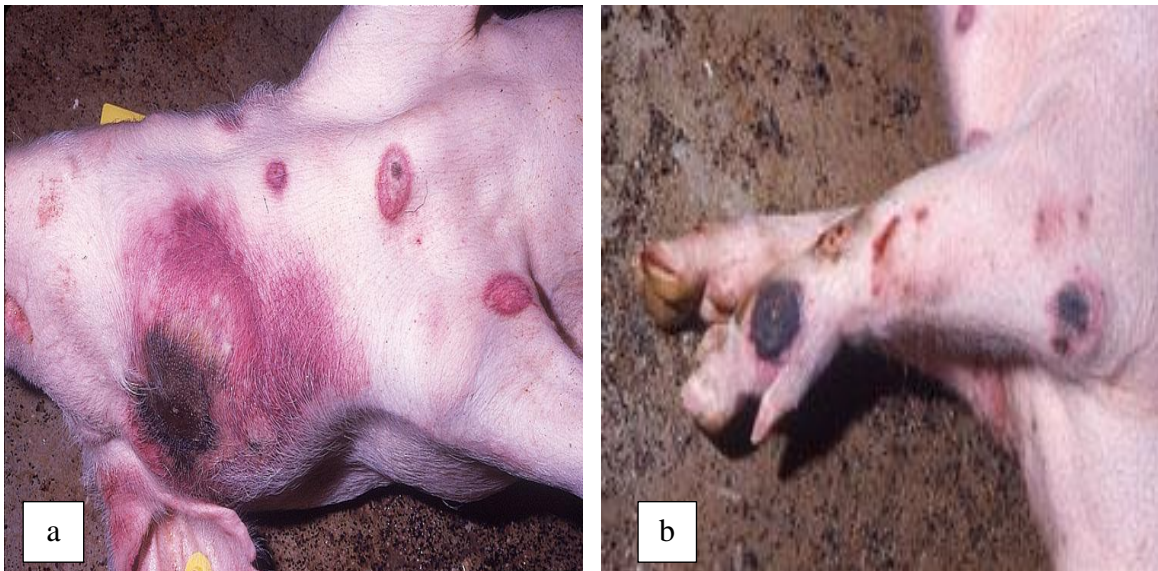


Figure 14: Chronic ASF: **a)** Skin necrosis **b)** Joint swellings & necrosis (Source: CFSPH, 2010)

2.11 Diagnosis

The detection of ASF is largely dependent on passive surveillance because detection through active surveillance is difficult due to the short viremia and high mortality rates associated with ASF. In order for passive surveillance to be effective, pig owners should be encouraged to report any suspicion of ASF to the relevant authorities in the veterinary

department to facilitate rapid diagnosis and compensation of affected farmers (FAO, 2013).

2.11.1 Clinical signs

Acute ASF should be suspected in pigs with a fever, nasal bleeding, erythematous flanks, back, and ventral abdomen. Petechiation and ecchymoses can also be seen on the skin around the ears, muzzle, and lower limbs (Yabe *et al.*, 2014). Congestive splenomegaly and pronounced haemorrhages in the gastro-hepatic and renal lymph nodes can also be seen on necropsy. Further, edema can occur in the lungs with blood-tinged froth being present in the trachea and bronchi (Oura *et al.*, 2013). Chronic ASF should be suspected when there is stunted growth, joint swellings and skin necrosis. Infection with less virulent strains is usually not easy to diagnose clinically and during necropsy (Oravainen *et al.*, 2011).

2.11.2 Differential diagnosis

The manifestation of ASF is similar to other diseases. These diseases include;

2.11.2.1 Classical swine fever (hog cholera)

The clinical manifestation and lesions of hog cholera and ASF are very similar such that it is impossible to differentiate between the two using clinical and post-mortem examination (Oura, 2013). A laboratory confirmation is always required to make a diagnosis (Moennig, 2000; Agüero *et al.* 2004).

2.11.2.2 Erysipelas

In erysipelas, all age groups are affected, there is reddening of the skin with some diamond-shaped lesions and the mortality rates are lower than in ASF. Pigs with

erysipelas respond to penicillin treatment while those with ASF do not respond to any form of treatment. Erysipelas can be confirmed using bacterial isolation (FAO, 2000).

2.11.2.3 *Salmonellosis, septicaemic pasteurellosis and other bacterial septicaemias*

The signs that are similar to ASF include fever, loss of appetite and respiratory or gastro-intestinal disorders. Congestion and hemorrhages may also be found at slaughter. Younger pigs are usually affected and normally respond to treatment with antibiotics. A confirmatory diagnosis is achieved by bacterial culture and isolation (Penrith *et al.*, 2004).

2.11.2.4 *Warfarin poisoning*

Features that are similar with ASF are hemorrhages which often lead to weakness and ataxia. Some manifestation of depression and anorexia may occur prior to hemorrhaging. The analysis of stomach contents, serum, or plasma for the presence of anticoagulants is used to confirm the diagnosis (FAO, 2000; Penrith *et al.*, 2004).

2.11.2.5 *Trypanosomosis*

The high mortality rate and fever observed in *Trypanosoma suis* infection are similar to those in ASF. It has been reported that *T. suis* causes a high fatality rate and is normally found in zones where pig keeping is not practised. Laboratory examination of blood smears to demonstrate the parasite is useful for confirmation (Neitz, 1963).

2.11.3 Laboratory diagnosis

The rapid and reliable detection of ASFV is required in order to prevent spread of the disease. During laboratory diagnosis, samples such as blood collected during the early

febrile stage in EDTA (0.5%), spleen, lymph nodes, tonsil and kidney stored at 4°C should be submitted in order to identify the agent while serum collected within 8–21 days after infection in convalescent animals should be submitted for serological diagnosis (World Organisation for Animal Health, 2013c). African swine fever virus cannot be found in aborted foetuses therefore blood should be collected from the sow when an abortion occurs (Centre for Food Security and Public Health, 2015).

2.11.3.1 Detection of the virus in cell culture

During viral isolation, blood or tissue samples from ASF suspected pigs are inoculated in pig leukocytes or bone marrow cultures prior to ASFV isolation. Porcine alveolar macrophages and blood monocyte cultures also support ASFV replication (Centre for Food Security and Public Health, 2015). The ASFV infected cells can be detected by their ability to induce hemadsorption of pig erythrocytes to their surfaces. When using this test, there is a possibility of missing some non-hemadsorbing isolates which are avirulent but able to cause an acute symptomatic disease. Hemadsorption “autorosette” test can also be used to detect ASFV in peripheral blood leukocytes from infected pigs (World Organisation for Animal Health, 2011b). Viral isolation and sequencing of the Polymerase Chain Reaction (PCR) product are recommended for confirming any new outbreak in ASF-free zones (Sánchez-Vizcaíno and Mur, 2013).

2.11.3.2 Detection of virus antigens by immunofluorescence

African Swine Fever Virus antigens can be detected easily in acute cases by immunofluorescence than in subacute or chronic cases because the test is less sensitive. The ASFV antigens can be found in tissue smears or cryostat sections, as well as in the buffy coat. The immunofluorescence test is not sufficient for diagnosis but is used in

conjunction with other assays as herd tests (World Organisation for Animal Health, 2012b).

2.11.3.3 *Detection of virus antigens by polymerase chain reaction (PCR)*

Nucleic acids can be detected with a PCR assay or by the hybridization of nucleic acid probes to tissue sections (Cubillos *et al.*, 2012). Polymerase chain reaction is particularly useful in putrefied samples that cannot be used for virus isolation and antigen detection. A rapid, real time PCR technique using tonsil scraping samples has been published (Oura *et al.*, 2012). This test can detect the virus a few days before the onset of symptoms thus the early detection technique of choice (Sánchez-Vizcaíno and Mur, 2013). Real-time PCR has been used in the past because of its high sensitivity, specificity, swift detection and quantification of ASFV DNA (Oura *et al.*, 2012).

2.11.3.4 *Detection of antibodies against ASF virus*

Serology is also useful for diagnosis, particularly in endemic regions. Antibodies to ASFV persist for long periods after infection. A number of serologic tests for the diagnosis of ASF have been developed though only enzyme-linked immunosorbent assay (ELISA), immunoblotting, indirect fluorescent antibody (IFA) and counter immunoelectrophoresis (immunoelectro-osmophoresis) have been standardized for routine use in diagnostic laboratories (Atuhaire *et al.*, 2013, Centre for Food Security and Public Health, 2015; African Union – Interafrican Bureau for Animal Resources, 2013). The recommended test for international trade is ELISA (World Organisation for Animal Health, 2011b). Enzyme-linked immunosorbent assay is used in surveillance programmes in affected areas for the detection of antibodies (Sánchez-Vizcaino and Mur, 2013).

2.12 Impact of African swine fever

The economic impacts of ASF are hard to quantify in Africa due to a dearth of disease recording, especially as this disease rapidly turns lethal in naive pig herds and active surveillance for the disease is rare. For instance, despite ASF being reported in the Southern part of Zambia in 2013, the total number of pigs that had died and those that were at risk was not known (Annual Report, MAL 2013).

The socio-economic impact of ASF is apparent both in areas where it is endemic and where new incursions have occurred. In Zambia, pigs and pig products cannot be moved or exported from the Eastern province to other parts of the country due to an indefinite ban (Samui *et al.*, 1996). Such an act results in the loss of additional income and profit for the households where pigs are sold for pork (Mekuriaw and Asmare, 2014). In Africa, ASF has potentially devastating effects on the commercial and subsistence pig production sectors, but the greatest losses are usually inflicted on the poorer pig producers who are less likely to implement effective prevention and control strategies or basic biosecurity. Fasina *et al.* (2011) found that a pig enterprise that is able to generate a profit of approximately US\$109 637.40 per annum has the potential to cause losses of up to US\$910 836.70 in a year.

African Swine Fever also has serious implications for food security, as pig production is an important source of human dietary protein in many countries. In addition to high mortality rates, ASF infection results in the loss of status for international trade and the implementation of drastic and costly control strategies to eradicate the disease (Costard *et al.*, 2009). In the 2013 ASF outbreaks experienced in Lusaka province, the Zambian government incurred about K10, 000,000 on disease containment and compensation of

affected farmers (Chifungula, 2015). African swine fever outbreaks often result in the closure of pig farms because farmers lack financial resources to restart production in the absence of compensation (Saka *et al.*, 2010). Apart from losses due to death or slaughter, other losses occur when farmers are treating the pigs prior to diagnosis of ASF and also during down-time when the affected area is forbidden to restock for a particular period as part of ASF eradication measure (Samui *et al.*, 1996). Further, ASF was identified as one of the factors that were responsible for the possible loss of genetic security or diversity of indigenous breeds (Ministry of Agriculture and Co-operatives, 2003).

2.13 Prevention and Control

The establishment of ASF outside Africa and its continuous threat to the highly developed pig industry in other countries has raised great interest worldwide. This scenario renders any country with a pig sector being at risk from an ASF introduction (FAO, 2014). ASF outbreaks are likely to continue in Africa if stringent measures to prevent contact between pigs and wildlife reservoirs and vectors are not put in place. Endemic ASF which occurs in several countries in Central and Southern Africa has continued to cause disease in the indigenous pig populations in these areas (Penrith, 2013).

Despite the absence of an effective treatment or vaccine against ASF, there is a possibility that the disease can be controlled and eradicated (FAO, 2001). In Africa, the impact of ASF was reduced in some countries by application of simple yet strict control measures thereby serving the pig industry which was relatively smaller than that of developed countries (Penrith and Vosloo, 2009). In order to control and eradicate ASF,

there is need for increased awareness of the socio-economic impact of this disease by educating all stakeholders in the pig industry (Sánchez-Vizcaino *et al.*, 2014).

In areas or countries that do not have ASF, implementation of strict import policies of live pigs and pork products and waste food from aircrafts, ships or vehicles is required (FAO, 2009b). In areas that are endemic to ASF, eradication of the disease is difficult because of its maintenance in the warthogs which are natural reservoirs. However, control of the soft tick vectors is important in preventing the disease. It is also important to ensure that meat from warthogs or infected animals is not fed to susceptible pigs (Sánchez-Vizcaino *et al.*, 2014; Department of Environment, Food and Rural Affairs Veterinary Science Team International Disease Monitoring, 2012).

The rapid diagnosis and implementation of quarantine and slaughter policies are advocated for effective control of the disease. All successful eradication programs have involved rapid diagnosis, slaughter and safe disposal of carcasses, compensation of affected farmers, banning swill feeding, garbage sterilization, movement controls, disinsectisation, thorough cleaning and disinfection of affected premises, and surveillance (World Organisation for Animal Health, 2011b). Disinfection is crucial to prevent the spread of these highly transmissible livestock pathogens during outbreaks and to facilitate the repopulation of livestock at agricultural facilities. The use of chemical disinfectants containing at least 2% citric acid for porous surface disinfection of ASFV is recommended (Krug *et al.*, 2012).

CHAPTER 3

MATERIALS AND METHODS

3.1 Study area

The study was conducted in Lusaka province, one of Zambia's ten provinces which covers an area of about 21,898km² thus representing 3% of Zambia's total land area. The province has eight (8) political and administrative districts, namely; Shibuyunji, Chilanga, Lusaka, Chongwe, Kafue, Chirundu, Rufunsa and Luangwa districts with Lusaka district (S15°25'S, 28°17'E) being the capital city of Zambia (Figure 15).



Figure 15: Map of Lusaka province showing the districts and veterinary check points© Westwood (A), Kabangwe (B), Moono (C), Kafue (D), Nkalamabwe (E) and Luangwa (F)

These districts are divided into camps which are manned by the Veterinary assistants (VAs) who report to the District Veterinary Officers (DVOs). The DVOs are charge of the districts and are responsible for co-ordinating disease prevention and control programs in their respective districts.

In Zambia, there are three categories of pig farmers that are distributed throughout the ten provinces. These include; traditional, medium-scale and commercial farmers.

The traditional farmers are found in rural areas, do not have title deeds for the land and keep few numbers of animals which are scavengers. Traditional farming is characterized by poor disease and parasite control, no supplemental feeding and lack housing facilities. Indigenous breeds are mainly kept though crosses of exotic breeds may be found.

The medium-scale farmers have some formal education; have title deeds for the land, provide housing facilities and realistic disease and parasite control. In addition to scavenging, supplemental feeding is provided. Indigenous breeds, crossbreeds and exotic breeds are mainly found in this category.

The commercial farmers are mainly found along the line of rail and the farms have title deeds with all the necessary livestock handling facilities. The standards of management at the farms are very high and have well defined objectives for the pig enterprise. The breeds are exotic and intensive feeding is practised. The pig population on these farms varies from few to thousands.

In Lusaka province, the total number of pig farmers and pig population is not known. During the study period, 187 pig farmers were registered by MAL though registration

was on-going. These farmers were located in Lusaka (92), Chilanga (19), Kafue (37) and Chongwe (39) districts and were not categorized into traditional, medium-scale or commercial.

Lusaka province has four (4) permanent veterinary check points; Kafue Bridge, Westwood, Nkalamabwe and Luangwa Bridge (Figure 15). The Kafue Bridge check point is located on the Kafue Bridge along Kafue road while Westwood check point is located in Lusaka West on Mumbwa road. Nkalamabwe and Luangwa Bridge check points are located along the Great East Road. These check points are manned by Veterinary staff from MAL and police officers from the Zambia Police Service 24 hours a day. The duty of these check points is to ensure that no pigs or pork products are allowed in and out of the province during ASF outbreaks and only pigs with movement permits are allowed to move when there is no outbreak (Appendix 8.2). Temporal veterinary check points such as Moono and Kabangwe on Great East Road and Great North Road respectively are usually mounted when there is an outbreak.

Lusaka province has 3 large markets for pigs and pig products, namely; Small Livestock Association of Zambia (SLAZ), Chibolya and City market. These markets have managers who are in charge of the traders and manage the affairs of these markets. The province also has 19 registered abattoirs and processing plants which are located in Lusaka (16), Chilanga (1), Kafue (1) and Chongwe (1) districts. The Ministry of Local Government and Housing (MLGH) through their meat inspectors ensures that only disease-free pork and pork products reach the consumers by carrying out meat inspection once the pigs are slaughtered.

4.2 Study design

A cross-sectional study was used to identify the risk factors associated with the outbreaks of ASF in Lusaka province. The study was conducted from September 2014 to June 2015.

The participants were selected purposively from the four (4) districts of Lusaka province that had cases of ASF diagnosed by CVRI and reported by the Director of Veterinary Services in the 2013-2014 outbreaks. The districts include Lusaka, Chilanga, Kafue and Chongwe. The participants included 3 DVOs, 3 VAs, 3 meat inspectors from MLGH, 3 market chairpersons and 15 traders. A participant (Veterinary staff or police officer) from each of the 6 veterinary checkpoints was included from all the check points despite Luangwa Bridge and Nkalamabwe not being in Lusaka, Chilanga, Kafue and Chongwe. This is because Luangwa Bridge serves as a permanent check point for pigs and pork products from Eastern province which is endemic for ASF (Samui *et al.*, 1996). Nkalamabwe check point is in Rufunsa district which is bordering Luangwa district of Eastern province that had active cases of ASF in 2013 (MAL, Personal communication). Further, 5 abattoirs and processing plants were also selected purposively from Lusaka (2), Chilanga (1), Kafue (1) and Chongwe (1).

Since there was limited information on registered pig farmers (no physical addresses and contact numbers), respondents were identified using a respondent-driven sampling which allows the researcher to make asymptotically unbiased estimates about the hidden population. Respondent-driven sampling is a variation of chain referral sampling based on snowball technique. In this technique, the respondents are not selected from a sampling frame but from the friendship network of existing members of the sample.

Sampling begins when the researcher selects initial participants known as seeds who later recruit others. This process of sample members recruiting future samples continues until the desired sample size is reached (Salganik and Heckathorn, 2004).

In this study, 50 pig farmers were selected. The initial participants were identified with the help of VAs in the district camps and upon completion of the interview; they were asked where possible participants could be found and their location. The farmers that had their pigs slaughtered in the 2013-2014 ASF outbreaks because they had ASF or were exposed were included in this study. However, the ASF positive cases being referred to in the results are those that were confirmed by CVRI during the study period.

4.3 Data collection

Data was collected using interview guides and questionnaires (appendices 8.3 to 8.10).

4.3.1 Interviews

The DVOs, VAs, meat inspectors, personnel manning check points, market managers and pig traders were interviewed at their respective places of work at an agreed time and date (Table 1). The responses were recorded on the spaces provided on the interview guide.

Table 1: Description of the sample population, theme of data and technique used to collect the data

Type of respondent	Workplace	Theme	Tool	Number	Total
District Veterinary Officer	District veterinary office in the Dept. of Livestock and Fisheries	Overview of ASF control measures put in place during ASF outbreaks and perceived causes of ASF spread	Key-informant interviews (Appendix 8.3)	1x3 districts	3
Veterinary assistants	Veterinary camps in the districts	Understanding the behaviour of farmers during ASF outbreaks and veterinarian-farmer interaction	Key-informant interviews (Appendix 8.4)	1x3 districts	3
Meat inspectors	Ministry of Local Government and Housing	Overview of meat inspection, ASF detection and challenges	Key-informant interviews (Appendix 8.5)	1x3 districts	3
Police officers (4) & Veterinary assistants (2)	Veterinary check points	Understanding pig and pig product movement control and challenges	Key-informant interviews (Appendix 8.6)	1x6 Veterinary check points	6
Market managers	Pig markets	Understanding the market regulations, behaviour of traders during ASF outbreaks, price fluctuations during ASF outbreaks and perceptions of control measures	Semi-structured interviews (Appendix 8.7)	1x3 markets	3
Traders	Pig markets	Understanding the sources and sell of pigs and ASF knowledge among traders	Semi-structured interviews (Appendix 8.8)	5x3markets	15

4.3.2 Questionnaire administration

Self-administered questionnaires comprising closed and open-ended questions were used to collect background information, respondent's attitudes, knowledge and perceptions on ASF.

The questionnaire was administered to 5 Managers of abattoirs and processing plants (Appendix 8.9). Background information (sources and transportation of pigs, market for pork and pork products), hygiene and biosecurity (cleaning and disinfection, protective clothing for workers, disinfection of vehicles and people) and views and perceptions on ASF outbreaks (knowledge on ASF, sources of information and control) was obtained.

A questionnaire was completed by 50 pig farmers (Appendix 8.10). Information was obtained on three aspects; (i) background information (age, gender, education level, duration of pig keeping, source of advice and alternative income), (ii) levels of pig production, marketing and sales (composition of the herd, cleaning and disinfection of piggeries, feeds and their sources, pig inspection, marketing and challenges) and (iii) views and perceptions on ASF outbreaks (knowledge on ASF, sources of information and control).

4.4 Data analysis

Data from interviews (DVOs, VAs, check points, market managers and pig traders) was ordered, coded and thematic analysis carried out. This information was then summarized using narrations, tables and flow charts. Some key statements or quotations emerging from the interviews were used to illustrate the main ideas. The data was then interpreted and inferences or conclusions drawn.

Data from questionnaire for abattoirs and processing plants was ordered, coded and summarized using tables and narrations. Information from the questionnaire for farmers was coded and entered into Microsoft Excel. The coded data was then transferred to STATA® Version 12 (STATA Corporation, College Station, Texas).

The variables that could be associated with spread of ASF such as location, duration of pig keeping, alternative source of income, absence of a boar, type of feed, source of feed/ingredient, ASF screening, market availability, knowledge on ASF transmission, occurrence of ASF outbreak and regulation on pig movement were identified. The significance of these factors was tested univariately using Chi-square to determine the effect of each independent variable on the dependant variable (ASF). All the factors were later subjected to a multivariate analysis using logistic regression. A multivariable logistic regression with a confidence interval of 95% was used to ascertain the effects of the above factors on ASF positivity. The *P*-value for the test was >0.05 meaning that the logistic model used was an adequate fit for the data.

4.5 Confidentiality and privacy of participants

In this study, the name or any form of identity of the respondent was not required. Only respondents that were willing to participate were included in the study and were assured that all the information given would be treated with utmost confidentiality and anonymity. The respondents were also informed that the data that was collected was purely for academic research and only authorized persons would have access to it.

CHAPTER 4

RESULTS

4.1 General findings from interviews

4.1.1 Overview of ASF control measures put in place during ASF outbreaks and perceived causes of ASF spread

A common narrative from all the 3 District Veterinary Officers (DVO) revealed that when there was suspicion of ASF in an area, the field Veterinary Assistant (VA) informed the DVO who later informed the District Agricultural Coordinator (DACO), and then Provincial Veterinary Officer (PVO), Director of Veterinary Services (DVS), Permanent Secretary (PS) and finally the minister was informed. Sample collection and testing was done during the process. Untimely disease reporting due to inadequate manpower and transport at camp level was the major challenge. For instance, in the 2013-2014 ASF outbreaks, the disease was confirmed on 18th November, 2013 when the pigs started dying a month earlier.

The DVS decided whether or not to institute a ban on all movements and processing of pigs and pig products during ASF outbreaks after disease confirmation. The DVS announced the ban in the government gazette. Veterinarians with the help of the police ensured that the ban was adhered to. However, the DVS only lifted the movement ban when they were satisfied that the disease was under control, i.e. all affected farms and those in the 2km radius had their farms depopulated, disinfected 3 times and no further cases were recorded. These affected farms could only restock their farms after being given a certificate of freedom from the disease by MAL.

The rampant spread of ASF was attributed to various factors as attested by the veterinary officers:

'That's a good question! ...formites, we veterinarians are culprits. We think it is an opportunity to make money so we move from one farm to another. These farms do not have footbaths, wheel baths and are not fenced so it is easy to spread infection when veterinary staff are invited to a farm when there is suspicion of disease or workers visiting other farms for advice' (Interview: DVO Participant 1).

'The check points are very porous and there are a lot of illegal movements of pigs and pig products. Some farmers buy pigs for breeding from Chibolya market which is a dumping place for exposed and sick animals... Government will not compensate the farmers whose pigs will be slaughtered as a result of being infected with ASF like they have done in past in accordance with the Animal Health Act of 2010. The pigs were weighed before slaughter and affected farmers were being paid K13 per kilogram. It's like paying someone for spreading the disease. Despite having ASF outbreaks now, pig movement has not been banned because farmers, traders and other stakeholders were adversely affected during the recent movement ban (November, 2013 to January, 2014). Only pigs that have been tested negative and issued with a stock movement permit by the DVS will be allowed to be slaughtered' (Interview: DVO Participant 2).

'I think that we have not done much in terms of disease surveillance due to erratic funding. Bran from Eastern Province, pigs move to Lusaka province from almost everywhere without being tested for ASF and some of these areas where they come from have active cases of ASF which are not reported' (Interview: DVO Participant 3).

4.1.2 Understanding the behaviour of farmers during ASF outbreaks and veterinarian-farmer interaction

Pig farmers will try by all means to treat their pigs when they are sick first and only report to the veterinary department when there is a high mortality rate. As the participants in the camps expressed:

'Hiding information that the pigs are sick; the workers move from one farm to the other looking for assistance. When the disease becomes serious, the veterinary department is involved though some decide to sell the pigs because they are afraid of losing them' (Interview: VA Participant 1).

'Some pig owners in Solobon and Zambia compounds do not report such deaths because their pigs are very few and mostly scavenging. The farmers normally assume that the pigs ate something poisonous. Some sick pigs are slaughtered before they die and the pork sold to consumers and vendors who braai and it sale in taverns' (Interview: VA Participant 2).

'Some farmers slaughter the pigs and put them in freezers either for sale or consumption' (VA Participant 3).

It was reported that all the 3 VAs could not manage to survey all the farms in their camps. The veterinary camps were too big and the motorbikes they used for field services did not have fuel all the time. Hence a farmer needed to provide fuel or transport of their own for a VA if they had a problem on their farms.

4.1.3 Understanding movement control on pigs and pig products and its challenges

At the time of the study 5/6 check points were manned by police officers though only 2/6 checkpoints had veterinary staff. The police officers and veterinary staff at the check points reported that pig farmers and traders had alternative routes which they used during periods of livestock movement bans.

'Dubious ways of transporting pigs such as use of illegal movement permits which had different locations where there was no ASF outbreak, car boots, loading pigs in trucks first and then other goods on top in order to hide the pigs, dried pork in suitcases (from Eastern province), trucks via the bush and crossing rivers and streams using canoes are used. These people normally notified one another whether the routes were safe or not using cell phones therefore making it difficult for veterinarians and police to enforce the movement ban' (Interview: VA Participant 2).

Ensuring that there was no movement of pigs and pig products during ASF outbreaks was not easy as some participants had to say:

'...most people are not aware of these movement bans because they are in remote areas or did not hear the news because of electricity outage. Such people normally have their pigs seized and destroyed, an act which they feel is unfair but we have to abide with the law. As you can see I am alone with one police officer, I cannot manage to inspect all vehicles on both lanes of the road. Therefore even though I saw people crossing the Kafue river with pigs, I would not go after them because of inadequate manpower and transport' (Interview: VA Participant 1).

'We are not trained to detect animal diseases, our duty is to check whether the people moving the animals are the rightful owners or not with the help of livestock movement permits. If they do not have a movement permit, we impound the vehicle and charge them an admission of guilt fine. The offender pays K10 per animal to the local council but the amount paid to the police varies though a government receipt is given. We also give movement permits when the papers are available, if not, we refer them back to the veterinary services' (Interview: Police Participant 3).

4.1.4 Overview of meat inspection, ASF detection and challenges

All the 3 meat inspectors in the Ministry of Local Government and Housing (MLGH) stated that not all pork processing plants and abattoirs were registered by MLGH nor these have trading licences or their pork inspected. They narrated that they inspected the registered abattoirs and processing plants every time they were slaughtering pigs and different inspectors were assigned to each abattoir all the time.

The inspectors were able to detect ASF during meat inspection but had never detected any cases. However, one inspector had suspected one carcass which was confirmed negative at CVRI in March, 2014. The inspectors were able to trace back the origin of these pigs based on the information the suppliers submitted to the abattoirs. Nevertheless, they ensured that the suspected carcasses did not reach the consumer by burning the carcasses in front of witnesses after collection of samples. Burning was not left to the abattoir management because some workers could not be trusted with condemned carcasses.

The meat inspectors had several challenges in ensuring that only safe pork and pork products reached the consumer:

'Illegal slaughter of pigs and sale of pork products in non-designated areas such as backyards, behind butcheries and in Chibolya market which supplies hundreds of people' (Interview: Meat inspector Participant 3).

'Inspection of already slaughtered animals is not done; this meat is passed on to the consumers without our knowledge' (Interview: Meat inspector Participant 2).

Meat inspectors also felt that it was necessary to sensitize the general public on the importance of buying safe meat and meat products from reputable sources and intensifying inspection of pigs and slaughtered pigs at check points or road blocks.

4.1.5 Understanding the market regulations, behaviour of traders during ASF outbreaks, price fluctuations during ASF outbreaks and perceptions of control measures

Only traders registered by the market management were free to sell in these pig markets on a daily basis though everyone was free to supply their products to traders or sell directly to consumers when they brought their pigs. According to the market managers, 2 markets (markets I and II) did not request for movement permits when the pigs were being taken to their markets while it was mandatory to have a movement permit in 1 market (market III). None of the 3 markets had their pork inspected by meat inspectors (Table 2).

Table 2: Marketing of pigs and pig products

Description	Market I	Market II	Market III
ASF screening required	No	No	Yes
Meat inspection present	No	No	No
Products on sale	Pork	Live pigs/Pork	Pork
Buyers/Customers	Consumers	Pig farmers	Consumers
	Vendors	Consumers	COMESA market
		Vendors	Butcheries
		Congo DR	Vendors
		Butcheries	Restaurants

It was noted that there was an increase in movement of people from one farm to another when news of ASF spreads in the area.

'During the initial period of the ASF outbreak, pig farmers were scared of losing their pigs hence sold them at a giveaway price. Traders considered this as an opportunity to make money hence moved from one farm to another to buy pigs' (Interview: Market manager Participant 3).

When movement bans were imposed, the supply of pigs decreased while the demand increased. Market managers revealed that where normally more than 200 pigs were slaughtered per day, the number of pigs slaughtered dropped to about 50 pigs per day and at times even zero. The prices of pork on the market also increased from an average K300 when there was no outbreak to K400 or K450 and very large pigs could fetch as high as K1000. Farmers and traders determined the prices based on the quality of their

pigs. Furthermore, a drop in supply of pigs reduced during the rainy season as most farmers were busy in the fields.

'...farmers and traders are losing colossal sums of money due to the ban on the movement of pigs and pig processed products in Lusaka Province. However, we are sure that the government will combat the outbreak to avoid further loses to our small-scale farmers' (Interview: Market manager Participant 1).

The market managers felt that farmers should not be burdened with high livestock levies and slaughter fees as this was what made them find illegal routes to their final destinations. Farmers had to bear the cost of pigs being tested for ASF despite being in areas that were far from the research centre. If a farmer had few pigs, he would not want to spend more money by getting the pigs certified hence sold them to middlemen. The middlemen often robbed the farmers' profits.

4.1.6 Understanding the sources and sell of pigs and ASF knowledge among traders

The flow chart below (Figure 15) shows where pigs were produced (A, B and C) and how they reached the consumers (J) using various routes (D to I).

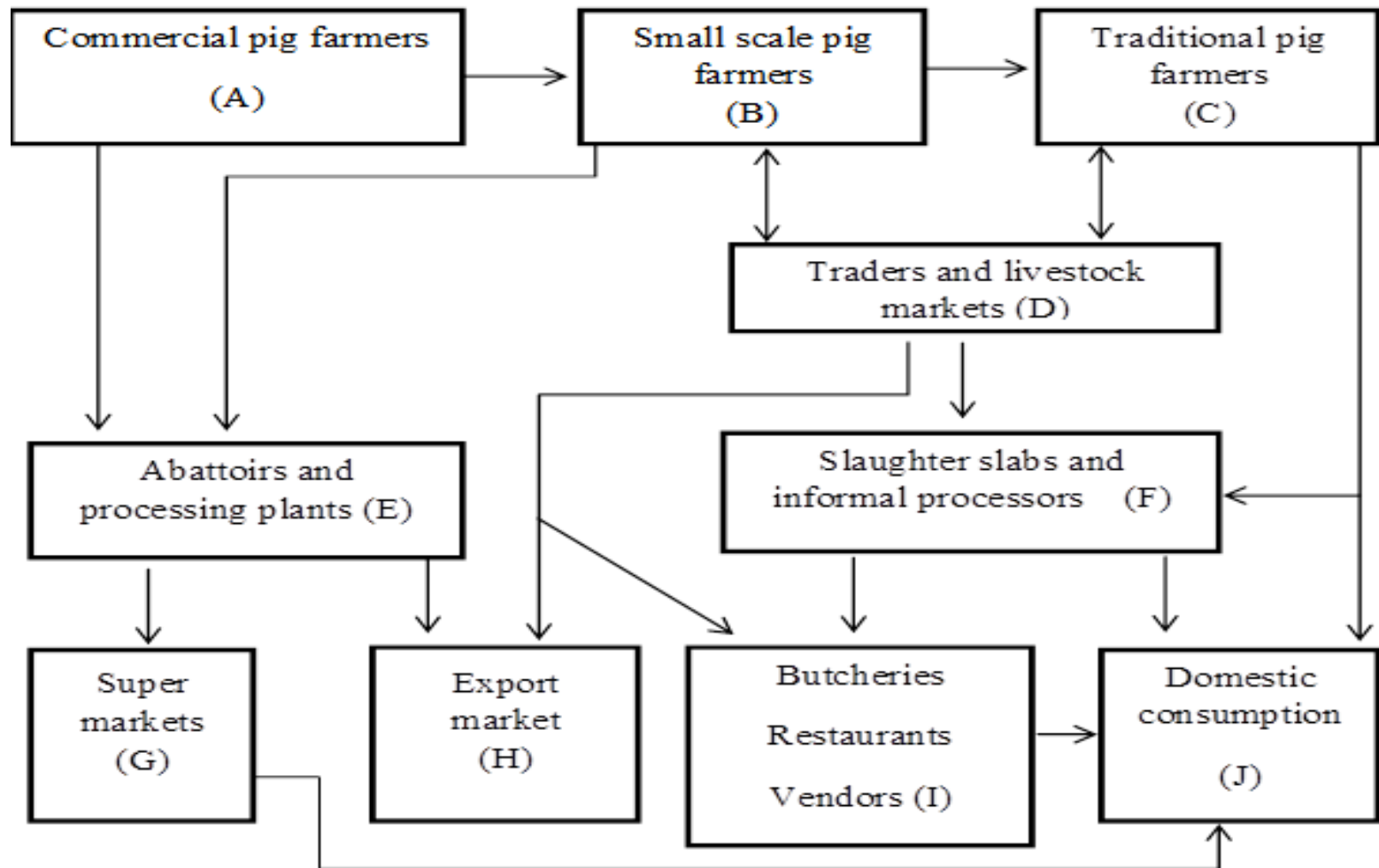


Figure 16: Production and movement of pigs and pig products in Lusaka province

Pigs mainly came from Southern (Choma, Kalomo, Namwala and Monze), Western and Lusaka provinces. Commercial farmers (A) sold their pigs to small-scale pig farmers (B) and abattoirs/processing plants (E). Small-scale farmers sold their pigs to traditional farmers (C) and traders/livestock markets (D). Traders (D) collected the pigs from various farms across the countries which were sold to small-scale (B) and traditional farmers (C), slaughter slabs/informal processors (F), Common Market for Eastern and Southern Africa (COMESA) market, butcheries, braai stands (popularly known as *muchopo*) and families (I). A named market revealed that some of the pigs were taken to Congo DR using trucks (H). Pork from abattoirs and processing plants was sold to supermarkets (G) for domestic consumption (G) while some was exported (H).

The traders used different modes of transport depending on its availability in the area. These included bicycles, wheelbarrows, ox carts, and vehicles and at times traders made the pigs walk if the destination was nearby. The modes of transport were mostly hired therefore traders had no knowledge whether the owners disinfected the transport used or not. If the villages were within close proximity of each other, the same transport would be used to collect the pigs from one household or farm to another. The traders did not have their pigs tested for ASF before movement though some got Livestock ant-theft clearance reports from the police to show that the animals were not stolen.

Nine out of 15 (60%) pig traders had heard of ASF but only 5 (33%) had knowledge of ASF. Six out of 15 (40%) traders had not heard about ASF though they had heard about the police officers mounting up check points to impound pigs.

4.2 Questionnaire response from Abattoirs and processing plants

All the five abattoirs and processing plants visited sourced pigs from farmers and traders from all parts of the country except Eastern province. For these abattoirs and processing plants, it was mandatory that the pigs purchased were screened for ASF (Appendix 8.11). One out of five abattoirs and processing plants provided transport for the farmer if they had more than 40 pigs to sell and the truck moved from one farm to the other to collect the pigs. However, the non-availability of a consistent supply of quality pigs and adequate numbers was the main challenge for these abattoirs and processing plants.

All processing plants and abattoirs had heard about ASF, 4 out of 5 knew how it was transmitted and felt that movement bans were an effective way to control the disease. However, they felt that their businesses were greatly affected because the supply of pigs went down or stopped but had to pay their workers. Therefore, they would prefer that these movement bans were only restricted to the affected areas and other areas allowed to market their pigs.

4.3 Questionnaire response for pig farmers

4.3.1 Descriptive statistics

The description of the study area and population of pig farmers in this study is shown in Table 3.

Table 3: Description of the study area according to stratum, population of pig farmers sampled and their confidence intervals ($n=50$)

Strata/Location (District)	Population (n)	Standard error (S.E.)	Proportion (%)	95% Confidence Interval (C.I.)
Lusaka	25	0.07	50	35.6-64.3
Chilanga	10	0.05	20	8.5-31.5
Kafue	5	0.04	10	1.4-18.6
Chongwe	10	0.05	20	8.5-31.5

The farmers in each stratum were required to complete a questionnaire and a summary of their personal characteristics is presented in Table 4.

Table 4: Personal characteristics of pig farmers ($n=50$)

Personal characteristics	Description	N	Percent	95% C.I.
Gender	Male	33	66	52.4-79.6
	Female	17	34	20.4-47.6
Education level	Nil	4	8	1.4-18.6
	Primary	2	4	0.0-6.0
	Secondary	7	14	4.0-23.9
	Tertiary	37	74	61.4-86.6

There were more male farmers than and female pig farmers in this study. Most of the farmers (74%) had a tertiary education while those that had secondary (14%) and no education (8%) education were few. A minority of them had primary education (4%).

Framers had variable farming experience (Table 5). Only 28% of the pig farmers had more than 4 years' farming experience. More farmers however (38%) had less than a year in pig production. The majority (88%) had an alternative source of income.

Table 5: Distribution of years spent on pig farming duration and alternative sources of income for pig farmers ($n=50$)

Characteristic	Description	<i>n</i>	Percent (%)	95% Confidence Interval
Pig farming (years)	<1	19	38	25.9-54.0
	1-2	11	22	8.5-31.4
	>2-3	6	12	2.6-21.3
	>4	14	28	15.1-40.8
Alternative income	Yes	44	88	78.7-97.3
	No	6	12	2.6-21.3

Three out of four strata had ASF positive pig farms during the study. The total numbers of ASF confirmed positive pig farms according to their stratum are highlighted in Table 6.

Table 6: Total number of pig herds showing positive and negative cases for ASF by strata

Strata	ASF positive (%)	ASF negative (%)
Lusaka	1 (4%)	24 (96%)
Chilanga	2 (20%)	8 (10%)
Kafue	0 (0%)	5 (100%)
Chongwe	1 (10%)	9 (90%)

4.3.2 Risk factors

4.3.2.1 Absence of breeding boars

Farmers stated that they bought breeding stock from fellow farmers and live pig markets (e.g. Chibolya market near the Lusaka Central Business District). However, 4/50 (8%) pig farmers had no boars hence took their sows out to other farms for servicing.

4.3.2.2 Source of advice for pig farmers

The major source of advice for the farmers was the veterinary department and private veterinarians (46%), and friends (34%), while only 2% was through the media. Many had different combinations of sources. For example, 8% of the pig farmers obtained their advice from both friends and veterinary consultants with only 2% utilizing both veterinary consultants and the media as their source of information. However, 8% of the pig farmers utilized all the sources of information mentioned above (Table 7).

Table 7: Distribution of sources of advice for pig farmers ($n=50$)

Source of advice	<i>n</i>	Percentage	95% Confidence Interval
Veterinary service providers	23	46	31.6-60.3
Friends	17	34	20.4-47.5
Media	1	2	0.2-6.0
Friends and Veterinary consultants	4	8	0.2-15.7
Veterinary consultants and media	1	2	0.2-6.0
All the above	4	8	0.2-15.7

4.3.2.3 Feed and sources of feed/ingredients

Seventy-six percent of the farmers formulated their own feed while 22% used commercial feed which was ready to be fed to pigs. Only 1 farmer fed the pigs on household scrapes (Table 8)

Table 8: Description of the type of feed used by pig farmers ($n=50$)

Type of feed	Frequency (<i>n</i>)	Percent (%)	95% Confidence Interval (C.I.)
Commercial	11	22	11.7-36.2
Home made	38	76	61.4-86.5
Household scrapes/scavenging	1	2	0.2-6.0

The feed and ingredients used were mostly obtained from different sources (Table 9). Seventy percent of the pig farmers bought their feed or ingredients from agro-shops

while 16% from traders/markets. Six percent of the pig farmers sourced their feed/ingredients from millers while 8% utilized all the options as their sources.

Table 9: Distribution of the source of feed/ingredients for pig farmers ($n=50$)

Source of feed/ingredients	Frequency (n)	Percent (%)	95% Confidence Interval (C.I.)
Agro-shop	35	70	56.8-83.1
Traders	8	16	5.4-26.5
Millers	3	6	0.0-12.8
All the above	4	8	0.2-15.7

4.3.2.4 Cleaning and disinfection of pig pens

Only 2% of the farmers cleaned the pig pens more than once a day (Figure 17). Most of them cleaned only once or twice. Fifty-four percent farmers cleaned once a day, 40% twice a day while 4% had enclosed the pigs in a wire fence without cleaning. Only 58% farmers disinfected their pig pens at least once a week.

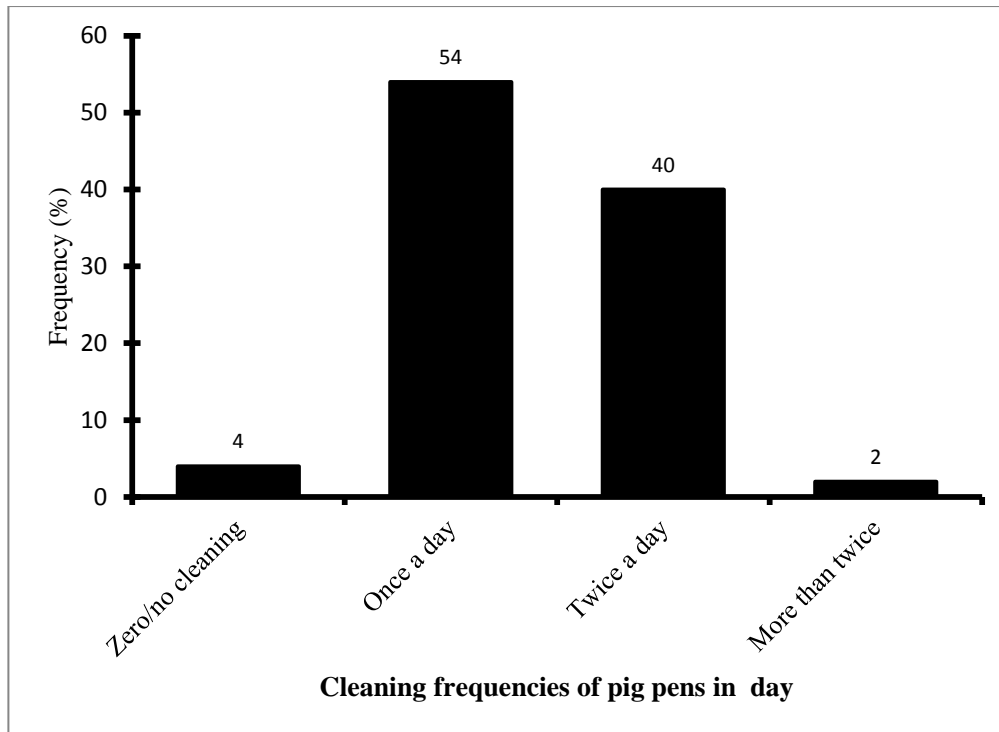


Figure 17: Distribution of cleaning frequencies of pig pens by farmers in a day

4.3.2.5 Market availability, sale patterns and ASF screening

From this study, 82% farmers felt that the market for pigs was readily available while 18% farmers thought that the market was inadequate. Pig farmers sold their pigs to other pig farmers (6%) as breeders or replacement stock, traders or markets (32%), butcheries (6%), individuals (8%), abattoirs and processing plants (26%) while those that sold to all these options were 22%. Farmers delivered their pigs to these abattoirs and markets using their own transport or hired transport which was not disinfected. Only half (50%) of the farmers had their pigs screened for ASF before being sold.

4.3.2.6 Challenges for pig production

There were a number of challenges that affected the farmers pig production activities (Figure 18). The majority stated that accessing technical advice from veterinarians

(30%) was not easy. This was followed by high feed costs (22%), lack of good market prices (18%), limited access to loans for capital investment (12%) and stock theft (8%) while 10% had all the above challenges.

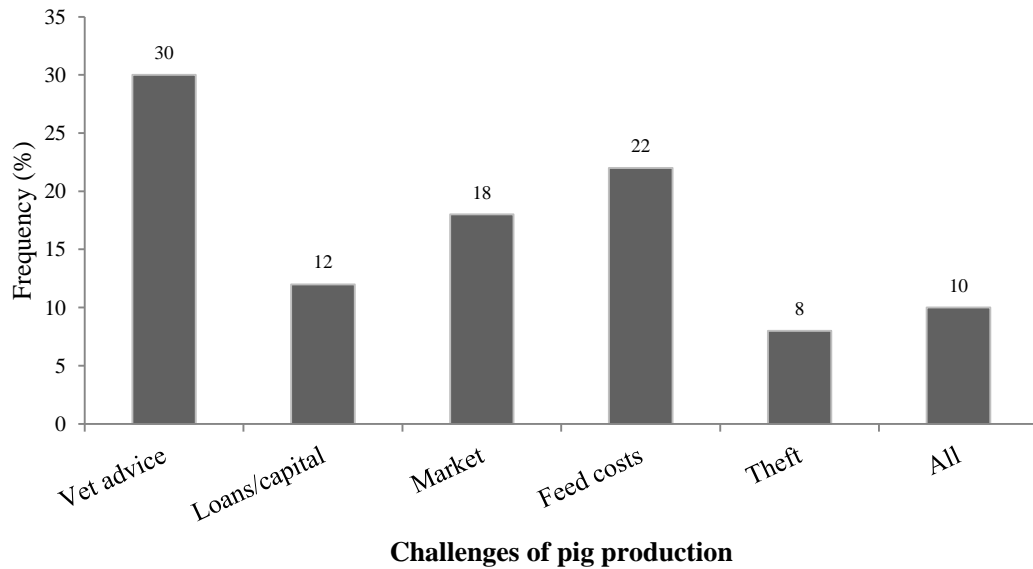


Figure 18: Pig production challenges of farmers in Lusaka province

4.3.2.7 Knowledge of transmission and perceptions of ASF outbreaks

All the farmers interviewed had heard of ASF through the media, friends, college/university or MAL with the media (42%) being the major source of information (Figure 19). However, of these only about half (48%) knew how ASF was transmitted. Some (38%) felt that their pig enterprises were severely affected during ASF outbreaks while 62% felt that the occurrence of ASF did not affect their business in any way.

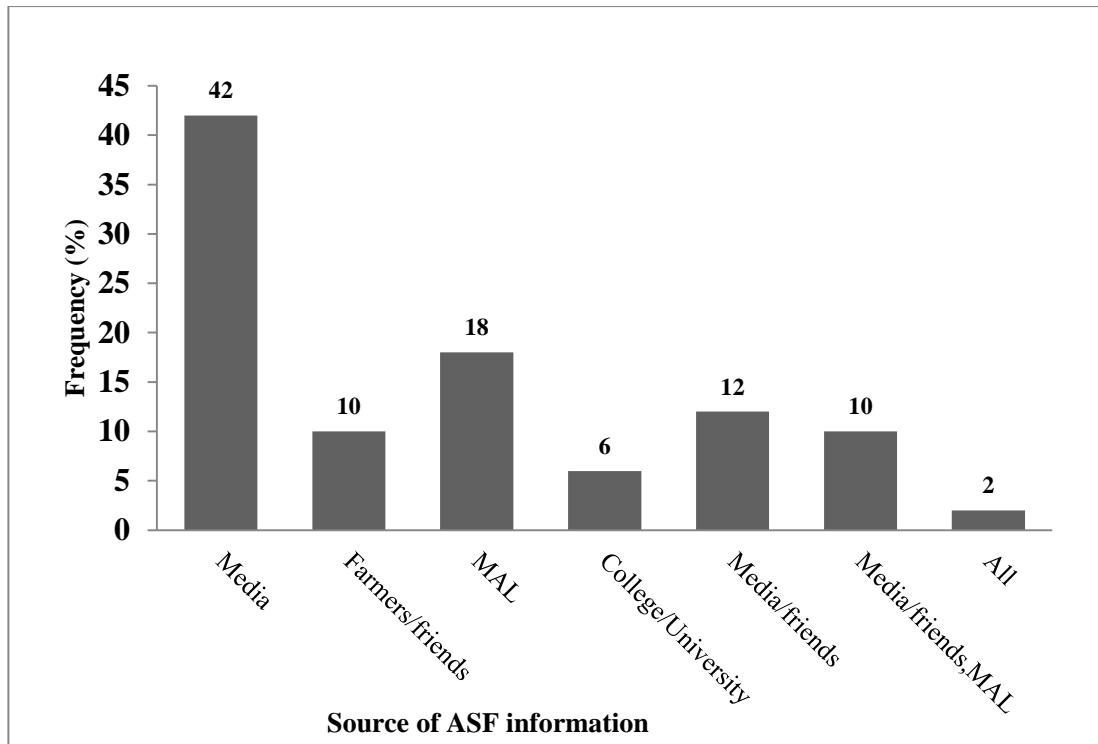


Figure 19: Sources of ASF information for pig farmers in Lusaka province

4.3.2.8 Regulation of pig movement and perceived ASF mitigation measures

The movement ban imposed on pig movement was perceived as a good way of controlling the disease by 58% pig farmers while 24% felt that it was bad. Only 10% felt that it was both good and bad with 8% not knowing whether it was a good measure or not.

Several ASF mitigation measures were suggested by pig farmers as shown in Figure 20.

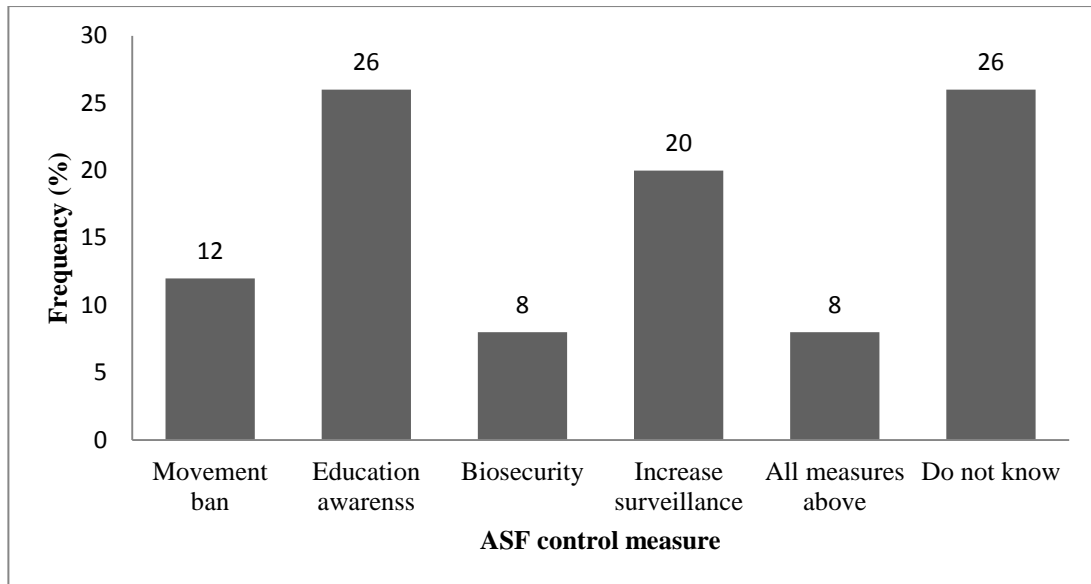


Figure 20: Distribution of ASF control measures suggested by pig farmers

Pig movement ban was perceived to be an efficient means of controlling ASF by a minority of farmers 12% pig farmers while others felt that education awareness (26%), biosecurity (8%) and increasing surveillance (20%) would be effective. While only 8% pig farmers perceived all the measures mentioned above to be useful in mitigating the disease, a substantive number (26%) did not know how to control the disease.

4.3.3 Association of risk factors to ASF presence

In order to counteract the effects of confounders on the presence of ASF, risk factors obtained from the questionnaire data were analysed individually using chi-square and results tabulated (Table 10).

Table 10: Factors that were analysed individually to test for association with ASF presence

Factor	Chi-square	P-value
Location	2.98	0.39
Pig keeping duration	2.73	0.43
Alternative source of income	0.59	0.44
Absence of a boar	10.42	0.001
Type of feed	1.65	0.43
Source of feed/ingredient	2.54	0.46
ASF screening	1.08	0.29
Market availability	0.95	0.32
Knowledge on ASF transmission	0.92	0.33
Occurrence of ASF outbreaks	7.09	0.008
Regulation on pig movement	8.12	0.04

Of all the factors identified, only the absence of a boar ($P=0.001$), occurrence of ASF outbreak ($P=0.008$) and regulation on pig movement ($P=0.04$) were significant on univariate analysis.

The results of the logistic regression were tabulated as shown in Table 4.10. The risk factors that were significant on univariate analysis using chi-square were also significant on multivariate analysis using logistic regression. These were absence of a boar ($P=0.01$, 95% C.I:8.22-68.41) and occurrence of ASF outbreaks ($P=0.08$, 95% C.I:0.23-35.54). However, regulation on pig movement ($P=0.13$, 95% C.I:1.43-2.09) could have been a confounder.

Table 11: Risk factors associated with ASF positivity using multivariable logistic regression

ASF presence	Standard Error	P-value	95% Confidence Interval
Location	0.03	0.81	0.73-5.78
Pig keeping duration	0.02	0.67	0.45-6.95
Alternative source of income	0.13	0.25	1.12-41.69
Absence of a boar	0.14	0.01	8.22-68.41
Type of feed	0.09	0.75	1.70-23.38
Source of feed/ingredient	0.04	0.18	1.67-3.40
ASF screening	0.08	0.74	1.99-14.41
Market availability	0.10	0.21	0.77-33.50
Knowledge on ASF transmission	0.07	0.57	1.97-11.07
Occurrence of ASF outbreaks	0.09	0.08	0.23-35.54
Regulation on pig movement	0.04	0.13	1.47-2.09

CHAPTER 5

DISCUSSION

Several factors associated with the outbreaks of ASF in Lusaka province were identified as poor adherence or absence of biosecurity measures, laxity in enforcing livestock movement bans by police and veterinary staff manning check points, evading pig checks at check points by traders who use alternative routes, low awareness levels of ASF transmission among pig farmers and traders, purchase of pigs by pig farmers (replacement and breeding stock) from markets and one another, lack of enforcement of regulations at pig markets and inadequacy of ASF screening. However, absence of a boar and occurrences of ASF in the previous year were significantly associated with the risk of ASF outbreaks.

The identified factors for ASF outbreaks are not linked only to farmers but are multisectoral involving all the players from production to marketing. These factors are grouped according to levels, namely; farm level factors, factors associated with animal movement from farm to market, and marketing level factors.

At farm level, improved hygiene and movement control were listed as good practices for biosecurity in the pig sector (FAO, 2010b). In this study, it was noted that disinfection of piggeries was poorly implemented by pig farmers. Further, it was observed that farm workers obtained advice from friends in the absence of farm owners who were mostly weekend farmers because they were busy with white collar jobs; an act which increases the frequency of movement of people between farms. When news of ASF outbreak

spread in Lusaka, farmers became scared because of the serious implications that ASF has economically. This led to the invitation of Veterinarians to their farms just to ascertain that the pigs were healthy. Veterinarians were implicated in the spread of ASF because they travelled from one suspected ASF farm to another without changing their protective clothing. In an attempt to avoid total losses due to mortalities, some farmers sold both healthy and sick pigs to middlemen who moved from one farm to another in order to buy as many pigs as they could (Muwonge *et al.*, 2012). This implies that ASF transmission could occur through fomites if the premises were contaminated because ASFV can survive in such premises for a month (Maurer, 1975). Penrith (2009) also revealed that ASF can be controlled by using a farmer-based approach of high biosecurity on their farms. However, the application of high biosecurity measures in the areas most affected by ASF in Lusaka requires a change from traditional extensive low input husbandry to more intensive systems that place a higher demand on the producer (Penrith *et al.*, 2007). Therefore, minimal requirements such as improved hygiene (cleaning and disinfection) in piggeries, footbaths and wheel baths on the entrances should be made mandatory by the government through the Ministry of Agriculture and Livestock so that visitors/workers can disinfect themselves.

At livestock movement level (screening, movement permit, check points), the movement ban that was put in place from 18th November, 2013 to 14th January, 2014 during the ASF outbreak in Lusaka Province had not completely achieved its purpose of halting the spread of ASF because it was violated by the pig producers, sellers and buyers of pork products who resorted to conducting sales at night when the veterinarians and police were not on active duty. There is also a possibility that the movement ban was lifted

before the disease was controlled and eradicated in the province. Despite the DVS being responsible for deciding when to impose and lift the movement ban on pig and pig products, politicians have had debates in parliament on how long the ban should remain effective; a situation that can lead to premature removal of movement ban because the politicians have an upper hand when making decisions. The movement of pigs and pig products indicated during movement bans are similar to the findings of Muhangi *et al.* (2014) where movement of pigs was found to be a risk factor for ASF occurrence. The movements of pigs and pork products have been precipitated by the lack of organisation and enforcement of regulations in pig markets such as selling and slaughtering of pigs which have not been screened for ASF thus presenting a loophole for ASF spread. In spite of the government instituting ASF control policies such as ASF screening and movement control using permits, half of the farmers did not have their pigs screened before sell. Further, the pigs that were sold or slaughtered at the markets were neither screened for ASF nor have movement permits despite coming from provinces that have recorded ASF outbreaks. The pork from these markets and other illegal slaughtering facilities reached the consumer without being inspected. Inadequate ASF screening and selling of ASF exposed pigs from affected farms before the movement ban is effected that are indicated are ways in which ASF-contaminated pigs move from one farm to another and the market or vice versa.

At market level (purchase of pigs, supervision and adherence to regulations in livestock markets and slaughtering facilities), the tendency to buy pigs (breeding and replacement stock) from unestablished livestock markets and other pig farmers could be associated with the spread of ASF because the health status of these pigs cannot be established. The

presence of unregulated slaughtering facilities and markets indicated in the present study will facilitate ASF transmission through waste disposal, sale of contaminated pork and pork products if the pigs are infected because farmers often present unthrifty and sick animals for slaughter without establishing the cause (Randriamparany *et al.*, 2005; Muhangi, 2014). Lack of organisation, live pig markets, low incentives for improving pig production, lack of proper slaughtering facilities and reliable meat inspection were risks that were posed by marketing systems for the spread of ASF (Penrith *et al.*, 2013). Therefore, improving pig husbandry and marketing of pigs and pig products by enforcing regulations by MAL, MLGH and Ministry of Home Affairs is one way of preventing ASF caused by marketing systems (Penrith, 2013). Furthermore, establishment of slaughter facilities at provincial level would discontinue the movement of pigs and pig products across the provinces. These slaughter facilities should have a proper waste disposal mechanism in place, regulators and inspectors. Such markets would provide better incentives and improve pig production, a situation that occurred in Kenya (Penrith *et al.*, 2013).

The out sourcing of breeding boars indicated in the study is a driver for ASF spread among farms. These findings concur with those of Muhangi *et al.* (2014) in which sharing of breeding boars was implicated in the transmission of ASF in Uganda's pig value chain. In this study, absence of breeding boars was the most significant risk factor for ASF outbreaks. Another risk factor that was significant was the occurrence of ASF in the previous. The ASF outbreaks in 2014 could have been a spill-over from the 2013 outbreak. These findings were in agreement with Nantima *et al.* (2015) who reported that purchase of pigs from the previous year was a major risk factor for ASF occurrence

along the Uganda-Kenya border. The exposed pig herds serve as carriers therefore resulting in recurrences of ASF outbreaks when they come into contact with susceptible herds (Maurer, 1975).

In summary, in order to effectively control ASF in Lusaka, mitigation measures must be enforced at each level outlined above. Any breach whether at the farm level, livestock movement level or at the marketing stage will lead to recurrent ASF outbreaks. This can be accomplished by ensuring that all stakeholders in the pig industry understand the disease and the precautions they need to take in order to prevent the disease in the areas of their operation is crucial (Penrith and Vosloo, 2009). The low levels of ASF awareness among pig farmers, abattoirs and processing plants and traders indicated in the current study merit attention as these are key players in the pig value chain. These findings are similar to those found in Uganda (The pig site, 2014) where limited knowledge about the disease and its epidemiology was one of the constraints to ASF control. The collection of pigs for slaughter from farms by a named abattoir/processing plant using a truck without disinfecting it is one way in which ASF can be spread between farms (Mur *et al.*, 2012). The behaviour of hiding sick pigs exhibited by farmers during ASF outbreaks is a risk for ASF spread because the surviving pigs become carriers and poses a great challenge for ASF control (Sanchez-Vizcaino *et al.*, 2012). The slaughter of sick pigs for sale or preservation by freezing facilitates ASF spread because the African swine fever virus is highly resistant to environmental conditions (Centre for Food Security and Public Health, 2010; Defra, 2014). The non-reporting of ASF related deaths indicated in the current study can result in disease recurrences and spread (Penrith and Vosloo, 2009). This scenario of hiding and

slaughtering sick pigs and not reporting ASF-related deaths has been complicated by the removal of compensation to farmers with diseased animals. It was assumed that farmers had become reluctant in taking precautions against ASF introduction and spread because they knew that the government would compensate them. A point of note is that the government had a part to play in the spread of ASF because the disease was only diagnosed a month later when it had already spread to other farms. In addition, the government did not announce in the national gazette or institute a ban on the movement of pigs and pig products during the ASF outbreak experienced in 2014 to 2015 which is a requirement whenever there is an outbreak. Therefore, compensation to such farmers should be re-introduced and incentives put in place to encourage compliance with disease control policies. In addition, more VAs should be employed in the camps to enhance interaction with farmers, knowledge dissemination and disease detection. There is also need to increase producer and stakeholder awareness on the disease through the media, visual aids, entertainment groups and artists since there is no vaccine or treatment (Weiland *et al.*, 2011; Swai and Lyimo, 2014).

This study had a major limitation that is worth mentioning. The total number of pig farmers and their location were not known thus making the population hard to reach. Failure by the Ministry to maintain an up to date data base on livestock has a negative impact on the management of diseases. Creation of a data base indicating their physical and contact addresses will enable the policy makers and control and prevention teams to determine the number of affected farms, their location and the herd population therefore implementing effective control policies.

CONCLUSION AND RECOMMENDATIONS

The study revealed that uncontrolled marketing of pigs and pig products, low awareness levels on ASF transmission among pig farmers and traders, poor adherence or lack of biosecurity and porous check points were factors associated with the outbreaks of ASF in Lusaka province. However, only absence of breeding boar and occurrence of ASF in the previous year were significant risk factors. In this study, the source(s) of ASF infection was not established therefore studies that would determine the genetic character(s) of the ASFV should be carried out. Improving pig husbandry and the marketing trends of pigs and pig products, education awareness programmes, reinforcement of staff at check points and active surveillance are some of the ways in which future outbreaks can be prevented.

The following are the proposed mitigation measures;

- I. Coercion among government ministries (MLGH, MAL and Ministry of Home Affairs) to ensure that all abattoirs/processing plants or slaughtering facilities are registered and inspected and shutting down of all illegal slaughter premises.
- II. Active ASF screening by veterinary staff from MAL through creation of one-stop centrally located research centres, regulated markets and slaughtering facilities, proper housing infrastructure and adequate biosecurity (footbaths and fencing) and punitive measures put in place for offenders.

- III. Control animal movement through infrastructure creation (shelter and toilets), reinforcement of staff (police and veterinarians) and provision of transport at check points.
- IV. Employ more Veterinary assistants in camps to increase interaction with farmers for knowledge exchange and early detection of diseases.
- V. Extension workers from MAL and ZNFU should increase education awareness programs for farmers, pig traders and general public on the economic importance of ASF and its transmission using the media, visual aids, entertainment groups and artists.

REFERENCES

- Adesehinwa A. O. K., Makinde G. E. O and Oladele O I. 2003. Socio-economic characteristics of pig farmers as determinant of pig feeding pattern in Oyo state, Nigeria. *Livestock Research for Rural Development*, 15 (12).
- African Union – Interafrican Bureau for Animal Resources (AU-IBAR). 2013. African swine fever. *Animal Health and Production Compendium*. www.cabi.org. Accessed on 15th September, 2014.
- Anderson, E.C. 1986. African swine fever: Current concepts on its pathogenesis and immunology. *Rev. Sci. Tech. Off. Int. Epiz.*, 5 (2), 477-486.
- Anderson, E.C., Hutchings, G.H., Mukarati, N. and Wilkinson, P.J. 1998. African swine fever virus infection of the bushpig (*Potamochoerus porcus*) and its significance in the epidemiology of the disease. *Veterinary Microbiology*, 30; 62(1):1-15.
- Animal Health Australia. 2014. Disease strategy: African swine fever (Version 4.0). Australian Veterinary Emergency Plan (AUSVETPLAN), Edition 4, Australian Agriculture Ministers' Forum, Canberra, ACT.
- Annual report, Ministry of Agriculture and Livestock. 2013. Compiled by National Epidemiology and Information Centre (NALEIC).

- Agüero, M., Fernández, J., Romero, L.J., Zamora, M.J., Sánchez, C., Belák, S., Arias, M., Sánchez- Vizcaíno J.M. 2004. A highly sensitive and specific gel-based multiplex RT-PCR assay for the simultaneous and differential diagnosis of African swine fever and Classical swine fever in clinical samples. *Veterinary Research*, 35(5):551-563.
- Ajala M. K., Adesehinwa A. O. K. and Mohammed A. K. 2007. Characteristics of smallholder pig production in southern Kaduna of Kaduna state, Nigeria. *American-Eurasian Journal of Agricultural and Environmental Science*, 2(2): 182-188.
- Atuhaire, D., Afayoa, M., Ochwo, S., Mwesigwa, S., Mwiine, F., Okuni, J., Olaho-Mukani, W. and Ojok, L. 2013. Prevalence of African swine fever virus in apparently healthy domestic pigs in Uganda. *BMC Veterinary Research*, 9(1):263.
- Blome, S., Gabriel, C. and Beer, M. 2013. Pathogenesis of African swine fever in domestic pigs and European wild boar. *Virus Research*, 173(1):122-30.
- Boshoff, C.I., Bastos, A.D.S., Gerber, L.J. and Vosloo, W. 2007. Genetic characterization of African swine fever viruses from outbreaks in southern Africa (1973-1999). *Veterinary Microbiology*, 121:45–55.
- Carrasco, L., Chacon-Mdelara, F., Gomez-Villamandos, J.C. and Bautista, M.J. 1996. The pathogenic role of pulmonary intravascular macrophages in acute African swine fever. *Research in Veterinary Science*, 61:193–198.

Centre for Food Security and Public Health. 2010. Technical Fact Sheets. African swine fever at www.cfsph.iastate.edu/DiseaseInfo/factsheets.htm. Accessed on 10th July, 2014.

Centre for Food Security and Public Health. 2011. Fast Facts. African swine fever at www.cfsph.iastate.edu/DiseaseInfo/factsheets.htm. Accessed on 10th July, 2014.

Centre for Food Security and Public Health. 2015. African swine fever at www.cfsph.iastate.edu/DiseaseInfo/factsheets.htm. Accessed on 15th November, 2015.

Chifungula, A.O. 2015. Report of the Auditor General on the Management and Control of Livestock Diseases.

Costard, S., Mur, L., Lubroth, J., Sanchez-Vizcaino, J. and Pfeiffer, D. 2013a. Epidemiology of African swine fever virus. *Virus Research*, 173(1):191-197.

Costard, S., Jones, B., Martinez-Lopez, B., Mur, L., de la Torre, A., Martinez, M., Sanchez-Vizcaino, F., Sanchez-Vizcaino, J., Pfeiffer, D. and Wieland, B. 2013b. Introduction of African Swine Fever into the European Union through Illegal Importation of Pork and Pork Products. *PLoS one*, 8(4):1104.

Costard, S., Wieland, B., de Glanville, W., Jori, F., Rowlands, R., Vosloo, W., Roger, F., Pfeiffer, D. and Dixon, L. 2009. African swine fever: how can global spread be prevented?. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364(1530):2683-2696.

Cubillos, C., Gómez-Sebastian, S., Moreno, N., Nunez, M.C., Mulumba- Mfumu, L.K., Quembo, C.J., Heath, L., Etter, E.M.C., Jori, F., Escribano J.M. and Blanco, E. 2013. African swine fever virus serodiagnosis: A general review with a focus on the analyses of African serum samples. *Virus Research*, 173(1):159-167.

Dixon, L.K., Escribano, J.M., Martins, C., Rock, D.L., Salas, M.L. and Wilkinson, P.J. 2005. Asfarviridae. In: Fauquet, C. M., M.A. Mayo, J. Maniloff, U. Desselberger, and L.A. Ball (eds), *Virus Taxonomy*. VIII. Report of the ICTV, pp. 135–143. Elsevier, Academic Press, London.

Department of Environment, Food and Rural Affairs Veterinary Science Team International Disease Monitoring. 2012. African Swine Fever in Ukraine, Preliminary Outbreak Assessment.

Dutch wildlife health centre. 2014. African swine fever in wild boar and African wild suids.

Emergency Prevention System for Transboundary Animals and Plant Pest Diseases (EMPRES). 2004. Outbreak of African swine fever in Zambia. <http://www.fao.org>. Accessed on 15th June, 2014.

Emergency Prevention System for Transboundary Animals and Plant Pest Diseases (EMPRES). 2012. Transboundary Animal Diseases Bulletin No. 40. <http://www.fao.org/docrep/015/i2811e/i2811e.pdf>. Accessed on 15th September, 2014.

- Fasina, F.O., Agbaje, M., Ajani, F.L., Talabi, O.A., Lazarus, D.D., Gallardo C., Thompson, P.N. and Bastos, A.D. 2012. Risk factors for farm-level African swine fever infection in major pig-producing areas in Nigeria, 1997-2011. *Preventive Veterinary Medicine* 107, 65-75.
- Fasina, F., Lazarus, D., Spencer, B., Makinde, A. and Bastos, A. 2011. Cost Implications of African Swine Fever in Smallholder Farrow-to-Finish Units: Economic Benefits of Disease Prevention Through Biosecurity. *Transboundary and Emerging Diseases*, 59(3):244-255.
- FAO. 2000. Animal health manual. Recognizing African swine fever. ISBN 92-5-104471-6 www.fao.org/empres. Accessed on 13th June, 2014.
- FAO. 2001. Manual on the preparation of African Swine Fever Contingency Plans. FAO Animal Health Manual No. 11. www.fao.org/empres. Accessed on 13th June, 2014.
- FAO. 2008. EMPRES Watch – African swine fever in the Caucasus. (<ftp://ftp.fao.org/docrep/fao/011/aj214e/aj214e00.pdf>). Accessed on 15th June, 2014.
- FAO. 2009a. EMPRES Watch – African swine fever spread in the Russian Federation and the risk for the region. <ftp://ftp.fao.org/docrep/fao/012/ak718e/ak718e00.pdf>. Accessed on 15th September, 2014.

- FAO. 2009b. Preparation of African swine fever contingency plans. Edited by M.L. Penrith, V. Guberti, K. Depner and J. Lubroth. FAO Animal Production and Health Manual No. 8. Rome. (available at <ftp://ftp.fao.org/docrep/fao/012/i1196e/i1196e00.pdf>). Accessed on 15th September, 2014.
- FAO. 2010a. FAO takes a close look at the pig sector in Eastern Europe to better understand the threats of African swine fever. *EMPRES Watch*. Rome (available at www.fao.org/docrep/012/ak755e/ak755e00.pdf). Accessed on 15th September, 2014.
- FAO. 2010b. Good Practices for Biosecurity in the Pig Sector: Issues and Options in Developing and Transition Countries. FAO Animal Production and Health Paper no. 169. (available at <http://www.fao.org/docrep/012/i1435e/i1435e00.pdf>). Accessed on 2nd August 2015.
- FAO. 2012. African Swine Fever (ASF) Recent developments and timely updates – Worrysome dynamics: Steady spread towards unaffected areas could have disastrous impact. In Focus on No. 6. [electronic bulletin]. Rome, FAO (available at <http://www.fao.org/docrep/016/ap372e/ap372e.pdf>). Accessed on 15th September, 2014.
- FAO. 2013. African swine fever in the Russian Federation: risk factors for Europe and beyond. *EMPRES WATCH*, Vol. 28. Rome. (available at www.fao.org/ag/empres.html) Accessed on 18th October, 2014.

FAO. 2014. The Global Platform for African swine fever and other important diseases of swine. Animal Production and Health Report No. 4. Rome. (available at www.fao.org/publications) Accessed on 14th June, 2015.

FAO Statistical database. 2015: Statistical database of the Food and Agriculture Organization of the United Nations (FAOSTAT). Available at: <http://faostat.fao.org/>. Accessed on 14th June, 2015.

Gallardo, C., Soler, A., Nieto, R., Carrascosa, A., De Mia, G., Bishop, R., Martins, C., Fasina, F., Couacy-Hymman, E., Heath, L., Pelayo, V., Martan, E., Siman, A., Martan, R., Okurut, A., Lekolol, I., Okoth, E. and Arias, M. 2013. Comparative evaluation of novel African swine fever virus (ASF) antibody detection techniques derived from specific ASF viral genotypes with the OIE internationally prescribed serological tests. *Veterinary Microbiology*, 162(1):32-43.

Glanville, W., Vial, L., Costard, S., Wieland, B. and Pfeiffer, D. 2014. Spatial multi-criteria decision analysis to predict suitability for African swine fever endemicity in Africa. *BMC Veterinary Research*, 10(1):9.

Gogin, A., Gerasimov, V., Malogolovkin, A. and Kolbasov, D. 2013. African swine fever in the North Caucasus region and the Russian Federation in years 2007-2012. *Virus Research*, 173(1):198-203.

- Gomez-Villamandos, J.C., Hervas, J., Méndez, A., Carrasco, L., Villeda, C.J., Wilkinson, P.J. and Sierra, M.A. 1995a. A pathological study of the perisinusoidal unit of the liver in acute African swine fever. *Research in Veterinary Science*, 59,146–151.
- Gomez-Villamandos, J.C., Hervas, J., Méndez, A., Carrasco, L., Villeda, C.J., Wilkinson, P.J. and Sierra, M.A. 1995b. Ultrastructural study of the renal tubular system in acute experimental African swine fever: Virus replication in glomerular mesangial cells and in the collecting ducts. *Archives of Virology*, 140,581–589.
- Gomez-Villamandos, J.C., Bautista, M.J., Sanchez-Cordón, P.J., and Carrasco, L. 2013. Pathology of African swine fever: the role of monocyte-macrophage. *Virus Research*, 173, 140– 149.
- Hamdy, F.M. and Dardiri, A.H. 1984. Clinical and immunologic responses of pigs to African swine fever virus isolated from the Western Hemisphere. *American Journal of Veterinary Research*, 45,711–714.
- Jori, F. and Bastos, A. 2009. Role of Wild Suids in the Epidemiology of African Swine Fever. *International Association for Ecology and Health*, 6(2):296-310.
- Krug, P., Larson, C., Eslami, A. and Rodriguez, L. 2012. Disinfection of foot-and-mouth disease and African swine fever viruses with citric acid and sodium hypochlorite on birch wood carriers. *Veterinary Microbiology*, 156(1-2):96-101.

- Laddomada, A., Patta, C., Pittau, G., Ruiu, A., Firinu, A., 1991. Epidemiology and control of African Swine Fever in Sardinia. Proceeding of the Workshop of African Swine Fever, Lisbon.
- Lekule, F.P. and Kyvsgaard, N.C. 2003. Improving pig husbandry in tropical resource-poor communities and its potential to reduce risk of porcine cysticercosis. *Acta Tropica* 87:111-117.
- Maurer, O.F. 1975. African Swine Fever in Diseases of Swine. Edited by Howard W. Dunne and Allen D. Leman. The Iowa State University Press, Ames, Iowa, U.S.A. Fourth edition.
- Mebus, C.A. 1988. African swine fever. In: Maramorosch, K. (Ed.). *Advances in Virus Research*. 251-269.
- Mekuriaw, Y. and Asmare, B. 2014. Assessment of Pig Production and Constraints in Mecha District, Amhara Region, Northwestern Ethiopia. *Advances in Agriculture*, 1-5.
- Ministry of Agriculture and Co-Operatives. 2003. Report on the state of animal genetic resources in Zambia. A contribution to the first report on the world's animal genetic resources. Department of Veterinary Services and Livestock Development, Farm Animal Genetic Resource (FAnGR) National Focal Point, Mazabuka, Zambia.
- Moennig, V. 2000. Introduction to classical swine fever: Virus, disease and control policy. *Veterinary Microbiology*, 73(2-3): 93-102.

- Mohammad. 2008. *Ornithodoros* ticks photo. <http://picasaweb.google.com>. Accessed on 12th December, 2015.
- Muwonge, A., Munangandu, H., Kankya, C., Biffa, D., Oura, C., Skjerve, E. and Oloya, J. 2012. African swine fever among slaughter pigs in Mubende district, Uganda. *Tropical Animal Health Production*, 44(7):1593-1598.
- Muhangi, D. 2014. African Swine Fever: An Epidemiological Overview. *British Journal of Virology*, 1(1): 42-47.
- Muhangi, D., Masembe, C., Berg, M., Stahl, K. and Ocaido, M. 2014. Practices in the pig value chain in Uganda; implications to African swine fever transmission. *Livestock Research for Rural Development*. Volume 26(94).
- Mur, L., Martínez-lópez, B. and Sánchez-vizcaíno, J.M. 2012. Risk of African swine fever introduction into the European Union through transport-associated routes: returning trucks and waste from international ships and planes. *BMC Veterinary Research*, 8(1):149.
- Nantima, N., Ocaido, M., Ouma, E., Davies, J., Dione, M., Okoth, E., Mugisha, A. and Bishop, R. 2015. Risk factors associated with occurrence of African swine fever outbreaks in smallholder pig farms in four districts along the Uganda-Kenya border. *Tropical Animal Health Production*, 47:589–595.
- Neitz, W.O. 1963. African swine fever. In: *Emerging Diseases of Animals*. FAO Agricultural Studies No 61. Rome: Food and Agriculture Organization of the United Nations.

- Oganesyan, A.S., Petrova, O.N., Korennoy, F.I., Bardina, N.S., Gogin, A.E. and Dudnikov, S.A. 2013. African swine fever in the Russian Federation: Spatio-temporal analysis and epidemiological overview. *Virus Research*, 173(1):204–211.
- Oravainen, J., Sahlström, L. and Lyytikäinen, T. 2011. Possible routes of entry into the country for African swine fever – Risk profile. *Evira Research Reports* 5:1-62. Finnish Food Safety Authority Evira.
- Ouma E, Dione M, Lule P, Roesel K and Pezo D. (2014). Characterization of smallholder pig production systems in Uganda: constraints and opportunities for engaging with market systems. *Livestock Research for Rural Development*. Volume 26(56).
- Oura, C.A., Denyer, M.S., Takamatsu, H. and Parkhouse, R.M. 2005. In vivo depletion of CD8+ T lymphocytes abrogates protective immunity to African swine fever virus. *Journal of General Virology*, 86:2445-2450.
- Oura, C. 2013. Overview of African swine fever. In: Kahn CM, Line S, Aiello SE, editors. *The Merck veterinary manual*. 10th ed. Whitehouse Station, NJ: Merck and Co. Available at: http://www.merckvetmanual.com/mvm/generalized_conditions/african_swine_fever/overview_of_african_swine_fever.html. Accessed on 15th October, 2015.
- Oura, C., Edwards, L. and Batten, C. 2013. Virological diagnosis of African swine fever; Comparative study of available tests. *Virus Research*, 173(1):150-158.

- Penrith, M.L., Lopes Pereira, C., Lopes da Silva, M.M., Quembo, C., Nhamusso, A. and Banze, J. 2007. African swine fever in Mozambique: review, risk factors and considerations for control. *Onderstepoort Journal of Veterinary Research*, 74:149-160.
- Penrith, M.L., Thomson, G.R. and Bastos, A.D.S. 2004. African Swine Fever. In: *Infectious Diseases of Livestock with Special Reference to Southern Africa*. (J.A.W. Coetzer & R.C. Tustin, eds). Cape Town Oxford University Press, 1087–1119.
- Penrith, M-L. 2009. African swine fever. *Onderstepoort Journal of Veterinary Research*, 76:91–95.
- Penrith, M-L. and Vosloo, W. 2009. Review of African swine fever: Transmission, spread and control. *Journal of the South African Veterinary Association*, 80(2):58–62.
- Penrith, M-L. 2013. History of “swine fever” in Southern Africa. *Journal of the South African Veterinary Association*, 84(1).
- Penrith, M-L., Vosloo, W., Jori, F. and Bastos, A.D. 2013. African swine fever virus eradication in Africa. *Virus Research*, 173(1):228–246.
- Phiri, I.K., Dorny, P., Gabriel, S., Willingham, A.L. III, Speybroeck, N. and Vercruysse, J. 2002. The prevalence of porcine cysticercosis in Eastern and Southern provinces of Zambia. *Veterinary Parasitology*, 108(1):31–39.

- Plowright, W. 1986. African swine fever: a retrospective view. *Rev. sci. tech. Off. int. Epiz.*, 5(2):455-468.
- Plowright, W., Thomson, G.R. and Naser, J.A. 1994. African swine fever. In: Infectious Diseases of livestock with special reference to Southern Africa (J.A.W.Coetzer, G.R.Thomson, & R.C.Tustin, eds). Cape Town Oxford University Press, 567-599.
- Randriamparany, T., Grenier, A., Tourette, I., Maharavo Rahantamala, C.Y., Rousset, D. and Lancelot, R. 2005. Epidemiological situation of African swine fever in Lake Alaotra Region (Madagascar) and possible consequences on the organization of disease control and surveillance. *Rev. Elev. Med. Vet. Pays Trop.*, 58:15–20.
- Riedel, S., Schiborra, A., Huelsebusch, C., Huanming, M. and Schlecht, E. 2012. Opportunities and challenges for smallholder pig production systems in a mountainous region of Xishuangbanna, Yunnan Province, China. *Tropical Animal Health Production*, 44(8):1971-1980.
- Rowlands, R.J., Michaud, V., Heath, L., Hutchings, G., Oura, C., Vosloo, W., Dwarka, R., Onashvili, T., Albina, E., Dixon, L.K. 2008. African swine fever virus isolate, Georgia, 2007. *Emerging Infectious Diseases*. 14, 1870–1874.
- Salganik, M.J. and Heckathorn, D.D. 2004. Sampling and Estimation in Hidden Populations Using Respondent-Driven Sampling. *Sociological Methodology*, 34:193-239

- Saka, J. O., Adeshinwa, A. O. K. and Ajala, M. K. 2010. Incidence of African swine fever (ASF) disease and its associated implications on pig production in Lagos state, Nigeria. *Bulgaria Journal of Agricultural Science*, 16: 80-90.
- Samui, K.L., Mwanaumo, B. and Chizyuka, H.G.B. 1991. African swine fever in Zambia-Report on the first outbreak outside the endemic zone. In: Proceedings of the 6th International Symposium on Veterinary Epidemiology and Economics: 453-455. Ottawa, Canada.
- Samui, K.L., Nambota, A.M., Mweene, A.S., Onuma, M., 1996. African swine fever in Zambia: potential financial and production consequences for the commercial sector. *Japanese Journal of Veterinary Research*, 44:119-124.
- Sánchez-Vizcaíno, J.M., Martínez-López, B., Martínez-Avilés, M., Martins, C., Boinas, F., Vial, L., Michaud, V., Jori, F., Etter, E., Albina, E. and Roger, F. 2009. Scientific Review on African Swine Fever. CFP/EFSA/AHAW/2007/02: 1–141.
- Sanchez-Vizcaino, J.M. 1992. African swine fever. In: Diseases of Swine, 7th ed. (Leman, A.D., Straw, B.E., Mengeling, W.L., D'Allaire, S. and Taylor, D.J. eds.). Iowa State University Press, Ames, pp. 228±236.
- Sanchez-Vizcaino, J., Mur, L. and Martinez-Lopez, B. 2012. African Swine Fever: An Epidemiological Update. *Transboundary and Emerging Diseases*, 59:27-35.
- Sanchez-Vizcaino, J.M. and Mur, L. 2013. African swine fever diagnosis update. Vaccines and Diagnostics for Transboundary Animal Diseases. Karger. ISBN: 978-3-318-02365-7. Vol. 135, pp 159-165.

- Sánchez-Vizcaíno, J.M., Mur, L., Sánchez-Matamoros, A. and Martínez-López B. 2014. African Swine Fever: New challenges and measures to prevent its spread. 82nd General Session World Assembly. OIE, Paris.
- Steyn, D.G. 1928. Preliminary report on a South African virus disease amongst pigs. 13th and 14th Reports of the Director of Veterinary Education and Research, Union of South Africa, 415–428.
- Swai, E.S. and Lyimo, C.J. 2014. Impact of African Swine fever epidemics in smallholder pig production units in Rombo district of Kilimanjaro, Tanzania. *Livestock Research for Rural Development*. Volume 26 (32).
- The Pig Site: [Uganda fights African swine fever](#), 4 Nov 2014.
- Thomson, G. R., 1985. The epidemiology of African swine fever: The role of free-living hosts in Africa. *Onderstepoort Journal of Veterinary Research*, 52, 201-209.
- Wieland, B., Dhollander, S., Salman, M. and Koenen, F. 2011. Qualitative risk assessment in a data-scarce environment: A model to assess the impact of control measures on spread of African Swine Fever. *Preventive Veterinary Medicine*, 99(1)4-14.
- World Animal Health. 1989. Animal health status and disease control methods (Part one: Reports), Volume. V, number 2. OIE, Paris.

World Organisation for Animal Health. 1996–2002. Disease information. (available at www.oie.int/eng/info/en_infold.htm?e1d5). Accessed on 14th November, 2015.

World Organisation for Animal Health. 2007. Disease information. (available at www.oie.int/wahid-prod/public.php?page=home). Accessed on 14th November, 2015.

World Organization for Animal Health. 2011a. WAHID Database. Disease Information. Available at http://web.oie.int/wahis/public.php?page=disease_immediate_summary Accessed on 24th January, 2016.

World Organization for Animal Health. 2011b. Terrestrial Animal Health Code. Twentieth edition. www.oie.int. Accessed on 13th January, 2015.

World Organization for Animal Health. 2012a. African Swine Fever in Ukraine. Immediate Notification Ref OIE 12168; Report Date 31/07/2012. http://web.oie.int/wahis/reports/en_imm_0000012168_20120731_134719.pdf. Accessed on 15th September, 2014.

World Organisation for Animal Health. 2012b. Terrestrial Animal Health Code. OIE, Paris. www.oie.int. Accessed on 15th September, 2014.

World Organization for Animal Health. 2013a. WAHID Database. Weekly disease information. http://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?page_refer=MapFullEventReport&reportid=14413). Accessed on 29th February, 2016.

World Organization for Animal Health. 2013b. WAHID Database. Disease Information.
(http://www.oie.int/wahis_2/public/wahid.php/Diseaseinformation/statusdetail)

Accessed on 29th February, 2016.

World Organization for Animal Health. 2013c. African swine fever. www.oie.int.

Accessed on 5th September, 2014.

Wilkinson, P.J. 1986. Epidemiology of African swine fever. *Rev. Sci. Tech. Off. Int. Epiz.* 5(2):487–493.

Wilkinson, P.J., Pegram, R.G., Perry, B.D., Lemche, J. and Schels, H.F. 1988. The distribution of African swine fever virus isolated from *Ornithodoros moubata* in Zambia. *Epidemiology and Infection.* 101, 547–564.

Yabe, J., Hamambulu, P., Simulundu, E., Ogawa, H., Kajihara, M., Mori-Kajihara, A., Changula-Chitanga, K., Mwase, M., Mweemba-Muwowo, M., Chambaro, H.M., Mataa, L., Hang'ombe, B., Namangala, B., Fandamu, P., Sawa, H., Takada, A., Higashi, H. and Mweene, A.S. 2014. Pathological and molecular diagnosis of the 2013 African swine fever outbreak in Lusaka, Zambia. *Tropical Animal Health and Production*, Volume 47, Issue 2, pp 459-463.

Zambia Development Agency. 2011. Agriculture, Livestock and Fisheries, Sector Profile. Page 18.

ANNEXES

8.1 Gazette Notice

	REPUBLIC OF ZAMBIA	
	GOVERNMENT GAZETTE	
		<i>Price: K3.00 net</i>
Published by Authority		<i>Annual Subscription: Within Lusaka—K156.00</i> <i>Outside Lusaka—K186.00</i>
No. 6253	Lusaka, Monday, 18th November, 2013	[Vol. XLX, No. 107

GAZETTE NOTICE No. 806 of 2013

Notice

The UNDISSENTED Bill which it is proposed to be introduced in the National Assembly, is published with this Gazette for general information:

Bill No. 14 of 2013: The Road Traffic (Amendment).

D. K. K. Mwanza,
Clerk of the National Assembly

LUSAKA
14th November, 2013
[MAG. 52]

GAZETTE NOTICE No. 807 of 2013 [4799529

Animal Health Act
(Act No. 27 of 2010)

African Swine Fever (ASF) Outbreak Chilanga and Lusaka Districts

In accordance with the provisions of Section 12, 22 and 23 of the Animal Health Act of 2010 of the Laws of Zambia, it is notified for the information of the public in general and the farming community in particular that there is an outbreak of African Swine Fever (ASF) in Chilanga and Lusaka Districts of Lusaka Province. In view of this occurrence, the under listed measures will apply in Lusaka Province with immediate effect until further notice:

- (1) No pig/s or pig products will be allowed into or outside Lusaka Province
- (2) No pig/s will be allowed to be slaughtered within Lusaka Province
- (3) No pig/s will be allowed to move from one area to another within Lusaka Province


To this effect, the Ministry of Agriculture and Livestock has instituted control measures and farmers and members of the public are requested to cooperate as these measures are being implemented.

Any person or persons found contravening the measures directly or indirectly will be prosecuted and any pig or pigs or pig products involved will be destroyed without compensation.

Dr. J. Mwanza,
Director
Department of Veterinary Services

P.O. Box 50060
LUSAKA

8.2 Livestock movement permit


REPUBLIC OF ZAMBIA

No.: **68350**

MINISTRY OF LIVESTOCK AND FISHERIES DEVELOPMENT
DEPARTMENT OF VETERINARY SERVICES
STOCK MOVEMENT PERMIT
(Stock Diseases Act. Cap 252)

This is to certify that Mr./Mrs/Ms.....of
.....NRC No.
Address:

Transportation means..... Vehicle Reg. No.

Is permitted to move the following livestock:-
Cow..... Bulls..... Oxen..... Calves..... Goats..... Sheep.....
Poultry..... Pigs..... Others.....
From.....
(give specific details of destination)

Route to be followed:.....
Period allowed for movement:.....
Purpose of movement:.....
Identification (Ear - tag numbers and colours).....
.....
.....

In the event of an outbreak of a contagious disease amongst stock, this permit may be withdrawn at any time. This permit must be in the possession of the person traveling in charge of the stock and must be produced to any authorised person on demand. It does not entitle the person in charge to drive them over private and land without the owner's consent. Transported cattle must bear the registered brand of the owner.

.....
Signature of Veterinary/Livestock Officer.....
.....
Name of the Veterinary/Livestock Officer.....

Date:..... Amount fee paid:.....

Signature and stamp of the Veterinary Checkpoint where applicable

Original and Duplicate to be given to the transporter and should accompany the livestock. Duplicate to be handed to the Veterinary checkpoint. Triplicate to be posted to the District Veterinary Office of destination and Quadruplicate to remain in the box.

This Permit Serves as a Receipt

8.3 Interview guide for District Veterinary Officers

INTERVIEW GUIDE

Dear Respondent,

My name is Cynthia Siamupa. I am undertaking a Master's degree at the University of Zambia, School of Veterinary Medicine. I am conducting a research on the topic 'Risk factors associated with the outbreaks of African swine fever in Lusaka province, Zambia'. I hope that the findings of this research will contribute to the control or prevention of spread of ASF therefore saving the pig industry. There are several questions which you will be required to answer and your responses will be treated with confidentiality and anonymity. Furthermore, your responses will not be recorded though I will take some notes to make a summary of the responses which you are free to look at later on. You have the right not to participate or complete the interview. Do you have any questions before we begin?

INTERVIEW WITH DISTRICT VETERINARY OFFICERS

1. Who is responsible for informing the nation on animal disease outbreaks in an area?
.....
2. Is there any other government unit or department outside the Veterinary fraternity mandated to inform the nation on animal disease outbreak?
.....
.....
3. Who decides on whether or not to institute a ban on all movements and processing of pigs and pig products during ASF outbreaks?
.....
.....
4. Who ensures that the ban is adhered to knowing that we have farmers and traders who need to continue with their livelihoods and will try by all means to earn a living through pigs and pig product movement?
.....
.....
5. How would you describe the impact of the movement ban on the marketing patterns of pigs and pig products in Lusaka Province?
.....
.....
6. Was the ban able to meet its objectives of halting the spread of ASF?
.....
.....
7. What criteria are used to determine the length and scope of the ban?
.....
.....

8. What factors do you consider before lifting the ban?

.....
.....

9. It was in the media that barely two weeks after the ban was lifted in Lusaka province on 14th January 2014, outbreaks of ASF were reported in Chief Macha's area in Choma, Southern province. Do you think this outbreak was able to jump from Lusaka to Choma?

.....
.....

10. What do you think would be the cause of the rampant spread of ASF to other parts of the country?

.....
.....

11. What awareness programmes have been put in place to sensitize the farmers and the general public on issues relating to ASF?

.....
.....
.....

12. How well do you think ASF control measures can be implemented to yield best results in terms of preventing the recurrences of ASF in Lusaka province?

.....
.....
.....
.....

13. Closing remarks and thanking the participants.

8.4 Interview guide for Veterinary assistants

INTERVIEW GUIDE

Dear Respondent,

My name is Cynthia Siamupa. I am undertaking a Master's degree at the University of Zambia, School of Veterinary Medicine. I am conducting a research on the topic 'Risk factors associated with the outbreaks of African swine fever in Lusaka province, Zambia'. I hope that the findings of this research will contribute to the control or prevention of spread of ASF therefore saving the pig industry. There are several questions which you will be required to answer and your responses will be treated with confidentiality and anonymity. Furthermore, your responses will not be recorded though I will take some notes to make a summary of the responses which you are free to look at later on. You have the right not to participate or complete the interview. Do you have any questions before we begin?

VETERINARY ASSISTANTS

1. Have you ever heard of African Swine Fever (ASF)?

.....

2. In your own words, what causes ASF?

.....

.....

3. Which animals are affected and what would you see in these animals?

.....

4. How does this disease spread from one animal to another and from farm to farm?

.....

5. Have you ever experienced ASF in your area? (If yes, go to question 6, if no, go to question 7)?

.....

6. Can you describe exactly what the farmers did when ASF started?

.....

.....

7. What would you do if ASF broke out in your area?

.....

.....

8. What has been the effect of this disease on the food security, employment opportunities and income generation?

.....

.....

9. In your own opinion, what do you think are the reasons for ASF outbreak in the Lusaka province and the country at large?

.....
.....

10. What do you think about the government’s move to put a ban on all pigs and pig product movement into and out of the province and halting of all pig processing operations?

.....
.....

11. How well do you think this disease can be controlled or prevented to ensure that this province does not get affected?

.....
.....

12. How often do you interact with the farmers in your camp? Briefly explain the reason for your answer.

.....
.....

13. Are you available to go to the farm whenever the farmers need your help?

.....
.....

14. Is there anything else you would like to mention?

.....
.....

15. Closing remarks and thanking the participants

8.5 Interview guide for Meat inspector in the Ministry of Local Government and Housing

INTERVIEW GUIDE

Dear Respondent,

My name is Cynthia Siamupa. I am undertaking a Master's degree at the University of Zambia, School of Veterinary Medicine. I am conducting a research on the topic 'Risk factors associated with the outbreaks of African swine fever in Lusaka province, Zambia'. I hope that the findings of this research will contribute to the control or prevention of spread of ASF therefore saving the pig industry. There are several questions which you will be required to answer and your responses will be treated with confidentiality and anonymity. Furthermore, your responses will not be recorded though I will take some notes to make a summary of the responses which you are free to look at later on. You have the right not to participate or complete the interview. Do you have any questions before we begin?

INTERVIEW WITH MEAT INSPECTORS

1. Are all pork processing plants and abattoirs registered?
.....
2. Do all pork processing plants and abattoirs have meat inspectors?
.....
3. How often do they inspect these abattoirs and processing plants?
.....
4. Do you have specific people assigned to each abattoir or processing plants?
.....
5. Are these people able to detect ASF during meat inspection?
.....
6. Have they ever detected ASF at any of the abattoirs or processing plant? If yes,
what action was done?
.....
7. What would they do if they found carcasses suspected to have ASF lesions?
.....
8. Is there a way in which they would trace the source of these suspected pigs?
.....
9. As the public health sector, what measures have you put in place to ensure that
these pigs suspected to have ASF do not reach the consumer?
.....

10. What challenges have you faced in ensuring that only safe meat and meat products reach the consumer?

.....

11. How well do you think these challenges can be addressed?

.....

12. Is there anything else you would like to say or add on?

.....

13. Closing remarks and thanking the participant.

8.6 Interview guide for veterinary check points

INTERVIEW GUIDE

Dear Respondent,

My name is Cynthia Siamupa. I am undertaking a Master's degree at the University of Zambia, School of Veterinary Medicine. I am conducting a research on the topic 'Risk factors associated with the outbreaks of African swine fever in Lusaka province, Zambia'. I hope that the findings of this research will contribute to the control or prevention of spread of ASF therefore saving the pig industry. There are several questions which you will be required to answer and your responses will be treated with confidentiality and anonymity. Furthermore, your responses will not be recorded though I will take some notes to make a summary of the responses which you are free to look at later on. You have the right not to participate or complete the interview. Do you have any questions before we begin?

INTERVIEW WITH POLICE OFFICERS AT VETERINARY CHECK POINTS

1. How do you regulate or monitor the movement of pigs in and out of Lusaka?
.....
2. Who directs you to stop all pigs and pig product movements into and out of the province?
.....
3. Do you think you have enough manpower to ensure that all pig movements are stopped?
.....
4. How do you know whether a vehicle has some pig products or not?
.....
5. Have you ever impounded any pigs or pig products during the ban?
.....
6. What is the standard operating procedure when you impound a vehicle with pigs or pig products?
.....
7. Do you think that all pig farmers and traders are aware during the ban that they are not allowed to move the pigs and pig products in and out of the province?
.....

8. Do you think traders have alternative ways of transporting the pigs & pig products that would avoid the check points? Briefly explain the reason for your answer.

.....

9. How best do you think movement of pigs and pig products can be monitored to prevent ASF outbreaks?

.....

10. Is there anything else you would like to say or add on this subject?

.....

11. Closing remarks and thanking the participants.

8.7 Interview guide for market managers

INTERVIEW GUIDE

Dear Respondent,

My name is Cynthia Siamupa. I am undertaking a Master's degree at the University of Zambia, School of Veterinary Medicine. I am conducting a research on the topic 'Risk factors associated with the outbreaks of African swine fever in Lusaka province, Zambia'. I hope that the findings of this research will contribute to the control or prevention of spread of ASF therefore saving the pig industry. There are several questions which you will be required to answer and your responses will be treated with confidentiality and anonymity. Furthermore, your responses will not be recorded though I will take some notes to make a summary of the responses which you are free to look at later on. You have the right not to participate or complete the interview. Do you have any questions before we begin?

INTERVIEW WITH MARKET MANAGERS

1. How many pig traders do you have in this market?

.....

2. Is anyone free to come and sell their pigs here or there is a procedure to be followed?

.....

.....

3. Where do they buy there pigs from?

.....

.....

4. Are there any documents they are supposed to have to authorize them to buy pigs?

.....

.....

5. What time do they move their pigs?

.....

.....

6. Do you monitor if the pigs that they bring have movement permits?

.....

.....

7. Who do they sell their pigs to?

.....

.....

8. Do you feel they make enough money from pig sells?

.....

.....

9. What do these traders do during ASF outbreaks?

.....

.....

10. How are prices of pigs and pig products during ASF outbreaks?

.....
.....

11. Farmers are scared of losing their pigs when there are ASF outbreaks and will do anything to sell their pigs. Do pig traders and marketers see this as an opportunity to make money?

.....
.....

12. What do they do to the pigs that they have when there is a ban on all movement and processing of pigs and pig products?

.....
.....

13. Do you think the move by government to ban movement and halt all pig processing in the affected area a good way of controlling ASF?

.....
.....

14. What do you think would be the cause of this rampant spread of ASF?

.....
.....

15. Do you think traders play a role in spreading this disease from one place to another?

.....

16. How best do you think ASF can be controlled without disadvantaging anyone involved in pig business?

.....
.....

17. Is there anything else you would like to say or add on this?

.....
.....

18. Closing remarks and thanking the participants.

8.8 Interview guide for traders

INTERVIEW GUIDE

Dear Respondent,

My name is Cynthia Siamupa. I am undertaking a Master's degree at the University of Zambia, School of Veterinary Medicine. I am conducting a research on the topic 'Risk factors associated with the outbreaks of African swine fever in Lusaka province, Zambia'. I hope that the findings of this research will contribute to the control or prevention of spread of ASF therefore saving the pig industry. There are several questions which you will be required to answer and your responses will be treated with confidentiality and anonymity. Furthermore, your responses will not be recorded though I will take some notes to make a summary of the responses which you are free to look at later on. You have the right not to participate or complete the interview. Do you have any questions before we begin?

INTERVIEW WITH TRADERS

1. How long have you been in this pig business?
.....
2. Where do you buy your pigs from?
.....
3. What challenges do you face when sourcing these pigs?
.....
.....
4. Where do you sell these pigs?
.....
.....
5. What challenges do you encounter when selling these pigs?
.....
.....
6. What do you use to transport these pigs from the area where you buy them to where you sell them?
.....
.....
7. Who owns this transport?
.....
8. Do you use this same transport to move from one farm to another or where you buy these pigs from?
.....
9. Do you clean this mode of transport?
.....
10. If yes, when and what do you use to clean this mode of transport? (If no, go to question 11)
.....

11. Have you ever heard of African Swine Fever (ASF)?
.....
12. Where did you hear it from?
.....
13. How does it spread?
.....
14. Is your business affected during ASF outbreaks?
.....
15. During ASF outbreaks, farmers do not want to lose their pigs hence will do anything to sell them. Do you see this as an opportunity to make money?
.....
16. What do you do to the pigs that you have or have already ordered when there is a movement ban on all pigs and pig products?
.....
17. Does the government consider your situation that you need to continue selling pigs to earn a living when they effect movement bans on pigs and pig products? Give reasons for your answer?
.....
18. What do you do for a living during pig movement bans?
.....
19. Do you think trading of pigs and pig products can spread ASF? Briefly explain the reason for your answer.
.....
20. How best do you think the government can help you during these pig movement bans?
.....
21. How do you think the government can prevent or control these ASF outbreaks?
.....
22. Is there anything else you would like to say or add on the subject?
.....
23. Closing remarks and thanking the participants.

8.9 Questionnaire for abattoirs and processing plants

THE UNIVERSITY OF ZAMBIA
SCHOOL OF VETERINARY MEDICINE
DEPARTMENT OF DISEASE CONTROL

QUESTIONNAIRE FOR ABATTOIRS AND PROCESSING PLANTS

Dear Respondent,

I am a student at the University of Zambia, Great East Road Campus, and I am conducting a research on 'Risk factors associated with the outbreaks of African swine fever in Lusaka province, Zambia'.

You have been randomly selected to participate in this study. Be rest assured that all the information given in this questionnaire will be treated with utmost confidentiality and anonymity. Above all, this study is purely an academic research required for the partial fulfillment of the Award of the Master of Science in One Health Analytical Epidemiology (Msc OHAE) Degree at the University of Zambia.

Thank you for your cooperation!

Yours Researcher

Cynthia Siamupa

Mobile: 0977 318 811

Response Number.....

Area.....

QUESTIONNAIRE

Instruction

Kindly fill in the blanks.

A: BACKGROUND INFORMATION

1. How long have you been processing pork?
.....
2. How many pigs do you slaughter in a day?
.....
3. Where do you buy these pigs from?
.....
4. How do these pigs reach your abattoir or processing plants?
.....
5. Is there a Veterinarian who inspects your pigs before you slaughter them?
Explain why.
.....
6. How do you identify and trace back the source of pigs that you slaughter in your
abattoir or processing plant?
.....
7. Where do you sell your pork and pork products?
.....
8. Is the market readily available for pork products?
.....
9. What challenges have you faced as a pork processor?
.....

B. HYGIENE AND BIO-SECURITY

10. How often do you clean and disinfect your abattoir or processing plant?
.....

11. What do you use for cleaning and disinfecting your abattoir or processing plant?
.....
12. What do your workers wear when they are in the abattoir or processing plant?
.....
13. How do you ensure that the vehicles and people entering the abattoir or processing plant do not contaminate your premises?
.....

C. VIEWS AND PERCEPTIONS ON ASF OUTBREAKS

14. Have you ever heard about African swine fever (ASF)?
.....
15. If your answer to above is yes, where did you hear it from?
.....
16. How is ASF transmitted?
.....
17. Did the ASF outbreak in Lusaka affect your business in any way? Briefly explain why and how.
.....
18. Do you think the move by the government to introduce a movement ban and stop all processing of pigs and pig products a good way of controlling it? Explain why.
.....
19. Did you retain all your workers at the abattoir or processing plant during the ban of pig movement and processing? Briefly explain the reason for your answer.
.....
20. In your opinion, how well do you think the ASF outbreaks can be controlled?
.....

Thank you very much for your participation.

8.10 Questionnaire for pig farmers

THE UNIVERSITY OF ZAMBIA
SCHOOL OF VETERINARY MEDICINE
DEPARTMENT OF DISEASE CONTROL

QUESTIONNAIRE FOR PIG FARMERS

Dear Respondent,

I am a student at the University of Zambia, Great East Road Campus, and I am conducting a research on 'Risk factors associated with the outbreaks of African swine fever in Lusaka province, Zambia'.

You have been randomly selected to participate in this study. Be rest assured that all the information given in this questionnaire will be treated with utmost confidentiality and anonymity. Above all, this study is purely an academic research required for the partial fulfillment of the Award of the Master of Science in One Health Analytical Epidemiology (Msc OHAE) Degree at the University of Zambia.

Thank you for your cooperation!

Yours Researcher

Cynthia Siamupa

Mobile: 0977 318 811

Response Number.....

Area.....

QUESTIONNAIRE

Instruction

Kindly tick in the brackets and fill in the blanks where appropriate.

A: BACKGROUND INFORMATION

1. Age

(1) (20 – 30) years []

(2) (31 – 40) years []

(3) (41 – 50) years []

(4) (51 – 60) years []

(5) (61 and above) years []

2. Sex

(1) Male []

(2) Female []

3. What is your marital status?

(1) Single []

(2) Married []

(3) Widowed []

(4) Divorced []

(5) Others, specify.....

4. How many family members are there in your household?

(1) Less than 5 []

(2) Between 5 and 10 []

(3) Between 10 and 15 []

(4) 15 and above []

5. Educational level

(1) Nil []

(2) Primary []

(3) Secondary []

(4) Tertiary []

(5) Others.....

6. How long have you been keeping pigs?

(1) Less than 1 year []

(2) Between one and two years []

(3) Between two and three years []

(4) Four years and above []

7. Who takes care of these pigs?

.....

8. Where do you get advice from on how to manage your pigs?

.....

9. Are you engaged in any income generating activity apart from pig farming?

(1) Yes []

(2) No []

10. If yes, what activity is it? (If no, go to question 11)

.....

11. Do you own land?

(1) Yes []

(2) No []

12. Is the land you own enough to accommodate the pigs you would like to keep?

(1) Yes []

(2) No []

B. LEVELS OF PIG PRODUCTION, MANAGEMENT AND SALES

13. What is the composition of your pig herd? Fill in the table below.

Type of pigs	Breeding sows	Boars	Average number of piglets born	Fattening pigs (growers and finishers)	Average number of deaths	Average number of pigs sold
Number of pigs						

14. How often do you clean your pig houses?

.....

15. What do you use for cleaning your pig houses?

.....

16. What do you feed your pigs on?

17. Where do you get this feed?

18. Is there a Veterinarian who inspects your pigs before you sell them? Explain why.

19. Where do you sell your pigs?

20. When do you sell your pigs?

21. What factor(s) influence the sale of your pigs?

22. Is the market (were to sell pigs) readily available for pigs?

23. How do you access the pig markets?
 (1) Take own pigs
 (2) Sale to traders
 (3) Own slaughter, packaging and selling
 (4) Other(s)
24. What challenges have you faced during your life as a pig farmer?

25. Do you get enough money from pig sales to enable you re-stock the breeding stock and meet your daily essentials? Yes () No ()
 Briefly explain the reason for your answer.

C. VIEWS AND PERCEPTIONS OF FARMERS ON ASF OUTBREAKS

26. Have you ever heard about African swine fever (ASF)?

.....

27. If your answer to above is yes, where did you hear it from?

.....

28. How is ASF transmitted?

.....

.....

29. Did the ASF outbreak in Lusaka affect you in any way? Briefly explain why and how.

.....

.....

.....

30. Do you think the move by the government to introduce a movement ban and stop all processing of pigs and pig products is a good way of controlling it? Explain why.

.....

.....

31. In your opinion, how well do you think the ASF outbreaks can be controlled?

.....

.....

Thank you very much for your participation.

8.11 African swine fever screening form



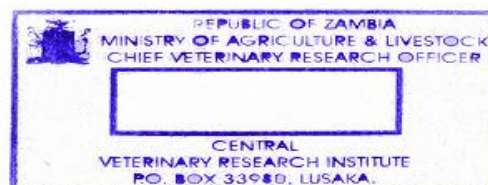
REPUBLIC OF ZAMBIA
 Ministry of Agriculture and Livestock
CENTRAL VETERINARY RESEARCH INSTITUTE
 P.O. BOX 33980, Lusaka, LUSAKA CENTRAL
 Tel: +260 211 213444 Fax: +260 211 845608
 e-mail: cvri@gmail.com



Date reported: 03-03-2016

SIAVONGA VET OFFICE
 SIAVONGA VET OFFICE
 Siavonga Central

YEAR 2016 Submission Number 401



Client Ref. No:

TEST REPORT No: TR - CVRI 401/2016

This is to report the results of the samples analysed as per from 03-03-2016 to 03-03-2016

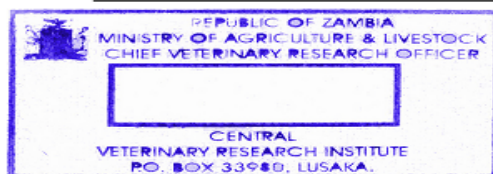
# Samples	Specimen	Species	Date Sampled	Date Received	Owner	Owner's Address
5	WHOLE BLOOD	Porcine	02/03/2016	03/03/2016	MR LIKANDO LEBANI	P.O BOX

Sample: WHOLE BLOOD - Species: Porcine

Samples Submitted	Sample Id	Test	Test Result	Method
1	1	African Swine Fever - Hemadsorption test	Negative	Hemadsorption
1	2	African Swine Fever - Hemadsorption test	Negative	Hemadsorption
1	3	African Swine Fever - Hemadsorption test	Negative	Hemadsorption
1	4	African Swine Fever - Hemadsorption test	Negative	Hemadsorption
1	5	African Swine Fever - Hemadsorption test	Negative	Hemadsorption

Test	Method	Test procedure	Laboratory
African Swine Fever - Hemadsorption test	Hemadsorption	-	Central Veterinary Research Institute

Section _____ Head of Section _____
 Virology _____ George Dautu _____



Head of Laboratory _____

Dr. Paul Fandamu _____