Journal of
Animal Health
(JAH)

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Jiregna Dugassa

Abebe Fromsa

Abebe Wirtu

IPRJB
INTERNATIONAL PEER REVIEWED JOURNAL AND BOOK PUBLISHING

Journal of Animal Health
ISSN 2709-5517 (online)
Vol.2, Issue 1, No. 4 pp 62-84, 2020
www.iprjb.org

THE ROLE OF CANINE SURGICAL STERILIZATION AND OTHER DOG POPULATION MANAGEMENT STRATEGIES TO COMPLEMENT RABIES PREVENTION AND CONTROL PROGRAMS

[1*]Jiregna Dugassa (DVM, MVSc, Assistant Professor)

[2] Abebe Fromsa (DVM, MVSc, Associate Professor)

[3] Abebe Wirtu (MVSc, Lecturer)

[123]Department of Clinical Studies, College of Veterinary Medicine and Agriculture, Addis Ababa University, Bishoftu, Ethiopia.

Corresponding author E-Mail: Jiregnadu@gmail.com

Abstract

Purpose: To assess the role of canine surgical sterilization and other dog population management strategies to complement rabies prevention and control programs.

Findings: Rabies is highly fatal viral anthropozoonotic disease which is caused by virus of the genus *Lyssavirus and* transmitted from rabid animals to humans by bite or scratch from rabid animals. Rabies is preventable and controllable disease through integration of one or more animal population control and vaccination methods. However, the primary focus of a rabies control program in dogs is vaccination by implementation of mass dog vaccination aiming for 70% vaccination in order to promote and maintain levels of protection above thresh hold between campaigns which consequently reduces ongoing transmission. Not only these but also, interlinking of one or more of other DPM tools such as prevention and control of reproduction, acceptable euthanisation, surgical sterilization, education and legislation of responsible dog ownership can create effective DPM programs. In developing country the integration of animal birth control and vaccination is not at grass root level so well coordination of veterinarians, human health professionals and other stake holders are vital.

Key Words*:* *Dog Population Management, Rabies, Vaccination and Birth Control*

Journal of Animal Health
ISSN 2709-5517 (online)
Vol.2, Issue 1, No. 4 pp 62-84, 2020
www.iprjb.org

1. INTRODUCTION

Rabies is highly fatal viral anthropozoonotic disease of public health significance[2]. The disease is caused by a virus of the genus *Lyssavirus* of the family Rhabdoviridae. Dogs as well as other animals play a crucial role in maintenance and circulation of the rabies virus [3]. Wild and domestic dogs (*Canis lupus familiaris*) are responsible for over 99% of human deaths due to rabies. The disease is mainly transmitted from rabid animals to humans through introduction of infected saliva via bite or scratch and invariably results in death [4]. Normally, rabies can be controlled and prevented through vaccination and integrated dog population management [5] but remains as one of the major public health problem resulting in an estimated loss of approximately 60,000 lives worldwide each year [4, 6, 8].

Even though there are many rabies control and prevention programs, rabies remains endemic in over 80 countries over the world [6, 9, 10]. Ethiopia was among the high burdened country where 10,000 people per annum were estimated to have died [11]. In world rabies survey report, Ethiopia was found the second leading country in rabies deaths. In 2012, over 1400 deaths were estimated to have occurred due to rabies by canines [7, 12, 13]. Next to canine, feline species appears to be the second most affected animal in Ethiopia [14, 15, 16]. Meanwhile, rabies also affects domestic and endangered animals like the Ethiopian Wolf [17]. Overall, rabies is a public health, animal health and livelihood concern in Ethiopia. In addition, large free-roaming dog populations can lead to conflicts with humans due to nuisance through noise and pollution, aggressive behavior towards people especially, children and predation of livestock and wildlife [19, 20].

Despite various advances in DPM, surgical sterilizations of dogs are currently the main control method advocated in controlling free-roaming dog populations [21]. However, undertaking surgical sterilization on a large scale is logistically challenging in many parts of the world due to limited human power, resources, political, cultural and socio-economic factors, notably in low income settings where the need to control these populations is often the greatest [22]. Even though surgical sterilization is currently the method of choice for controlling free-roaming dog populations in addition to enhancing rabies vaccination to promote human and animal health in different countries, there are still a significant challenges to neutering and spaying large numbers of dogs in developing countries like Ethiopia due to limited objective information on its role and efficacy in rabies control programs. So this seminar paper is written with the objectives:

- To overview the role of surgical sterilization and other dog population management practices with rabies vaccination in an attempt to reduce human rabies incidence.
- To describe the basic methods used for dog population management and their supposed effectiveness.

2. LITERATURE REVIEW

2.1. Surgical Sterilization and Its Role in Dogs

Surgical sterilization in dogs involves removal of the part/s of reproductive tract in both female and or male to prevent the reproduction. Most of the time regardless of the surgical technique used, the ovaries in their entirety should be removed in females. Surgical sterilization is advantageous over chemical or hormonal immunization as it provides lifelong reproductive control and may also reduce problematic behaviors such as some forms of aggression or the propensity for specific dogs to roam. It could improve animal welfare by reducing the dumping and killing of unwanted puppies and the stress experienced by female dogs that produce litters repeatedly in addition to preventing cancers and other diseases in both male and female dogs but needs skilled veterinarians [23, 24].

During surgical sterilization, the highest surgical standards and protocols should be adhered to unless the it can be associated with major complications including hemorrhage, ovarian remnant syndrome, stump pyometra, adhesions, and wound dehiscence or infection, as well as anaesthetic complications and drug reactions [25]. Pregnant females should be sterilized where it is surgically safe to do so, and fetuses should be euthanized when they are found to be alive once removed. Population simulation models predict that the effect of sterilizing females is far more significant than that of sterilizing males in terms of reducing population sizes. Dog population sizes can be reduced where enough female dogs are sterilized, but this is a long-term goal for which very high throughput surgery is often required. It is important that if only females are targeted for sterilization, male dogs should still be vaccinated to prevent rabies [26].

A variety of non-surgical methods can be used to prevent reproduction. These include physical restraint of females and males, as well as injectable, implantable and oral contraceptives [27]. A study on the island of New Providence in the Bahamas estimated that for the population to reach equilibrium, 83% of females would need to be prevented from breeding [28]. The length of time required to achieve a desired outcome will also vary according to population turnover and sterilization efforts. Studies of sterilization programs in different settings have suggested that their full impact on reducing population size would not be achieved for over 30 years for a shelter based spay/ neuter campaign in the US [29], up to 10 years for sterilization of free-roaming dogs in Brazil [30] and between 13 and 18 years for sterilization of free roaming dogs in India [31].

All surgical methods require general anaesthesia. Surgical castration involves surgical removal of the testicles, and vasectomy which involves the cutting or tying off of the vas deferens [31]. Females may be surgically sterilized by ovariohysterectomy or ovariectomy [32]. In the scenario where a bitch may be compromised by surgery, it may be preferable to allow her to go to full term and then humanely euthanize the pups at birth, if there is no option of adoption [34]. But in settings where there are large numbers of community owned or un owned dogs, programs that capture, sterilize, vaccinate and return free roaming dogs to their communities may be more effective [35, 36].

2.2. Theoretical Benefits of Dog Population Management

Most of the time dog population management (DPM) refers to a program devised and aimed with the intention of reducing a stray dog population to a particular level and/or maintaining it at that level and/or managing it in order to meet a predetermined objective [37]. Stable dog populations with relatively low turnover rates make continuous vaccination coverage highly feasible. However, in many countries in which canine rabies persists, economic barriers and cultural attitudes toward dogs enable the maintenance of large free roaming dog populations [38]. Dog population management (DPM) is also a multifaceted concept which aims to improve the health

Journal of Animal Health
ISSN 2709-5517 (online)
Vol.2, Issue 1, No. 4 pp 62-84, 2020 www.iprjb.org

and well being of free roaming dogs, reduce problems they may cause, and may also set goals to reduce the size or turnover of the population [33].

DPM may be enacted for numerous animal welfare, public health and safety, in addition to economic reasons. These reasons include reducing the incidence of human bite injuries, secondary infections, and death; reducing or eliminating the transmission of rabies and other zoonotic diseases; reducing the level of noise and the amount of fecal contamination of the environment and minimizing the impact of reductions in tourism associated with free-roaming dog populations [21, 39]. Puppies comprise large proportions of dog populations in many rabies endemic areas, even where almost all dogs are owned [40, [41]. A survey in Nepal also estimated 60% puppy mortality [42, 43]. All dogs, including puppies, can transmit rabies and should be vaccinated during mass vaccination campaigns [44, 45]. There are several benefits from effective DPM programs.

2.1.1. Maintaining vaccination coverage

The primary focus of a rabies control program in dogs is vaccination. Mass dog vaccination programs generally aim for 70% vaccination coverage so that between campaigns, levels of protection stay above the threshold necessary to prevent ongoing transmission [8, 46]. There is now much evidence that achieving 70% vaccination coverage, even where dog population turnover is high, is feasible, but it can be challenging [37, 47]. This is particularly true of free roaming dogs that are difficult to handle or un owned dogs which are often the most time consuming to vaccinate [45, 47, 48].

The general prevention of human exposure to rabies relies on taking Post Exposure Prophylaxis (PEP). Globally, close to 15 million people receive PEP annually which is considered very costly and not accessible for developing countries like Ethiopia [49, 7] whereas dog population management and mass dog vaccination are shown to be cost effective measures in rabies prevention and control [50]. In Africa, majority (98%) of dogs is believed to be owned and feasible strategies for successful mass dog vaccination were recommended [51]. However, the impetus towards the implementation of these strategies is highly hampered due to socio-economic and political factors in developing countries [13]. Lack of information on the extent of the burden and risk factors significantly led to rabies being overlooked and thus, reduced collaboration including financing for implementation of successful intervention strategies such as mass dog vaccination [7].

2.1.2. Reducing bite incidents

The most effective means of reducing prevalence of dog bites are education and placing responsibility on the owner. Dog owners should be educated in principles of responsible dog ownership [52]. Legal mechanisms that enable the Competent Authorities to impose penalties or otherwise deal with irresponsible owners are necessary. Mandatory registration and identification schemes will facilitate the effective application of such mechanisms. Young children are the group at highest risk for dog bites. Public education program focusing on appropriate dog directed behavior have been demonstrated to be effective in reducing dog bite prevalence and should be encouraged programmes [53].

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ISSN 2709-5517 (online)
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2.1.3. Increasing support for interventions and sustainability

A combined program of DPM and rabies control programs may bring on board additional partners with expertise and funding [10]. Appropriate, acceptable DPM programs can allow communities to live in better balance with the free roaming dogs in their environments and consequently it makes easier to maintain high vaccination coverage in populations of dogs [47, 47]. Anecdotal reports from some community may suggest that where DPM has achieved a reduction in dog population size, the remaining dogs are better cared for [54, 55].

2.1.5. Mass dog culling

Mass dog culling is still used as a misguided emergency response to rabies outbreaks, based on the mistaken belief that reducing the size of dog populations will reduce rabies transmission [56]. In fact, mass dog culling has been shown to have no long term impact on the control of rabies within cities [57]. When modeled in realistic scenarios, culling is not as effective as sterilization programs in reducing population size in the long term [22]. This is because culling does not address the source of new or replacement animals, and has only a temporary effect on population size. Furthermore, rapid dog replacement rates have been documented in some areas following culling, leading to a younger population of generally rabies susceptible dogs [55, 58].

Culling often meets with public resistance both within the local area and outside, especially as the methods employed are often inhumane [59, 60, 61].

2.2. Humane DPM Tools, Benefits and Drawbacks

Much of the motivation for DPM in rabies control efforts comes from the desire to reduce the size or the turnover of the free-roaming dog population to make effective vaccination more feasible [62, 63]. Both permanent and temporary methods of reproductive control are available (summarized in Table 1). Permanent sterilization is preferable in most settings where rabies control is the objective, but temporary contraceptive methods will be more appropriate where owners may wish to breed dogs in the future [25].

Table 1: Reproductive control tools currently used for dog population management

Reproduction control tool	Required resources	Targeted popu.n	Product	Target Sex	Infertility duration	Potential complication	Reference
Surgical sterilization	Veterinarian (surgeon) and surgical equipments	Un/ owned dogs	-	Male and female	Permanent	Intra and Post surgical complications	65, 30

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ISSN 2709-5517 (online)
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Injectable contraceptives	Veterinarian and Accessible veterinary service	Un/owned dogs	Zinc gluconate (ZeuterinTM / EsterilsolTM / NeutersolTM)	Male	Permanent	Abscess at injection site, temporary swelling of testicles	25,66
			Progestins [melengestrol acetate(MGA)]	Female	6 months	Requires regular monitoring, metritis and may be death	66,63
			Calcium chloride	Male	Permanent	Temporary swelling of testicles and scrotal abscesses	25
Implantable contraceptives	Veterinarian and Accessible veterinary service	Un/owned or owned dogs	Progestins (MGA)	Female and male	Up to 2 years	In Females: Induces estrus from 4 to 6 weeks, regular monitoring, metritis cancer, and may be death	25
			GnRH agonists (*SuprelorinTM)*	Female and male	Up to 27 months	Initially causes estrus and ovulation	66
Oral contraceptives	Accessible veterinary service	Owned dogs	Megestrol acetate	Female	Daily	Uterine infections and cancers	25

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ISSN 2709-5517 (online)
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Physical confinement	Trained, responsible owner, Suitable dog confinement	Owned dogs	NA	Female and male	Not applicable	pregnancy, Welfare and safety concerns from Improper confinement	65

Source: (Adapted and modified from table summarized by [64].

Contraceptives that are increasingly used to control overabundant wildlife could also be employed to manage dog populations [67, 68]. Many of the contraceptives currently available for companion and zoo animals are either too expensive to be used on a large scale, or require a primer dose followed by one or more boosters at specific intervals, which makes them unsuitable for large scale DPM programmes [69,70]. It is also recommended that hormones should not be used to prevent more than one estrus cycle due to increased risks of side effects [71, 72, 73].

The promotion of responsible dog ownership through legislation and education is a necessary part of a dog population control programme. Collaboration with local government authorities, animal welfare NGOs, kennel clubs, private veterinarians and veterinary organizations will assist Veterinary Authorities in establishing and maintaining, management and sustainability of DPM programs [74]. Legislation can also be used to ensure as DPM is carried out humanely, by avoiding culling, indiscriminate breeding and importing, that owners of biting dogs are held accountable. But such mechanisms may fail if enforcement is not seen as a priority, corrupt officials are an issue, or the community members' ability to pay fines is low [75].

Many high income country models of DPM rely on a model where free roaming dogs are collected from the streets by authorities and taken to shelters, from where they are ideally collected by their owners or rehomed. But shelters are expensive and time consuming to run, and once facilities are overwhelmed with animals, animal welfare standards can fall dramatically [33]. The Humane Society of the US estimates that each year $2.5 billion is spent by humane organizations and $800 million to $1 billion is spent by animal control organizations on managing the pet overpopulation problem [76]. An OIE survey of DPM strategies found that shelters were prohibitively costly for most low-income countries [56].

Ideally, euthanasia should be reserved for animals who are incurably ill, or whom suffers from behavioral problems or lack of guardianship which cannot be alleviated with available resources. Unfortunately, many dogs are euthanized as a means of population control as well. When the decision for euthanasia is made, it must be carried out by qualified veterinary staff with access to the necessary drugs and training in humane handling and euthanasia [33]. When euthanasia is practiced, the general principles in the Terrestrial Codes should be followed, with the emphasis on using the most practical, rapid and humane methods and by ensuring operator safety as summarized in Table 2. Confirmation of death for all methods of euthanasia used, death should

Journal of Animal Health
ISSN 2709-5517 (online)
Vol.2, Issue 1, No. 4 pp 62-84, 2020

be confirmed before animals are disposed of or left unattended. If an animal is not dead, another method of euthanasia should be performed. Carcasses should be disposed of in a manner that complies with legislation. Finally, attention should be paid to the risk of residues occurring in the carcass if consumption is desired by some animals so incineration is generally the safest way of carcass disposal [74].

Table 2: Common methods and techniques used for euthanasia in dogs

Methods	Specific Techniques	Animal welfare implications	Key animal welfare requirement	Animal management and control	Advantages	Disadvantages
Injectable Chemicals	Barbiturates	Restraint and right route of administration	IV injection.	Well restraining and control	smooth induction, less discomfort and cheap	ingestion of cadaver/s may leads to sedation or death of animals
	Embutramide +Mebezonium +Tetracaine	paralysis of muscle may occur before loss of consciousness	Use slow IV injection with sedation	well restraint and with well trained personnel	Quite low cost	Unavailable/ unlicensed in Some countries.
	Thiopentone or Propofenol	Under dosing may lead to recovery	IV injection of a sufficient dose	Well restraining, and veterinary supervision	Quick action and minimal discomfort	Requires Large volume (cost implications)
	Potassium chloride (KCl)	cardiotoxic and painful without other	Only used on Premedicated	Requires trained Personnel	Readily available	Prior need for anaesthetic (cost and

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ISSN 2709-5517 (online)
Vol.2, Issue 1, No. 4 pp 62-84, 2020
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		anaesthetic	animals, IV Injection.			availability Implications) .
Mechanical	Free bullet	Requires well targeting and to avoid the escaping of wounded dog	Requires Skilled technicians	Risk of injury to operators	Avoids handle or capture of dogs	Brain tissue Damage and Legal constraints on use of fire arms
	Penetrating captive bolt followed by pithing to ensure death	Requires Targeting properly	Requires Skilled operator	Well restraining of animals	No risk to operator	Similar to free bullet
	Exsanguinations	hypovolaemia	Only used on unconscious animal.	Mechanical injury on operator during operation	Minimal material requirements	Need to render Animal unconscious. Aesthetically objectionable
Gaseous	Carbon monoxide (CO)	Requires adequate concentration of CO to cause lethal effect	Requires Compressed CO (effective operation)	Odourless (Very hazardous and Toxic)	Dog dies quite rapidly if concentration of 4 to 6% used.	Cause anxiety and suffocation before death
	Carbon dioxide (CO_2)	Gas is aversive and requires adequate concentratio	Requires Compressed CO (effective	Minimal hazard to operator when properly	Gas is not flammable or explosive	Unconsciousness (in minutes, but death may take some

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ISSN 2709-5517 (online)
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		n to bring effect	operation)	used	and Low cost.	time.
	Inert gas (nitrogen, N2;argon, Ar)	hypoxemia precedes loss of consciousness	Requires Concentration above 98% to bring an effect.	Minimal hazard to operator if properly used	Not flammable, explosive and is odorless	High cost and Little data on animal welfare
	Anaesthetic gas overdose (halothane or enflurane)	Anxiety and Vapours (irritating and excitement).	Requires Supplementation of O_2 (to avoid hypoxemia)	Some gases are hazardous and toxic .	Gas is not flammable and Valuable with small animals (<7 kgs).	High cost, Isoflurane has a Pungent odour. Methoxyflurane'(slow action and agitation (dogs).
Electrical	Electrocution	Cardiac fibrillation and severe pain, due to violent extension of organs	Only use on unconscious Dogs.	Hazardous for operator without proper procedure	Low cost	Need to render Animal Unconscious.

Source: [77].

Steps should also need to be taken to exclude dogs from sources of food (e.g. rubbish dumps and abattoirs, and installing animal proof rubbish containers). Food waste in garbage has been suggested as an important factor in maintaining dog populations and better waste management has been implemented as part of some documented DPM programs. However, there is a lack of evidence on the impact of removal of food sources in garbage dumps and market-places on dog population size or rabies control [78].

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Figure 1: Street dogs in Finfinne, Ethiopia [79].

Measures for the control of dog movement in a country are generally invoked for the following reasons for: rabies control when the disease is present in a country, public safety reasons, safety of "owned dogs" in an area or locality when a stray dog control programme is in place, protection of wildlife and livestock [80]. Dogs may be owned for a variety of reasons, such as for companionship, for guarding the home or livestock, for hunting, or as a source of food depending on particular country. These relationships may affect the degree to which they are cared for and whether veterinary services or reproductive control may be sought by the owner [81, 82].

Own fewer dogs are never confined, but a free-roaming dog may be owned, community owned, or feral so that at higher risk for contracting diseases, injuries such as those caused by road traffic accidents or acts of cruelty and culling by governments or local communities, compared to owned and confined dogs[83, 84]. Moreover, Knowledge, attitude and practices survey of the community can be particularly helpful in elucidating what would be the most acceptable and therefore successful DPM components to apply in a particular setting [85]. Finally, it is important to understand that DPM strategies will not have the desired impact without community participation and other stake holders. The use of mixed DPM interventions, though often advisable, makes it very difficult to determine which of the individual interventions is responsible for success [86, 87].

There is some evidence that in low income countries, leashing or confinement of dogs can be both effective at reducing contact between dogs and well tolerated during rabies outbreak situations, but after an outbreak is over it is less likely to be tolerated, as communities prefer dogs to roam freely [88]. Thus, the value of confinement as a means to reduce dog populations is unlikely to be high in most settings, and there can be welfare implications for dogs depending on the method and duration of confinement [89, 90]. Poor results from DPM programs have been suggested to be the result of a lack of public awareness about the program [91, 92].

In most Asian and African countries, the major prophylactic measures for controlling rabies in reservoirs comprise culling free ranging dogs using various methods and vaccination [93]. An efficient method of controlling wildlife rabies is distributing bait rabies vaccine to risk regions to interrupt the transmission from rabid animals to healthy ones, and ultimately to eliminate the wild RABV from those vectors [94].

2.3. Status of Rabies Control and Prevention in Ethiopia

2.3.1. Efforts and challenges of rabies control

A number of obstacles prevent a coordinated approach to the global elimination of canine rabies; including a lack of awareness and education of the public health and veterinary sectors, the absence of diagnostic facilities, inadequate surveillance and reporting systems, limited access to modern vaccines and failures of responsible dog ownership [92]. The lack of effective control of canine rabies in developing countries is often attributed to low prioritization, insufficient financial resources, epidemiological and operational constraints [5]. There are a number of challenges in the prevention and control of rabies in Ethiopia. One of these is inadequate laboratory capacity and lack of diagnostic centers at different sites for effective surveillance and response. Rabies diagnosis and management is largely dependent on diagnosis of rabid animals at one center, at Ethiopian Public Health Institute. Thus, there is only one laboratory that has the capacity to confirm rabies in humans or animals resulting in poor management of rabies cases. Dog bites are used as a proxy for suspected rabies cases in humans for rabies surveillance and response system [92].

In Ethiopia, there is also inadequate sharing of surveillance data between human and animal health care sectors at both local and national levels, resulting in loss of opportunities to prevent human rabies, early detection and timely response to rabies outbreak. The national surveillance data is unreliable, meaning that the true burden of the disease in the country or high risk areas remains undefined; making it difficult to target prevention and control measures. There is also little awareness, coordination and collaboration between the human and animal health sectors and other stake holders responsible for rabies disease control. Studies showed that, high canine rabies burden and lack of sufficient awareness about the disease and high reliance on traditional treatment that interferes with timely post exposure management account for a major human cases [95].

In Ethiopia, a retrospective data conducted between 2001 and 2009 at one center (EPHI) showed that the fatal human cases were 386 with annual range of 35 to 58 [96]. Study done at North Gonder of Ethiopia also indicated an annual estimated rabies incidence of 2.33 cases per 100,000 humans; 412.83 cases per 100,000 dogs; 19.89 cases per 100,000 cattle; 67.68 cases per 100,000 equines, and 14.45 cases per 100,000 goats [95]. Dog bite was the source of infection for almost all fatal rabies cases throughout the country. Even the research conducted in Addis Ababa from September 2009 to March 2013, on the human death cases reported from a total of 96 deaths reported, nearly all 93 (97%) fatal cases were attributed to dogs where only one (1%) was due to cats and the rest (1%) were due to wild animal. Domestic animals such as dog, cat, cattle and wild animals like apes and foxes were associated with human exposure [97].

Furthermore many studies also revealed that, high canine rabies burden and lack of sufficient awareness about the disease and high reliance on religious and traditional medical treatment that interfere with timely post exposure management account for a major human cases in the country [98]. Most patients who die from rabies are either do not report the case immediately or do not receive timely and appropriate post exposure treatment after exposure to the virus. On the other hand, knowledge of the responsible dog ownership and dog population management among the public is low and there is little understanding among the public of dog vaccination and the value of timely post exposure treatment following animal bite. There is also lack of awareness among policy makers on the importance and burden of rabies and the cost effectiveness of rabies control through dog vaccination [99].

The Fermi type adult sheep brain nervous tissue vaccine produced at the Ethiopian Public Health Institute (EPHI) since 1940's. The country is still producing and using this long time WHO banned Fermi type anti-rabies vaccine for post exposure treatment. Regardless of its quality, there is limited supply of rabies vaccine and also lack of adequate, safe and effective PET and PEP biologics in public health. Whereas high quality vaccine may be available in some private facilities, the cost is prohibitive and cannot be afforded by public at large. The possibility of producing rabies vaccines locally have been explored during the last five years and currently produced from Pasteur Virus (PV) and Evinyl Rokitnki Abelseth (ERA) rabies virus strains, and pre-clinical trial completed [97].

The current rabies control and prevention activities, particularly dog vaccination, by the concerned body are not at grass root level. According to rabies control strategy prepared by the Ministry of Agriculture and Rural Development in 2010, only vaccination of dogs and cats during outbreak was indicated and no further prevention strategy was mentioned for sustainable prevention and control of the disease. Thus, rabies control activities are not adequate or even not in place resulting in little impact on rabies prevention and control activity. In addition, the country does not have guidelines on rabies control that capture the requisite integrated approach that involves all the stakeholders like Ministry of Agriculture and Ministry of Health. This inadequacy has resulted in uncoordinated and largely ineffective actions [92].

2.3.2. Opportunity for rabies elimination

A number of factors have come together to make this an opportunity time to undertake rabies control and elimination strategy. These factors include the establishment of a One Health Office in the country and increased interest in rabies elimination by partners. A pilot project was designed by the joint efforts of the University of Gondar, Ethiopian Public Health Institute, Ohio State University, and the US Centers for Disease Control and Prevention; with the aim to control canine rabies in a northern Gonder of Ethiopia which can be used for further scale up. Rabies, which is endemic in Ethiopia, also causes livestock losses estimated at over $50 million USD. A recent article in morbidity and mortality of weekly report describes a pilot program to improve the reporting and management of dog bites in Gondar, Ethiopia [100].

The CDC, the Ohio State University, the University of Gondar, and the Ethiopian Public Health Institute collaborated to develop an integrated bite case management program in the city of Gondar. This program has been shown to increase bite detection rates and reduce the use of unneeded rabies post exposure prophylaxis. "Because an integrated bite case management program represents integration of both human and animal health, it offers an opportunity to prevent human rabies deaths" and reduce the cost of post exposure prophylaxis [81]. In an integrated bite case management program, bites are reported by human health facilities to animal health workers, whose assessments of the animals guide treatment decisions for human patients. The program has three goals: Recording dog bites, testing dogs suspected of having rabies and reduces human rabies exposure [7].

The other measures that have been taken to improve dog bite management in Ethiopia include the following: Training more animal health workers, laboratory employees, and supervisors, improving access to post exposure prophylaxis and canine rabies vaccine, developing a rabies surveillance system, identifying a temporary diagnostic laboratory to use while a rabies laboratory is being constructed, building regional animal quarantine facilities. The recommendations for further work includes; increasing community awareness of the bite case management program (to increase reporting of suspected rabid animals), ensuring that rabies vaccines are handled by facilities with proper cold chain capacity, and encouraging traditional healers to send dog bite patients for post exposure prophylaxis [17].

The other opportunity is the ability for local production of safe and effective modern rabies vaccine for both animal and humans. Modern cell culture anti-rabies vaccine production for animal use has been transferred to National Veterinary Institute from the Ethiopian Public Health Institute for mass production. For human purpose, the effort to replace Fermi type with modern cell culture vaccine is in progress at EPHI and currently preclinical trials were finalized and will begin in the coming years, it is assumed to replace Fermi vaccine which is expected to contribute to the control and elimination of the disease in Ethiopia [101].

2.4. Dog Population Management and Future Prospects Of Rabies Control

Humane DPM tools offer the theoretical possibility of better integration of dogs into communities and stabilization, or even reduction in size of dog populations where it is easier to maintain vaccination coverage [102]. In some countries where population reduction of free-roaming dogs is wanted by owners and communities, veterinary services are abundant, and political will and funding are sufficient to address the issue, there is evidence that high throughput sterilization and release programs can achieve population reduction [31]. However, where sterilization, vaccination and release programs do not reach 70% of dogs, additional vaccination must be encouraged to ensure that vaccination levels are sufficient to halt rabies transmission as quickly as possible [10].

In few areas such as where veterinary services and funding to pay for DPM programs are insufficient, theoretical arguments would suggest that waste management programs to reduce food resources for free-roaming dogs should be encouraged. Along with promotion of RDO to reduce free roaming dog population sizes, waste management could be the best option to reduce dog populations and the spread of diseases in resource limited settings but evidence of this method's effectiveness is currently lacking [33]. It is possible that large-scale DPM success in most low-income countries will require the development of a cost effective (non- surgical) safe and permanent sterilizing agent for female dogs. Such research is being actively pursued and progress is being made [103]. Small scale safety trials of GonaCon given along with rabies vaccinations have been completed in female dogs in Mexico [104] and on an American Indian reservation in the US [105], but there are as yet no data on its effects on fertility. However, until such a permanent sterilizing agent becomes available, a safe and effective sterilant that lasted even 2–4 years could still be very beneficial to animal welfare and rabies control [106].

3. CONCLUSION AND RECOMMENDATIONS

Canines remain the major mediators to almost all rabies deaths and economic loss. Integrating Canine surgical sterilization into as dog population management for rabies elimination programs were tried in some parts of the world that proved to supplement the goal of breaking the rabies transmission cycle in addition to stabilizing dog populations and improving animal welfare issues. Even though few attempts were made to control dog population as an integral part of preventing the incidence of human rabies, and rabies still remains imposing a great risk to the animals and humans worldwide, there is a clue that DPM through surgical sterilization may have a positive impact in augmenting rabies control efforts. However, since dogs have diverse functions and values in societies, any DPM including surgical sterilization program needs to define appropriate, culturally specific and acceptable measures related to animal welfare, human health and environmental soundness based on scientific evidence. Some of the challenges for control of rabies and dog population managements through surgical sterilization in Ethiopia are related with lack of resources, absence of compulsory canine vaccination and registration, poor collaboration and cooperation among stakeholders and haphazard trend of dog control and immunization, lack of public education and inadequate information about the disease. So depending on the above conclusion the following recommendations were forwarded.

- ➢ Government should have to device strategies and policies regarding canine and feline surgical sterilization to reduce their population size and human rabies incidence.
- ➢ All relevant stakeholders should be involved in the development of comprehensive rabies control and prevention strategies including sustainable DPM and canine vaccination with continuous monitoring and objective evaluation of the intervention outcomes.

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