

EPIDEMIOLOGICAL STUDIES ON RABIES IN PUNJAB, INDIA

Dissertation

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In partial fulfillment of the requirements for the degree of**

**DOCTOR OF PHILOSOPHY
in
VETERINARY PUBLIC HEALTH AND EPIDEMIOLOGY
(Minor Subject: Veterinary Pathology)**

By

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CERTIFICATE – I

This is to certify that the dissertation entitled, “**EPIDEMIOLOGICAL STUDIES ON RABIES IN PUNJAB, INDIA**” submitted for the degree of **Ph.D.**, in the subject of **Veterinary Public Health and Epidemiology** (Minor subject: **Veterinary Pathology**) of the Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, is a bonafide research work carried out by **Gurlal Singh Gill (L-2014-V-22-D)** under my supervision and that no part of this dissertation has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknowledged.

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ABSTRACT

The current study was carried out to determine the magnitude of animal rabies in Punjab state of India. We prospectively followed canine and livestock populations residing in four sub-district(s) in Punjab, during 2016-2017. The annual canine rabies incidence was estimated to be 4.51 (95% Uncertainty Interval [UI] 0.066-21.88) per 10,000 population in pet dogs and 4.89 (95% UI 0.141-69.97) per 10,000 stray dogs in India. For livestock species, the disease incidence in domestic cattle populations was estimated to be 0.62 (95% UI 0.0034-4.21) per 10,000 domestic cattle in India. The disease incidence of 19.8 (95% UI 0.27-158.4) per 10000 populations was reported in the stray cattle populations. Stray dog and cattle count was carried out during 2016-2017 in the selected villages/wards in the Punjab, India. Overall, 22 villages and 10 wards were surveyed. We used a mark-re-sight procedure with slight modifications to estimate the stray animal populations. The data analyses indicated that based on the number of villages and wards in the state, there are a median of 672005 (95% CI: 241802, 1198024) stray dogs in Punjab state of India. Similarly, we estimated that there are a median of 679, 071 stray cattle based on the number of wards and villages, 354, 858 based on the adult human population residing in the surveyed areas and 435, 042 based on the residential (built-up) areas in Punjab. Lack of knowledge on rabies prevention and control measures were recorded in the target populations such as students and animal owners.

Keywords: Canine, Dog, Incidence, India, Livestock Punjab, Rabies, Stray

Signature of Major Advisor

Signature of the Student

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LIST OF ABBREVIATIONS

@	:	At the rate of
()	:	Circular brackets
=	:	Equal, the sign of equality
%	:	Per cent
±	:	Plus minus
≥	:	Greater-than or equal to
≤	:	Less-than or equal to
x	:	Sign of multiplication
Hr	:	Hours
Km ²	:	Square Kilometer
HRIG	:	Human rabies immunoglobulin
°C	:	Degree Celsius
<i>et al</i>	:	and others
Fig.	:	Figure
R ²	:	Coefficient of determination
i.e.	:	That is
mg	:	Milligram
min	:	Minute
St. β	:	Standardised Beta
CL	:	Confidence Interval
UI	:	Uncertainty Interval
I-ELISA	:	Indirect-Enzyme linked immunosorbent assay
PCR	:	Polymerase chain reaction
Eq	:	Equation
IU	:	International Units
PPE	:	Personal Protective Equipment
PP	:	Post-Prophylaxis
OD	:	Optical Density
LCL	:	Lower Confidence Limit
UCL	:	Upper Confidence Limit

CHAPTER I

INTRODUCTION

Rabies is a devastating zoonotic disease of mammals resulting in acute encephalitis and death (Jackson and Wunner 2007). Rabies virus is primarily transmitted through the bite of a rabid animal and dogs contribute to a great extent as rabies virus reservoirs in African and Asian countries (Suraweera *et al* 2012 and Jemberu *et al* 2013). Although the first vaccine against rabies was developed by Louis Pasteur in 1885 (WHO 2010), the disease still remains a neglected disease in humans, particularly in poor and marginalized populations in low-resource settings. It is estimated that canine rabies poses a threat to more than 3.3 billion people in the world (WHO 2010).

Rabies is endemic in developing countries of Africa and Asia (WHO 1998). Recent assessments suggest that worldwide, about 59,000 people die annually of rabies with most deaths reported from Asia and Africa (Hampson *et al* 2011). In Africa, the annual disease incidence has been reported to be 0.7 per 100,000 in Chad and 4.9 per 100,000 human population in Tanzania (Cleaveland *et al* 2002 and Frey *et al* 2013). In India, the annual incidence of rabies have been reported to be 2 per 100,000 human populations with 20,000 estimated deaths every year in India, making it one of the worst affected countries in the world with one-third of the annual global rabies burden (Hampson *et al* 2015 and Sudarshan *et al* 2007). The actual number of deaths could be higher, because rabies is not a notifiable disease in India and there is no organized surveillance system of human or animal cases.

Rabies also causes a huge health and economic impact in human and animal populations. For example, Hampson *et al* (2015) estimated that globally canine rabies causes approximately 3.7 million (95% CIs: 1.6-10.4 million) disability-adjusted life years (DALYs) and in Africa and Asia, death due to rabies responsible for 1.74 million DALYs (Knobel *et al* 2005). The annual cost of rabies in Africa and Asia has been estimated to be US\$ 583.5 million and globally canine rabies causes 8.6 billion USD losses (Knobel *et al* 2005 and Hampson *et al* 2015). Further, the annual cost of livestock losses as a result of rabies has been estimated to be US\$ 12.3 million in the Africa and Asia (Knobel *et al* 2005). As per World Health Organization (WHO 2013), children younger than 15 years account for 40% of the human rabies deaths

particularly in rural areas in low-resource communities. Although rabies is 100% preventable through prompt administration of post-exposure prophylaxis vaccine to a patient and can be controlled through mass vaccination of dogs (Hampson *et al* 2015); It was estimated that only around 20% of the 19 million humans bitten by dogs in the South-East Asia Region receive one or more doses of rabies vaccine (Gongal and Wright 2011). The post-exposure prophylaxis vaccine in these areas is very low and could be the reason for high rabies incidence in the South-East Asia Region as compared to the remaining world. The risk and burden of rabies falls disproportionately on the most vulnerable groups such as farmers and pet owners which account for highest rabies cases followed by students and children (Wang *et al* 2010 and Zhou *et al* 2016). Outdoor activities are an important risk for occurrence of rabies in adult men and children (Shah *et al* 2012, Sudarshan *et al* 1995, and Sudarshan *et al* 2001). In addition, factors such as false beliefs, myths, lack of knowledge about rabies and bite wound management also result in human rabies in countries such as India (Sekhon *et al* 2002 and Shah *et al* 2012). Health education programs in risk groups could improve people's knowledge and a change in their attitude and practices to minimize the disease burden (Mascie-Taylor *et al* 2003). Understanding the knowledge, attitude and practices of risk groups could help identifying knowledge gaps, cultural beliefs and behavior patterns that may pose hurdle in controlling infectious diseases (Fevre *et al* 2005, Mascie-Taylor *et al* 2003, Koenraadt *et al* 2006, Krentel *et al* 2006, Quick *et al* 1996 and Mfinanga *et al* 2003), and will provide essential baseline data for planning, implementation and evaluation of national control programs.

Information about the incidence of rabies in domestic dogs is limited. The annual rabies incidence has been reported to be 14 per 10,000 dogs in Chad (Kayali *et al* 2003) and 41.28 per 10,000 dogs in Ethiopia (Jemberu *et al* 2013). In India, information is not available about incidence of disease in livestock and canine populations. Stray dogs are responsible for most of the human and animal bites cases in India (Sudarshan *et al* 2006 and Shah *et al* 2012); dogs are considered an important reservoir host for rabies in India (Ghosh 2006), and are believed to be responsible for > 97% of human rabies deaths (Suraweera *et al* 2012). The elimination of canine rabies, particularly in stray dogs, is a serious concern in India. Factors such as poor dog population management and low standards of dog care (including infrequent

veterinary consultation) are considered responsible for high endemicity of canine rabies in India (Sudarshan *et al* 2006).

Annual disease incidences of 1.98, 6.76 and 1.44 per 10,000 cows, equines and goats, respectively, have been reported in Ethiopia (Jemberu *et al* 2013). In Tanzania, Meslin (2008) reported an incidence of 1.23 per 10,000 cattle which was quite high as compared to Brazil, where Rodenbusch *et al* (2016) reported an annual incidence of 0.079 per 10,000 bovines.

Recent studies on a passive Rabies diagnostic laboratory oratory oratory data revealed that rabies is an endemic disease in Punjab (Brookes *et al* 2017). However, passive reports often underestimate disease incidence. There is lack of accurate quantitative information about the status of rabies in animal population(s), especially in stray animal population(s) which have a significant role in endemicity of the disease (Brookes *et al* 2017).

Rather than rabies stray dogs significantly contribute to environment pollution and can act as reservoirs of many important zoonotic parasites (*Toxocara*, *Ancylostoma* and *Echinococcus*) via faecal contamination of soil and water (Overgaauw 2013, Da Silva 2010 and Macpherson and Torgerson 2013). It has been estimated that a population of 100,000 dogs deposits between 3–11 tons of faeces daily into the environment (Beck 1973), causing a substantial public and animal health concern. Stray dogs also contribute to incidents such as bites, accidents and damage to wildlife populations (Ugbomoiko *et al* 2008, Tenzin *et al* 2011, Lunney *et al* 2011 and Høgåsen *et al* 2013).

The overpopulation of stray dogs is an important animal welfare and public health concern in India (Amaku *et al* 2010 and Garcia *et al* 2012). It has been reported that 97% of human rabies deaths occur in the country due to infection from infected dogs (Suraweera *et al* 2012). Stray dogs transmit many important zoonotic pathogens in India (Sharma *et al* 2017). Huge numbers of animals continuously roam on the streets (Hiby *et al* 2011, Totton *et al* 2010 and Punjabi *et al* 2012). The abandonment of dogs might be related to irresponsible breeding and religious, cultural and socioeconomic factors. Many factors – such as easy availability of food, lack of predators, low number of competitors, and ease with which a breeding partner can be found – have led to increases in stray dog populations in certain areas (Sarcase 1985).

In certain regions of the world a severe decline in vultures' population has led to the availability of large amounts of animal carcasses, which then act as a source of food for stray dogs and promotes an increase in the size of such populations. Furthermore, it has been estimated that a female and its offspring have the potential to give birth to 67000 individuals during a six year period (Neamtu 1979).

Mass culling of dog populations was historically used to control rabies in India (Reece 2007), but this has been replaced by animal birth control (ABC) programs under the Prevention of Cruelty to Animals Act, 1960 and the Animal Birth Control Rules, 2001. Within an ABC program, street dogs are sterilized, vaccinated and subsequently released into the same area from which they were captured. The ABC program has been implemented in small areas in India with effective results (Reece *et al* 2008, Hiby *et al* 2011, Totton *et al* 2010 and Reece and Chawla 2006).

In addition to stray dogs, the abundance of stray cattle is also a serious concern in India. Many factors such as mechanization of agriculture, expanding human populations, decrease in forest land, shortage of fodder and forage land, introduction of artificial insemination (AI) have lead to an increase stray cattle population. Although exact national data on stray cattle populations remains unavailable, estimates reveal that the capital city of New Delhi alone is home to more than 20,000 stray cows (Rathore 2008). Stray cattle are either aged cattle at the end of their productive life or non-productive animals turned out on the streets by their owners (Singh *et al* 2013). It is noteworthy that absence of cow slaughter has substantially increased the problem of stray cattle.

In view of this, the current study focused on the following objectives:

1. Estimation of annual incidence of rabies in animal hosts in Punjab (India)
2. Estimation of stray dog population in urban and rural areas of Punjab (India)
3. To understand the level of awareness on rabies in target populations in Punjab (India)

CHAPTER II

REVIEW OF LITERATURE

Rabies is a viral disease caused by rabies virus of the genus *Lyssavirus* (family *Rhabdoviridae*; order *Mononegavirales*) (ICTV 2011). Many mammals such as the red fox and raccoon dog in Europe (Finnegan *et al* 2002), vampire bat in Central and South America (Schneider *et al* 2009) and raccoons, skunks, foxes and bats in North America (Finnegan *et al* 2002) serve as natural reservoirs. However, dogs significantly contribute to the occurrence of the disease in humans' in African and Asian countries (Prager *et al* 2012).

Rabies virus has a negative-sense, non-segmented, single stranded RNA genome and a distinctive bullet shape. The structure of the virion has been described in detail elsewhere (Tordo 1996, Murphy *et al* 1999, and Wunner 2007). The virus is quite fragile and is easily destroyed by detergents such as phenol, ether, formalin, halogens, mercurials, mineral acids and soap solution (Turner and Kaplan 1967). Desiccation, ultraviolet radiation, and sunlight rapidly inactivate the virus and it does not survive for long periods in the environment. The virus can remain stable for a few days at 0 to 4°C in the internal organs; in saliva in temperate climate for about 24 hours and survives indefinitely when freeze dried or kept at -70°C (Kaplan *et al* 1986). Glycerol acts as a preservative and brain or other tissues are preserved in 50% glycerol in phosphate buffered saline solution (Barrat 1996 and OIE 2011). The virus can be excreted in saliva of infected animals for many days before and after the onset of clinical signs (Fekadu *et al* 1982, Charlton 1988 and Fekadu *et al* 1981). The presence of virus in the milk does not pose a major hazard as viral particles are easily destroyed by enzymes present in the milk (Kaplan *et al* 1986 and Beran and Steele 1994). The rabies virus is relatively fragile and does not survive for long in the environment. The virus remains viable in a carcass for less than 24 hours at 20°C.

The direct bite is the most common route of infection but the infrequent transmission route(s) include licking, scratching or contact with freshly abraded skin or mucous membranes such as conjunctiva, and nasal mucosa. Ingestion of raw meat from animals infected with rabies has not been documented as a source of human infection (WHO 2010) barring few reports (Tariq *et al* 1991, Kureishi *et al* 1992, Wallerstein 1999, Hu *et al* 2009, Wertheim *et al* 2009, Dimaano *et al* 2011 and Hanh

2011). Other risks include skinning and handling of carcasses with bare hands and touching eyes or lips with hands while they are contaminated by traces of the dog's fluids (Kureishi *et al* 1992). Pasteurization and cooking will inactivate the virus (Turner and Kaplan 1967) and render the pasteurized or boiled milk and thoroughly cooked meat non-infectious (WHO 2010 and CDC 2011). Inhalation of rabies aerosol into is an important route of transmission in some species such as foxes and bats (Beran and Steele 1994).

Human-to-human transmission of rabies through corneal transplant (CDC 1980, Thongcharoen *et al* 1981, Gode and Bhide 1988 and Javadi *et al* 1996) or other organ tissue transplants (Srinivasan *et al* 2005 and Johnson *et al* 2005) have been reported in some countries. The transmission of rabies virus in human subjects from other body fluids has not been documented (Madhusudana and Sukumaran 2008) except rare reports (Sipahioglu and Alpaut 1985). The transplacental transmission has been reported in skunks, bats and cows (Greene and Dreesen 1990). The virus transmission occurs through sensory and motor nerves at the initial site of infection (Hemachudha 1989 and Jackson 2007, Tsiang *et al* 1991). In the brain, the virus replicates and disseminates within the CNS. The virus travels centrifugally from the CNS through peripheral nerves to various tissues, most notably the salivary glands, and the transmission cycle is repeated (Hemachudha 1989 and Jackson 2007). Foxes, coyotes, jackals, wolves, mongooses and certain rodents are the most susceptible animal groups. Caribbean mongoose rabies type is a unique variant and most closely related to canine types (Beran and Steele 1994, Eng and Fishbein 1990). Younger animals are usually more susceptible to rabies infection than older ones (Greene and Dreesen 1990). The proportion of animals that develop rabies and the duration after exposure depends on the site of the bite, severity of the bite, species of animals involved, age of bitten individual, strain and amount of virus and post-exposure treatment (Murphy *et al* 1999).

The first signs reported by human include feeling generally unwell, loss of appetite, headache, fever, irritability restlessness and anxiety. In the furious form, the patient may show stage of excitement with painful muscle spasm followed by hydrophobia aerophobia and periods of extreme excitement (Kaplan *et al* 1986). In the dumb form, the patient may become literally dumb due to paralysis of laryngeal muscles.

In dogs and cats, the first symptoms usually reflect abnormal sensation e.g licking, scratching, rubbing or chewing at the wound site even if it has been completely healed (Kaplan *et al* 1986). The prodromal signs of nervousness, solitude, fever and behavioural changes are also noted. Animals then become restless, hypersensitive to auditory and visual stimuli, excitable, photophobic and hyperaesthetic and bark and snap at imaginary objects. The dogs usually roam and eat unusual objects, and may avoid contact with people or prefer hiding in dark or quiet places. They may try to bite or attack when caged or confined and develop muscular inco-ordination, disorientation and seizure. Rabid cats are often more savage and dangerous than rabid dogs (Kaplan *et al* 1986, Greene and Dreesen 1990). In cattle, symptoms are similar to other animals but the furious phase is uncommon. In horses, the clinical symptoms are similar to other animals with signs of pain and discomfort in the infected site.

The Fluorescent Antibody Test (FAT) is a commonly used for the diagnosis of rabies. Virus isolation on cell culture is preferable to the mouse inoculation test because cell culture tests give more rapid results, and help avoid the use of animals. Both tests require longer turnaround times compared to FAT (4-days for cell culture test and 28-days for mouse inoculation test) (King 1996, Fooks *et al* 2009 and OIE 2011). A direct Rapid immunohistochemical test employs anti-rabies monoclonal antibodies specific for the nucleoprotein (a viral protein produced in abundance during productive infection), and can detect rabies antigen by direct staining of fresh brain impressions within 1 hour (Fooks *et al* 2009, Lembo *et al* 2006 and Durr *et al* 2008). Rabies virus antigen can also be detected from brain samples using rapid immunodiagnostic test (RIDT) which works based on the principles of immunochromatography (Fooks *et al* 2009 and Servat *et al* 2012). Molecular diagnostic tests, for example the detection of viral RNA by reverse transcription polymerase chain reaction (RT-PCR), PCR-ELISA, real-time PCR, semi-nested PCR, and nested PCR are used as rapid and sensitive tests for rabies diagnosis (Fooks *et al* 2009 and OIE 2011). Serological tests are used to measure the level of virus neutralizing antibody in vaccinated individuals and to detect host response to rabies infection by measuring antibodies in cerebrospinal fluid/serum in suspected rabid cases (Fooks *et al* 2009). The WHO recommended virus neutralization tests include Rapid fluorescent focus inhibition test (RFFIT) (Smith *et al* 1973) and fluorescent

virus neutralization test (FVNT) (Cliquet *et al* 1998, Zhang *et al* 2009 and OIE 2011). Several enzyme-linked immunosorbent assays (ELISA) based methods using either the whole virus or purified G glycoprotein as the detection antigen are available to effectively detect and quantify rabies antibody in the sera of vaccinated animals or humans, and are applicable for testing large numbers of field sera (Sugiyama *et al* 1997, Cliquet *et al* 2000, Servat and Cliquet 2006, Servat *et al* 2007 and Zhang *et al* 2009). Rabies is generally regarded as an inevitably fatal disease both in human and animals. However, there are many reports of dogs surviving after rabies infection (Fekadu 1993).

The first step of post exposure treatment is immediate and thorough wound cleansing and flushing with soap and water. Human rabies immunoglobulin and vaccine are needed after exposure to rabid or rabies suspected animals (Greene and Dreesen 1990). The Pre-exposure prophylaxis has been found to be highly protective for people with a high risk of occupational exposure to rabies such as veterinarians or rabies lab personnel (Greene and Dreesen 1990). The recommended post-exposure prophylaxis (PEP) includes thorough cleaning of the bite wound with soap and water or detergent, administration of rabies vaccine to stimulate an active immune response, and administration of rabies immunoglobulin to provide immediate passive immunity (WHO 2010). The proper cleaning of the wound would remove most of the virus but this simple and cheap treatment procedures are often omitted in most cases (Warrell and Warrell 2004, WHO 1973 and Dean 1975).

Rabies can be effectively eliminated in the dog population when 70 to 80 percent of animals have been successfully immunised (Kaplan *et al* 1986). The maintenance of rabies in animal populations requires the availability of a susceptible host and contact between vector animals. Control of rabies may be achieved by breaking these cycles (Beran and Steele 1994).

Animal disease surveillance systems comprise passive and active surveillance. Active surveillance systems, although they provide better data, are more expensive (Dorrell 2007). The risk-based surveillance concept is gaining importance and can provide a higher benefit-cost ratio with existing or reduced resources (Doherr *et al* 2001 and Stärk *et al* 2006). A targeted enhanced rabies surveillance system is also carried out by the wildlife biologists (Slate *et al* 2009). The rabies surveillance data

are analysed and published in a summary report each year in the USA (Krebs *et al* 2005, Blanton *et al* 2006a, Blanton *et al* 2006b and Blanton *et al* 2009). In Europe, rabies cases are confirmed by laboratory tests and the rabies surveillance data are collected electronically in Rabies Bulletin Europe (www.rbe.fli.bund.de) and is published quarterly every year as a summary report (Freuling and Müller 2010, 2011). In South America, the Pan American Health Organization (PAHO), established a rabies surveillance information system called ‘The Regional Information System for Epidemiological Surveillance of Rabies in the Americas (Belloto 2004 and Belotto *et al* 2005).

Canine rabies free countries have a strict quarantine and regulatory system for the import of dogs and cats from rabies endemic countries. Despite these regulations, imported cases of dog rabies are occasionally recorded in those countries (Mailles *et al* 2004, Castrodale *et al* 2008, Fooks *et al* 2008, Mangieri *et al* 2008, McQuiston *et al* 2008, Johnson *et al* 2011a and Johnson *et al* 2011b). The cases of human imported rabies are also reported. A total of 42 human deaths from rabies were reported in Europe, the United States and Japan between 1990 and 2010, all of these victims were assumed to have contracted the rabies infection abroad (Malerczyk *et al* 2011).

The rabies surveillance systems are largely missing in the developing world (Cleaveland *et al* 2002, Knobel *et al* 2005, Ly *et al* 2009, Wu *et al* 2009, Sudarshan *et al* 2007, Hossain *et al* 2011 and Kitala *et al* 2000) as compared to the developed countries. At the global level, the WHO collects rabies data through World Survey of Rabies, which obtains rabies data electronically (called RABNET) and has become accessible through the internet for data consultation and online data entry (WHO 1999, Knobel *et al* 2005). The active rabies surveillance has demonstrated that the passive surveillance and the official records grossly underestimate the true incidence of human rabies by about 75 to 100 times in Kenya and Tanzania (Kitala *et al* 2000, Cleaveland *et al* 2002 and Mallewa *et al* 2006).

2.1 Rabies in India: Systematic review and meta-analysis

In this section, we reviewed the rabies research carried out in India during the year 1980-2017. Initially, we reviewed the scientific literature in PubMed and Google Scholar. For PubMed, the query was built that included the defined key words “Rabies OR Rabid OR Lyssavirus AND India” in the title or abstract of the published records. Similar search was performed in Google Scholar except that the search was

restricted to the title of the published record. The additional language filter (the papers only Published in English) was activated for both the searches. The PubMed search resulted in 227 records, while the search in Google scholar resulted in 223 records. The results were checked for duplicity and 29 repetitive records in the Google scholar were removed. The records from PubMed (227) and Google Scholar (194) were merged leading to 333 records. All the records were scrutinised and 143 irrelevant records were removed leading to 190 records. Finally, the records published before 1980 were discarded and 128 records were retained in the final analysis.

These records included 36 review papers (28.10%), three systematic reviews and meta-analysis papers (2.3%), and 89 (69.5%) research papers. The mean average output of the scientific literature for 37 years was 3.46 articles per year. The number of research publications significantly increased after the year 2005. Maximum 35.9% (32/89) of research articles (excluding review papers) were published from the Karnataka state followed by 16.8% (15/89) from Maharashtra, 14.6% (13/89) from Tamil Nadu and 12.3% (11/89) from Kerala state of India. Less than 8% of the records were published from other parts of the country (Fig. 1).

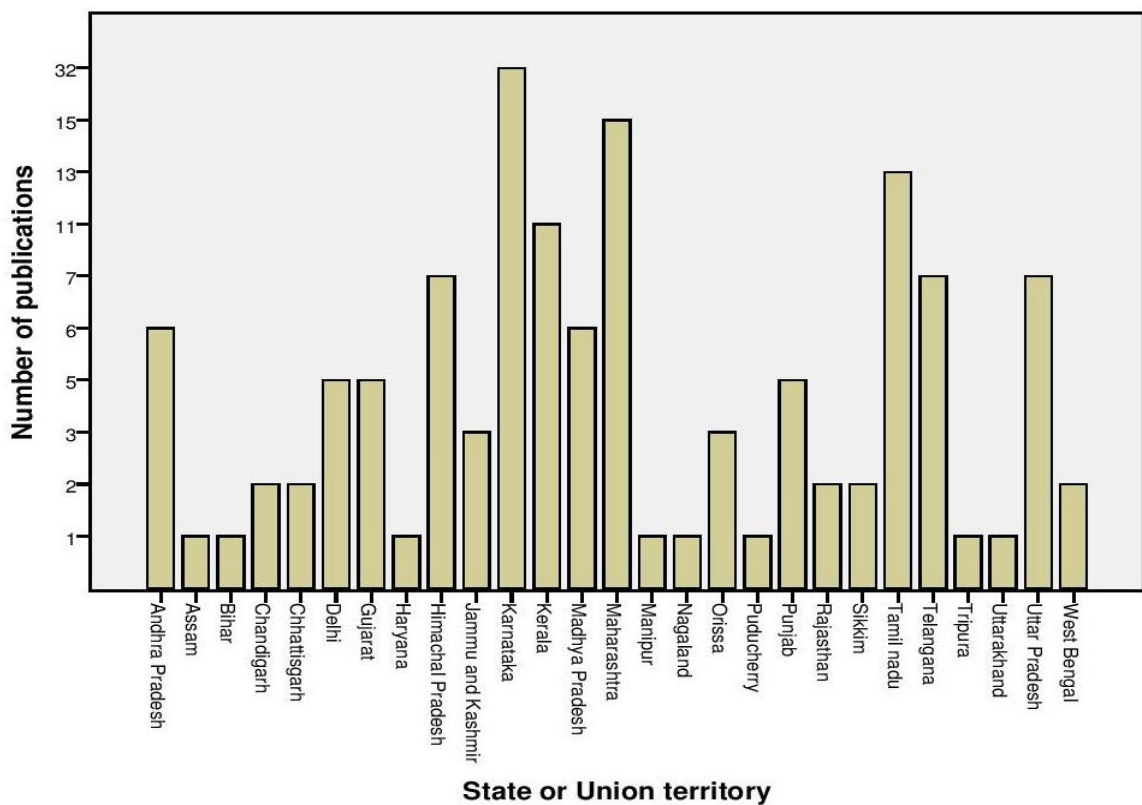


Fig. 1: State/Union territory wise distribution of rabies research publications in India during 1981-2017

For the 89 research articles, a maximum of 73% (65/89) research was associated with humans followed by 25.8% (23/89) with dogs, 17.9% (16/89) with bovines, 11.2% (10/89) with wild animals and less than 10.5% with other species. We record a single publication involving bats from Nagaland state of India (Fig. 2). Similarly, 74.3% (29/39) of the review papers were focused on human rabies, 23.07% (9/39) focused on both human and animal rabies and only one paper exclusively reviewed rabies in animal populations.

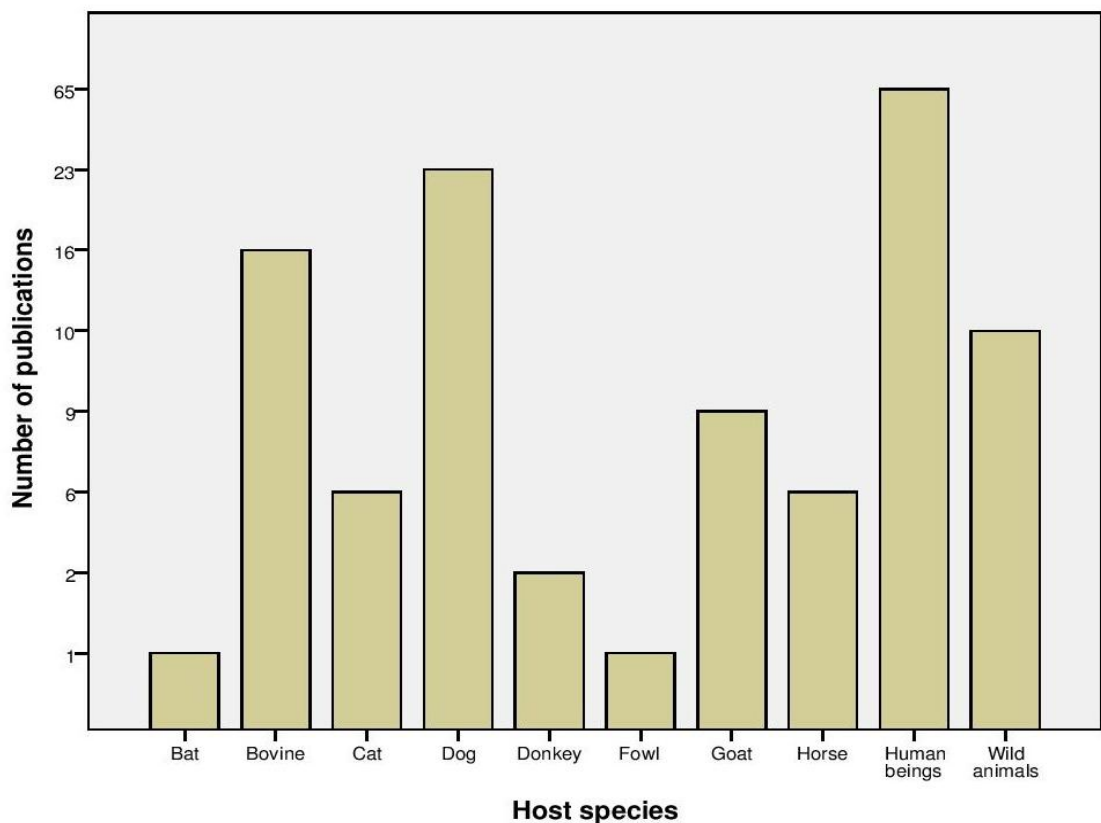


Fig. 2: Research publications published on rabies involving different host species in India from 1981-2017

The analysis of the 89 research publications indicated that maximum of the research was focused on immunization (35.9%) followed by knowledge attitude and practices studies (15.7%) and molecular epidemiology (14.6%) (Fig. 3). The molecular studies reported that the rabies virus in India had more homology to Arctic rabies lineage genotypic 1. It was further reported that dog rabies virus variants were main variants circulating in India. Rapid fluorescent focus inhibition test (RFFIT) was used in 22 records to detect the antibody titer after vaccination, and to investigate the

rabies cases followed by reverse transcriptase polymerized chain reaction (16), florescent antibody inhibition test (10), real time PCR (6), ELISA (4), and brain histopathology (3). Other diagnostic tests included mouse inoculation test, florescent antibody virus neutralization test (FAVN), mouse neutralization test, immunohistochemistry, indirect immunoperoxidase, direct immunofluorescence, DNA fragmentation and the TUNEL technique.

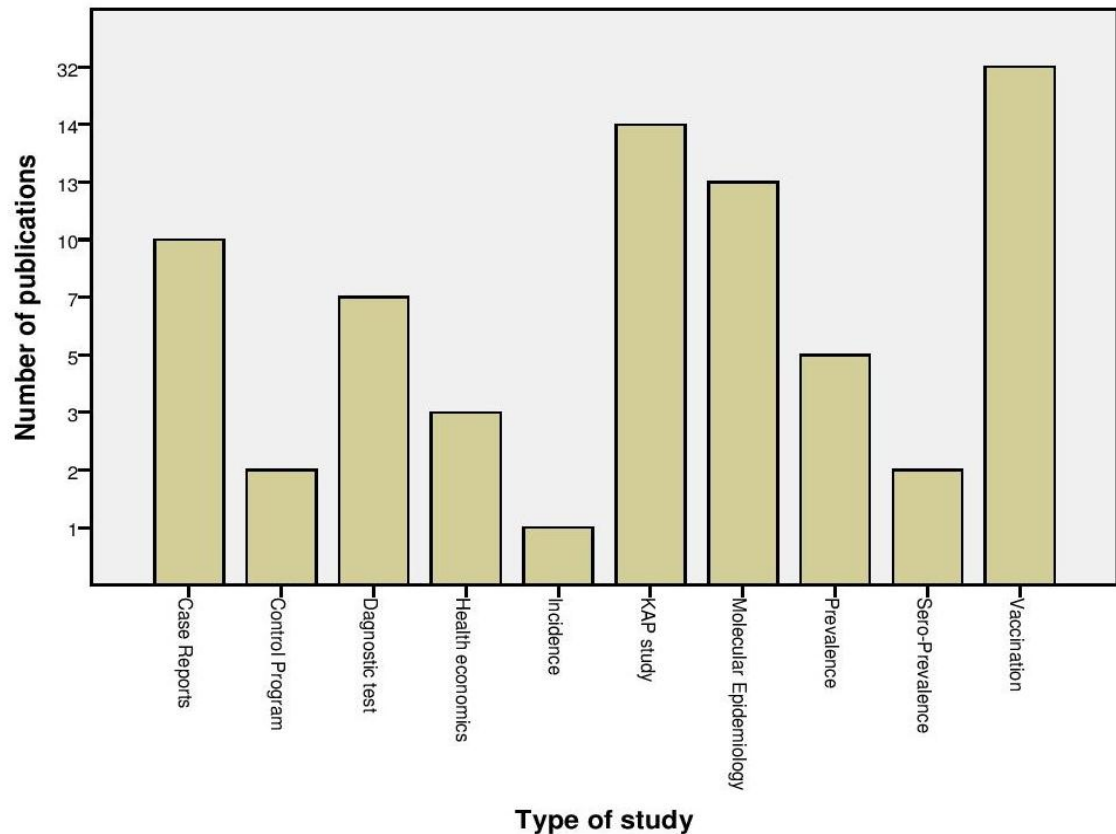


Fig. 3: Type of studies published on rabies in India from 1981-2017

2.2 Stray dogs and public health: a systematic review and meta-analysis

The scope of this review was to determine the status of free-ranging/stray dog population in different countries. To estimate the global burden of stray dogs, we reviewed the scientific literature in PubMed and Google Scholar. For PubMed, the queries were built that included the defined key-words “stray dog OR free-roaming dog OR free-ranging dog” in the title or abstract of the scientific literature. A similar query was built in Google Scholar except that search was restricted to title of the published literature. The additional language filter (the paper only Published in English) and time filters (1992-2017) were activated for both the searches. The

PubMed resulted in 519 articles, while 200 records were retrieved in the Google scholar. The data from PubMed (519) and Google Scholar (200) were collected. The records were individually scrutinised and irrelevant records were discarded. Finally, 16 articles having data on free-roaming dog population were retained in the analysis.

The results indicated that a maximum of 56.25% (9/16) records were published during 2015–2017 and 43.75% (7/16) records were published during the years 2001-2014. We could not find any stray dog estimation study from 1992-2000. There was an exponential growth in the free-ranging dog estimation studies after the year 2001. The stray dog estimation studies were conducted in India (3), Bhutan (2), Brazil (2), and Nepal (2). In addition, one study each was recorded from Nigeria, Panama, Puerto Rico, Romania, Russia, Serbia, Taiwan, Turkey, Bangladesh, Bosnia, Costa Rica, Cuba, Indonesia and Japan indicating the presence of stray dogs in these countries. Maximum research was carried out in India indicating that it is a serious issue in this country.

Based on the human population, we found that maximum number of stray dogs was recorded from Kathmandu, Nepal with a human-dog population ratio of 4.7:1 followed by Shimotsui, Japan with a human-dog population ratio of 5.2:1; Bhutan with a human-dog population ratio of 14.9:1; Divinoópolis, Brazil with a human-dog population ratio of 42:1 and Dhaka, Bangladesh with a human-dog population ratio of 828:1.

Based on the area, a high density of stray dogs was reported from Kathmandu, Nepal (2930 dogs per Km²). The lowest density of stray dogs was reported from Southern Bhutan (1.26 dogs per Km²). The densities of stray dogs reported from other cities in different countries are as follows: Dhaka, Bangladesh (52 dogs per Km²); Mumbai, India (57 dogs per Km²); Omsk, Russia (69 dogs per Km²); Phuentsholing, Bhutan (95.6 dogs per Km²); Gelephu, Bhutan (Gelephu =141.2 dogs per Km²) and Shimotsui, Japan (225). There were studies that estimate the stray dog population per kilometre only. These included three cities (Kljuc, Mrkonjic Grad and Trebinje) of Bosnia (0.78-9.07); five cities (Badovinci, Bogatic, Crna Bara, Dublje and Klenje) of Serbia (0.142-0.85); two cities (Cernavoda and Agigea) of Romania (4.79-6.52); four cities (San Miguelito, Casco Viejo, Juan Diaz and Kuna Nega) of Panama (1.07-5.83); three cities (Aguadilla, Fajardo and Toa Alta) of Puerto Rico

(1.13-1.73); five cities (San Jose, Heredia Y Belen, Cartago, Alajuela and Rancho Redondo) of Costa Rica (1.5-4.09) and one to eight zone of Nepal (8.4-27.14). Overall, the analysis revealed that the presence of stray dogs is an important concern in many South Asian countries such as India, Bangladesh, Nepal and Bhutan. Furthermore, these countries are endemic for rabies indicating a strong association between the occurrence of rabies and the presence of stray dogs.

CHAPTER III

MATERIALS AND METHODS

3.1 Estimation of annual incidence of rabies in animal populations in Punjab, India

3.1.1 Ethics statement

The study Performa was approved by the Institutional Ethics Committee, Dayanand Medical College and Hospital, Ludhiana, Punjab (approval no. DMCH/R&D/2017/482). Participants were provided with Participant Information Statement explaining the purpose of the study, and written consent was obtained from all participants before data for the study were collected.

3.1.2 Study area

The current study was carried out in Punjab state of India. Punjab is an agricultural state located in the North West of India with populations of approximately 27.74 million humans and 0.47 million domestic dogs (Census 2011 and DAHP 2012). The state has a total livestock population of 8.1 million including 2.4 million cattle, 5.2 million buffalo, 0.45 million small ruminants and 0.04 million equines (DAHP 2012). Punjab has 22 districts and an area of 50,362 km² (<http://punjab.gov.in/know-punjab>). The state has a Veterinary University (Guru Angad Dev Veterinary & Animal Sciences University; GADVASU) and the Rabies diagnostic laboratory in this university is the only diagnostic facility for rabies in Punjab.

3.1.3 Sub-district selection

Information derived from rabies case records from the GADVASU, Rabies diagnostic laboratory (Brookes *et al* 2017) were used to select the sub-districts for the current study. Based on the animal rabies cases reported from the sub-district(s) in Punjab, the sub-districts were divided into four groups: no rabies cases reported, 1-6 rabies case reported, 7-12 rabies case reported and those reporting >12 rabies cases during the years 2004—2014 (Table 1). For this prospective study, we selected one sub-district from each group (sub-districts; Kotkapura [0 cases], Phull [4 Cases], Nihal Singh Wala [9 cases] and Ludhiana East [46 cases] on the convenience basis.

Table 1: The number of positive cases reported in different sub-districts from 2004-2014 in Rabies diagnostic laboratory, Guru Angad dev Veterinary and Animal Sciences University, Ludhiana (Brookes *et al* 2017)

No. of case(s) 2004-2014	Name of the sub-district(s)
No case reported	Balachaur, Banga, Bhulath, Budhlada, Dera Baba Nanak, Kotkapura, Mukerian, Patran, Samana, Sardulgarh, Sultanpur Lodhi, Sunam, Amritsar-2, Baba Bakala, Batala, Dasua, Dharamkot, Gurdaspur, Jalalabad, Jalandhar-2, Khadur Sahib, Lehra, Mansa, Maur, Nangal, Phagwara, Talwandi Sabo
1	Gidderbaha, Patti, Guru harsahai, Fazilka, Tarn Taran, Ambala, Muktsar, Garhshankar, Nakodar
2	Hoshiarpur, Abohar, Malerkotla, Chandigarh, Malout, Dhuri, Moonak, Jalandhar 1, Faridkot, Anandpur Sahib, Ajnala, Jalandhar, Nawanshahr, Tapa, Amritsar-1, Kapurthala, Sangrur
3	Dera bassi, Shahkot, Baghapurana, Khanna, Jaitu
4	Khamanon, Phull, Bassi Pathana, Phillaur
5	Kharar, Mohali, Nabha, Payal, Amlon
6	Samrala, Rajpura, Zira
7	Ropar
8	Bathinda, Patiala
9	Nihal Singh Wala, Fategharh Sahib, Firozpur, Raikot
11	Jagraon
14	Chamkaur Sahib
15	Moga
16	Barnala, Ludhiana West
46	Ludhiana East

3.1.4 Demographic data and data triangulation

The sub-district level livestock, pet and stray animal population data (19th livestock census) were provided by the district office(s) of the Deputy Director(s), Department of Animal Husbandry, Punjab (Table 2). State and national level livestock and pet population data were obtained from the official data (DAHP 2012 and BAHS 2014).

Population sizes for stray dog and cattle populations were not available for the sub-districts Nihal Singh Wala and Phull. Similarly, the population data for equines was not available for the sub-district Nihal Singh Wala. The ratio of stray and owned cattle and dogs in each respective district, state and at national level were used to derive three estimates of sub-district populations, according to Equation 1. These measurements were used in a triangular distribution (minimum, most likely and maximum) of population size in sub-districts for which census data were not available.

$$\text{Stray cattle population of the Kotkapura} = \frac{(\text{Stray cattle population of India or Punjab or District 1} / \text{Domestic cattle population of India or Punjab or District 1}) \times \text{Domestic cattle population of Kotkapura}}{\text{Kotkapura}} \quad \text{Eq. 1.}$$

3.1.5 Sub-district monitoring

The livestock and canine populations in the selected sub-districts were prospectively followed for a period of one year from August 15, 2016 to August 14, 2017. The list of veterinary doctors and veterinary pharmacists (or veterinary nurses or veterinary inspectors) serving in the selected sub-districts were obtained from the respective offices of the Deputy Director, Department of Animal Husbandry, Punjab. The veterinary doctors and pharmacists working in the selected sub-districts were requested to report any suspected rabies case they encountered in their area to the research team, GADVASU using a questionnaire designed for this purpose (Appendix I). Regular contact between researchers and veterinary doctors and pharmacists was maintained throughout the period of the study. Information about the study was also disseminated among livestock farmers, who were also asked to report any suspected rabies case either to the department veterinarians, veterinary pharmacists or directly to the School of Public Health and Zoonoses, GADVASU.

Table 2: Livestock, pet and stray populations in the selected areas of India

Name of the area	Livestock			Pet	Stray		References
	Cattle	Buffalo	Equine	Dogs	Dogs	Cattle	
Sub-district (s)							
Ludhiana East	51308	107838	774	17526	11503	2258	Deputy Director Department of Animal Husbandry Ludhiana (2017)
Phull	36238	81326	680	7748	*6741 (95% UI 4128-11930)	*1603 (95% UI 993-2383)	Deputy Director Department of Animal Husbandry Bathinda (2017)
Nihal Singh Wala	20360	40080	-	5899	*4703 (95% UI 1777-9110)	* 731 (95% UI 556-846)	Deputy Director Department of Animal Husbandry Moga (2017)
Kotkapura	19565	28191	287	4175	1201	928	Deputy Director Department of Animal Husbandry Faridkot (2017)
District (s)							
Ludhiana	203980	467439	4157	53359	31723	6252	DAHP (2012)
Bathinda	122361	259111	2022	22944	12094	8078	DAHP (2012)
Moga	108267	225310	1773	30581	8979	4090	DAHP (2012)
Faridkot	69367	124006	1688	16289	5688	3228	DAHP (2012)
State							
Punjab	2427714	5159734	40933	470558	305482	100991	DAHP (2012)
Country							
India	190904110	108702120	1186450	11673000	18099800	5187777	BAHS (2014)

3.1.6 Questionnaire design and information collection

A detailed questionnaire was designed for the collection of demographic data, vaccination status, geographic co-ordinates and the clinical timeline of all suspected cases (Appendix I). For pet and domestic animals, the information was collected from the owner. For stray animals, available data at the site at which the animal was observed were collected.

3.1.7 Clinical evaluation

The suspected cases of animal rabies from the selected sub-districts were clinically evaluated by the local veterinary doctor or veterinary pharmacist and were later followed-up by the expert from the GADVASU. The disease history and the clinical information received from the vet or pharmacist were recorded. The history of an occupational exposure and exposure to human subjects or other animals were also recorded. Suspected cases were supervised up to the death of the animal or for at least 10 days.

3.1.8 Laboratory testing

The whole brain samples were collected after the death of a suspected rabid animal Fig.4. The person involved in the collection of samples received pre-exposure anti-rabies vaccination and wore personal protective equipment sufficient to prevent rabies exposure during the collection of the samples. Samples were labeled and transported within 4-8 hours of collection (in sterilized leak-proof plastic containers with low temperature maintained using cold packs) to the GADVASU Rabies diagnostic laboratory, Ludhiana, Punjab. Rabies was diagnosed via the direct fluorescent antibody technique (dFAT; Meslin, Kaplan and Koprowski 1996) in the Rabies diagnostic laboratory at GADVASU. Laboratory data were recorded and compiled with the relevant epidemiological data.

3.1.9 Data handling and statistical analysis

Data were entered into an excel spreadsheet (Microsoft Office Excel 2007) and checked for transcribing errors and consistency (for example, date format). Statistical analyses were conducted in the R statistical program (R statistical package version 3.4.0, R Development Core Team [2015], <http://www.r-project.org>).

Laboratory confirmed (dFAT positive) and clinically diagnosed rabies cases were displayed as point maps of all cases, as well as cases in pet and stray dogs, stray cattle and in livestock animals (Projected Coordinate System: Kalianpur 1975 UTM Zone 43N, Projection: Transverse Mercator; ArcGIS 10.2; ESRI, Redlands, CA, USA).

Descriptive statistics and frequency distributions were generated of clinical symptoms, exposure histories and types of exposure to other animals and humans for each sub-district, species and season for all laboratory confirmed rabies cases. The annual rabies incidence at the sub-district level in the domestic and stray animal populations was estimated from the clinically suspected rabies cases from the population at risk during the study period. The incidence estimate in each sub-district was expressed as cases/10,000 individuals at risk per year and uncertainty around point estimates was modelled as a beta distribution.

Sub-district level data were extrapolated to estimate the annual disease incidence of rabies in the populations in which rabies was reported in the current study at Punjab state and national level. Uniform distributions were applied to the sub-district level data to estimate the disease incidence at the state and country level(s). Due to the lack of specific information on births, deaths and animal movements, we assumed the populations to be stable during the study period. Odds ratios were estimated for the occurrence of rabies in stray or pet dogs and for stray or domestic cattle, respectively.

3.2 Estimation of free roaming/stray dog population in urban and rural area of Punjab

The current study was carried out from August 2016 to November 2017 in selected villages/wards in the Punjab state of India.

3.2.1 Study area

This current study was conducted in Punjab state (latitudes 29.30° North to 32.32° North and longitudes 73.55° East to 76.50° East) situated in the northwest region of India. The state has 22 districts which are further divided into 81 tehsils (sub districts). Punjab has a human population of 27,743,338 with a density of 551 per Km². As per the official data, the state has a land area of 50,362 Km² comprising



Fig. 4: Collection of brain sample from a suspected rabid dog found in the Phull (sub-district) in Punjab state of India

48,265 Km² rural and 2,097 Km² urban areas. There are 237 towns and cities (<http://punjab.gov.in/know-punjab>).

3.2.2 Selection of villages and wards

In total, 22 villages and 10 wards were selected and surveyed. There are 81 sub-districts containing 12,581 villages and 217 towns/cities (18 with more and 199 with less than a human population of 100,000) in Punjab state of India (Census of India 2011). For village selection from the rural areas, 22 sub-districts (one representing each district) were randomly selected followed by purposeful selection of one village each from the selected sub-district(s). For municipal ward selection from the urban areas, 3 towns (with less than a human population of 100,000) and 2 large cities (with more than a human population of 100,000) were randomly selected followed by purposeful selection of two wards each from the selected towns and cities.

3.2.3 Demographic data

The number of village(s) and wards in the state were recorded from the official data (Census 2011, Table 3). The official adult human population data were collected from the respective village heads or municipal councilors (Table 4). The state level rural and urban built-up area data (NIDM 2012) were also used to extrapolate the stray dog population to the state level.

Table 3: Total number of wards in different cities/towns in Punjab state of India (Census of India 2011)

Name of the city/town	Status of the city/town	District	Human population	Number of wards
Abohar	Municipal Council	Ferozpur	145,302	31
Adampur	Municipal Council	Jalandhar	20,922	13
Ahmedgarh	Municipal Council	Sangrur	31,302	15
Ajnala	Nagar Panchayat	Amritsar	21,107	13
Akargarh	Census Town	Ludhiana	7,678	1
Alawalpur	Municipal Council	Jalandhar	7,815	11
Alhoran	Census Town	Patiala	10,218	1
Amargarh	Census Town	Sangrur	7,339	1

Name of the city/town	Status of the city/town	District	Human population	Number of wards
Amloh	Municipal Council	Fatehgarh Sahib	14,696	13
Amritsar	Municipal Corporation with Outgrowth	Amritsar	1,159,227	88
Amritsar Cantonment	Cantonment (Board)	Amritsar	10,410	7
Anandpur Sahib	Municipal Council	Rupnagar	16,282	13
Apra	Census Town	Jalandhar	6,258	1
Aur	Census Town	Shahid Bhagat Singh Nagar	4,063	1
Baba Bakala	Census Town	Amritsar	8,946	1
Baddowal	Census Town	Ludhiana	6,825	1
Badhni Kalan	Nagar Panchayat	Moga	6,786	11
Bagha Purana	Municipal Council	Moga	25,206	15
Balachaur	Municipal Council	Shahid Bhagat Singh Nagar	21,631	13
Balongi	Census Town	Sahibzada Ajit Singh Nagar	15,982	1
Banga	Municipal Council	Shahid Bhagat Singh Nagar	20,906	13
Banur	Municipal Council	Sahibzada Ajit Singh Nagar	18,775	13
Bareta	Municipal Council	Mansa	17,432	13
Bariwala	Nagar Panchayat	Muktsar	8,668	11
Barnala	Municipal Council	Barnala	116,449	25
Baryar	Census Town	Gurdaspur	3,520	1
Bassi Pathana	Municipal Council	Fatehgarh Sahib	20,288	13
Batala	Municipal Council with Outgrowth	Gurdaspur	158,621	35
Bathinda	Municipal Corporation	Bathinda	285,788	50

Name of the city/town	Status of the city/town	District	Human population	Number of wards
Begowal	Nagar Panchayat	Kapurthala	10,116	11
Behrampur	Census Town	Gurdaspur	5,432	1
Bhadaur	Municipal Council	Barnala	18,561	13
Bhadson	Nagar Panchayat	Patiala	7,260	1
Bhagta Bhai Ka	Nagar Panchayat	Bathinda	14,467	13
Bhamian Kalan	Census Town	Ludhiana	13,174	1
Bhankharpur	Census Town	Sahibzada Ajit Singh Nagar	10,768	1
Bhattian	Census Town	Ludhiana	11,066	1
Bhawanigarh	Municipal Council	Sangrur	22,320	13
Bhikhi	Nagar Panchayat	Mansa	17,825	13
Bhikhiwind	Census Town	Tarn Taran	20,526	1
Bhisiana	Census Town	Bathinda	4,890	1
Bhogpur	Nagar Panchayat	Jalandhar	17,549	13
Bhucho Mandi	Municipal Council	Bathinda	14,961	13
Bhulath	Nagar Panchayat	Kapurthala	10,548	13
Budha Theh	Census Town	Amritsar	10,979	1
Budhlada	Municipal Council	Mansa	26,172	13
Bungal	Census Town	Gurdaspur	5,257	1
Chachoki	Census Town	Kapurthala	4,307	1
Chamkaur Sahib	Nagar Panchayat	Rupnagar	13,920	13
Cheema	Nagar Panchayat	Sangrur	11,615	11
Chogawan	Census Town	Amritsar	5,416	1
Chohal	Census Town	Hoshiarpur	7,304	1
Chomon	Census Town	Jalandhar	3,704	1
Daper	Census Town	Sahibzada Ajit Singh Nagar	5,936	1
Dasua (Dasuya)	Municipal Council	Hoshiarpur	25,192	13

Name of the city/town	Status of the city/town	District	Human population	Number of wards
Daulatpur	Census Town	Gurdaspur	12,988	1
Dera Baba Nanak	Municipal Council	Gurdaspur	6,394	11
Dera Bassi	Municipal Council	Sahibzada Ajit Singh Nagar	26,295	13
Dhaki	Census Town	Gurdaspur	4,203	1
Dhanaula	Municipal Council	Barnala	19,920	13
Dharamkot	Municipal Council	Moga	19,057	13
Dhariwal	Municipal Council	Gurdaspur	16,772	13
Dhilwan	Nagar Panchayat	Kapurthala	8,157	11
Dhin	Census Town	Jalandhar	5,961	1
Dhuri	Municipal Council	Sangrur	55,225	17
Dina Nagar	Municipal Council	Gurdaspur	23,976	13
Dirba	Nagar Panchayat	Sangrur	16,952	13
Doraha	Municipal Council	Ludhiana	25,424	13
Faridkot	Municipal Council with Outgrowth	Faridkot	87,695	22
Fatehgarh Churian	Municipal Council	Gurdaspur	13,070	13
Fateh Nangal	Census Town	Gurdaspur	7,721	1
Fazilka	Municipal Council	Ferozpur	76,492	21
Ferozpur	Municipal Council	Ferozpur	110,313	25
Ferozpur Cantonment	Cantonment (Board)	Ferozpur	53,199	8
Gardhiwala	Municipal Council	Hoshiarpur	7,593	11
Garhshankar (Garhshanker)	Municipal Council	Hoshiarpur	16,955	13
Ghagga	Nagar Panchayat	Patiala	10,162	11
Ghanauli	Census Town	Rupnagar	4,894	1
Ghanaur	Nagar Panchayat	Patiala	6,985	11

Name of the city/town	Status of the city/town	District	Human population	Number of wards
Ghoh	Census Town	Gurdaspur	6,883	1
Gidderbaha (Giddarbaha)	Municipal Council	Muktsar	45,370	17
Gill	Census Town	Ludhiana	28,884	1
Gobindgarh (Mandi Gobindgarh)	Municipal Council with Outgrowth	Fatehgarh Sahib	82,266	22
Goniana	Municipal Council	Bathinda	15,208	13
Goraya	Nagar Panchayat	Jalandhar	16,462	13
Gurdaspur	Municipal Council with Outgrowth	Gurdaspur	77,928	24
Guru Har Sahai	Municipal Council	Ferozpur	17,192	13
Halwara	Census Town	Ludhiana	9,761	1
Handiaya	Nagar Panchayat	Barnala	12,507	11
Haryana	Municipal Council	Hoshiarpur	8,928	11
Hazipur (Hajipur)	Census Town	Hoshiarpur	6,091	1
Hoshiarpur	Municipal Council	Hoshiarpur	168,653	31
Hussainpur	Census Town	Kapurthala	15,575	1
Jagraon	Municipal Council	Ludhiana	65,240	19
Jaitu	Municipal Council with Outgrowth	Faridkot	37,377	16
Jalalabad	Municipal Council with Outgrowth	Ferozpur	39,525	16
Jalandhar [Jullundur]	Municipal Corporation with Outgrowth	Jalandhar	868,929	63
Jalandhar Cantonment	Cantonment (Board)	Jalandhar	47,845	7
Jandiala	Municipal Council	Amritsar	29,232	15
Jandiala	Census Town	Jalandhar	8,487	1
Jodhan	Census Town	Ludhiana	3,845	1
Jugial	Census Town	Gurdaspur	15,210	1

Name of the city/town	Status of the city/town	District	Human population	Number of wards
Kapurthala	Municipal Council	Kapurthala	98,916	27
Kartarpur	Municipal Council	Jalandhar	25,662	15
Kathanian	Census Town	Amritsar	10,679	1
Khamanon	Nagar Panchayat	Fatehgarh Sahib	10,135	11
Khambra on Nakodar Road	Census Town	Jalandhar	5,483	1
Khanauri	Nagar Panchayat	Sangrur	14,096	13
Khanna	Municipal Council	Ludhiana	128,137	27
Kharar	Municipal Council	Sahibzada Ajit Singh Nagar	74,460	15
Khem Karan	Nagar Panchayat	Tarn Taran	13,446	13
Khilchian	Census Town	Amritsar	4,588	1
Khothran	Census Town	Shahid Bhagat Singh Nagar	5,046	1
Korianwali	Census Town	Ferozpur	5,770	1
Kot	Census Town	Gurdaspur	5,406	1
Kot Fatta	Municipal Council	Bathinda	7,412	11
Kot Ise Khan	Census Town	Moga	12,800	1
Kot Kapura	Municipal Council	Faridkot	91,979	23
Kotla Nihang	Census Town	Rupnagar	4,715	1
Kurali	Municipal Council	Sahibzada Ajit Singh Nagar	31,060	13
Lalru	Census Town	Sahibzada Ajit Singh Nagar	21,394	1
Lehragaga	Municipal Council	Sangrur	22,588	13
Lohian Khass	Nagar Panchayat	Jalandhar	10,362	11
Longowal	Municipal Council	Sangrur	23,851	13
Ludhiana	Municipal Corporation	Ludhiana	1,618,879	75
Machhiwara	Municipal Council	Ludhiana	24,916	13

Name of the city/town	Status of the city/town	District	Human population	Number of wards
Mahilpur	Nagar Panchayat	Hoshiarpur	11,360	13
Majitha	Municipal Council	Amritsar	14,503	13
Makhu	Nagar Panchayat	Ferozpur	14,658	13
Malerkotla	Municipal Council	Sangrur	135,424	31
Malikpur	Census Town	Gurdaspur	4,645	1
Mallanwala Khass	Nagar Panchayat	Ferozpur	16,183	13
Maloud (Malaudh)	Nagar Panchayat	Ludhiana	7,567	11
Malout	Municipal Council	Muktsar	81,406	21
Mamun	Census Town	Gurdaspur	32,689	1
Mansa	Municipal Council	Mansa	82,956	21
Manwal	Census Town	Gurdaspur	6,496	1
Maur	Municipal Council	Bathinda	31,849	15
Mehna	Census Town	Bathinda	27,733	1
Mirpur	Census Town	Sahibzada Ajit Singh Nagar	5,967	1
Moga	Municipal Council with Outgrowth	Moga	163,397	33
Moonak	Nagar Panchayat	Sangrur	18,141	13
Morinda	Municipal Council	Rupnagar	24,022	13
Mubarakpur	Census Town	Sahibzada Ajit Singh Nagar	5,217	1
Mudal	Census Town	Amritsar	3,882	1
Mudki	Nagar Panchayat	Ferozpur	10,415	11
Mukerian	Municipal Council	Hoshiarpur	29,841	15
Muktsar (Sri Muktsar Sahib)	Municipal Council	Muktsar	116,747	23
Mullanpur Dakha	Nagar Panchayat	Ludhiana	16,356	13

Name of the city/town	Status of the city/town	District	Human population	Number of wards
Mullanpur Garib Dass	Census Town	Sahibzada Ajit Singh Nagar	6,165	1
Nabha	Municipal Council	Patiala	67,972	23
Nakodar	Municipal Council	Jalandhar	36,973	15
Nangal	Municipal Council with Outgrowth	Rupnagar	48,497	21
Nangli	Census Town	Amritsar	20,440	1
Narot Mehra	Census Town	Gurdaspur	8,885	1
Nawanshahr	Municipal Council	Shahid Bhagat Singh Nagar	46,024	17
Naya Gaon	Nagar Panchayat	Sahibzada Ajit Singh Nagar	50,869	15
Nehon	Census Town	Rupnagar	9,439	1
Nilpur	Census Town	Patiala	8,391	1
Nurmahal	Municipal Council	Jalandhar	14,560	13
Partap Singhwala	Census Town	Ludhiana	10,843	1
Pathankot	Municipal Council with Outgrowth	Gurdaspur	156,306	35
Patiala	Municipal Corporation with Outgrowth	Patiala	446,246	57
Patran	Municipal Council	Patiala	27,963	15
Patti	Municipal Council	Tarn Taran	40,976	15
Payal	Municipal Council	Ludhiana	7,923	11
Phagwara	Municipal Council	Kapurthala	97,864	27
Phagwara Sharki	Census Town	Kapurthala	20,102	1
Phillaur	Municipal Council	Jalandhar	24,688	15
Qadian	Municipal Council with Outgrowth	Gurdaspur	23,632	16
Rahon	Municipal Council	Shahid Bhagat Singh Nagar	15,676	13

Name of the city/town	Status of the city/town	District	Human population	Number of wards
Raikot	Municipal Council	Ludhiana	28,734	15
Rail	Census Town	Shahid Bhagat Singh Nagar	7,589	1
Raipur Rasulpur	Census Town	Jalandhar	3,916	1
Raja Sansi	Nagar Panchayat	Amritsar	14,298	13
Rajpura	Municipal Council	Patiala	92,301	25
Rakri	Census Town	Hoshiarpur	5,722	1
Raman	Municipal Council	Bathinda	22,553	13
Ramdas	Municipal Council	Amritsar	6,398	9
Phull	Municipal Council with Outgrowth	Bathinda	51,023	20
Rayya	Nagar Panchayat	Amritsar	14,506	13
Rupnagar	Municipal Council	Rupnagar	56,038	17
Rurki Kasba	Census Town	Patiala	10,509	1
Sahnawal	Nagar Panchayat	Ludhiana	22,484	13
Saloh	Census Town	Shahid Bhagat Singh Nagar	4,481	1
Samana	Municipal Council	Patiala	54,072	17
Samrala	Municipal Council	Ludhiana	19,678	13
Sanaur	Municipal Council	Patiala	21,201	13
Sangat	Municipal Council	Bathinda	2,744	9
Sangrur	Municipal Council	Sangrur	88,043	21
Sansarpur	Census Town	Jalandhar	4,657	1
Sarai Khas	Census Town	Jalandhar	7,044	1
Sardulgarh	Nagar Panchayat	Mansa	19,219	13
Sarna	Census Town	Gurdaspur	5,847	1
S.A.S. Nagar (Mohali, Ajitgarh)	Municipal Council with Outgrowth	Sahibzada Ajit Singh Nagar	166,864	

Name of the city/town	Status of the city/town	District	Human population	Number of wards
Satyewala	Census Town	Ferozpur	8,724	1
Shahkot	Nagar Panchayat	Jalandhar	14,488	13
Sham ChaurasI	Municipal Council	Hoshiarpur	4,426	9
Shikar	Census Town	Gurdaspur	4,001	1
Sirhind Fatehgarh Sahib	Municipal Council	Fatehgarh Sahib	58,097	17
Sohana	Census Town	Sahibzada Ajit Singh Nagar	9,306	1
Sri Hargobindpur	Municipal Council	Gurdaspur	8,241	13
Sufipind	Census Town	Jalandhar	9,406	1
Sujanpur	Municipal Council	Gurdaspur	28,270	13
Sultanpur	Municipal Council	Kapurthala	16,877	13
Sunam	Municipal Council with Outgrowth	Sangrur	69,069	20
Talwandi Bhai	Municipal Council	Ferozpur	17,285	13
Talwandi Sabo	Nagar Panchayat	Bathinda	20,589	13
Talwara	Census Town	Hoshiarpur	19,485	1
Tapa	Municipal Council	Barnala	23,248	13
Tarn Taran	Municipal Council	Tarn Taran	66,847	19
Tharial	Census Town	Gurdaspur	5,081	1
Tharike	Census Town	Ludhiana	12,294	1
Tibri	Census Town	Gurdaspur	11,845	1
Urmar Tanda	Municipal Council	Hoshiarpur	23,419	13
Zira	Municipal Council with Outgrowth	Ferozpur	37,498	16
Zirakpur	Municipal Council	Sahibzada Ajit Singh Nagar	95,553	15
Total cities/towns (217)				2496
Total number of villages				12581

Table 4: The adult human population and the residential area covered in the survey in the selected village(s)/wards and the Punjab state of India (Census of India 2011, Punjab assembly polls: The complete fact sheet)

Name of the village/ward	District	Adult human population	Residential area (in Km ²)
Rural			
Galib Ran Singh	Ludhiana	929	0.07
Pipli	Faridkot	2808	0.37
Jodhpur	Barnala	2728	0.27
Rauli	Hoshiarpur	753	0.08
Mangewala	Moga	1836	0.15
Karahal Kalan	Kapurthala	583	0.05
Deugarh	Patiala	836	0.08
Mander	Mansa	1986	0.16
Rali Ali Kalan	Gurdaspur	950	0.09
Mahdian	Fateghrsahib	1211	0.1
Rangian	Ropar	1150	0.09
Gobindpura	Bathinda	4822	0.42
Kot Kalan	Jalandher	663	0.1
Khoba	Pathankot	792	0.03
Gobindgarh	Fazilka	3153	0.4
Jethuwal	Amritsar	2985	0.23
Bugar	Sangrur	1930	0.07
Haraj	Muktsar	1159	0.16
Nabipur	Tarntarn	999	0.12
Kheda	Mohali	772	0.07
Tut	Firozpur	1656	0.16
Sodhian	Nawanshehar	755	0.06
Urban			
Bhagta Bhai ka ward :8	Bathinda	1136	0.05
Bhagta Bhai ka ward :1	Bathinda	964	0.14
Balachaur ward :4	Nawanshehar	1066	0.2
Balachaur ward :5	Nawanshehar	1136	0.05

Name of the village/ward	District	Adult human population	Residential area (in Km ²)
Bathinda ward :9	Bathinda	3695	0.37
Bathinda ward :11	Bathinda	4370	0.49
Zeera ward: 15	Firozpur	1461	0.17
Zeera ward: 16	Firozpur	1732	1.29
Ludhiana ward: 62	Ludhiana	6415	0.47
Ludhiana ward: 63	Ludhiana	16067	1.21
State level			
Punjab	Rural	12201170	1857.24
	Urban	7315518	1139.39

3.2.4 Stray dog count

The stray and pet dogs were differentiated as per WSPA (2009) guidelines. Before the commencement of the stray dog count, an announcement was made in the relevant villages/wards about the stray dog counting to encourage owners to put lashes on their owned dogs, to avoid over-estimation of the population.

We used a mark–re-sight procedure (Seber 1970) with modifications as per Tenzin *et al* (2015) to estimate the stray dog populations. In brief, a two–three person survey team was formed and formally trained to count dogs in all the selected village(s)/ward(s). On first day early in the morning (5.30–6.30 AM in the summer and 6.30–7.30 AM in the winter), the team marked stray dogs observed in the street using sprayed water-soluble red color; marking occurred during a transect walk, and no dogs were physically restrained or captured (Fig. 5). In addition, data related to demography, health status (gross examination for the presence of open wound, skin disease, skeletal deformity), gender, age group (young or adult by observing the external genitalia) were also recorded. The village area covered during the stray dog estimation was recorded using Arc GIS expo 10.2.1 software. For ease of marking and to make it dog-friendly, we used baits (dog biscuits, dog feed) to feed stray dogs. For dogs that ran away or were missed during marking, we took the pictures. We used red colour to mark dogs. However, the red color was not helpful for marking those dogs with a reddish, black or mixed color coat(s); additional images were also taken of these dogs so as to avoid double-counting on the second day. The village/ward



Fig. 5: Marking of the stray dogs with a water soluble colour on day one of the stray dog count in the Bhagta Bhaika ward 1 and village Rali Ali Kalan in Punjab state of India

corners, garbage dumps and all nearby sites where dogs can lay or hide themselves were systematically searched. The number of dogs marked with color or which were photographed on the first day was recorded and represented ‘n1’ within the mark–re-sight framework.

The day one procedure was repeated on the next (second) day in all the selected village(s)/ward(s) and the same time, route(s) and direction were followed. The marked dogs encountered on the second day were recorded separately. For proper identification, additional matching with photographs was carried out, if found to be necessary.

The total number of dogs counted on the second day is designated ‘n2’ and the number of re-sighted (marked or photographically identified) dogs is designated ‘m’ in the mark–re-sight framework. Finally, the stray dog population(s) were estimated using the Lincoln–Petersen’s formula with Chapman’s correction (Chapman 1951). The detailed estimation(s) are presented in Eq(s). 1-3.

$$N = \left[\frac{(n1+1)(n2+1)}{(m+1)} \right] - 1 \quad \text{Eq. 1}$$

$$\text{var}(N) = \left[\frac{(n1+1)(n2+1)(n1-m)(n2-m)}{(m+1)^2(m+2)} \right] \quad \text{Eq. 2}$$

$$95\% \text{ confidence interval (CI)} = N \pm 1.965 \sqrt{\text{var}(N)} \quad \text{Eq. 3}$$

where N is the estimate of the total population size, $n1$ is the total number of animals marked (or noted by taking pictures) on day 1, $n2$ is the total number of animals sighted on day 2, and m is the number of marked (or photographically identified) dogs re-sighted on day 2. An approximately unbiased variance of N was estimated by using Seber's formula (Seber 1970; Eq. 2). The 95% confidence interval for N was estimated as shown in Eq. 3.

3.2.5 Recapture probability

The recapture probability or the detectability rate (r) was estimated by dividing the number of dogs that were captured on the second day ($n2$) by the estimated population (N)

$$r = \frac{n2}{N}$$

3.2.6 Statistical analyses

Data were entered into an Excel spread sheet (Microsoft Office Excel 2007) followed by frequency, range and logic checks and matching with hard copy records. Data cleaning and the descriptive statistical analyses were conducted. Descriptive statistics and frequency distributions were generated for the area, gross health examination, gender and maturity/adult status of the stray dogs. The stray dog data counted in each village/ward was extrapolated to the number of villages/wards in the state, village/ward level adult human population data and the state built-up area to estimate the number of stray dogs in Punjab state of India. A triangular distribution was applied to the village/ward level data to estimate the number of stray dogs in Punjab state of India. The number of stray dogs in Punjab state of India was estimated in the R-statistical program (R statistical package version 3.4.0, R Development Core Team (2015), <http://www.r-project.org>).

3.2.7 Spatial analysis

The Arc GIS expo 10.2.1 software was used for area measurements and for mapping the densities of the dogs.

3.2.8 Sensitivity analysis

We included industrial area along with the urban built-up land area for estimating the urban built-up area. Therefore, a separate sensitivity analysis was conducted after excluding the industrial area from the urban built-up area to estimate number of stray dogs residing in the urban areas.

3.3 Estimation of stray cattle population in urban and rural area of Punjab

The methods used for the estimation of stray cattle have been mentioned in detail in section 3.2 (Fig. 6).

3.4 Understanding the level of awareness in school students in Punjab (India)

3.4.1 Ethics permission

The necessary ethics approval for the current study was granted by the Institutional Ethics Committee, Dayanand Medical College and Hospital, Ludhiana, Punjab (Approval No. DMCH/R&D/2017/482). This study was conducted between August 2016 and November 2017. Participant information statement explaining purpose of study was provided to all the respondents followed by a written consent



Fig. 6: Marking of the stray cattle with a water soluble color or turmeric powder on day one of the stray dog count in the Bhagta Bhaika ward 1in Punjab state of India

from the participant demonstrating his/her willingness to participate in this study. For information collection, a detailed questionnaire was developed in English and was translated in the local language (Punjabi). The English or translated questionnaire were made available as per the requirement of the participants. Participants were requested to complete a questionnaire and the information was recorded. The collected information was stored in a secure and confidential manner. A short lecture on rabies was given to all the participants after filling up the questionnaire.

3.4.2 Target and study population

The target population comprised of 6th-10th class school students in the government-funded schools located in the rural and urban areas of Punjab. The study population were the school students enrolled in the selected (22 rural and 10 urban) government-funded schools. Overall, 22 schools located in rural and 10 schools located in urban areas were covered. For the selection of schools, same study area as we mentioned in the section 3.2.2 were selected. The unit of study was an individual student (6th-10th class) enrolled in a government-funded school in Punjab during 2016-2017.

3.4.3 Sample size

As per the official data, there are 6237 government schools comprising of 3036 upper primary, 1663 high/secondary and 1538 intermediate/senior secondary government schools other than 13122 primary schools in Punjab state of India (BPMS 2012). We selected 32 schools from 6237 government schools (other than primary schools) in Punjab. Assuming that there will be 200 students in the Grade 6th -12th in a school, we estimated a population of 6400 Grade 6th-12th students. Assuming that 75% of the students have the factor of interest, a sample size of 307 was required for 90% response rate with 5% precision and 95% confidence (Dhand and Khatkar 2014).

3.4.4 Enrolment

The research team initially contacted the Principal or Head-teacher of the school(s) explaining the purpose of the study followed by a meeting arranged with the school students. The selection of students were not random and those available were enrolled in the study. Overall, 313 school students participated comprising of 226 rural and 87 urban school students.

3.4.5 Questionnaire design and data collection

The questionnaire was developed to collect detailed information related to demography, knowledge, attitude and perceptions of students related to rabies. The demographic information included age, gender, household size, level of education, whether residing in rural or urban areas. The student's knowledge, attitude, practices and perceptions about rabies was also recorded. The detailed questionnaire has been provided as a supplementary material (Appendix II).

3.4.6 Data handling and statistical analysis

Data were entered into an excel spread sheet (Microsoft Office Excel 2007) followed by matching with hard copy records. Descriptive statistics along with univariable and multivariable statistical analysis were conducted using package R commander in R software (R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL <http://www.R-project.org>.)

3.4.7 Explanatory and Outcome variables

The demographic characteristics such as age, gender, household size, type of area, educational qualification, district and presence of pet or dairy animals in the house were used as explanatory variables. The multiple dichotomous variables were created from all the nominal and ordinal variables except for age and education. The dichotomous independent variables with a response 'Yes' and 'No' were coded as '1' and '0', respectively. For gender, male and female was coded as '1' and '0', respectively. Similarly urban and rural area was coded as '1' and '0' respectively. For the household size, dichotomous variables were created by dividing the household size into two groups viz. less than six and more or equal to six family members in the house. The households having less than six family members in the house gave code as '0' and code '1' was used for those have more or equal to six numbers of family members in the house. For outcome variable(s), a knowledge score (range 1–20) was prepared by summing up students' knowledge about rabies. Each correct answer was awarded a score of 1.0 and zero score was awarded for an incorrect reply. Data were entered into excel sheet and descriptive analyses were carried out.

3.4.8 Univariable analyses

The unconditional association between explanatory variable and linear outcome variable was determined using univariable linear regression analyses.

Analysis was conducted using each demographic variable as an explanatory variable and knowledge score as the outcome variable. The explanatory variables with univariable p-value of <0.25 (based on the F test statistic) were considered for multivariable model building.

3.4.9 Multivariable analyses

Demographic variables showing statistical significance (p-value <0.25) in univariable analyses were retained in the final multiple linear regression model. Explanatory variables with a univariable p-value >0.25 were also retested using forward approach in the final multivariable model. The standard coefficient, adjusted R^2 , and the statistical significance levels (p value) of the coefficients were estimated. The adjusted R^2 was used to assess strength of the final multivariable model. Standardized and studentized residuals were used to test the overall fitness of the final model.

3.5 Understanding the level of awareness in animal owners in Punjab state of India

The target population was the animal owners residing in the Punjab state of India. The study population was the animal owners residing in 22 villages and 10 wards in Punjab. The villages and wards were selected as per the methods described in section 3.4.

3.5.1 Sample size

As per the National sample survey office data, the total operational holdings for all the livestock classes in Punjab have been reported to be 1499900 (NSSO 2013). There are 470,558 dogs in India (DAHP 2012). By assuming that livestock operational holdings and pet dog populations will be uniformly distributed across whole of the state, we estimated that there will be 46871 livestock operational holdings and 14704 dogs in the 22 villages and 10 wards selected in the study.

Further assuming that 90% of the animal farmers have the factor of interest, a sample size of 154 livestock and 153 pet owners was required for 90% response rate with 5% precision and 95% confidence (Dhand and Khatkar 2014).

3.5.2 Enrolment

Overall, 336 participants comprising of 175 pet owners and 161 dairy animal owners were enrolled in the study. There were 84 pet owners and 150 dairy animal

owners from the rural areas and 91 pet owners and 11 dairy animal owners resided in the urban areas. The selection of animal owners was not random but care was taken that only one subject from a household is allowed to participate in the study.

3.5.3 Questionnaire design and data collection

The close-ended questionnaire was designed to collect the relevant information from the participants. The demographic information included age, gender, house-hold size, level of education, place of residence (rural or urban) and presence of pet/dairy animal in the house. Detailed questionnaire used to collect information on knowledge attitude and practices have been provided as a supplementary material (Appendix III).

3.5.4 Data handling and statistical analysis

The data were entered into an Excel spread sheet (Microsoft Office Excel 2007) followed by cross checking with hard copy records. Statistical analysis was done by using package R commander in R software (R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL <http://www.R-project.org>).

3.5.5 Explanatory and Outcome variables

The demographic characteristics such as age, gender, household size, place of residence, level of education, and district were used as the explanatory variables and multiple dichotomous variables were created from all the nominal and ordinal variables. Due to skewed data, the variable house-hold size was converted into a dichotomous variable by households having less or more than five family members, and were coded as '0' and '1', respectively. For outcome variable(s), a knowledge score (range 1–20) was prepared as discussed in section 3.4.7. Data was entered into Excel sheet and descriptive analyses were carried out. Descriptive frequency tables related to demography, knowledge, attitude, perception and practices were prepared.

3.5.6 Univariable analyses

The univariable analyses were conducted as per section 3.4.8.

3.5.7 Multivariable analyses

The multivariable analyses were conducted as per section 3.4.9.

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Estimation of annual incidence of rabies in animal populations in Punjab

During 2016—2017, a total of 41 suspected rabies cases were reported by veterinary doctors (n = 25), veterinary inspectors (n = 12) and farmers (n = 4) in the selected sub-districts (Table 5). From the 41 suspected cases, 33 whole brain samples were submitted to the Rabies diagnostic laboratory, GADVASU. Out of these, 30 (91%) were confirmed positive for rabies. Eight samples from the suspected cases could not be submitted to the Rabies diagnostic laboratory; and were only clinically confirmed by the veterinary doctors (6) and veterinary pharmacists (2).

Table 5: Number of suspected rabies cases (2016-2017) reported by veterinary doctor(s), veterinary pharmacists and dairy farmers from the selected sub-districts in Punjab (India)

GADVASU Rabies diagnostic laboratory oratory oratory Results	Veterinary Doctor		Veterinary Pharmacist		Collected from Dairy farmer	Total
	Positive	Negative	Positive	Negative		
FAT (+)	16	2	8	1	3	30
FAT (-)	0	1	1	0	1	3
Not tested	6	0	2	0	0	8
Grand Total	22	3	11	1	4	41

From all the sub-district(s), rabies cases were recorded in the canine, cattle and buffalo populations (Table 6). Additionally, a feline and equine rabies case was also detected from the Ludhiana East and Phull, respectively (Table 6). The species and sub-district wise number of cases has been reported in Table 6.

Table 6: Species and sub-district wise distribution of clinically detected rabies cases in selected areas of India

Region	Species	Number of cases	Total Population	Annual Incidence per 10000 populations
Kotkapura	Stray Dog	0	1201	5.60100 (95% UI 0.00078–74.28000)
	Pet Dog	1	4175	3.9750 (95% UI 0.0452–26.2700)
	Total dogs	1	5376	3.04900 (95% UI 0.01301–21.55000)
	Stray cattle	3	928	39.79 (95% UI 2.35–172.90)
	Livestock cattle	0	19565	0.359300 (95% UI 0.000003–6.980000)
	Total cattle	3	20493	1.7940 (95% UI 0.1595–7.3560)
	Buffalo	3	28191	1.30300 (95% UI 0.06283–5.76400)
	Equine	0	287	-
Ludhiana East	Stray Dog	3	11503	3.2240 (95% UI 0.1747–18.2300)
	Pet Dog	1	17526	0.94880 (95% UI 0.01012–7.04800)
	Total dogs	4	29029	1.5930 (95% UI 0.1733–6.5970)
	Stray cattle	0	2258	3.0820 (95% UI 0.0001–42.1500)
	Livestock cattle	2	51308	0.51780 (95% UI 0.01222–2.67100)
	Total cattle	2	53566	0.498500 (95% UI 0.009778–2.407000)
	Buffalo	2	107838	0.246000 (95% UI 0.006591 0.006591–1.231000)
	Equine	0	774	-
	Feline	1	-	-

Region	Species	Number of cases	Total Population	Annual Incidence per 10000 populations
Nihal Singh Wala	Stray Dog	2	4703	5.61800 (95% UI 0.07667–52.39000)
	Pet Dog	2	5899	4.50900 (95% UI 0.06081–26.96000)
	Total dogs	4	10602	4.34 (95% UI 0.3032–19.07)
	Stray cattle	0	731	9.76600 (95% UI 0.00002–146.80000)
	Livestock cattle	1	20360	0.818400 (95% UI 0.006169–6.578000)
	Total cattle	1	21091	0.796200 (95% UI 0.006464–5.641000)
	Buffalo	0	40080	0.1746000 (95% UI 0.0000265–2.0170000)
	Equine	0	-	-
Phull	Stray Dog	1	6741	2.42300 (95% UI 0.00486–20.95000)
	Pet Dog	6	7748	8.537 (95% UI 1.368–25.480)
	Total dogs	7	14489	5.2190 (95% UI 0.9742–16.3000)
	Stray cattle	4	1603	29.120 (95% UI 2.229–142.300)
	Livestock cattle	2	36238	0.7331 (95% UI 0.0208–4.3250)
	Total cattle	6	37841	1.7590 (95% UI 0.2216–5.6850)
	Buffalo	3	81326	0.45440 (95% UI 0.01909–2.01500)
	Equine	1	680	14.71 (95% UI 14.71–14.71)

Region	Species	Number of cases	Total Population	Annual Incidence per 10000 populations
Punjab	Stray Dog	154 (95% UI 4 -2003)	305482	4.89 (95% UI 0.141–69.97)
	Pet Dog	212 (95% UI 3-1029)	470558	4.51 (95% UI 0.066v21.88)
	Stray cattle	200 (95% UI 3-1600)	100991	19.8 (95% UI 0.27–158.4)
	Livestock cattle	152 (95% UI 1-1023)	2427714	0.62 (95% UI 0.0034–4.21)
	Buffalo	369 (95% UI 2-2174)	5159734	0.71 (95% UI 0.003–4.21)
	Equine	30 (95% UI 0.0032-60)	40933	7.31 (95% UI 0.00079–14.71)
India	Stray Dog	8851 (95% UI 256-126600)	18099800	4.89 (95% UI 0.141–69.97)
	Pet Dog	5270 (95% UI 77-25540)	11673000	4.51 (95% UI 0.066–21.88)
	Stray cattle	10290 (95% UI 143-82200)	5187777	19.8 (95% UI 0.27–158.4)
	Livestock cattle	11980 (95% UI 65-80460)	190904110	0.62 (95% UI 0.0034–4.21)
	Buffalo	7777 (95% UI 33-45790)	108702120	0.71 (95% UI 0.003–4.21)
	Equine	867 (95% UI 0.1-1745)	1186450	7.31 (95% UI 0.00079–14.71)

Of the total rabies cases recorded in cattle and buffalo, 58.3% (7/12) and 87.5% (7/8) respectively, were recorded in females; likely due to the high proportion of female cattle and buffalo in the region. Of confirmed rabies cases in dogs, 56.2% (9/16) were from males. The rabies cases recorded in different months are presented in Fig. 7. Rabies cases in dogs were detected each month (range: 1-3 cases/month) from May to December, 2017. In livestock species (cattle, buffalo, and mule), sporadic rabies cases were reported, except during October 2016 when a peak of five rabies cases were detected in cattle.

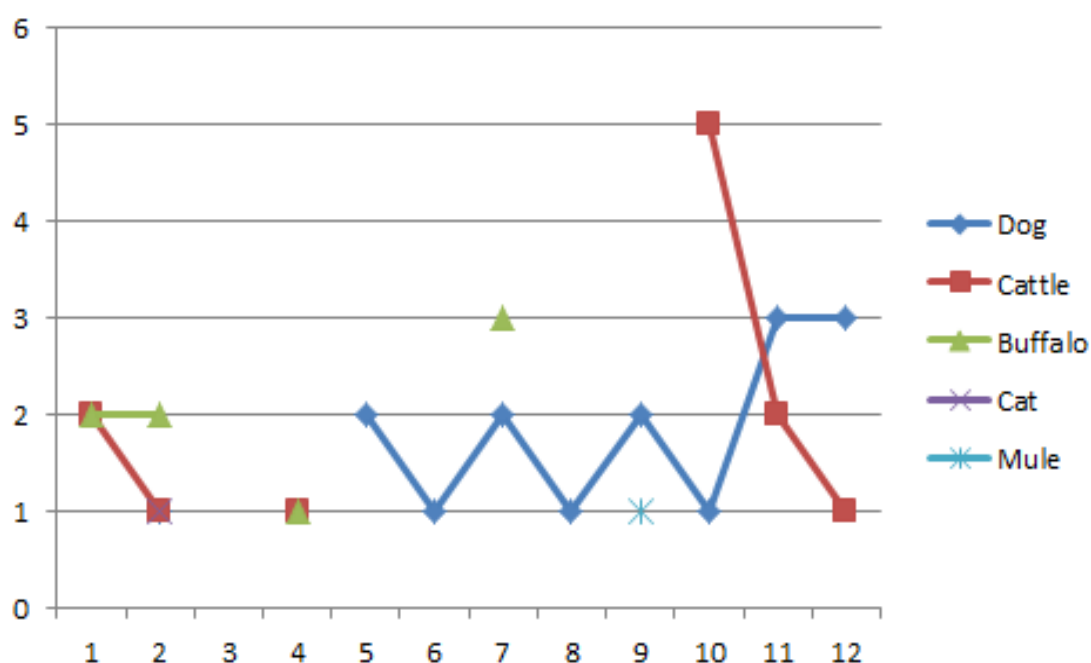


Fig. 7: Month wise distribution of rabies cases in different species from the selected sub-districts in Punjab (India)

4.1.1 Annual Incidence of rabies

The annual incidence of rabies in stray and pet dog populations for the different sub-districts have been presented in Table 6. In livestock species, the disease incidence in domestic cattle populations was 0.62 (UI 95% 0.0034-4.21) per 10000 domestic cattle in India. The disease incidence of 19.8 (95% UI 0.27-158.4) per 10000 populations was reported in the stray cattle populations (Fig. 8). In addition, annual disease incidence of 0.71 (95% UI 0.003-4.21) and 7.31 (95% UI 0.00079-14.71) per 10000 populations were recorded in buffalo and equine populations,

respectively (Table 6). The feline rabies incidence was not estimated due to lack of feline population data.

Based on the clinically and laboratory confirmed cases, the annual rabies incidence was estimated as 4.5/10,000 (UI 95% 0.07—21.9/10,000) pet dogs and 4.9/10,000 (UI 95% 0.141-70.0/10,000) in stray dogs in India (Fig. 8).

We estimate that annually, 154 (95% UI 4-2003) stray dogs, 212 (95% UI 3-1029) pet dogs, 200 (95% UI 3-1600) stray cattle, 152 (95% UI 1-1023) domestic cattle, 369 (95% UI 2-2174) buffalo, and 30 (95% UI 0 -60) equines are infected with rabies virus in Punjab (Table 6). Similarly, we estimate that annually, 8,851 (95% UI 256-126,600) stray dogs, 5,270 (95% UI 77-25,540) pet dogs, 10,290 (95% UI 143-82,200) stray cattle, 11,980 (95% UI 65-80,460) domestic cattle, 7,777 (95% UI 33-45,790) buffalo, and 867 (95% UI 0-1,745) equines are infected with rabies virus in India (Table 6, Fig. 9).

For stray dogs, the odds ratio of being infected was found to be 1.35 (95% UI 1.31–1.40) as compared to pet dogs. For stray cattle, a high odds ratio of being infected viz. 24.94 (95% UI 24.21–25.66) was found as compared to domestic cattle.

4.1.2 Clinical signs associated with canine and bovine rabies

The clinical signs associated with canine and bovine rabies are presented in Fig. 10 and 11, respectively. A change in behavior of the dog was the most frequently observed clinical sign in the rabies cases in dogs (n = 14/16; 87.5%) followed by biting at objects (n = 12/16; 75%), anorexia (n = 12/16; 75%), difficulty in standing (n = 11/16; 68.75%), salivation (n = 11/16; 68.75%), failure to recognize the owner (n = 10/16; 62.5%) and biting behavior (n = 5/16; 31.3%).

In bovines, dysphagia, hyper-salivation and anorexia were the most frequently observed clinical signs (n = 19/20; 95%), followed by non-specific behavior change (n = 18/20; 90%), biting objects (n = 14/20; 70%), paralysis (n = 12/20; 60%), and failure to recognize the owner (n = 11/20; 55%).

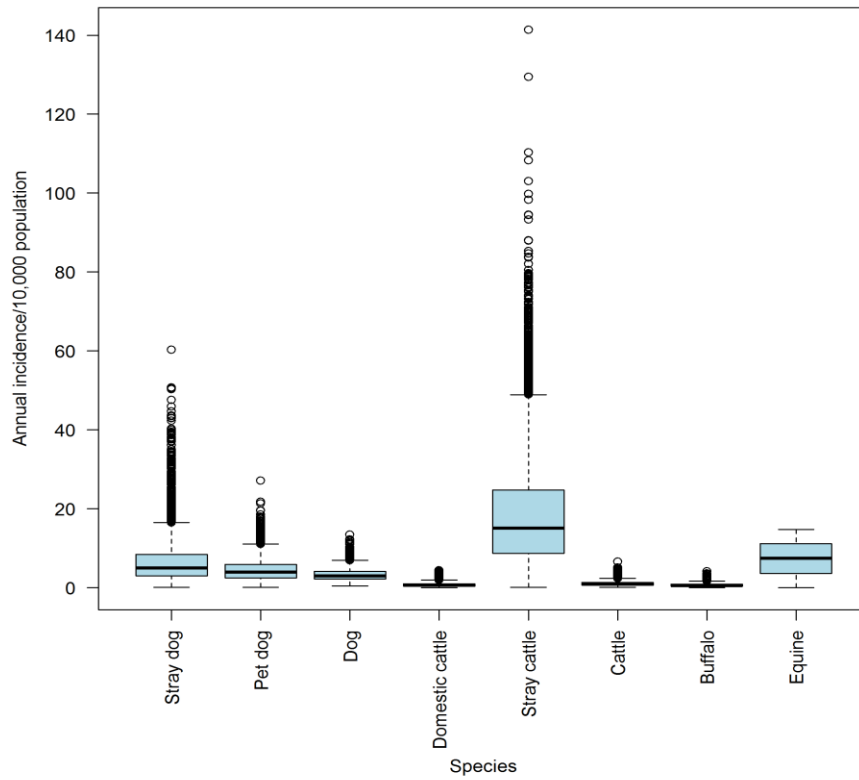


Fig. 8: Species wise annual incidence of rabies per 10000 populations in Punjab, India

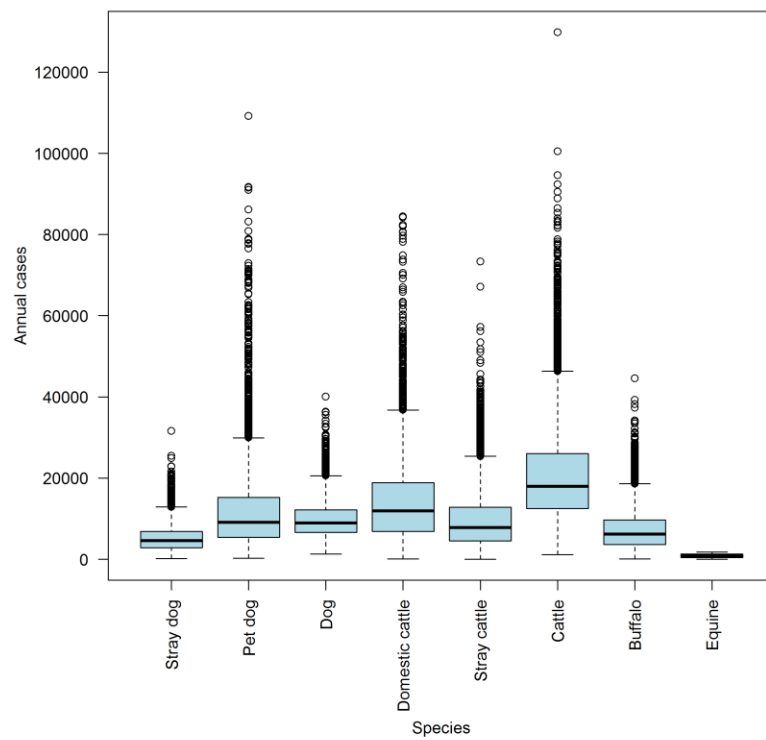


Fig. 9: Species wise number of reported rabies cases in India

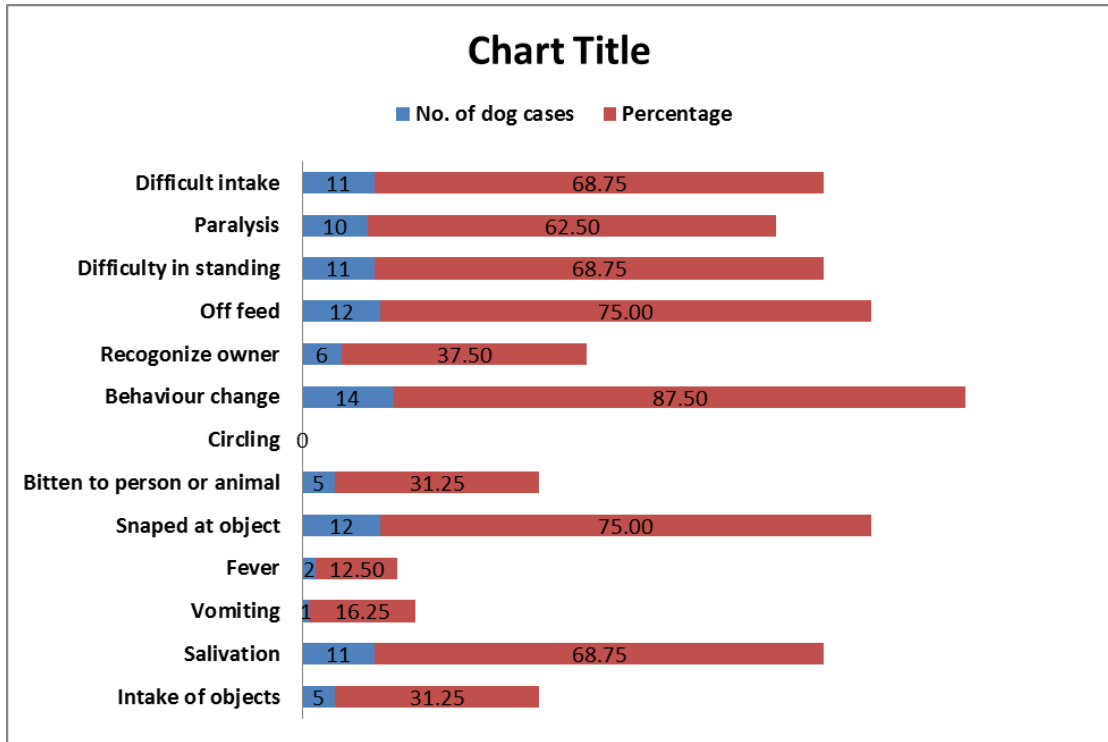


Fig.10: Different types of clinical signs reported from 16 canine rabies cases in Punjab, India

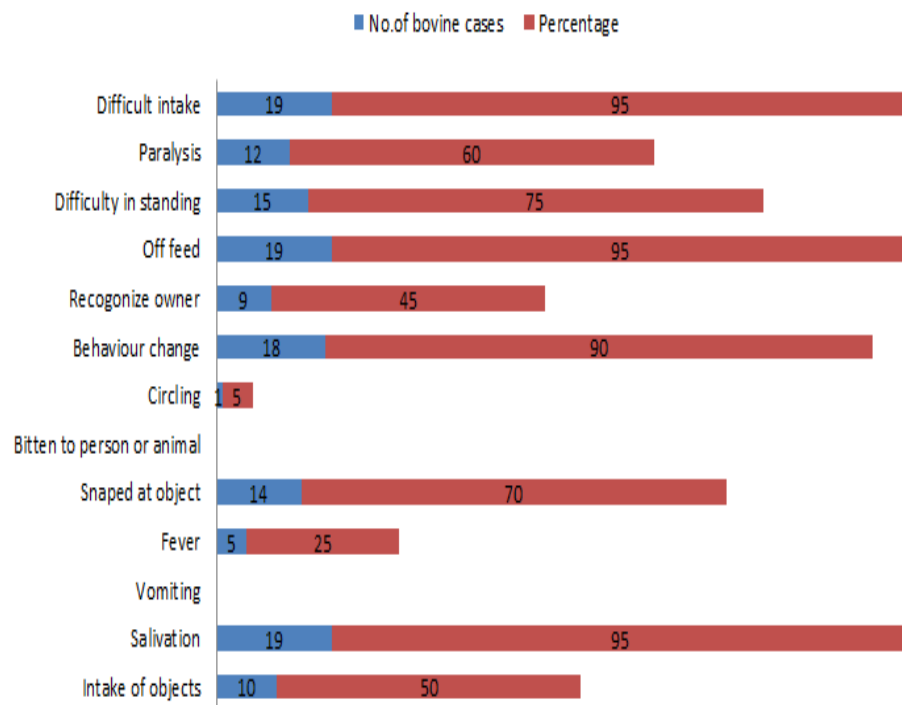


Fig. 11: Different types of clinical signs reported from 20 bovine rabies cases in Punjab, India

4.1.3 Case histories

A high proportion of cases (68%; 17/25) were reported from animals that were allowed to roam outside on the street, open area or in the village for periods of the day. For rabies cases in which the history of exposure was available (31.58%; 12/38), most were reported exposed to stray dogs (91.6%; 11/12) followed by 8.33% (1/12) to pet dogs. The route of exposure was via a bite in 83.3% (10/12) of cases. However, the bite wound could not be identified in 16.6% (2/12) of the cases. Therefore, the exposure history of contact with mucous membrane was recorded.

Some of the rabies-infected animals in this study (15.4%; 4/26) had ever received rabies vaccination previously, but the recommended annual vaccination schedules were not subsequently followed. In 34.21% (13/38) of the rabies cases, the animal owner noticed a bite wound on the animal's body but only 30.7% (4/13) of these owners requested veterinary treatment or vaccination of the animal.

All these animals died before completing the course of the post-exposure rabies prophylaxis vaccination. The exposure history in 11 healthy subjects; 9 (81.85%) dogs and one cow (9%) and buffalo (9%) each were recorded. The route of exposure was via a bite in 90.91% (10/11) of cases, followed by contact with mucous membrane in 9.09% (1/11) of the exposed subjects. A rabid dog was the source of rabies exposure in 90.91% (10/11) of the exposed population; one healthy animal was exposed from rabid cat (Table 7).

Twenty humans were reported as having been exposed (potential to transmit rabies virus) to the confirmed rabies cases in this study (Table 8). Of these, most (n = 13; 65%) were adult males followed by 3 (15%) young males, 3 (15%) adult females, and one (5%) young female. Most (including 3 young people) were reported to have received a type III exposure via a bite (exposure = 11; 55%), whereas 5 (25%) received a type II exposure and the remaining 4 (20%) were exposed by touching or licking by the animal on intact skin (type I exposure). All exposed humans received Post- exposure prophylaxis (PEP), which included human rabies immunoglobulin (HRIG) in two cases.

Table 7: Exposure of rabies in healthy animal populations from the rabies cases in Punjab (India)

Species exposed	Bite rate (range)	Total no. of healthy animals that got exposure	Exposure through bite	(MM) exposed with infectious saliva	Complete (PP)	In-complete (PP)	Zero (PP)
No. of animal exposed from rabid dog							
Dog	23.5% (1-4)	8	7	1	1	0	7
cow	100	1	1	0	1	0	0
buffalo	100	1	1	0	0	1	0
No. of animal exposed from rabid cat							
Dog	100	1	1	0	1	1	0
total		11	10	1	3	1	7

Mucous membrane (MM) post –prophylaxis (PP)

Table 8: Exposure of rabies in healthy human population from the rabies cases in Punjab (India)

Different Age groups	Bite rate (range)	Total no. of healthy person got exposure	Category of exposure mentioned by WHO			*No. of person take HRIG after bite of rabid animal	No. person take full PP
			III	II	I		
No. of human exposed from rabid dog							
Young male	41.1% (1-2)	3	2	0	1	0	3
Young female		1	1	0	0	1	1
Adult male		7	5	1	1	1	7
No. of human exposed from rabid cat							
Adult female	100% (3)	3	3	0	0	0	3
No. of human exposed from rabid cow							
Adult male	0	3	0	2	1	0	3
No. of human exposed from rabid buffalo							
Adult male	0	2	0	2	0	0	2
No. of human exposed from rabid mule							
Adult male	0	1	0	0	1	0	1
Grand Total	-	20	11	5	4	2	20
*Number of persons take Human rabies immunoglobulin, after bite from a rabid animal (PP) Post- prophylaxis							

4.1.4 Spatial analysis

The point distribution of the cases has been presented in Fig. 12 Overall, we found clustering of the cases in certain areas in all the selected sub-districts, however in Nihal Singh Wala, maximum clustering of positive cases were found as compared to the other sub district(s).

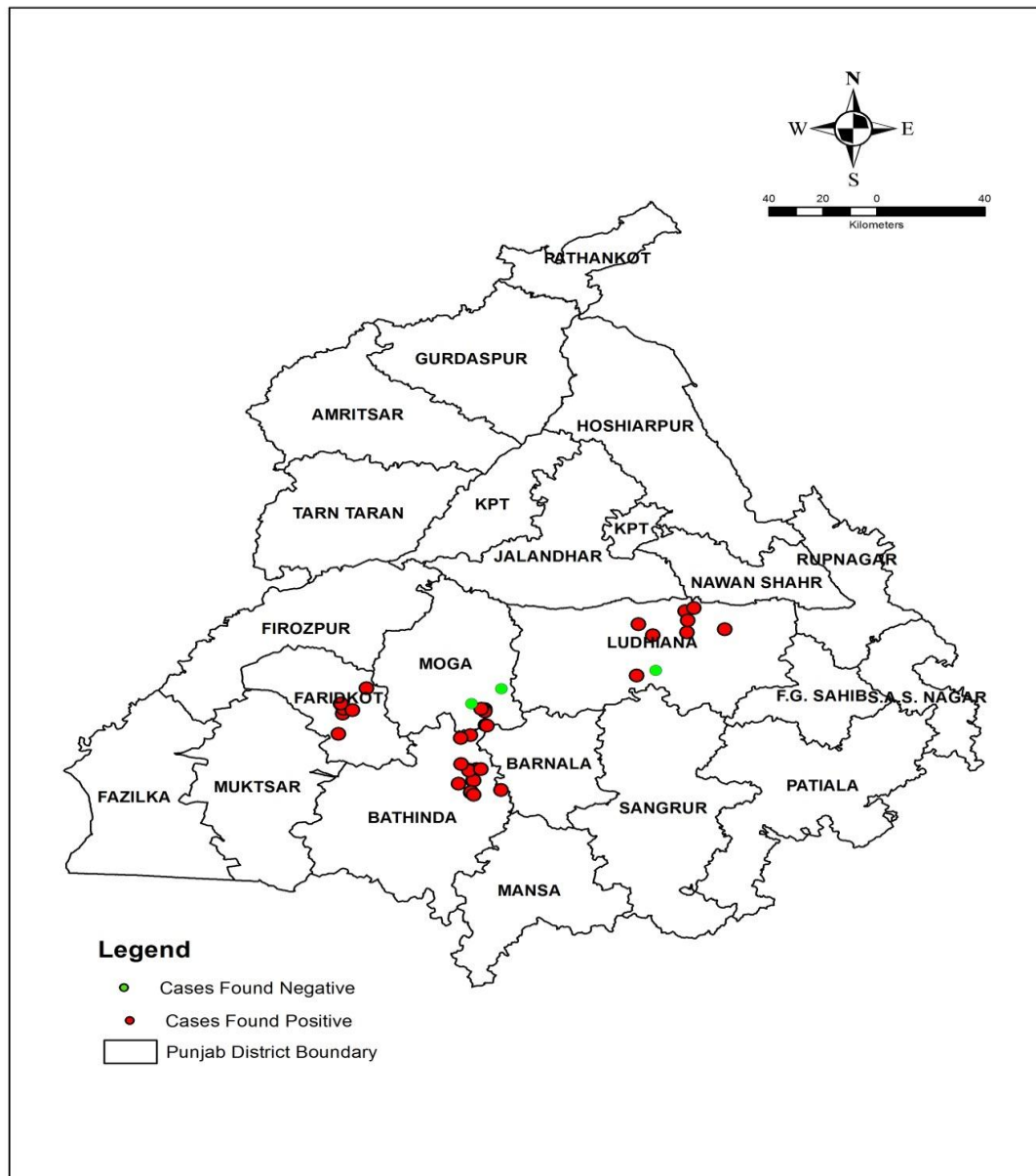


Fig. 12: Spatial analysis of clinically suspected cases confirmed by FAT

4.1.5 Sensitivity analysis

The estimates of the annual rabies incidence based on the laboratory confirmed cases have been presented in the supplementary Table 9.

Table 9: Species and Sub-district wise distribution of laboratory confirmed (FAT) rabies cases in Punjab (India)

Region	Species	Number of cases	Total Population	Annual Incidence per 10000 populations
				laboratory confirmed
Kotkapura	Stray Dog	0	1201	5.69 (95% UI 0.0001–88.16)
	Pet Dog	1	4175	4.02 (95% UI 0.0404–29.24)
	Total dogs	1	5376	3.122 (95% UI 0.022–21.46)
	Stray cattle	2	928	28.940 (95% UI 0.442–146.4)
	Livestock cattle	0	19565	0.357 (95% UI 0.000048–5.10)
	Total cattle	2	20493	1.30 (95% UI 0.0492–7.619)
	Buffalo	2	28191	0.95230 (95% UI 0.020–5.35)
	Equine	0	287	–
Ludhiana East	Stray Dog	3	11503	3.16 (95% UI 0.19–14.97)
	Pet Dog	1	17526	0.951 (95% UI 0.003817–6.782)
	Total dogs	4	29029	1.61 (95% UI 0.146–6.51)
	Stray cattle	0	2258	3.096 (95% UI 0.00031–43.96)
	Livestock cattle	1	51308	0.52 (95% UI 0.016–2.91)
	Total cattle	1	53566	0.497 (95% UI 0.0123–2.59)
	Buffalo	2	107838	0.246 (95% UI 0.0059–1.173)
	Equine	0	774	–
	Feline	1	-	–

Region	Species	Number of cases	Total Population	Annual Incidence per 10000 populations
				laboratory confirmed
Nihal Singh Wala	Stray Dog	1	4703	3.576 (95% UI 0.034–38.89)
	Pet Dog	2	5899	4.56(95% UI 0.1882–24.53)
	Total dogs	3	10602	3.40 (95% UI 0.2401–14.78)
	Stray cattle	0	731	9.48 (95% UI 0.00043–129.20)
	Livestock cattle	1	20360	0.818(95% UI 0.00253–7.38)
	Total cattle	1	21091	0.803 (95% UI 0.00244–6.076)
	Buffalo	0	40080	0.171 (95% UI 0.0000039–2.46)
	Equine	0	-	-
Phull	Stray Dog	1	6741	2.40 (95%UI 0.0173–24.15)
	Pet Dog	5	7748	7.29(95% UI 0.76–25.26)
	Total dogs	6	14489	4.49 (95% UI 0.72–16.98)
	Stray cattle	4	1603	28.920 (95% UI 2.907–154)
	Livestock cattle	1	36238	0.468 (95% UI 0.00594–4.168)
	Total cattle	5	37841	1.50 (95% UI 0.181–4.90)
	Buffalo	1	81326	0.207 (95% UI 0.00156–1.656)
	Equine	1	680	14.71 (95% UI 14.71–14.71)

Region	Species	Number of cases	Total Population	Annual Incidence per 10000 populations
				laboratory confirmed
Punjab	Stray Dog	151.5 (95% UI 1.35-1999)	305482	4.97 (95% UI 0.1305–73.75)
	Pet Dog	184.8 (95% UI 6.433-1041)	470558	3.92 (95% UI 0.1367–22.12)
	Stray cattle	153.9 (95% UI 1.865-1158)	100991	15.24 (95% UI 0.1847–114.7)
	Livestock cattle	151.3 (95% UI 1.734-1152)	2427714	0.62 (95% UI 0.0071–4.74)
	Buffalo	291.80 (95% UI 0.8631-2382)	5159734	0.56 (95% UI 0.0017–4.61)
	Equine	30.1 (95% UI 0.0007-60.19)	40933	7.37 (95% UI 0.00017–14.71)
India	Stray Dog	9005 (95% UI 236.1-133500)	18099800	4.97 (95% UI 0.1305–73.75)
	Pet Dog	4585 (95% UI 159.6-25820)	11673000	3.92 (95% UI 0.1367–22.12)
	Stray cattle	7908 (95% UI 95.83-59490)	5187777	15.24 (95% UI 0.1847–114.7)
	Livestock cattle	11890 (95% UI 136.4-90580)	190904110	0.62 (95% UI 0.0071–4.74)
	Buffalo	6147 (95% UI 18.18-50180)	108702120	0.56 (95% UI 0.0017–4.61)
	Equine	875 (95% UI 0.0203-1745)	1186450	7.37 (95% UI 0.00017–14.71)

As far as we are aware, this is the first systematic estimation of annual incidence risk of rabies in canine and livestock populations in India. For human rabies, an annual incidence of 0.2 per 10000 populations has been reported in India (Sudarshan *et al* 2007). The current study indicates that the annual rabies incidence has been approximately 23 times greater in pets, 4 times greater in buffalo, 3 times greater in domestic cattle than in human populations. The disease incidence was 25 times greater in stray dogs and 99 times greater in stray cattle when compared with estimated human rabies incidence in India.

The high incidence of 4.89 (95% UI 0.141-69.97) and 19.8 (95% UI 0.27-158.4) per 10000 populations was reported in the stray dog and cattle populations, respectively. In stray cattle, a high odds ratio of being infected viz. 24.94 (95% UI 24.21–25.66) was found as compared to domestic cattle, suggesting that the stray cattle could play an important role in the maintenance of rabies as compared to other domestic animals. Rabies has the greatest burden in poor communities, who use streets and open ground areas to support livestock farming. For example, Kayali *et al* (2003) reported more rabies cases (86%) in animals who roamed freely as compared to confined or partially confined animals. Stray dogs play an important role in the transmission of rabies and it has been reported that 91.5% bite cases are caused by dogs in India, out of which 60% are stray dogs (Menezes 2008). Globally, bites from rabies infected dogs (type III exposure) have been found to be the main cause of rabies in human and animal populations (Kitala *et al* 2000, Kayali *et al* 2003, Wang *et al* 2010, Yibrah and Damtie 2015).

We recorded an annual incidence of 4.51 (UI 95% 0.066-21.88) and 4.89 (UI 95% 0.141-69.97) per 10000 in pet and stray dog population(s) respectively. High annual canine rabies incidence of 41.28 per 10000 populations in Ethiopia (Jemberu *et al* 2013) and 14 per 10000 populations in Chad (Kayali *et al* 2003) have been reported. This might be due to socio-economic and demographic differences between these countries. Interestingly, annual incidence of human rabies have been reported to be 2.33 per 100000 populations in Ethiopia (Jemberu *et al* 2013) which was close to 2 per 100000 populations reported from India (Sudarshan *et al* 2007). Low human rabies death incidence of 0.7 per 100000 populations has been reported in Chad (Frey *et al* 2013), which was quite low as compared to both India and Ethiopia.

In India we reported an annual rabies incidence of 0.62 (UI 95% 0.0034-4.21) and 19.8 (UI 95% 0.27-158.4) per 10000 domestic and stray cattle respectively. On the other hand, a low annual rabies incidence 0.079 per 10000 in bovine populations has been reported from Brazil (Rodenbusch *et al* 2016) indicating that rabies in stray bovine population is a serious concern in India. In stray cattle, a high odds ratio of being infected viz. 24.94 (95% UI 24.21–25.66) was found compared to domestic cattle, suggesting that the stray cattle could play an important role in the maintenance of rabies as compared to other domestic animals. Rabies has the greatest burden in poor communities, who use streets and open ground areas to support livestock farming.

The current annual rabies incidence data indicated that 369 (95% 1.5-2174) buffaloes, 152 (95% UI 1-1023 domestic cattle, 212 (95% UI 3-1029) pet dog and 30 (95% 0.0032-60) equine are affected by rabies every year in Punjab state of India, with stray cattle (200; 95% UI 2.7-1600) and stray dogs (154; 95% UI 4.3-2003) being important contributors. The disease impact was much higher than that reported in passive disease surveillance data (Brookes *et al* 2017), in which 130 dogs, 95 buffalo, 78 cattle and 13 equine rabies cases were reported in a 10 year study period in Punjab, India. The huge difference in the active and passive disease surveillance data indicates that the rabies monitoring and surveillance programs need(s) to be strengthened in India.

The results are consistent with a previous study (Singh and Sandhu 2007) except that we reported high number of animals with anorexia (75%) and hypersalivation (68.75%). The clinical symptoms found associated with bovine rabies in the current study are also consistent with a previous study (Singh and Sandhu 2007) except a high proportion of animals with difficulty in standing (95%) and a lower proportion with fever (25%). Such differences could be because we encountered stray animals in contrast to the previous study. Stray animals usually receive veterinary attention at later stage of the infection.

Overall, rabies cases occurred throughout the year and were recorded in most of the study months. We reported maximum cases in October, and March had no rabies case (Fig. 7). However, different studies report different disease incidence

peaks in different months (Brookes *et al* 2017, Bharathy and Gunaseelan 2016, Gyllys *et al* 1998 and Singh and Sandhu 2007).

For exposure from rabid animals, high exposure rate (65%) was recorded in adult male subjects especially those involved in farming activities. This might be because 62.5% of total rural population in the state is involved in agricultural activities (Census 2011) which are at a higher risk of rabies due to their frequent contact with pets and livestock as well as stray animals. Similarly, a high incidence of rabies has been reported among farmers (82%) in China (Wang *et al* 2010). In the current study, a poor veterinary consultation after bite exposure, pre and post-prophylaxis vaccination were reported among the exposed individuals. Similarly, Sudarshan *et al* (2006) noted that the dog care and management practices were not satisfactory because veterinary consultations was as low as 35% in India, which should be a prominent factor to be focus to reduce the number of animal rabies cases in India. This indicates that public and animal health authorities should take concrete steps to uplift the knowledge and practices of farmers for prevention and control of rabies. All the exposed human subjects took complete post-prophylaxis. However, only 18.18% population took HRIG (expand this term) in case of type III exposure(s) so as to minimize the risk of rabies in exposed individuals. This is consistent with Kayali *et al* (2003), who reported that only 7% persons received HRIG after type III exposure from dog bites in Chad. Many factors such as lack of accessibility (distance to medical centers), shortage of vaccine and low economic status (making HRIG unaffordable) could be responsible for the improper medical care after rabies exposure in India (Joseph *et al* 2013).

We reported clustering of the cases in certain areas in all the selected sub-districts, especially in Nihal Singh Wala as compared to other sub-districts (Fig. 12). This indicates that efforts should be made to find the hot spots of rabies to inform control programs.

The current study has a number of limitations. The reporting of a suspected rabies case in the domestic and pet animal(s) was dependent on the nature of the contact of farmers with veterinary doctors and pharmacists and its further reporting to the concerned scientists(s). For stray animals, the reporting of a case was dependent on the neighboring farmers/exposed individuals or nearby people and its further

reporting to the concerned scientists(s). Therefore, under-reporting of the disease incidence could not be ruled out. To overcome this issue, a regular contact with the village-head(s) in the selected sub-districts was also maintained. Further, the study area (sub-districts) were not randomly selected which might have led to bias in the estimated disease incidence.

Our study also had number of strengths. This is the first estimation of annual rabies disease incidence in livestock and pet populations in India. We obtained laboratory confirmation of 79% of the suspected clinical rabies cases. The probability distributions were applied to overcome uncertainty and variability in the data. Overall, 59496 canine and 390426 bovine subjects were monitored during the study period to authenticate the current disease incidence data.

4.2 Estimation of free roaming/stray dog populations in urban and rural area of Punjab

4.2.1 Number and intensity of stray dogs in village(s)/ward(s)

The detailed information on the number of stray dogs estimated in the selected village(s)/ward(s) is shown in Table 10. Overall, we recorded 1,011 (614 rural and 397 urban) stray dogs on day one (n_1), 1,002 (606 rural and 396 urban) stray dogs on day two (n_2), and 664 (440 rural and 224 urban) stray dogs were re-sighted (m). The overall detectability rate (r) or recapture probability of stray dogs was 65.7%; with 71.7% recapture probability in rural areas as compared to 56.5% in the urban areas.

Table 10: Total number of stray dogs estimated in different village(s)/ward(s) in Punjab state of India

Name of the village/ward	District	Type of dog	n1	n2	M	Stray dog count per village/ward	95% CI	Dog Population /km ²	No. of dogs per thousand adult human population
Rural									
Galib Ran Singh	Ludhaina	Adult Male	13	11	10	14	13, 15	204	15.36
		Adult female	9	10	6	15	11, 18	210	15.83
		Total adult	22	21	16	29	24, 32	411	30.96
		Young male	3	4	3	4	4, 4	57	4.31
		Young female	2	1	1	2	2, 2	29	2.15
		Total young	5	5	4	6	5, 7	89	6.67
		Total male	16	15	13	18	17, 20	263	19.84
		Total female	11	11	7	17	13, 21	243	18.30
		Total dogs	27	26	20	35	31, 39	500.00	37.67
Pipli	Faridkot	Adult Male	18	21	12	31	25, 37	84	11.09
		Adult female	17	18	13	23	20, 26	63	8.34
		Total adult	35	39	25	54	48, 61	147	19.37
		Young male	5	4	2	9	5, 13	24	3.21
		Young female	3	5	2	7	4, 10	19	2.49

Name of the village/ward	District	Type of dog	n1	n2	M	Stray dog count per village/ward	95% CI	Dog Population /km ²	No. of dogs per thousand adult human population
		Total young	8	9	4	17	8, 26	46	6.05
		Total male	23	25	14	41	32, 49	110	14.46
		Total female	20	23	15	31	26, 35	82	10.86
		Total dogs	43	48	29	71	62, 80	192	25.24
Jodhpur	Barnala	Adult Male	21	19	14	28	24, 32	105	10.38
		Adult female	17	20	15	23	21, 24	84	8.30
		Total adult	38	39	29	51	47, 55	189	18.70
		Young male	3	4	2	6	4, 8	21	2.08
		Young female	6	5	4	7	6, 9	27	2.71
		Total young	9	9	6	13	10, 17	49	4.87
		Total male	24	23	16	34	29, 39	127	12.57
		Total female	23	25	19	30	28, 33	112	11.07
		Total dogs	47	48	35	64	59, 70	238	23.58
Rauli	Hoshiarpur	Adult Male	5	4	3	7	5, 8	81	8.63
		Adult female	6	5	4	7	6, 9	93	9.83
		Total adult	11	9	7	14	11, 17	175	18.59

Name of the village/ward	District	Type of dog	n1	n2	M	Stray dog count per village/ward	95% CI	Dog Population /km ²	No. of dogs per thousand adult human population
		Young male	1	2	1	2	2, 2	25	2.66
		Young female	2	2	1	4	2, 5	44	4.65
		Total young	3	4	2	6	3, 9	71	7.53
		Total male	6	6	4	9	7, 11	110	11.69
		Total female	8	7	5	11	8, 14	138	14.61
		Total dogs	14	13	9	20	16, 24	250	26.56
Mangewala	Moga	Adult Male	16	18	13	22	20, 25	147	12.02
		Adult female	15	12	10	18	16, 20	119	9.75
		Total adult	31	30	23	40	36, 44	269	21.97
		Young male	4	3	3	4	4, 4	27	2.18
		Young female	3	4	2	6	4, 8	38	3.09
		Total young	7	7	5	10	7,12	64	5.27
		Total male	20	21	16	25	24, 29	168	13.71
		Total female	18	16	12	24	20, 27	159	12.99
		Total dogs	38	37	28	50	46, 55	334	27.29

Name of the village/ward	District	Type of dog	n1	n2	M	Stray dog count per village/ward	95% CI	Dog Population /km ²	No. of dogs per thousand adult human population
Karahal Kalan	Kapurthala	Adult Male	8	6	4	12	8, 15	232	19.90
		Adult female	4	5	4	5	5, 5	100	8.58
		Total adult	12	11	8	16	13, 19	327	28.01
		Young male	2	3	1	5	2, 8	100	8.58
		Young female	3	4	3	4	4, 4	80	6.86
		Total young	5	7	4	9	6, 11	172	14.75
		Total male	10	9	5	17	11, 23	347	29.73
		Total female	7	9	7	9	9, 9	180	15.44
		Total dogs	17	18	12	25	21, 29	506	43.41
Devgarh	Patiala	Adult Male	13	10	7	18	14, 23	228	21.83
		Adult female	7	6	5	8	7, 10	104	9.96
		Total adult	20	16	12	26	22, 31	331	31.65
		Young male	2	2	2	2	2, 2	25	2.39
		Young female	4	3	3	4	4, 4	50	4.78
		Total young	6	5	5	6	6, 6	75	7.18
		Total male	15	12	9	20	16, 23	248	23.68
		Total female	11	9	8	12	11, 14	154	14.75
		Total dogs	26	21	17	32	28, 36	400	38.28

Name of the village/ward	District	Type of dog	n1	n2	M	Stray dog count per village/ward	95% CI	Dog Population /km ²	No. of dogs per thousand adult human population
Mander	Mansa	Adult Male	21	18	17	22	21, 23	139	11.19
		Adult female	16	14	12	19	17, 20	116	9.38
		Total adult	37	32	29	40	39, 43	255	20.54
		Young male	3	4	3	4	4, 4	25	2.01
		Young female	3	3	2	4	3, 6	27	2.18
		Total young	6	7	5	8	7, 10	52	4.19
		Total male	24	22	20	26	25, 28	165	13.28
		Total female	19	17	14	23	21, 25	144	11.58
		Total dogs	43	39	34	49	47, 52	308	24.82
Rali Ali Kalan	Gurdaspur	Adult Male	6	7	3	13	7, 19	144	13.68
		Adult female	4	5	2	9	5, 13	100	9.47
		Total adult	10	12	5	23	14, 32	254	24.03
		Young male	6	3	2	8	5, 12	93	8.77
		Young female	2	2	2	2	2, 2	22	2.11
		Total young	8	5	4	10	7, 13	109	10.32
		Total male	12	10	5	23	14, 32	254	24.03
		Total female	6	7	4	10	7, 13	113	10.74
		Total dogs	18	17	9	33	24, 42	369	34.95

Name of the village/ward	District	Type of dog	n1	n2	M	Stray dog count per village/ward	95% CI	Dog Population /km ²	No. of dogs per thousand adult human population
Mahdian	Fatehgarh Sahib	Adult Male	9	7	6	10	9, 12	104	8.61
		Adult female	4	6	3	8	5, 10	78	6.40
		Total adult	13	13	9	19	15, 22	186	15.36
		Young male	1	2	0	5	0, 10	50	4.13
		Young female	3	4	3	4	4, 4	40	3.30
		Total young	4	6	3	8	5, 11	78	6.40
		Total male	10	9	6	15	11, 18	147	12.15
		Total female	7	10	6	12	10, 13	116	9.55
		Total dogs	17	19	12	27	22, 31	267	22.04
Rangian	Rupnagar (Ropar)	Adult Male	11	12	8	16	13.35, 19.32	181	14.20
		Adult female	6	7	5	8	7.02, 9.64	93	7.24
		Total adult	17	19	13	25	21.35, 29.08	275	21.49
		Young male	1	1	1	1	1.00, 1.00	11	0.87
		Young female	3	3	2	4	3.02, 5.64	48	3.77
		Total young	4	4	3	5	3.79, 6.71	58	4.57
		Total male	12	13	9	17	14.43, 19.97	191	14.96
		Total female	9	10	7	13	10.65, 14.85	142	11.09
		Total dogs	21	23	16	30	26.36, 33.76	334	26.14

Name of the village/ward	District	Type of dog	n1	n2	M	Stray dog count per village/ward	95% CI	Dog Population /km ²	No. of dogs per thousand adult human population
Gobindpura	Bathinda	Adult Male	23	21	17	28	25.51,31.15	67	5.88
		Adult female	18	15	11	24	20.14, 28.52	58	5.05
		Total adult	41	36	28	53	47.61, 57.56	125	10.91
		Young male	4	5	4	5	5.00, 5.00	12	1.04
		Young female	5	2	2	5	5.00, 5.00	12	1.04
		Total young	9	7	6	10	8.63, 12.22	25	2.16
		Total male	27	26	21	33	30.56,36.17	79	6.92
		Total female	23	17	13	30	25.09, 32.62	71	6.19
		Total dogs	50	43	34	63	57.80,68.43	150	13.09
KotKalan	Jalandhar	Adult Male	6	7	4	10	7.26, 13.14	102	15.38
		Adult female	5	4	3	7	4.80, 8.20	65	9.80
		Total adult	11	11	7	17	13.07, 20.93	170	25.64
		Young male	1	2	0	5	0.19, 9.81	50	7.54
		Young female	1	2	1	2	2.00, 2.00	20	3.02
		Total young	2	4	1	7	-1.11, 14.11	65	9.80
		Total male	7	9	4	15	9.44, 20.56	150	22.62
		Total female	6	6	4	9	6.55., 11.05	88	13.27
		Total dogs	13	15	8	24	17.78, 30.00	239	36.03

Name of the village/ward	District	Type of dog	n1	n2	M	Stray dog count per village/ward	95% CI	Dog Population /km ²	No. of dogs per thousand adult human population
Khoba	Pathankot	Adult Male	4	3	3	4	4.00,4.00	133	5.05
		Adult female	3	4	2	6	3.60,7.74	189	7.16
		Total adult	7	7	5	10	7.69,11.65	322	12.21
		Young male	2	1	1	2	2.00, 2.00	67	2.53
		Young female	1	1	1	1	1.00, 1.00	33	1.26
		Total young	3	2	2	3	3.00, 3.00	100	3.79
		Total male	6	4	4	6	6.00, 6.00	200	7.58
		Total female	4	5	3	7	4.80,8.20	217	8.21
		Total dogs	10	9	7	13	10.65,14.85	425	16.10
Gobindgarh	Fazilka	Adult Male	25	20	14	35	29.18,41.62	89	11.23
		Adult female	15	16	12	18	15.56, 20.26	45	5.68
		Total adult	40	36	26	55	48.85,61.52	138	17.50
		Young male	3	4	3	4	4.00, 4.00	10	1.27
		Young female	4	5	4	5	5.00, 5.00	13	1.59
		Total young	7	9	7	9	9.00, 9.00	23	2.85
		Total male	28	24	17	39	33.36,45.20	98	12.46
		Total female	19	21	16	25	22.67,27.10	62	7.89
		Total dogs	47	45	33	64	57.99,69.89	160	20.28

Name of the village/ward	District	Type of dog	n1	n2	M	Stray dog count per village/ward	95% CI	Dog Population /km ²	No. of dogs per thousand adult human population
Jethuwal	Amritsar	Adult Male	19	17	14	23	20.59, 25.41	100	7.71
		Adult female	13	11	10	14	13.12, 15.43	62	4.78
		Total adult	32	28	24	37	34.58, 39.98	162	12.49
		Young male	2	4	2	4	4.00, 4.00	17	1.34
		Young female	6	6	4	9	6.55, 11.05	38	2.95
		Total young	8	10	6	13	9.88, 16.40	57	4.40
		Total male	21	21	16	27	24.47,30.47	119	9.20
		Total female	19	17	14	23	20.59, 25.41	100	7.71
		Total dogs	40	38	30	51	46.57, 54.59	220	16.94
Bugar	Sangrur	Adult Male	12	10	9	13	12.07, 14.53	190	6.89
		Adult female	9	10	7	13	10.65, 14.85	182	6.61
		Total adult	21	20	16	26	23.56, 28.80	374	13.56
		Young male	3	2	2	3	3.00, 3.00	43	1.55
		Young female	3	1	1	3	3.00,3.00	43	1.55
		Total young	6	3	3	6	6.00, 6.00	86	3.11
		Total male	15	12	11	16	15.02, 17.64	233	8.46
		Total female	12	11	8	16	13.35, 19.32	233	8.46
		Total dogs	27	23	19	33	29.46, 35.74	466	16.89

Name of the village/ward	District	Type of dog	n1	n2	M	Stray dog count per village/ward	95% CI	Dog Population /km ²	No. of dogs per thousand adult human population
Haraj	Mukstar	Adult Male	12	13	10	16	13.84,17.25	97	13.42
		Adult female	11	12	8	16	13.35, 19.32	102	14.09
		Total adult	23	25	18	32	28.42,35.26	199	27.47
		Young male	3	3	2	4	3.02, 5.64	27	3.74
		Young female	5	4	2	9	4.61, 13.39	56	7.77
		Total young	8	7	4	13	7.51, 19.30	84	11.56
		Total male	15	16	12	20	17.62,22.23	125	17.19
		Total female	16	16	10	25	20.01, 30.53	158	21.80
		Total dogs	31	32	22	45	39.54,50.29	281	38.75
Nabipur	Tarn Taran	Adult Male	6	7	4	10	7.26,13.14	85	10.21
		Adult female	7	5	5	7	7.00,7.00	58	7.01
		Total adult	13	12	9	17	14.43,19.97	143	17.22
		Young male	6	5	4	7	5.93,8.87	62	7.41
		Young female	3	2	2	3	3.00, 3.00	25	3.00
		Total young	9	7	6	10	8.63,12.22	87	10.44
		Total male	12	12	8	28	24.37,31.13	231	27.78
		Total female	10	7	7	10	10.00,10.00	83	10.01
		Total dogs	22	19	15	31	25.08, 37.22	260	31.18

Name of the village/ward	District	Type of dog	n1	n2	M	Stray dog count per village/ward	95% CI	Dog Population /km ²	No. of dogs per thousand adult human population
Kheda	Mohali	Adult Male	6	8	5	10	7.80,11.20	136	12.31
		Adult female	9	11	8	12	11.02, 13.64	176	15.97
		Total adult	15	19	13	22	19.61, 24.10	312	28.32
		Young male	1	2	1	2	2.00, 2.00	29	2.59
		Young female	1	2	1	2	2.00, 2.00	29	2.59
		Total young	2	4	2	4	4.00, 4.00	57	5.18
		Total male	7	10	6	12	9.71, 13.43	165	14.99
		Total female	10	13	9	14	12.93, 15.87	206	18.65
		Total dogs	17	23	15	26	23.52,28.48	371	33.68
Tut	Firozpur	Adult Male	11	15	9	18	15.36,21.04	114	10.99
		Adult female	13	12	10	16	13.84, 17.25	97	9.39
		Total adult	24	27	19	34	30.41, 37.59	213	20.53
		Young male	6	4	4	6	6.00, 6.00	38	3.62
		Young female	3	4	2	5	3.60, 7.74	31	3.02
		Total young	9	8	6	12	9.17, 14.55	74	7.16
		Total male	17	19	13	25	28.09,21.23	154	14.92
		Total female	16	16	12	21.	18.48, 23.98	133	12.82
		Total dogs	33	35	25	46	41.53, 50.63	288	27.83

Name of the village/ward	District	Type of dog	n1	n2	M	Stray dog count per village/ward	95% CI	Dog Population /km ²	No. of dogs per thousand adult human population
Sodhian	Nawanshahr	Adult Male	6	7	5	8	7.02, 9.64	139	11.03
		Adult female	4	5	4	5	5.00, 5.00	83	6.62
		Total adult	10	12	9	13	12.07, 14.53	222	17.62
		Young male	1	2	1	2	2.00, 2.00	33	2.65
		Young female	2	1	1	2	2.00, 2.00	33	2.65
		Total young	3	3	2	4	2.37, 6.30	72	5.74
		Total male	7	9	6	10	8.89, 11.97	174	13.81
		Total female	6	6	5	7	6.30, 8.03	120	9.50
		Total dogs	13	15	11	18	15.74, 19.59	295	23.40
Urban									
Zeera ward 15	Firozpur	Adult Male	10	12	5	23	14.08, 31.59	134	15.74
		Adult female	13	9	6	19	13.62, 24.38	112	13.00
		Total adult	23	21	11	43	31.57, 54.43	253	29.43
		Young male	3	2	1	5	2.22, 7.78	29	3.42
		Young female	2	3	2	3	3.00, 3.00	18	2.05
		Total young	5	5	3	8	4.48, 11.52	47	5.48
		Total male	13	14	6	29	18.24, 39.76	171	19.85
		Total female	15	12	8	22	16.84, 27.38	130	15.06
		Total dogs	28	26	14	51	39.32, 63.08	301	34.91

Name of the village/ward	District	Type of dog	n1	n2	M	Stray dog count per village/ward	95% CI	Dog Population /km ²	No. of dogs per thousand adult human population
Zeera ward 16	Firozpur	Adult Male	19	23	11	39	29.25, 48.75	30	22.52
		Adult female	15	17	12	21	18.0, 23.81	16	12.12
		Total adult	34	40	23	59	50.31, 67.27	46	34.06
		Young male	6	5	3	10	6.01, 12.99	7	5.77
		Young female	5	4	3	7	4.80, 8.20	5	4.04
		Total young	11	9	6	16	11.23, 21.06	13	9.24
		Total male	25	28	14	49	38.11, 60.43	38	28.29
		Total female	20	21	15	28	24.37, 31.38	22	16.17
		Total dogs	45	49	29	76	65.57, 85.76	59	43.88
Ludhiana ward 62	Ludhiana	Adult Male	31	26	17	47	38.74, 55.26	100.00	7.33
		Adult female	20	17	12	28	23.11, 33.04	60	4.38
		Total adult	51	43	29	75	65.39, 85.14	160	11.73
		Young male	9	7	4	15	9.44, 20.56	32	2.34
		Young female	7	9	3	19	9.37, 28.63	40	2.96
		Total young	16	16	7	35	20.81, 49.44	75	5.48
		Total male	40	33	21	62	51.86, 72.86	133	9.72
		Total female	27	26	15	46	36.84, 55.66	98	7.21
		Total dogs	67	59	36	109	94.58,123.96	232	17.03

Name of the village/ward	District	Type of dog	n1	n2	M	Stray dog count per village/ward	95% CI	Dog Population /km ²	No. of dogs per thousand adult human population
Ludhiana ward 63	Ludhiana	Adult Male	38	33	20	62	51.03,73.26	51	3.87
		Adult female	28	30	16	52	41.29, 62.47	43	3.23
		Total adult	66	63	36	115	98.84, 130.95	95	7.15
		Young male	11	12	8	16	13.35, 19.32	14	1.02
		Young female	14	13	9	20	16.16, 23.84	17	1.24
		Total young	25	25	17	37	31.04, 42.07	30	2.28
		Total male	49	45	28	78	67.10,89.52	65	4.87
		Total female	42	43	25	72	60.70, 82.84	59	4.47
		Total dogs	91	88	53	151	134.44,166.82	124	9.38
Bhagta Bhaika ward 8	Bathinda	Adult Male	4	6	2	11	5.19,16.15	213	9.39
		Adult female	5	3	2	7	4.22, 9.78	140	6.16
		Total adult	9	9	4	19	10.98,27.02	380	16.73
		Young male	1	2	1	2	2.00, 2.00	40	1.76
		Young female	1	1	0	3	0.22, 5.78	60	2.64
		Total young	2	3	1	5	-0.56, 10.56	100	4.40
		Total male	5	8	3	13	7.39,17.61	250	11.00
		Total female	6	4	2	11	5.19, 16.15	213	9.39
		Total dogs	11	12	5	25	14.98,35.02	500	22.01

Name of the village/ward	District	Type of dog	n1	n2	M	Stray dog count per village/ward	95% CI	Dog Population /km ²	No. of dogs per thousand adult human population
Bhagta Bhaika ward 1	Bathinda	Adult Male	9	8	5	14	9.93, 18.07	100	14.52
		Adult female	5	4	2	9	4.61, 13.39	64	9.34
		Total adult	14	12	7	23	16.61, 30.14	167	24.25
		Young male	2	3	1	5	2.22, 7.78	36	5.19
		Young female	4	5	3	7	4.80, 8.20	46	6.74
		Total young	6	8	4	12	7.10, 16.10	83	12.03
		Total male	11	11	6	20	13.62, 25.53	140	20.30
		Total female	9	9	5	16	10.72, 20.62	112	16.26
		Total dogs	20	20	11	36	27.17, 44.33	255	37.09
Balachaur ward 4	Nawanshahr	Adult Male	19	25	10	46	32.61,59.94	231	43.41
		Adult female	23	20	14	33	27.20,38.00	163	30.58
		Total adult	42	45	33	78	64.79,91.45	391	73.28
		Young male	7	4	3	9	6.22, 11.78	45	8.44
		Young female	3	4	3	4	4.00,4.00	20	3.75
		Total young	10	8	6	13	9.88,16.40	66	12.33
		Total male	22	29	19	57	41.98,71.73	284	53.34
		Total female	30	24	20	37	31.34,41.66	183	34.24
		Total dogs	52	53	39	91	77.84,104.81	457	85.67

Name of the village/ward	District	Type of dog	n1	n2	M	Stray dog count per village/ward	95% CI	Dog Population /km ²	No. of dogs per thousand adult human population
Balachaur ward 5	Nawanshahr	Adult Male	5	6	3	10	6.01,12.99	190	8.36
		Adult female	3	2	1	5	2.22-7.78	100	4.40
		Total adult	8	8	4	15	9.42, 20.98	304	13.38
		Young male	0	2	0	2	2.00, 2.00	40	1.76
		Young female	2	3	2	3	3.00, 3.00	60	2.64
		Total young	2	5	2	5	5.00, 5.00	100	4.40
		Total male	5	8	3	13	7.39, 17.61	250	11.00
		Total female	5	5	3	8	5.36, 10.64	160	7.04
		Total dogs	10	13	6	21	14.48,27.52	420	18.49
Bathinda ward 9	Bathinda	Adult Male	15	12	6	29	18.20, 39.23	78	7.77
		Adult female	9	8	5	14	9.93, 18.07	38	3.79
		Total adult	24	20	11	43	31.49, 54.01	116	11.57
		Young male	5	5	3	8	5.36, 10.64	22	2.17
		Young female	3	5	2	7	4.22, 9.78	19	1.89
		Total young	8	10	5	16	9.78, 21.22	42	4.19
		Total male	20	17	9	37	25.99,47.61	99	9.96
		Total female	12	13	7	22	15.70, 27.80	59	5.89
		Total dogs	32	30	16	59	46.13, 72.22	160	16.02

Name of the village/ward	District	Type of dog	n1	n2	M	Stray dog count per village/ward	95% CI	Dog Population /km ²	No. of dogs per thousand adult human population
Bathinda ward 11	Bathinda	Adult Male	14	18	8	31	21.64,39.70	63	7.02
		Adult female	16	19	10	30	22.92,36.90	61	6.84
		Total adult	30	37	18	61	49.02,72.98	124	13.96
		Young male	7	4	3	9	6.22,11.78	18	2.06
		Young female	4	5	3	7	4.80, 8.20	13	1.49
		Total young	11	9	6	16	11.23,21.06	33	3.69
		Total male	21	22	11	41	30.45,51.88	84	9.42
		Total female	20	24	13	37	29.21,43.79	74	8.35
		Total dogs	41	46	24	78	64.72,91.20	159	17.84

The median number of stray dogs per village was estimated to be approximate 32 (95% CI: 27, 37) with a minimum of 13 (95% CI: 11, 15; village Khoba, Pathankot) and a maximum of 71 (95% CI: 62, 80; village Pippli, Faridkot) stray dogs (Table 10). The median number of stray dogs per ward was estimated to be 67 (95% CI: 56, 78) with a minimum of 21 (95% CI: 14, 28; Balachaur ward 5, Nawan Shehar) and a maximum of 151 (95% CI: 134, 167; Ward 63, Ludhiana) stray dogs (Table 10).

Overall, 73,498 adult humans resided in the 22 selected villages (35,465 rural) and 10 selected wards (38,042 urban). There was a median of 26 (13, 43) stray dogs per thousand adult human population residing in the selected villages and a median of 20 (9, 86) stray dogs per thousand adult human population residing in the selected wards (Table 10).

Overall, we covered 7.77 square kilometer (sq km) of built-up area in the 22 selected villages (3.33 sq km rural) and 10 selected wards (4.44 sq km). There was a median of 290 (150, 506) stray dogs per sq km of built-up area covered in the selected villages and a median of 237 (59, 500) stray dogs per square kilometer (sq km) of built-up area covered in the selected wards (Table 10).

The detailed information on the number of male and female stray dogs estimated in the selected village(s)/ward(s) is shown in Table 10. Overall, we recorded 549 male and 462 female dogs on day one (*n1*), 552 male and 460 female dogs on day two (*n2*), and 349 male and 315 female dogs were re-sighted (*m*). The median number of male stray dogs per village were estimated to be 19 (95% CI: 17, 21) with a minimum of 6 and a maximum of 41 male stray dogs (Table 10). The median number of female stray dogs per village were estimated to be 15 (95% CI: 13, 18) with a minimum of 7 and a maximum of 31 female stray dogs (Table 10). The median number of male stray dogs per ward were estimated to be 39 (95% CI: 28, 50) with a minimum of 13 and a maximum of 78 male stray dogs (Table 10). The median number of female stray dogs per ward was estimated to be 25 (95% CI: 21, 29) with a minimum of 8 and a maximum of 72 female stray dogs (Table 10).

Overall, we recorded 227 young and 784 adult dogs on day one (*n1*), 230 young and 772 adult dogs on day two (*n2*), and 147 young and 517 adult dogs were re-sighted (*m*). The median number of young stray dogs per village was estimated to be 8 (95% CI: 7, 10) with a minimum of 3 and a maximum of 17 young stray dogs (Table 10). The median number of adult stray dogs per village was estimated to be 26 (95% CI: 23, 30) with a minimum of 10 and a maximum of 55 adult stray dogs (Table

10). The median number of young stray dogs per ward was estimated to be 14 (95% CI: 10, 19) with a minimum of 5 and a maximum of 37 young stray dogs (Table 10). The median number of adult stray dogs per ward was estimated to be 51 (95% CI: 41, 60) with a minimum of 15 and a maximum of 115 adult stray dogs (Table 10). The detailed adult, young and gender-wise information on the number of stray dogs per adult human population(s) and built-up area are shown in Table 10.

4.2.2 Stray dog count in Punjab (India)

Detailed information on the number of stray dogs in Punjab is presented in Table 11. Based on the number stray dogs per village/ward, we estimated that there are a median of 672,005 (95% CI: 241,802, 1,198,024) stray dogs in Punjab state of India, comprising of 470,366 (95% CI: 165,606, 881,597) and 191,326 (95% CI: 53,063, 374,020) stray dogs residing in rural and urban areas, respectively (Fig. 13). There were 384,787 (95% CI: 146,030, 662,358) male and 313,417 (95% CI: 146,046, 543,176) female stray dogs and the male to female ratio was estimated to be 1.2:1 (minimum 0.4:1 and maximum 4.0:1) (Fig. 13). There were 527,463 (95% CI: 184,364, 934,583) adult and 164,860 (95% CI: 62,973, 296,231) young dogs and the young to adult ratio was estimated to be 1:3.2 (minimum 1:0.9 and maximum 1:11.3).

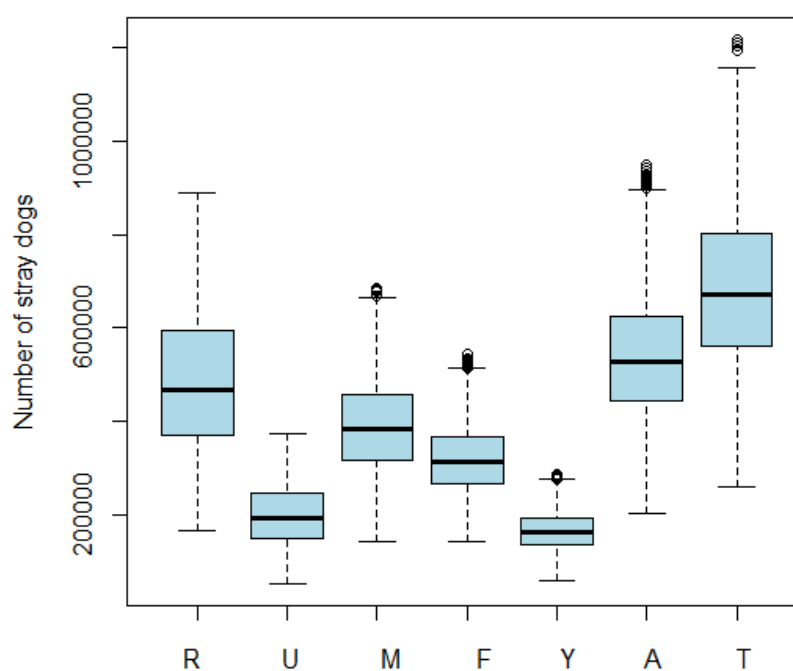


Fig. 13: Stray dog count based on the number of villages and wards in the Punjab state of India. R: stray dogs in rural areas; U: stray dogs in urban areas, M: Male stray dogs; F: Female stray dogs; Y: Young stray dogs; A: Adult stray dogs; and T: Total stray dogs.

Based on the adult human population residing in the surveyed areas, we estimated that there are a median of 607,095 (95% CI: 269,059, 1,106,020) stray dogs in Punjab state of India, comprising of 332,463 (95% CI: 162,137, 526,434) and 262,805 (95% CI: 69,818, 618,278) stray dogs residing in the rural and urban areas, respectively (Fig. 14). There were 380,042 (95% CI: 163,238, 698,560) male and 269,663 (95% CI: 114,843, 481,349) female stray dogs and the male to female ratio was estimated to be 1.4:1 (minimum 0.4:1 and maximum 4.1:1) (Fig. 14). There were 471,726 (95% CI: 198,874, 878,946) adult and 138,130 (95% CI: 50,271, 255,312) young dogs and the young to adult ratio was estimated to be 1:3.4 (minimum 1:1.0 and maximum 1:12.6).

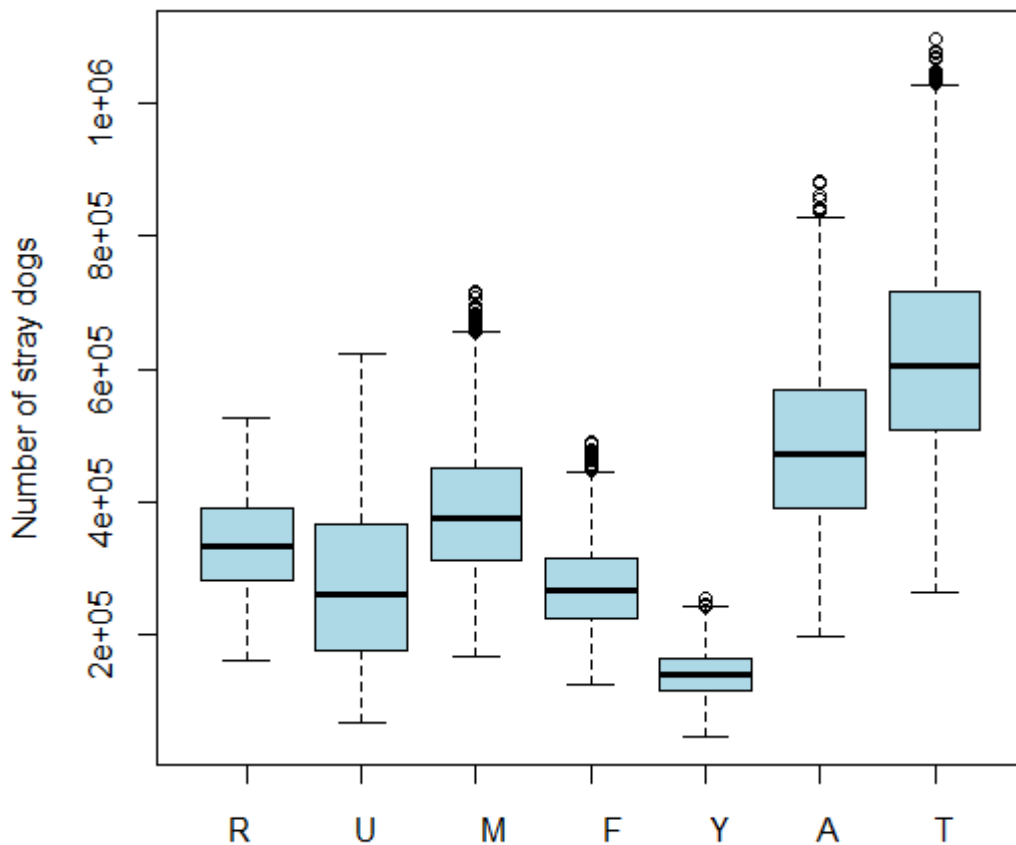


Fig. 14: Stray dog count based on the adult human population residing in different villages and wards in the Punjab state of India. R: stray dogs in rural areas; U: stray dogs in urban areas, M: Male stray dogs; F: Female stray dogs; Y: Young stray dogs; A: Adult stray dogs; and T: Total stray dogs.

Based on the number of stray dogs per built-up area, we estimated that there are a median of 883,504 (95% CI: 399,529, 1,445,014) stray dogs in Punjab state of India, comprising of 577,421 (95% CI: 284,621, 932,650) and 295,271 (95% CI: 71,436, 567,758) stray dogs residing in the rural and urban areas, respectively (Fig. 15). There were 525,581 (95% CI: 222,820, 917,371) male and 399,081 (95% CI: 170,730, 663,859) female stray dogs and the male to female ratio was estimated to be 1.3:1 (minimum 0.4:1 and maximum 4.7:1) (Fig. 15). There were 682,191 (95% CI: 339,637, 1,168,963) adult and 224,204 (95% CI: 66,411, 414,614) young dogs and the young to adult ratio was estimated to be 1:3.0 (minimum 1:1.0 and maximum 1:10.5).

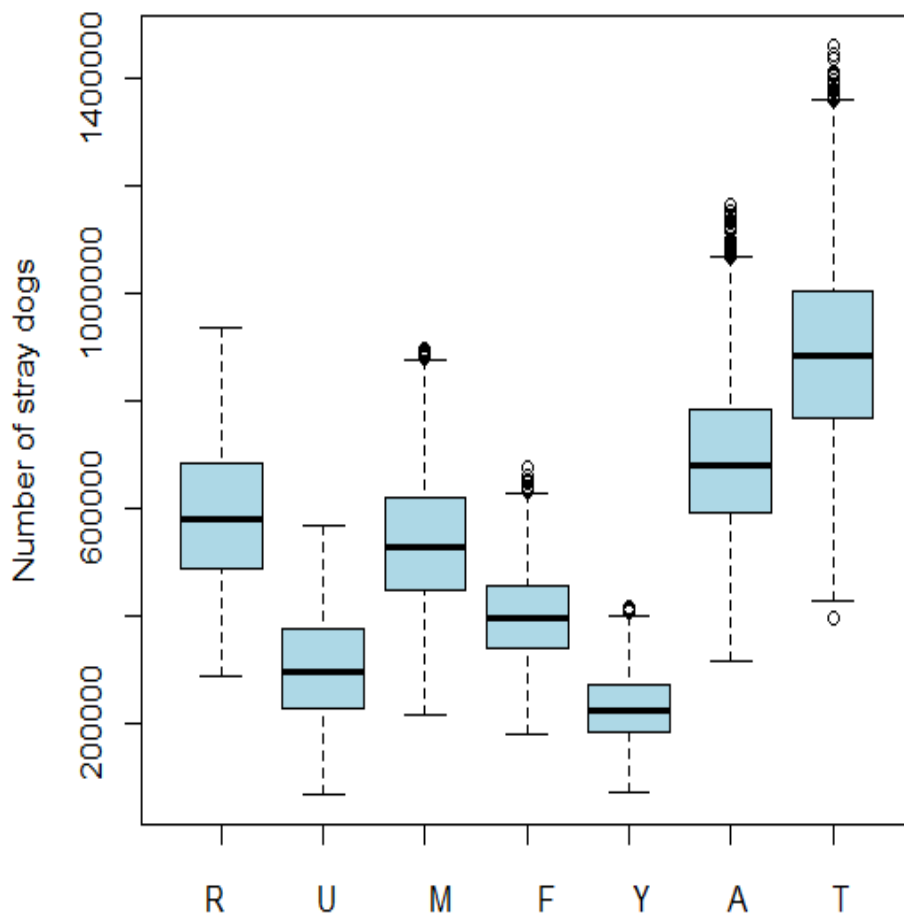


Fig. 15: Stray dog count based on the rural and urban built-up area in the Punjab state of India. R: stray dogs in rural areas; U: stray dogs in urban areas, M: Male stray dogs; F: Female stray dogs; Y: Young stray dogs; A: Adult stray dogs; and T: Total stray dogs.

Table 11: Estimated number of stray dogs in Punjab state of India

Area	Number of Villages/Wards	Total dog population [(95% confidence interval (CI))]	Male dogs (95% CI)	Female dogs (95% CI)	Ratio Male/female dogs (95% CI)	Adult dogs (95% CI)	Young dogs (95% CI)	Ratio Adult/young dogs (95% CI)
Based on the number of Village(s)/ward(s)								
Rural	12581	470366 (165606,881597)	267920 (78297,508634)	213618 (82415,381040)	1.2479 (0.2664,5.3630)	370421 (125079,687566)	116687 (38973,212602)	3.201 (0.648,14.389)
Urban	2496	191326 (53063,374020)	111803 (53552,194222)	93611 (52889,177507)	0.5235 (0.1535,2.1418)	150443 (54066,285309)	44802 (12915,90973)	3.3460 (0.7471,17.9287)
Total	15077	672005 (241802,1198024)	384787 (146030,662358)	313417 (146046,543176)	1.2235 (0.3603,3.9830)	527463 (184364,934583)	164860 (62973,296231)	3.2188 (0.9114,11.3494)
Based on the adult human population								
Rural	12201170	332463 (162137,526434)	199695 (86420,359839)	153879 (76724,265257)	1.2942 (0.3655,4.0291)	249946 (134132,386137)	88630 (27034,178130)	2.7885 (0.8721,12.8627)
Urban	7315518	262805 (69818,618278)	168521 (69578,389112)	106851 (33318,248150)	1.564 (0.310,9.332)	213501 (54180,529296)	46787 (17019,90038)	4.5487 (0.7131,25.8769)
Total	19516688	607095 (269059,1106020)	380042 (163238,698560)	269663 (114843,481349)	1.407 (0.408,4.145)	471726 (198874,878946)	138130 (50271,255312)	3.428 (1.021,12.620)
Based on the residential (built-up) area								
Rural	1857.24	577421 (284621,932650)	349028 (148539,639110)	269093 (116289,449185)	1.3034 (0.3753,4.6277)	450515 (234612,760051)	159253 (43016,317644)	2.8615 (0.8098,13.4114)
Urban	1139.39	295271 (71436,567758)	168931 (44465,322162)	124795 (26891,240741)	1.3636 (0.2156,9.7170)	216641 (52820,443461)	64745 (14826,113097)	3.4365 (0.5268,23.2682)
Total	2996.63	883504 (399529,1445014)	525581 (222820,917371)	399081 (170730,663859)	1.3265 (0.4241,4.7015)	682191 (339637,1168963)	224204 (66411,414614)	3.0292 (0.9812,10.5233)

4.2.3 Sensitivity analysis

A median stray dog count of 865,487 (95% CI: 398,006, 1,446,530) was estimated for the urban areas after excluding the industrial area from urban built-up area.

4.2.4 Abnormalities detected in stray dogs

During the stray dog count, we estimated gross health abnormalities in 4.4% (38/845) of the dogs residing in rural areas. We recorded wounds in 0.82% (7/845), skin diseases (scabies/mange/inflammation) in 1.30% (11/845), fractures in 0.23% (2/845), hind-limb paralysis in 0.35% (3/845), emaciation in 1.65% (14/845) and mandibular deformity in 0.11% (1/845) of the stray dogs residing in the rural areas. During the stray dog count, we estimated gross health abnormalities in 4.7% (33/701) of the dogs residing in the urban areas. We recorded wound in 0.99% (7/701), skin diseases (scabies/mange/inflammation) in 1.14% (8/701), fractures in 0.28% (2/701), hind-limb paralysis in 0.57% (4/701) and emaciation in 1.71% (12/701) of the stray dogs residing in the urban areas.

As far as we are aware, this is the first systematic estimation of stray dog population(s) in Punjab state of India. As per the 2012 official data, there are 305,482 stray dogs in Punjab state of India (DAHP 2012). However, we used a mark–re-sight framework for the current estimation. Mark–re-sight is considered a practical way to estimate the number and distribution of a stray dog population, if the assumption of a closed population is fulfilled (Seber 1970 and Cooch *et al* 2014). In the present investigation, marking and subsequent counting events were completed within two days and thus the assumption of a closed population was likely valid because the period between the counting events was very short. This large difference between our estimate and the official estimate could be due to fact that the animal husbandry department estimated stray dog population size in 2011, but there has been a continuous increase in the stray dog population due to the lack of effective stray dog control programs. As far as we are aware, the systematic approaches in the official stray dog counts have not been followed. Furthermore, many researchers believe that there has been a rapid increase in the stray dog populations in India (Davis and Menon 2016).

We also used data triangulation for our estimates. The number of stray dogs in the Punjab was extrapolated based on the number of wards and villages covered, total adult human population residing in the surveyed areas and the residential (built-up) areas covered in the study. We extrapolated the median number of stray dogs to be 672,005 based on the number of village(s)/ward(s), 607,095 based on the adult human population and 883,504 based on the built-up area in the Punjab state of India. We believe all these approaches to produce reasonably accurate estimates that relate well to the presence of stray dogs in the relevant areas. However, these approaches need to be further refined in future studies. We believe that this baseline information generated in the current study will help policymakers to plan and implement ABC programs.

We estimated an adult human to stray dog ratio of 38:1 in rural and 50:1 in urban areas approximating a human to stray dog ratio of 52:1 in rural and 40:1 in urban areas. The human to stray dog ratio have been reported to be 15:1 in Bhutan (Rinzin *et al* 2016); 4.7:1 in Kathmandu, Nepal and 5.2:1 in Shimotsui, Japan (Kato *et al* 2003); 828:1 and 120:1 in Bangladesh (Tenzin *et al* 2015 and Hossain *et al* 2013). The current estimates are higher than those reported in Bangladesh but lower than Bhutan, Nepal and Japan. This might be due to socio-cultural and human population density differences in different countries.

We estimated the dog density in rural and urban areas to be 290 and 238 per square kilometre built-up area, respectively. A range of dog densities have been reported: 185 free ranging dogs/km² from West Bengal, India (Pal *et al* 2001); 57 free-ranging dogs/km² in Mumbai, India (Punjabi *et al* 2012); 225 stray dogs/km² in Shimotsui, Japan (Kato *et al* 2003); 2930 stray dogs/km² in Kathmandu, Nepal (Kato *et al* 2003); 52 dogs/km² (Tenzin *et al* 2015) and 14 dogs/km² (Hossain *et al* 2013) in Bangladesh. These variations might be due to differences in the socioeconomic, cultural and the selected research area(s).

We observed a recapture probability of stray dogs of 66% (rural 72% and urban 56%). Recapture probabilities of 63% (Tenzin *et al* 2015) and 46–49% (Rinzin *et al* 2016) have been reported in other studies. The use of bait (dog biscuit) might have led to a higher recapture probability in the current study. We reported a high male versus female dog population, and this trend is supported by other national and

international studies (Pal 2001, Tatton *et al* 2010, Tenzin *et al* 2015 and Mustiana *et al* 2015). Many factors – such as higher male survivability or high mortality in female dogs – could have favored a high population of male dogs. The three times higher adult population estimated in the current study was consistent with many other international dog count estimates (Mustiana *et al* 2015, Totton *et al* 2010 and Nematu 1979).

We had a number of limitations. Although we took utmost care in estimating only the stray dog population, some portion of free-roaming owned dogs could have been counted as stray dogs. The stray dogs were not captured and conditions such as tick infestation(s) and body condition score could not be estimated. In addition, the attitude and practices of people towards stray dogs could not be explored. The presence of garbage dumps, natural carcass disposal sites and restaurants in some of the selected areas might have biased the results.

Our study had a number of strengths. The use of a recommended mark–re-sight framework, data triangulation and the software based measurements of residential area(s) improved the accuracy of the results. The 22 villages and 10 wards were purposely selected from the randomly selected sub-districts so as to represent the Punjab state of India. The probability distribution(s) were applied to account for uncertainty and variability in the data. Sensitivity analyses were also carried out for important input parameters. Overall, we believe that the current estimates genuinely represent the number of stray dogs present in the Punjab state of India.

4.3 Estimation of stray cattle population in urban and rural area of Punjab

We recorded 375 (211 rural and urban 164) stray cattle on day one (n1), 358 (192 rural and urban 166) stray cattle on day two (n2), and 200 (115 rural and urban 85) stray cattle were re-sighted (m) in the 22 villages and 10 wards surveyed in the current study. Overall, we covered 7.77 (3.33 sq km rural and 4.44 sq km urban) square kilometre built-up area where 73498 (35465 rural and 38042 urban) adult human population resided. The overall detectability rate (r) or recapture probability of stray cattle was 50.56%; with 54.59% recapture probability in rural area(s) as compared to 51.97% in the urban area(s). Detailed information on the number of male, female, young and adult stray cattle estimated in the selected village(s)/ward(s) have been provided in Table 12.

Table 12: Total number of stray cattle estimated in different village(s)/ward(s) in Punjab state of India

Name of the village/ward	District	Type of cattle	n1	n2	M	Stray cattle count per village/ward	95% CI	Cattle Population /km ²	No. of cattle per thousand adult human population
Rural									
Galib Ran Singh	Ludhiana	Adult Male	1	1	1	1.00	1.00, 1.00	14.29	1.08
		Adult female	2	1	0	5.00	0.19, 9.81	71.43	5.38
		Total adult	3	2	1	5.00	2.22, 7.78	71.43	5.38
		Young male	2	1	1	2.00	2.00, 2.00	28.57	2.15
		Young female	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Total young	2	1	1	2.00	2.00, 2.00	28.57	2.15
		Total male	3	2	2	3.00	3.00, 3.00	42.86	3.23
		Total female	2	1	0	5.00	0.18, 9.81	71.43	5.38
		Total cattle	5	3	2	7.00	4.22, 9.78	100.00	7.53
Pipli	Faridkot	Adult Male	4	2	1	6.50	2.69, 10.31	17.57	2.31
		Adult female	1	2	1	2.00	2.00, 2.00	5.41	0.71
		Total adult	5	4	2	9.00	4.61, 13.39	24.32	3.21
		Young male	0	1	0	1.00	1.00, 1.00	2.70	0.36
		Young female	0	0	0	0.00	0.00	0.00	0.00
		Total young	0	1	0	1.00	-	2.70	0.36
		Total male	4	3	1	9.00	2.79, 15.21	24.32	3.21
		Total female	1	2	1	2.00	2.00, 2.00	5.41	0.71
Total cattle	5	5	2	11.00	5.11, 16.90	29.73	3.92		

Name of the village/ward	District	Type of cattle	n1	n2	M	Stray cattle count per village/ward	95% CI	Cattle Population /km ²	No. of cattle per thousand adult human population
Jodhpur	Barnala	Adult Male	4	6	2	10.67	5.19, 16.15	39.52	3.91
		Adult female	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Total adult	4	6	2	10.67	5.19, 16.15	39.52	3.91
		Young male	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Young female	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Total young	0	0	0	0.00	-	0.00	0.00
		Total male	4	6	2	10.67	5.19, 16.15	39.52	3.91
		Total female	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Total cattle	4	6	2	10.67	5.19, 16.15	39.52	3.91
Rauli	Hoshiarpur	Adult Male	4	4	3	5.25	4.15, 6.35	65.63	6.97
		Adult female	5	4	2	9.00	4.61, 13.39	112.50	11.95
		Total adult	9	8	5	14.00	9.93, 18.07	175.00	18.59
		Young male	1	1	0	3.00	0.22, 5.78	37.50	3.98
		Young female	0	1	0	1.00	1.00, 1.00	12.50	1.33
		Total young	1	2	0	5.00	-	62.50	6.64
		Total male	5	5	3	8.00	5.36, 10.64	100.00	10.62
		Total female	5	5	2	11.00	5.11, 16.90	137.50	14.61
		Total cattle	10	10	5	19.17	12.36, 25.97	239.63	25.46

Name of the village/ward	District	Type of cattle	n1	n2	M	Stray cattle count per village/ward	95% CI	Cattle Population /km ²	No. of cattle per thousand adult human population
Mangewala	Moga	Adult Male	2	3	1	5.00	2.22, 7.78	33.33	2.72
		Adult female	1	2	1	2.00	2.00, 2.00	13.33	1.09
		Total adult	3	5	2	7.00	4.22, 9.78	46.67	3.81
		Young male	1	0	0	1.00	1.00, 1.00	6.67	0.54
		Young female	1	0	0	1.00	1.00, 1.00	6.67	0.54
		Total young	2	0	0	2.00	-	13.33	1.09
		Total male	3	3	1	7.00	2.46, 11.54	46.67	3.81
		Total female	2	2	1	3.50	1.80, 5.20	23.33	1.91
		Total cattle	5	5	2	11.00	5.11, 16.90	73.33	5.99
Karahal Kalan	kapurthala	Adult Male	1	0	0	1.00	1.00, 1.00	20.00	1.72
		Adult female	1	1	0	3.00	0.22, 5.78	60.00	5.15
		Total adult	2	1	0	5.00	0.19, 9.81	100.00	8.58
		Young male	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Young female	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Total young	0	0	0	0.00	-	0.00	0.00
		Total male	1	0	0	1.00	1.00, 1.00	20.00	1.72
		Total female	1	1	0	3.00	0.22, 5.78	60.00	5.15
		Total cattle	2	1	0	5.00	0.19, 9.81	100.00	8.58

Name of the village/ward	District	Type of cattle	n1	n2	M	Stray cattle count per village/ward	95% CI	Cattle Population /km ²	No. of cattle per thousand adult human population
Devgarh	Patiala	Adult Male	3	4	2	5.67	3.60, 7.74	70.88	6.78
		Adult female	3	3	2	4.33	3.02, 5.64	54.13	5.18
		Total adult	6	7	4	10.20	7.26, 13.14	127.50	12.20
		Young male	0	1	0	1.00	1.00, 1.00	12.50	1.20
		Young female	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Total young	0	1	0	1.00	-	12.50	1.20
		Total male	3	5	2	7.00	4.22, 9.78	87.50	8.37
		Total female	3	3	2	4.33	3.02, 5.64	54.13	5.18
		Total cattle	6	8	4	11.60	8.00, 15.20	145.00	13.88
Mander	Mansa	Adult Male	4	3	1	9.00	2.79, 15.21	56.25	4.53
		Adult female	2	3	1	5.00	2.22, 7.78	31.25	2.52
		Total adult	6	6	2	15.33	6.16, 24.50	95.81	7.72
		Young male	1	1	0	3.00	0.22, 5.78	18.75	1.51
		Young female	2	2	2	2.00	2.00, 2.00	12.50	1.01
		Total young	3	3	2	4.33	2.37, 6.30	27.06	2.18
		Total male	5	4	1	14.00	3.24, 24.76	87.50	7.05
		Total female	4	5	3	6.50	4.80, 8.20	40.63	3.27
		Total cattle	9	9	4	19.00	10.98, 27.02	118.75	9.57

Name of the village/ward	District	Type of cattle	n1	n2	M	Stray cattle count per village/ward	95% CI	Cattle Population /km ²	No. of cattle per thousand adult human population
Rali Ali Kalan	Gurdaspur	Adult Male	1	0	0	1.00	1.00, 1.00	11.11	1.05
		Adult female	1	0	0	1.00	1.00, 1.00	11.11	1.05
		Total adult	2	0	0	2.00	2.00, 2.00	22.22	2.11
		Young male	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Young female	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Total young	0	0	0	0.00	-	0.00	0.00
		Total male	1	0	0	1.00	1.00, 1.00	11.11	1.05
		Total female	1	0	0	1.00	1.00, 1.00	11.11	1.05
		Total cattle	2	0	0	2.00	2.00, 2.00	22.22	2.11
Mahdian	Fatehgarh Sahib	Adult Male	0	2	0	2.00	2.00, 2.00	20.00	1.65
		Adult female	1	0	0	1.00	1.00, 1.00	10.00	0.83
		Total adult	1	2	0	5.00	0.19, 9.81	50.00	4.13
		Young male	1	0	0	1.00	1.00, 1.00	10.00	0.83
		Young female	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Total young	1	0	0	1.00	-	10.00	0.83
		Total male	1	2	0	5.00	0.19, 9.81	50.00	4.13
		Total female	1	0	0	1.00	1.00, 1.00	10.00	0.83
		Total cattle	2	2	0	8.00	-.34, 16.34	80.00	6.61

Name of the village/ward	District	Type of cattle	n1	n2	M	Stray cattle count per village/ward	95% CI	Cattle Population /km ²	No. of cattle per thousand adult human population
Rangian	Rupnagar(Ropar)	Adult Male	0	1	0	1.00	1.00, 1.00	11.11	0.87
		Adult female	0	1	0	1.00	1.00, 1.00	11.11	0.87
		Total adult	0	2	0	2.00	2.00, 2.00	22.22	1.74
		Young male	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Young female	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Total young	0	0	0	0.00	-	0.00	0.00
		Total male	0	1	0	1.00	1.00, 1.00	11.11	0.87
		Total female	0	1	0	1.00	1.00, 1.00	11.11	0.87
		Totalcattle	0	2	0	2.00	2.00, 2.00	22.22	1.74
Gobindpura	Bathinda	Adult Male	5	6	3	9.50	6.01, 12.99	22.62	1.97
		Adult female	2	4	2	4.00	4.00, 4.00	9.52	0.83
		Total adult	7	10	5	13.67	9.99, 17.34	32.55	2.83
		Young male	2	1	1	2.00	2.00, 2.00	4.76	0.41
		Young female	1	2	1	2.00	2.00, 2.00	4.76	0.41
		Total young	3	3	2	4.33	2.37, 6.30	10.31	0.90
		Total male	7	7	4	11.80	7.95, 15.65	28.10	2.45
		Total female	3	6	3	6.00	6.00, 6.00	14.29	1.24
		Total cattle	10	13	7	18.25	13.94, 22.56	43.45	3.78

Name of the village/ward	District	Type of cattle	n1	n2	M	Stray cattle count per village/ward	95% CI	Cattle Population /km ²	No. of cattle per thousand adult human population
KotKalan	Jalandhar	Adult Male	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Adult female	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Total adult	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Young male	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Young female	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Total young	0	0	0	0.00	-	0.00	0.00
		Total male	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Total female	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Totalcattle	0	0	0	0.00	0.00, 0.00	0.00	0.00
Khoba	Pathankot	Adult Male	1	1	0	3	0.22, 5.78	100.00	3.79
		Adult female	1	0	0	1.00	1.00, 1.00	33.33	1.26
		Total adult	2	1	0	5.00	0.19, 9.81	166.67	6.31
		Young male	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Young female	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Total young	0	0	0	0.00	-	0.00	0.00
		Total male	1	1	0	3.00	0.22, 5.78	100.00	3.79
		Total female	1	0	0	1.00	1.00, 1.00	33.33	1.26
		Total cattle	2	1	0	5.00	0.19, 9.81	166.67	6.31

Name of the village/ward	District	Type of cattle	n1	n2	M	Stray cattle count per village/ward	95% CI	Cattle Population /km ²	No. of cattle per thousand adult human population
Gobindgarh	Fazilka	Adult Male	38	39	21	69.91	57.04, 82.78	174.78	22.17
		Adult female	45	34	30	50.94	47.45, 54.42	127.35	16.16
		Total adult	83	73	51	118.54	107.68, 129.40	296.35	37.60
		Young male	14	11	9	17.00	14.49, 19.51	42.50	5.39
		Young female	7	2	2	7.00	7.00, 7.00	17.50	2.22
		Total young	21	13	11	24.67	20.78, 28.56	61.68	7.82
		Total male	52	50	30	86.19	73.97, 98.41	215.48	27.34
		Total female	52	36	32	58.42	54.38, 62.47	146.05	18.53
		Total cattle	104	86	62	144.00	132.17, 155.83	360.00	45.67
Jethuwal	Amritsar	Adult Male	3	5	1	11.00	3.14, 18.86	47.83	3.69
		Adult female	1	4	1	4.00	4.00, 4.00	17.39	1.34
		Total adult	4	9	2	15.67	7.00, 24.33	68.13	5.25
		Young male	1	3	1	3.00	3.00, 3.00	13.04	1.01
		Young female	0	1	0	0.00	0.00, 0.00	0.00	0.00
		Total young	1	4	1	4.00	4.00, 4.00	17.39	1.34
		Total male	4	8	2	14.00	6.39, 21.61	60.87	4.69
		Total female	1	5	1	5.00	5.00, 5.00	21.74	1.68
		Total cattle	5	13	3	20.00	11.00, 29.00	86.96	6.70

Name of the village/ward	District	Type of cattle	n1	n2	M	Stray cattle count per village/ward	95% CI	Cattle Population /km ²	No. of cattle per thousand adult human population
Bugar	Sangrur	Adult Male	5	4	3	6.50	4.80, 8.20	92.86	3.37
		Adult female	2	1	1	2.00	2.00, 2.00	28.57	1.04
		Total adult	7	5	4	8.60	6.67, 10.53	122.86	4.46
		Young male	2	1	1	2.00	2.00, 2.00	28.57	1.04
		Young female	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Total young	2	1	1	2.00	2.00, 2.00	28.57	1.04
		Total male	7	5	4	8.60	6.67, 10.53	122.86	4.46
		Total female	2	1	1	2.00	2.00, 2.00	28.57	1.04
		Total cattle	9	6	5	10.67	8.60, 12.74	152.43	5.53
Haraj	Mukstar	Adult Male	3	2	2	3.00	3.00, 3.00	18.75	2.59
		Adult female	2	1	1	2.00	2.00, 2.00	12.50	1.73
		Total adult	5	3	3	5.00	5.00, 5.00	31.25	4.31
		Young male	2	2	2	2.00	2.00, 2.00	12.50	1.73
		Young female	1	1	1	1.00	1.00, 1.00	6.25	0.86
		Total young	3	3	3	3.00	3.00, 3.00	18.75	2.59
		Total male	5	4	4	5.00	5.00, 5.00	31.25	4.31
		Total female	3	2	2	3.00	3.00, 3.00	18.75	2.59
		Totalcattle	8	6	6	8.00	8.00, 8.00	50.00	6.90

Name of the village/ward	District	Type of cattle	n1	n2	M	Stray cattle count per village/ward	95% CI	Cattle Population /km ²	No. of cattle per thousand adult human population
Nabipur	Tarn Taran	Adult Male	4	3	3	4.00	4.00, 4.00	33.33	4.00
		Adult female	2	1	1	2.00	2.00, 2.00	16.67	2.00
		Total adult	6	4	4	6.00	6.00, 6.00	50.00	6.01
		Young male	1	1	1	1.00	1.00, 1.00	8.33	1.00
		Young female	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Total young	1	1	1	1.00	1.00, 1.00	8.33	1.00
		Total male	5	4	4	5.00	5.00, 5.00	41.67	5.01
		Total female	2	1	1	2.00	2.00, 2.00	16.67	2.00
		Totalcattle	7	5	5	7.00	7.00, 7.00	58.33	7.01
Kheda	Mohali	Adult Male	3	2	2	3.00	3.00, 3.00	42.86	3.89
		Adult female	1	1	0	3.00	0.22, 5.78	42.86	3.89
		Total adult	4	3	2	5.67	3.60, 7.74	81.00	7.34
		Young male	2	1	1	2.00	2.00, 2.00	28.57	2.59
		Young female	1	1	1	1.00	1.00, 1.00	14.29	1.30
		Total young	3	2	2	3.00	3.00, 3.00	42.86	3.89
		Total male	5	3	3	5.00	5.00, 5.00	71.43	6.48
		Total female	2	2	1	3.50	1.80, 5.20	50.00	4.53
		Totalcattle	7	5	4	8.60	6.67, 10.53	122.86	11.14

Name of the village/ward	District	Type of cattle	n1	n2	M	Stray cattle count per village/ward	95% CI	Cattle Population /km ²	No. of cattle per thousand adult human population
Tut	Firozpur	Adult Male	3	3	1	7.00	2.46, 11.54	43.75	4.23
		Adult female	2	2	1	3.50	1.80, 5.20	21.88	2.11
		Total adult	5	5	2	11.00	5.11, 16.90	68.75	6.64
		Young male	1	0	0	1.00	1.00, 1.00	6.25	0.60
		Young female	1	0	0	1.00	1.00, 1.00	6.25	0.60
		Total young	2	0	0	2.00	-	12.50	1.21
		Total male	4	3	1	9.00	2.79, 15.21	56.25	5.43
		Total female	3	2	1	5.00	2.22, 7.78	31.25	3.02
		Total cattle	7	5	2	15.00	6.21, 23.79	93.75	9.06
Sodhian	Nawanshahr	Adult Male	1	0	0	1.00	1.00, 1.00	16.67	1.32
		Adult female	1	1	0	3.00	0.22, 5.78	50.00	3.97
		Total adult	2	1	0	5.00	0.19, 9.81	83.33	6.62
		Young male	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Young female	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Total young	0	0	0	0.00	-	0.00	0.00
		Total male	1	0	0	1.00	1.00, 1.00	16.67	1.32
		Total female	1	1	0	3.00	0.22, 5.78	50.00	3.97
		Total cattle	2	1	0	5.00	0.19, 9.81	83.33	6.62

Name of the village/ward	District	Type of cattle	n1	n2	M	Stray cattle count per village/ward	95% CI	Cattle Population /km ²	No. of cattle per thousand adult human population
Balachaur ward 4	Nawanshahr	Adult Male	11	8	4	20.60	11.78, 29.42	103.00	19.32
		Adult female	9	11	6	16.14	11.93, 20.35	80.70	15.14
		Total adult	20	19	10	37.18	27.16, 47.21	185.90	34.88
		Young male	4	7	3	9.00	6.22, 11.78	45.00	8.44
		Young female	3	3	2	4.33	3.02, 5.64	21.65	4.06
		Total young	7	10	5	13.67	9.26, 18.07	68.35	12.82
		Total male	15	15	7	31.00	20.52, 41.48	155.00	29.08
		Total female	12	14	8	20.67	15.94, 25.39	103.35	19.39
		Total cattle	27	29	15	51.50	40.31, 62.69	257.50	48.31
Balachaur ward 5	Nawanshahr	Adult Male	4	2	1	6.50	2.69, 10.31	130.00	5.72
		Adult female	5	4	2	9.00	4.61, 13.39	180.00	7.92
		Total adult	9	6	3	16.50	8.70, 24.30	330.00	14.52
		Young male	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Young female	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Total young	0	0	0	0.00	-	0.00	0.00
		Total male	4	2	1	6.50	2.69, 10.31	130.00	5.72
		Total female	5	4	2	9.00	4.61, 13.39	180.00	7.92
		Total cattle	9	6	3	16.50	8.70, 24.30	330.00	14.52

Name of the village/ward	District	Type of cattle	n1	n2	M	Stray cattle count per village/ward	95% CI	Cattle Population /km ²	No. of cattle per thousand adult human population
Bathinda ward 9	Bathinda	Adult Male	12	8	4	22.40	12.58, 32.22	60.54	6.06
		Adult female	8	6	5	9.50	7.80, 11.20	25.68	2.57
		Total adult	20	14	9	30.50	22.70, 38.30	82.43	8.25
		Young male	6	5	4	7.40	5.93, 8.87	20.00	2.00
		Young female	4	2	2	4.00	4.00, 4.00	10.81	1.08
		Total young	10	7	6	11.57	9.40, 13.74	31.27	3.13
		Total male	18	13	8	28.56	20.59, 36.52	77.19	7.73
		Total female	12	8	7	13.63	11.64, 15.61	36.84	3.69
		Total cattle	30	21	15	41.63	34.25, 49.00	112.51	11.27
Bathinda ward 11	Bathinda	Adult Male	14	15	9	23.00	17.97, 28.03	46.94	5.26
		Adult female	9	10	4	21.00	11.78, 30.22	42.86	4.81
		Total adult	23	25	13	43.57	33.65, 53.49	88.92	9.97
		Young male	5	4	3	6.50	4.80, 8.20	13.27	1.49
		Young female	2	3	2	3.00	3.00, 3.00	6.12	0.69
		Total young	7	7	5	9.67	7.29, 12.04	19.73	2.21
		Total male	19	19	12	29.77	24.11, 35.42	60.76	6.81
		Total female	11	13	6	23.00	15.39, 30.61	46.94	5.26
		Total cattle	30	32	18	52.84	43.26, 62.43	107.84	12.09

Name of the village/ward	District	Type of cattle	n1	n2	M	Stray cattle count per village/ward	95% CI	Cattle Population /km ²	No. of cattle per thousand adult human population
Bhagta Bhaika ward 8	Bathinda	Adult Male	3	1	0	7.00	0.19, 13.81	140.00	6.16
		Adult female	0	2	0	2.00	2.00, 2.00	40.00	1.76
		Total adult	3	3	0	15.00	-1.67, 31.67	300.00	13.20
		Young male	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Young female	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Total young	0	0	0	0.00	-	0.00	0.00
		Total male	3	1	0	7.00	0.19, 13.81	140.00	6.16
		Total female	0	2	0	2.00	2.00, 2.00	40.00	1.76
		Total cattle	3	3	0	15.00	-1.67, 31.67	300.00	13.20
Bhagta Bhaika ward 1	Bathinda	Adult Male	6	3	1	13.00	3.51, 22.49	92.86	13.49
		Adult female	5	6	2	13.00	5.65, 20.35	92.86	13.49
		Total adult	11	9	3	29.00	12.33, 45.67	207.14	30.08
		Young male	1	1	1	1.00	1.00, 1.00	7.14	1.04
		Young female	1	1	1	1.00	1.00, 1.00	7.14	1.04
		Total young	2	2	2	2.00	2.00, 2.00	14.29	2.07
		Total male	7	4	2	12.33	5.78, 18.88	88.07	12.79
		Total female	6	7	3	13.00	7.30, 1870	92.86	13.49
		Total cattle	13	11	5	27.00	15.88, 38.12	192.86	28.01

Name of the village/ward	District	Type of cattle	n1	n2	M	Stray cattle count per village/ward	95% CI	Cattle Population /km ²	No. of cattle per thousand adult human population
Zeera ward 15	Firozpur	Adult Male	2	4	1	6.50	2.69, 10.31	38.24	4.45
		Adult female	1	2	0	5.00	0.19, 9.81	29.41	3.42
		Total adult	3	6	1	13.00	3.51, 22.49	76.47	8.90
		Young male	1	0	0	1.00	1.00, 1.00	5.88	0.68
		Young female	1	0	0	1.00	1.00, 1.00	5.88	0.68
		Total young	2	0	0	2.00	-	11.76	1.37
		Total male	3	4	1	9.00	2.79, 15.21	52.94	6.16
		Total female	2	2	0	8.00	0.34, 16.34	47.06	5.48
		Total cattle	5	6	1	20.00	3.56, 36.44	117.65	13.69
Zeera ward 16	Firozpur	Adult Male	18	25	10	43.91	31.35, 56.46	34.04	25.35
		Adult female	10	16	8	19.78	16.00, 23.55	15.33	11.42
		Total adult	28	41	18	63.11	50.87, 75.35	48.92	36.44
		Young male	7	9	4	15.00	9.44, 20.56	11.63	8.66
		Young female	5	3	2	7.00	4.22, 9.78	5.43	4.04
		Total young	12	12	6	23.14	14.11, 32.17	17.94	13.36
		Total male	25	34	14	59.67	45.01, 74.32	46.26	34.45
		Total female	15	19	10	28.09	21.90, 34.28	21.78	16.22
		Total cattle	40	53	24	87.56	71.94, 103.18	67.88	50.55

Name of the village/ward	District	Type of cattle	n1	n2	M	Stray cattle count per village/ward	95% CI	Cattle Population /km ²	No. of cattle per thousand adult human population
Ludhiana ward 62	Ludhiana	Adult Male	2	2	1	3.50	1.80, 5.20	7.45	0.55
		Adult female	1	0	1	0.00	0.00, 0.00	0.00	0.00
		Total adult	3	2	2	3.00	3.00, 3.00	6.38	0.47
		Young male	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Young female	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Total young	0	0	0	0.00	-	0.00	0.00
		Total male	2	2	1	3.50	1.80, 5.20	7.45	0.55
		Total female	1	0	1	0.00	0.00, 0.00	0.00	0.00
		Total cattle	3	2	2	3.00	3.00, 3.00	6.38	0.47
Ludhiana ward 63	Ludhiana	Adult Male	3	1	1	3.00	3.00, 3.00	2.48	0.19
		Adult female	1	2	1	2.00	2.00, 2.00	1.65	0.12
		Total adult	4	3	2	5.67	3.60, 7.74	4.69	0.35
		Young male	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Young female	0	0	0	0.00	0.00, 0.00	0.00	0.00
		Total young	0	0	0	0.00	-	0.00	0.00
		Total male	3	1	1	3.00	3.00, 3.00	2.48	0.19
		Total female	1	2	1	2.00	2.00, 2.00	1.65	0.12
		Total cattle	4	3	2	5.67	3.60, 7.74	4.69	0.35

4.3.2 Stray cattle count in Punjab (India)

The detailed information on the number of stray cattle in Punjab is presented in Table 13. Based on the number stray cattle per village/ward, we estimated that there are a median of 679071 (95% CI: 27316, 1932466) stray cattle in Punjab, comprising of 580100 (95% CI: 5781, 1782375) cattle in the rural and 87211 (95% CI: 7830, 217161) stray cattle residing in the urban areas (Fig. 16). The male to female ratio was estimated to 1.56:1 (minimum 0.08:1 and maximum 38.68:1) among the stray cattle (Fig. 16). The young to adult stray cattle ratio were estimated to be 1:4.5 (minimum 1:0.18 and maximum 1:148). The results indicate that there are 28 stray cattle per 100 domestic cattle in the state.

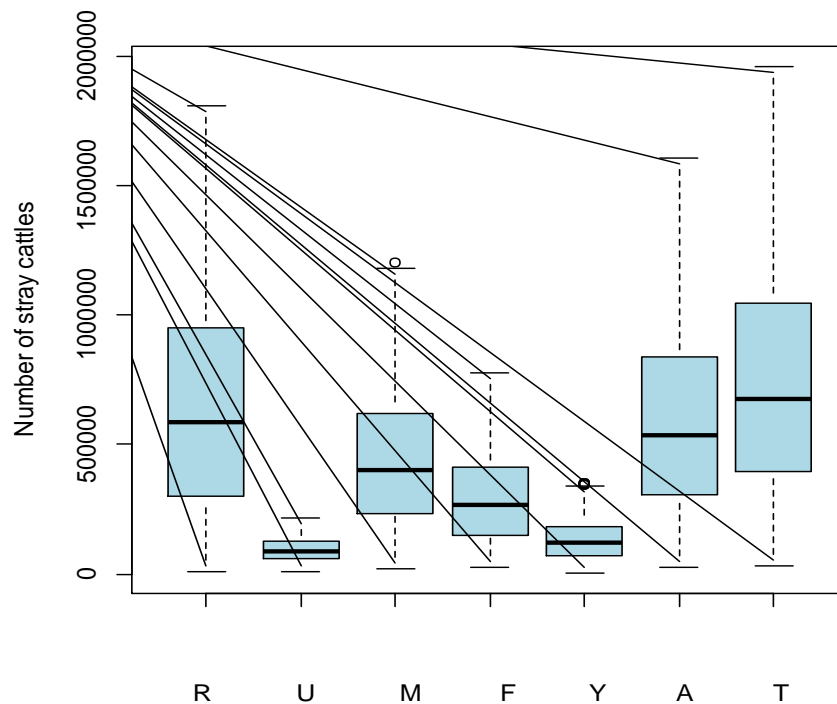


Fig. 16: Stray cattle count based on the number of villages and wards in the Punjab state of India. R: stray cattle in rural areas; U: stray cattle in urban areas. M: Male stray cattle; F: Female stray cattle; Y: Young stray cattle; A: Adult stray cattle; and T: Total stray cattle.

Based on the adult human population, we estimated that there are a median of 354858 (95% CI: 36968, 884577) stray cattle in Punjab, comprising of 194000 (95% CI: 2212, 551233) cattle in the rural and 141649 (95% CI: 3596, 364555) stray cattle residing in the urban areas (Fig. 17). The results indicate that there are 15 stray cattle per 100 domestic cattle in the state, based on adult human population estimation.

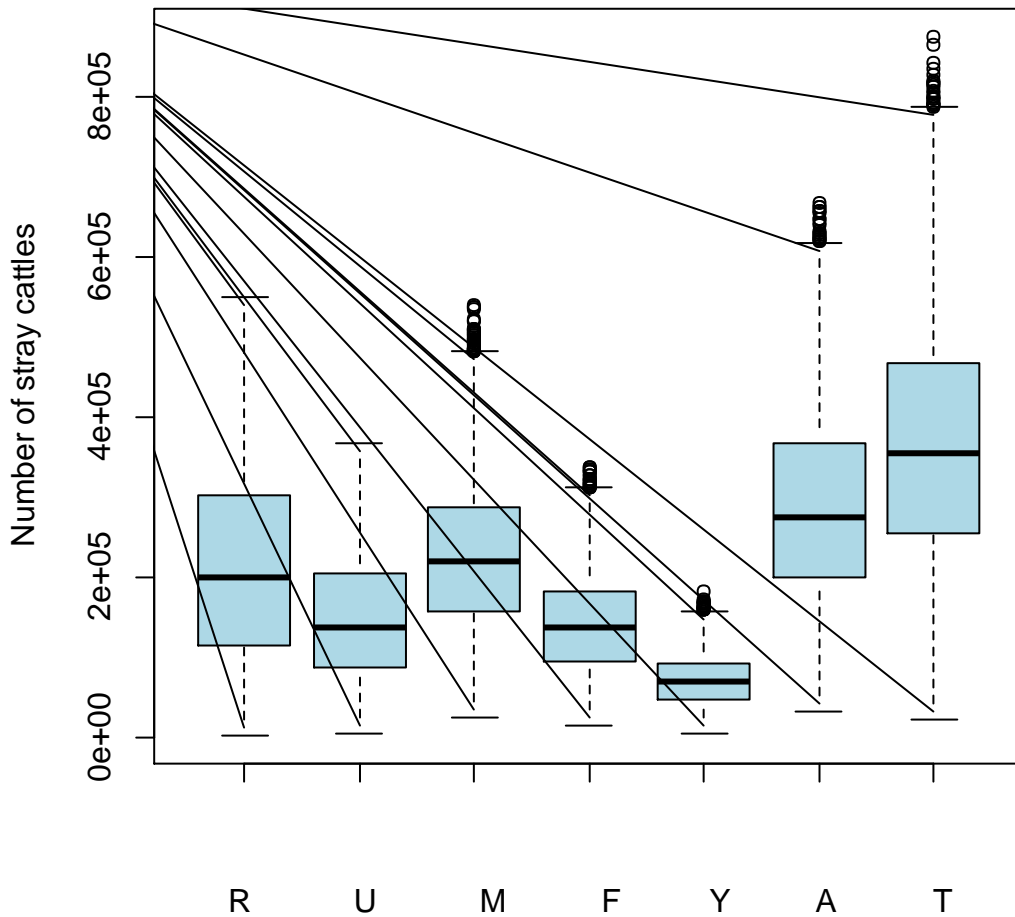


Fig. 17: Stray cattle count based on the adult human population residing in different villages and wards in the Punjab state of India. R: stray cattle in rural areas. U: stray cattle in urban areas, M: Male stray cattle; F: Female stray cattle; Y: Young stray cattle; A: Adult stray cattle; and T: Total stray cattle.

Based on the number of stray cattle per built-up area, we estimated that there are a median of 435042 (95% CI: 45402, 983987) stray cattle in Punjab, comprising of 263073 (95% CI: 4531, 660442) cattle in the rural and 158607 (95% CI: 8343, 374464) stray cattle residing in the urban areas (Fig. 18). As per our estimate, there are 18 stray cattle per 100 livestock cattle in Punjab state.

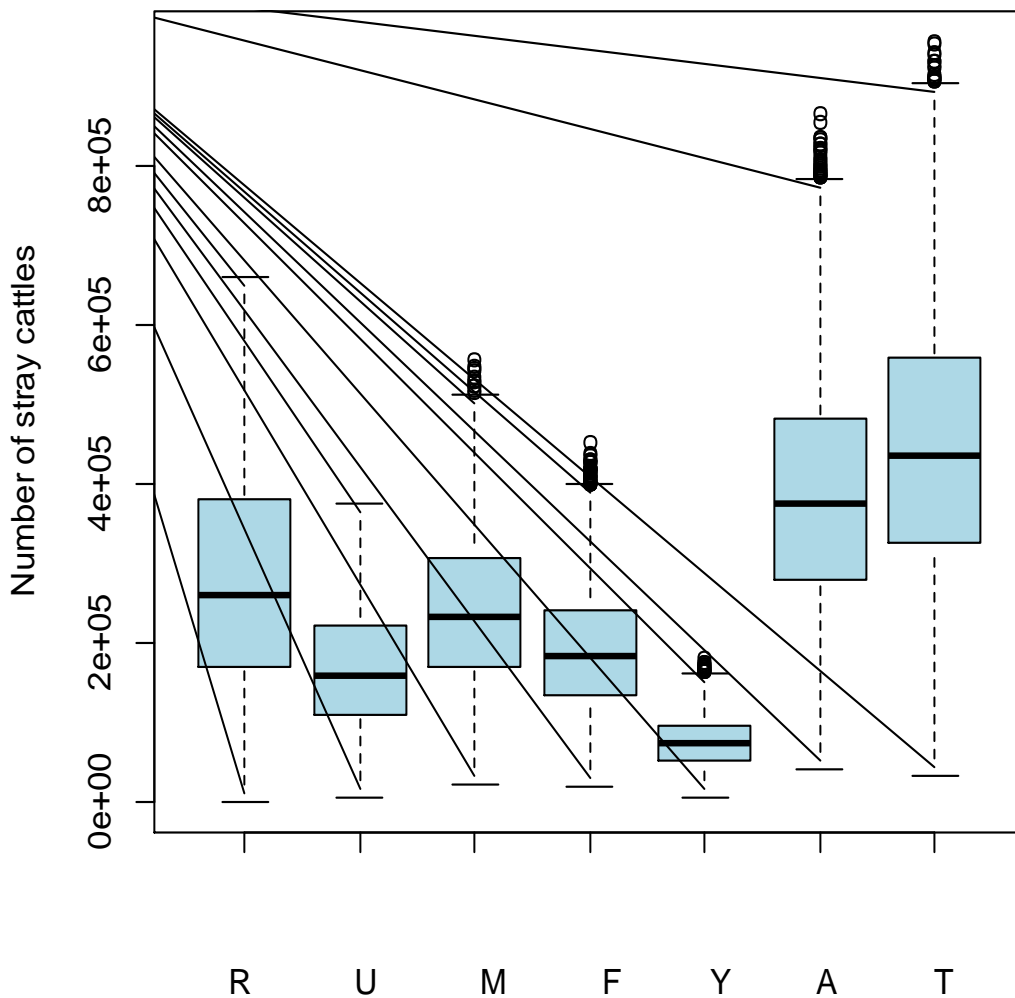


Fig. 18: Stray cattle count based on the rural and urban built-up area in the Punjab state of India. R: stray cattle in rural areas; U: stray cattle in urban areas. M: Male stray cattle; F: Female stray cattle; Y: Young stray cattle; A: Adult stray cattle; and T: Total stray cattle.

Table 13: Estimated number of stray cattle in Punjab state of India

Area	Number of Villages/ Wards	Total cattle population [(95% confidence interval (CI)]	Male cattle (95% CI)	Female cattle (95% CI)	Ratio Male/female cattle (95% CI)	Adult (95% CI) cattle	Young cattle (95% CI)	Ratio Adult/young cattle (95% CI)
Based on the number of Village(s) /ward(s)								
Rural	12581	580100 (5781-1782375)	345287 (2937-1077798)	225068 (552-726945)	1.528 (0.0114-509.79)	463464 (3474-1469838)	98723 (901-307596)	4.759 (0.0417-819.90)
Urban	2496	87211 (7830-217161)	56129 (8224-147842)	33454 (7735-69746)	0.251 (0.013-111.94)	70233 (8693-156229)	18979 (229-57018)	3.7577 (0.2491-325.65)
Total	15077	679071 (27316-1932466)	405507 (31144-1202324)	260358 (19650-772822)	1.569 (0.08318-38.68)	535539 (30557-1603542)	120625 (5359-337957)	4.505 (0.182-148.04)
Based on the adult human population								
Rural	12201170	194000 (2212-551233)	114703 (2180-331617)	74681 (941- 223423)	1.54 (0.0173-205.5)	157418 (1919-455881)	32213 (222-95448)	4.89 (0.0381-623.74)
Urban	7315518	141649 (3596-364555)	92599 (2706-250328)	54430 (693-141321)	1.690 (0.03169-261.80)	106459 (4021-265770)	30298 (185-96641)	3.486 (0.0662-340.51)
Total	19516688	354858 (36968-884577)	219516 (17044-540421)	136465 (10836-343882)	1.60 (0.0846-36.85)	275005 (23643-665024)	68198 (5805-170764)	4.13 (0.229-69.34)
Based on the residential (built-up) area								
Rural	1857.24	263073 (4531-660442)	146143 (1365-394171)	96305 (415-268529)	1.54 (0.016-331.07)	212080 (2069-546498)	42823 (177-115327)	4.93 (0.104-812.89)
Urban	1139.39	158607 (8343-374464)	83652 (4163-174643)	80930 (973-204699)	1.014 (0.031-107.48)	149060 (6366-373429)	28137 (544-76844)	5.32 (0.15-393.05)
Total	2996.63	435042 (45402-983987)	237067 (14272-543084)	184835 (15698 – 442806)	1.27 (0.099-1.909)	377618 (36985-863191)	75134 (7271-181363)	5.06 (0.33-59.61)
Based on the livestock (cattle, buffalo) population								
Total	7205110	305700 (25623-899139)	133652 (13247-372856)	161776 (2234-516620)	0.82677 (0.03385-67.66443)	231964 (25769-651703)	71773 (270-235036)	3.22 (0.154-813.3)

4.3.3 Sensitivity analysis

The median stray cattle count of 425409 (95% CI: 44350, 965673) were estimated for the urban areas after excluding the industrial area from urban built-up area.

4.3.4 Abnormalities detected in stray cattle

During the stray cattle count, we estimated gross health abnormalities in 8.54% (30/351) of the cattle residing in rural areas. We recorded wound in 3.13% (11/351), fractures in 1.42% (5/351) and emaciation in 3.98% (14/351). During the stray cattle count, we estimated gross health abnormalities in 9.71% (31/319) of the cattle residing in the urban areas. We recorded wound in 2.19% (7/319), fractures in 0.94% (3/319), and emaciation in 6.58% (21/319) of the stray cattle residing in the urban areas.

As far as we are aware, this is a first systematic estimation of stray cattle population in the Punjab state of India. The 2012 official data reported 100,991 stray cattle in Punjab state of India (DAHP 2012); however the methods used for these estimates remain unknown. It is worth mentioning that these cattle are in addition to the cattle living in cow sanctuaries (Gaushala).

Control of stray cattle population has emerged as a serious challenge for India. Presence of stray cattle have been associated with multiple problems such as road accidents, risk of zoonotic diseases, crop destruction, injuries due to aggressive behaviour of male cattle, compromised biosecurity of dairy farms, and environmental pollution. Stray animal faeces, urine, fallen carcasses create environmental problems, particularly in the urban areas (Singh *et al* 2013). Lastly, stray cattle are animals living with a compromised animal welfare and need urgent attention.

Stray cattle population is typically a problem of India; therefore no such estimates are available from other countries. Therefore, a mark-resight approach was used for the first time for stray cattle counting. This method has already been used by researchers for wildlife population estimates (Focardi *et al* 2002). The mark re-sight framework is primarily applicable for closed populations (Seber 1970, Cooch and White 2014). The assumption of a closed population was fulfilled by completing

the whole procedure within two days. The assumption of closed population was likely to be valid because a very short period was given for marking and counting events to avoid migration of cattle from one area to another.

As per our estimates, there were 15-28 stray cattle per 100 domestic cattle in the state, which was a serious concern for us, with a sign of unsuccessful management programs towards stray cattle. The national data on stray cattle population remains unavailable, however it has been reported that there are more than 20,000 stray cows in the Indian capital New Delhi (Rathore 2008).

Stray cattle are basically the culled or non-productive cattle with no economic value. We recorded more adult than young stray cattle. It is believed that reproductive problems such as repeat-breeding, infertility are important diseases responsible for straying of cattle. We also recorded more male than females. Non-utility of male cattle and a ban on cow slaughter result in straying of male cattle in Punjab, India.

Our study had a number of limitations. We could not perform a body condition score and characteristics such as breed, animal identification number (ear tags, tattoo, branding) and dehorning status could not be recorded, which would have given us an idea about the number of animals abandoned by the state dairy farmers. In addition, the attitude, practices and perceptions of people towards stray cattle were not estimated, which could have helped for the development of a policy for control of stray cattle. The factors responsible for huge variation in stray cattle population in different village(s)/wards(s) could not be accounted. These approaches need to be refined in future studies.

Our study had a number of strengths. We used a mark re-sight framework, data triangulation and the software based measurements of residential area(s) which improved the accuracy of the results. The 22 villages and 10 wards were purposely selected from the randomly selected sub-districts and cities/towns of Punjab. The probability distribution(s) were applied to account for uncertainty and variability in the data. Sensitivity analyses were also carried out for important input parameters. Overall, we believe that the current estimates genuinely represent the number of stray cattle present in the Punjab state of India.

4.4 Understanding the level of awareness in school students in Punjab (India)

4.4.1 Distribution of participants

We surveyed 313 students comprising of 196 male and 117 female students. Out of these, 226 (72.20%) and 87 (27.8%) students belonged to rural and urban areas. Descriptive frequencies of demographic data are presented in Table 14.

Table 14: Frequency table for demographic variables in a KAP study relating to rabies among school students in Punjab, during 2016-2017

Variable	Category	Frequency	Relative Frequency (%)
Demography			
Gender	Male	196	62.60
	Female	117	37.40
Level of Education	5 th	52	16.60
	8 th	224	71.60
	10 th	37	11.80
House hold size	< 6	150	47.90
	≥ 6	163	52.10
Presence of pet animal (cat/dog) at home	Yes	113	36.10
	No	200	63.90
Presence of dairy animal (cow/ buffalo) at home	Yes	189	60.40
	No	124	39.60
Area of the respondents	Rural	226	72.20
	Urban	87	27.80
District	Pathankot	7	2.2
	Amritsar	11	3.5
	Trantarn	8	2.6
	Gurdaspur	8	2.6
	Jalandhar	10	3.20
	Kapurthala	8	2.60
	Hoshiarpur	12	3.8
	Rupnagar	12	3.8

Variable	Category	Frequency	Relative Frequency (%)
	Mohali	13	4.2
	Nawansher	29	9.3
	Mansa	7	2.2
	Moga	7	2.2
	Ludhiana	28	9.0
	Fazilka	11	3.5
	Firozpur	25	8.0
	Faridkot	10	3.20
	Barnala	11	3.5
	Sangrur	7	2.2
	Patiala	10	3.2
	Fatehgarh sahib	11	3.5
	Bathinda	52	16.60
	Muktsar	16	5.10
Past history			
Have you ever come in contact with a stray dog?	Yes	124	39.60
	No	189	60.40
Have you ever been bitten by a stray dog?	Yes	9	2.90
	No	304	97.10
If Yes, was your parent/guardian reported to the hospital?	Yes	7	77.80
	No	2	22.20

4.4.2 Descriptive analyses of knowledge score, attitude, perception and practices

Overall, 65% of the students had a rabies knowledge score more than 50%. Most of the respondents (84.70%) were aware that rabies is a fatal disease, and can lead to death. Most of the students (91.70%) knew that rabies can be prevented in human beings but 57.20% students did not know that bite wound should be washed with soap and water. Surprisingly, 34.80% students believed that rabies can be prevented using traditional therapeutic approaches. Detailed information on knowledge, attitude, practices and perceptions of school students have been presented in Table 15.

Table 15: Frequency table for knowledge, attitude and practices of school students related to rabies in Punjab, during 2016-2017

Variable	Category	Frequency	Relative Frequency (%)
Knowledge related to rabies			
Do you believe that rabies can be transmitted from animals to humans?	Yes	304	97.1
	No	9	2.9
How rabies can be transmitted from rabid animal to human?			
1. Through bite	Yes	307	98.10
	No	6	1.90
2. Direct contact of fresh wound with infectious saliva	Yes	164	52.40
	No	149	47.60
3. Direct contact of mucosal (eye, nose, mouth) surface with infectious saliva	Yes	188	60.10
	No	125	39.90
4. Direct contact of scratches or abrasions without bleeding with infectious saliva	Yes	83	26.50
	No	230	73.50
Do you know that rabies is a fatal disease?	Yes	265	84.70
	No	48	15.30
Do you know that rabies can be transmitted from one animal to another animal?	Yes	302	96.50
	No	11	3.50

Variable	Category	Frequency	Relative Frequency (%)
Please mention the transmission route of rabies from rabid animal to another animal?			
1. Through bite	Yes	293	93.60
	No	20	6.40
2. Direct contact of fresh wound with infectious saliva	Yes	212	67.70
	No	101	32.30
3. Direct contact of mucosal (eye, nose, mouth) surface with infectious saliva	Yes	165	52.70
	No	148	47.30
4. Direct contact of scratches or abrasions without bleeding with infectious saliva	Yes	105	33.50
	No	208	66.50
Do you know rabies can be prevented in humans?	Yes	269	85.90
	No	44	14.10
Do you know rabies can be prevented in animals?	Yes	147	47
	No	166	53
Do you believe that rabies can be prevented using traditional methods?	Yes	109	34.80
	No	204	65.20
Do you know that rabies can be prevented by post prophylaxis in humans?	Yes	287	91.70
	No	26	8.30
Do you know that rabies can be prevented by post prophylaxis in animals?	Yes	214	68.40
	No	99	31.60
Are you aware that dog bite wound should be washed with soap and water?	Yes	134	42.80
	No	179	57.20
Do you know that suspected animal rabies cases have to be confirmed using laboratory tests? (take brain sample to the laboratory and do laboratory test)	Yes	114	36.40
	No	199	63.60
Do you think clinical rabies can be treated in humans?	Yes	249	79.60
	No	64	20.40
Do you think clinical rabies can be treated in animals?	Yes	176	56.20
	No	137	43.80

Variable	Category	Frequency	Relative Frequency (%)
Attitude related to rabies			
What will you do if you see a suspected rabid stray dog?			
1. Do you kill them?	Yes	123	39.30
	No	190	60.7
2. Do you report to veterinary hospital?	Yes	164	52.40
	No	149	47.60
3. Do you inform to your neighbor?	Yes	24	7.70
	No	289	92.30
4. Do you move away from them?	Yes	64	20.40
	No	249	79.60
What will you do if you see a suspected rabid pet dog?			
1. Do you kill them?	Yes	68	21.70
	No	245	78.30
2. Do you report to veterinary hospital?	Yes	183	58.50
	No	130	41.50
3. Do you inform to your neighbor?	Yes	61	19.50
	No	252	80.50
4. Do you move away from them?	Yes	67	21.40
	No	246	78.60
What will you do if you see a suspected rabid livestock animal?			
1. Do you kill them?	Yes	54	17.30
	No	259	82.70
2. Do you report to veterinary hospital?	Yes	211	67.40
	No	102	32.60
3. Do you inform to your neighbor?	Yes	38	12.10
	No	275	87.90
4. Do you move away from them?	Yes	61	19.50
	No	252	80.50

Variable	Category	Frequency	Relative Frequency (%)
What will you do if you see a suspected rabid stray animal (cow, pig)?			
1. Do you kill them?	Yes	79	25.20
	No	234	74.80
2. Do you report to veterinary hospital?	Yes	144	46.00
	No	169	54.00
3. Do you inform to your neighbor?	Yes	59	18.80
	No	254	81.20
4. Do you move away from them?	Yes	88	28.10
	No	225	71.90
Will you report to the hospital for treatment, if, you are bitten by stray dog?	Yes	306	97.80
	No	7	2.2
Will you report to the hospital for treatment, if, you are bitten by owned dog?	Yes	277	88.50
	No	36	11.5
Will you report to the hospital for treatment, if, you are bitten by stray cat?	Yes	252	80.50
	No	61	19.50
Will you report to the hospital for treatment, if, you are bitten by owned cat?	Yes	224	71.60
	No	89	28.40
Will you report to the hospital for treatment, if, you are scratched by stray dog?	Yes	176	56.20
	No	137	43.80
Will you report to the hospital for treatment, if, you are bitten by wild animal?	Yes	286	91.40
	No	27	8.60
Will you report to the hospital for treatment, if, you are bitten by dog in other country	Yes	250	79.90
	No	63	20.10
Practice(s) related to rabies			
Do you play with stray dogs?	Yes	270	86.30
	No	43	13.70

Variable	Category	Frequency	Relative Frequency (%)
Did your parents/guardians advise you to be careful and not to play with stray dogs?	Yes	299	95.50
	No	14	4.50
Perceptions related to rabies			
Are the stray dogs a problem for your community?	Yes	244	78
	No	69	22
Do you believe it is important to control dog population in Punjab?	Yes	277	88.50
	No	36	11.50
Do you think vaccination of stray dogs will be the most appropriate method to control dog population in Punjab?	Yes	95	30.40
	No	218	69.60
Do you think impounding of stray dogs in dog shelters will be the most appropriate method to control dog population in Punjab?	Yes	166	53.00
	No	147	47.00
Do you think sterilization of stray dogs by operation will be the most appropriate method to control dog population in Punjab?	Yes	68	21.70
	No	245	78.30
Do you think killing of stray dogs will be the most appropriate method to control dog population in Punjab?	Yes	20	6.40
	No	293	93.60

4.4.3 Univariable analyses

The unconditional association between each demographic variable (explanatory variables) and linear outcome variable (knowledge score) was determined using univariable linear regression analyses. The results of univariable linear regression analysis are presented in Table 16. The age, presence of dairy animals in the house, gender and the level of education were significantly associated with the knowledge score (Table 16). The house-hold size, district, presence of pet animal(s) at home, and the rural or urban location had no significant association with the knowledge score (Table 16).

Table 16: Univariable linear regression analysis demonstrating the influence of explanatory variables (demography) on the outcome variable in school students in Punjab, during 2016-2017

Variable	St. β	P-value	Adjusted R^2	Overall p value
Dependent variable: knowledge score				
Age	0.33	< 0.001	0.044	< 0.001
Presence of dairy animals	0.748	0.0049	0.022	0.0049
District (referent group Amritsar)				
Barnala	-1.272	0.195	0.0096	0.301
Bathinda	-0.973	0.202		
Faridkot	0.245	0.807		
Fatehgarh	0.818	0.404		
Fazilka	-0.363	0.711		
Firozpur	-1.734	0.037		
Gurdaspur	0.295	0.782		
Hoshiarpur	0.128	0.893		
Jalandhar	-1.354	0.178		
Kapurthala	-0.329	0.758		
Ludhiana	-1.133	0.167		
Mansa	-1.740	0.118		
Moga	-0.883	0.427		
Mohali	-1.146	0.224		
Mukatsar	-0.579	0.52		
Nawansheher	-1.247	0.126		
Pathankot	-0.025	0.981		
Patiala	-0.454	0.651		
Ropar	-1.204	0.210		
Sangrur	-1.168	0.294		
Taran taran	-0.329	0.758		
House hold size (referent group:< 6 members)				
Equal/more than 6 members	-0.1305	0.618	-0.0024	0.618
Presence of pet animal at home	0.444	0.102	0.00536	0.102
Gender (male)	0.675	0.0121	0.016	0.0120
Education (referent group : 5 th class)				
8 th class	0.969	0.0062	0.021	0.013
10 th class	1.219	0.013		
Type of area (Rural)	0.527	0.070	0.0073	0.070

4.4.4 Multivariable analyses

The results of multivariable analysis are presented in Table 17. Increase in age, presence of dairy animal in the house and gender were the significant parameters found associated with the rabies knowledge (Table 17). However, only 9% of the variation in the knowledge score was explained by this model, indicating need to further refine this model.

Table 17: Multivariable linear regression analysis demonstrating the influence of explanatory variables on the outcome variable in school students in Punjab, during 2016-2017

Variable	St. β	P-value	Adjusted R^2	Overall p value
Dependent variable: Knowledge score			0.09	<0.001
Age	0.28	<0.001		
Gender (referent: female)	0.91	<0.001		
Presence of dairy animal in house	0.93	<0.001		

We assessed the knowledge, attitude, practices and level of understanding of the school students about rabies in Punjab. We targeted grade 6th -10th school students, one of the most vulnerable age group for rabies. In the current study, 98.10% students knew that rabies can be transmitted through bite of a rabid animal to humans indicating that students had a good baseline level of rabies knowledge; however key gaps were identified regarding other route(s) of rabies transmission and prevention methods. Similar findings have also been reported from studies carried out in other parts of the country (Sancheti and Mangulikar 2016). Globally a study conducted by Nilsson (2014) in Malwai reported that 75.0% students know that rabies can be transmitted through dog bite.

We found that students had little knowledge about the correct prevention methods for rabies; over 34.0% students believed that rabies can be prevented by use of traditional healing methods. Similarly, only 42.8% students were aware that dog bite wound should be washed with soap and water. However in current study it was find out that students know very well that rabies can be prevented by using post-prophylaxis, which was in correlation to the published literature (Nilsson 2014, Sancheti and Mangulikar 2016 and Singh *et al* 2018).

In the current study, 2.9% student population has a history of being bitten by a stray dog. However, only 77.80% parents/guardians of the children bitten by a dog reported to hospital for the treatment. This might be due to low awareness in parents about rabies in India. Therefore, there is a need to educate the students along with their parents so as to reduce the risk of rabies in India. Further, more than 86.30% students informed that they play with stray dogs, even against their parent's advice (95.50%). According to Spiegel (2000), children love dogs and often feel very emotionally attached with dogs (Vizek Vidović *et al* 1999). Children are considered to be most venerable group for rabies as they often spend more time with the animals than adults (Depani *et al* 2012 and Mallewa *et al* 2007). We recommend educating the children at the school, to change their practices and attitudes towards free-roaming dogs.

The level of education was found to be significantly associated with their rabies knowledge. Presence of dairy animal at home significantly affected the knowledge score; this might be due to certain farm practices or parents contribution in their knowledge. Previous studies report that a health education intervention could significantly improve the knowledge of school students about rabies (Kanda *et al* 2014, Nilsson 2014, Sancheti and Mangulikar 2016, Auplish *et al* 2017 and Hossain 2017). We recommend educating school students on prevention and control measures on important zoonotic diseases such as rabies in India.

4.5 Understanding the level of awareness in animal owners in Punjab (India)

4.5.1 Descriptive analysis

The information was collected from 336 animal owners, consisting of 175 (52.08%) pet and 161 (47.91%) livestock (cow, buffalo) owners. There were 178 male and 158 female respondents; 234 resided in rural and 102 in the urban areas. Detailed information about household size, age, district and the level of education of pet and dairy animal owners have been presented in Tables 18 and 19. The median 80% (16/20) knowledge score of livestock owners was higher than 70% (14/20) score of pet owners. It was found that more than 95% of the dairy animal and pet owners were aware that rabies can be transmitted from animal to humans. More than 99% of the respondents were also aware that rabies can be transmitted by bite of an infected

animal. Sixty percent of the respondents knew that rabies can be prevented through post-prophylaxis in both animals and humans. However, 19.9% (31/130) dairy animal owners and 21.7% (38/137) pet owners believed that rabies can be prevented by traditional therapeutic methods and less than 50% of the respondents were aware that bite wound should be washed with soap and water. Detailed information on the knowledge, attitude, practices and perceptions of the respondents has been presented in Tables 20 and 21.

Table 18: Frequency table for demographic variables in a KAP study relating to rabies among diary animal owners in Punjab during 2016-2017

Variable	Category	Frequency	Relative Frequency (%)
Age (Years)	Less than 25	44	27.30
	25-37	30	18.60
	37-51	47	29.20
	More than 51	40	24.80
Gender	Male	126	78.30
	Female	35	21.70
Level of Education	Illiterate	35	21.70
	5 th	28	17.40
	8 th	17	10.60
	10 th	26	16.1
	12 th	29	18
	Graduate/Under graduate	26	16.1
Members in the household	Less or equal to 5	75	46.60
	More than 5	86	53.40
Presence of pet (cat/dog) animal at home	Yes	59	36.60
	No	102	63.40
Area of the respondents	Rural	150	93.20
	Urban	11	6.80
District	Pathankot	4	2.5
	Amritsar	6	3.7
	Trantarn	7	4.3

Variable	Category	Frequency	Relative Frequency (%)
	Gurdaspur	5	3.1
	Jalandhar	9	5.6
	Kapurthala	6	3.7
	Hoshiarpur	5	3.1
	Rupnagar	8	5.0
	Mohali	4	2.5
	Nawansher	8	5.0
	Mansa	8	5.0
	Moga	7	4.3
	Ludhiana	8	5.0
	Fazilka	6	3.7
	Firozpur	7	4.3
	Faridkot	9	5.60
	Barnala	7	4.3
	Sangrur	8	5.0
	Patiala	11	6.8
	Fatehgarh sahib	6	3.7
	Bathinda	17	10.60
	Muktsar	5	3.1

Table 19: Frequency table for demographic variables in a KAP study relating to rabies among pet owners in Punjab during 2016-2017

Variable	Category	Frequency	Relative Frequency (%)
Age (Years)	Less than 25	42	24
	25-37	48	27.4
	37-51	45	25.7
	More than 51	40	22.9
Gender	Male	52	29.7
	Female	123	70.3
Level of Education	Illiterate	17	9.7

Variable	Category	Frequency	Relative Frequency (%)
	5 th	27	15.4
	8 th	7	4
	10 th	23	13.1
	12 th	24	13.7
	Graduate/Under graduate	77	44
Members in the household	Less or equal to 5	124	70.9
	More than 5	51	29.1
Area of the respondents	Rural	84	48
	Urban	91	52
District	Pathankot	2	1.1
	Amritsar	5	2.9
	Trantarn	2	1.1
	Gurdaspur	4	2.3
	Jalandhar	4	2.3
	Kapurthala	4	2.3
	Hoshiarpur	4	2.3
	Rupnagar	4	2.3
	Mohali	5	2.9
	Nawansher	28	16
	Mansa	4	2.3
	Moga	5	2.9
	Ludhiana	25	14.3
	Fazilka	2	1.1
	Firozpur	20	11.4
	Faridkot	6	3.4
	Barnala	4	2.3
	Sangrur	1	0.6
	Patiala	5	2.9
	Fatehgarh sahib	7	4
Bathinda	32	18.3	
Muktsar	2	1.1	

Table 20: Frequency table for knowledge, attitude and practices of dairy animal owners related to rabies in Punjab during 2016-2017

Variable	Category	Frequency	Relative Frequency (%)
Knowledge related to rabies			
Do you believe that rabies can be transmitted from animals to humans?	Yes	157	97.5
	No	4	2.5
How rabies can be transmitted from rabid animal to human?			
1. Through bite	Yes	160	99.40
	No	1	0.6
2. Direct contact of fresh wound with infectious saliva	Yes	138	85.70
	No	23	14.30
3. Direct contact of mucosal (eye, nose, mouth) surface with infectious saliva	Yes	110	68.30
	No	51	31.70
4. Direct contact of scratches or abrasions without bleeding with infectious saliva	Yes	70	43.50
	No	91	56.50
Do you know that rabies is a fatal disease?	Yes	155	96.30
	No	6	3.7
Do you know that rabies can be transmitted from one animal to another animal?	Yes	161	100
	No	0	0
Please mention the transmission route of rabies from rabid animal to another animal?			
1. Through bite	Yes	158	98.1
	No	3	1.9
2. Direct contact of fresh wound with infectious saliva	Yes	144	89.40
	No	17	10.60
3. Direct contact of mucosal (eye, nose, mouth) surface with infectious saliva	Yes	102	63.40
	No	59	36.60
4. Direct contact of scratches or abrasions without bleeding with infectious saliva	Yes	90	55.90
	No	71	44.10

Variable	Category	Frequency	Relative Frequency (%)
Do you know rabies can be prevented in humans?	Yes	152	94.40
	No	9	5.60
Do you know rabies can be prevented in animals?	Yes	136	84.50
	No	25	15.50
Do you believe that rabies can be prevented using traditional methods?	Yes	31	19.30
	No	130	80.70
Do you know that rabies can be prevented by post prophylaxis in humans?	Yes	153	95
	No	8	5
Do you know that rabies can be prevented by post prophylaxis in animals?	Yes	127	78.9
	No	34	21.10
Are you aware that dog bite wound should be washed with soap and water?	Yes	83	51.60
	No	78	48.40
Do you know that suspected animal rabies cases have to be confirmed using laboratory tests? (take brain sample to the laboratory and do laboratory test)	Yes	74	46
	No	87	54
Do you think clinical rabies can be treated in humans?	Yes	87	54
	No	74	46.00
Do you think clinical rabies can be treated in animals?	Yes	66	41
	No	95	59.0
Attitude related to rabies			
What will you do if you see a suspected rabid stray dog?			
1. Do you kill them?	Yes	104	64.60
	No	57	35.40
2. Do you report to veterinary hospital?	Yes	37	23
	No	124	77
3. Do you inform to your neighbor?	Yes	16	9.90
	No	145	90.10
4. Do you move away from them?	Yes	27	16.80
	No	134	83.20

Variable	Category	Frequency	Relative Frequency (%)
What will you do if you see a suspected rabid pet dog?			
1. Do you kill them?	Yes	84	52.20
	No	77	47.80
2. Do you report to veterinary hospital?	Yes	69	42.90
	No	92	57.10
3. Do you inform to your neighbor?	Yes	12	7.50
	No	149	92.50
4. Do you move away from them?	Yes	9	5.60
	No	152	94.40
What will you do if you see a suspected rabid livestock animal?			
1. Do you kill them?	Yes	52	32.30
	No	109	67.70
2. Do you report to veterinary hospital?	Yes	100	62.10
	No	61	37.90
3. Do you inform to your neighbor?	Yes	10	6.20
	No	151	93.80
5. Do you move away from them?	Yes	10	6.20
	No	151	93.80
What will you do if you see a suspected rabid stray animal (cow, pig)?			
1. Do you kill them?	Yes	72	44.70
	No	89	55.30
2. Do you report to veterinary hospital?	Yes	69	42.90
	No	92	57.10
3. Do you inform to your neighbor?	Yes	14	8.70
	No	147	91.30
4. Do you move away from them?	Yes	16	9.90
	No	145	90.10
Will you report to veterinary hospital for treatment, if, your animal is bitten by stray dog?	Yes	157	97.50
	No	4	2.50

Variable	Category	Frequency	Relative Frequency (%)
Will you report to veterinary hospital for treatment, if, your animal is bitten by owned dog?	Yes	132	82
	No	29	18
Will you report to veterinary hospital for treatment, if, your animal is bitten by stray cat?	Yes	135	83.90
	No	26	16.10
Will you report to veterinary hospital for treatment, if, your animal is bitten by owned cat?	Yes	107	66.50
	No	54	33.50
Will you report to veterinary hospital for treatment, if, your animal is scratched by stray dog?	Yes	101	62.70
	No	60	37.30
Will you report to veterinary hospital for treatment, if, your animal is bitten by wild animal?	Yes	149	92.50
	No	12	7.5
Practices related to rabies			
Do you protect your livestock from contact with stray dogs?	Yes	106	65.80
	No	55	34.20
Perceptions related to rabies			
Are the stray dogs a problem for your community?	Yes	140	87
	No	21	13
Do you believe it is important to control dog population in Punjab?	Yes	154	95.70
	No	7	4.30
Do you think vaccination of stray dogs will be the most appropriate method to control dog population in Punjab?	Yes	28	17.40
	No	133	82.60
Do you think impounding of stray dogs in dog shelters will be the most appropriate method to control dog population in Punjab?	Yes	37	23
	No	124	77.00
Do you think sterilization of stray dogs by operation will be the most appropriate method to control dog population in Punjab?	Yes	49	30.40
	No	112	69.60
Do you think killing of stray dogs will be the most appropriate method to control dog population in Punjab?	Yes	62	38.50
	No	99	61.50

Table 21: Frequency table for knowledge, attitude and practices of pet owners related to rabies in Punjab during 2016-2017

Variable	Category	Frequency	Relative Frequency (%)
Knowledge related to rabies			
Do you believe that rabies can be transmitted from animals to humans?	Yes	171	97.7
	No	4	2.3
How rabies can be transmitted from rabid animal to human?			
1. Through bite	Yes	175	100
	No	0	0
2. Direct contact of fresh wound with infectious saliva	Yes	125	71.4
	No	50	28.6
3. Direct contact of mucosal (eye, nose, mouth) surface with infectious saliva	Yes	112	64
	No	63	36
4. Direct contact of scratches or abrasions without bleeding with infectious saliva	Yes	64	36.6
	No	111	63.4
Do you know that rabies is a fatal disease?	Yes	156	89.1
	No	19	10.9
Do you know that rabies can be transmitted from one animal to another animal?	Yes	165	94.3
	No	10	5.7
Please mention the transmission route of rabies from rabid animal to another animal?			
5. Through bite	Yes	172	98.3
	No	3	1.7
6. Direct contact of fresh wound with infectious saliva	Yes	140	80
	No	35	20
7. Direct contact of mucosal (eye, nose, mouth) surface with infectious saliva	Yes	101	57.7
	No	74	42.3
8. Direct contact of scratches or abrasions without bleeding with infectious saliva	Yes	71	40.6
	No	104	59.4
Do you know rabies can be prevented in humans?	Yes	158	90.3
	No	17	9.7

Variable	Category	Frequency	Relative Frequency (%)
Do you know rabies can be prevented in animals?	Yes	136	77.7
	No	39	22.3
Do you believe that rabies can be prevented using traditional methods?	Yes	38	21.7
	No	137	78.3
Do you know that rabies can be prevented by post prophylaxis in humans?	Yes	137	78.3
	No	38	21.7
Do you know that rabies can be prevented by post prophylaxis in animals?	Yes	105	60
	No	70	40
Are you aware that dog bite wound should be washed with soap and water?	Yes	92	52.6
	No	83	47.4
Do you know that suspected animal rabies cases have to be confirmed using laboratory tests? (take brain sample to the laboratory and do laboratory test)	Yes	78	44.6
	No	97	55.4
Do you think clinical rabies can be treated in humans?	Yes	71	40.6
	No	104	69.4
Do you think clinical rabies can be treated in animals?	Yes	53	30.3
	No	122	69.7
Attitude related to rabies			
What will you do if you see a suspected rabid stray dog?			
1. Do you kill them?	Yes	72	41.1
	No	103	58.9
2. Do you report to veterinary hospital?	Yes	75	42.9
	No	100	57.1
3. Do you inform to your neighbor?	Yes	13	7.4
	No	162	92.6
4. Do you move away from them?	Yes	22	12.6
	No	153	87.4

Variable	Category	Frequency	Relative Frequency (%)
What will you do if you see a suspected rabid pet dog?			
1. Do you kill them?	Yes	55	31.4
	No	120	68.6
2. Do you report to veterinary hospital?	Yes	98	56.0
	No	77	44.00
3. Do you inform to your neighbor?	Yes	18	10.30
	No	157	89.70
4. Do you move away from them?	Yes	18	10.3
	No	157	89.7
What will you do if you see a suspected rabid livestock animal?			
5. Do you kill them?	Yes	55	31.40
	No	120	68.60
1. Do you report to veterinary hospital?	Yes	108	61.70
	No	67	38.30
1. Do you inform to your neighbor?	Yes	11	6.30
	No	164	93.70
2. Do you move away from them?	Yes	18	10.30
	No	157	89.7
What will you do if you see a suspected rabid stray animal (cow, pig)?			
1. Do you kill them?	Yes	66	37.70
	No	109	62.30
2. Do you report to veterinary hospital?	Yes	73	41.70
	No	102	58.30
3. Do you inform to your neighbor?	Yes	21	12.00
	No	154	88.00
4. Do you move away from them?	Yes	28	16.00
	No	147	84.00
Will you report to the veterinary hospital for treatment, if, your animal/pet is bitten by stray dog?	Yes	172	98.30
	No	3	1.7

Variable	Category	Frequency	Relative Frequency (%)
Will you report to the veterinary hospital for treatment, if, your animal/pet is bitten by owned dog?	Yes	157	89.7
	No	18	10.3
Will you report to the veterinary hospital for treatment, if, your animal/pet is bitten by stray cat?	Yes	150	85.70
	No	25	14.3
Will you report to the veterinary hospital for treatment, if, your animal/pet is bitten by owned cat?	Yes	128	73.3
	No	47	26.90
Will you report to the veterinary hospital for treatment, if, your animal/pet is scratched by stray dog?	Yes	114	65.10
	No	61	34.90
Will you report to the veterinary hospital for treatment, if, your animal/pet is bitten by wild animal?	Yes	152	86.90
	No	23	13.10
Practices related to rabies			
Is your dog vaccinated against rabies? (during last year or this year)	Yes	127	72.6
	No	48	27.4
Are the stray dogs a problem for your community?	Yes	140	80
	No	35	20
Do you believe it is important to control dog population in Punjab?	Yes	150	85.70
	No	25	14.30
Do you think vaccination of stray dogs will be the most appropriate method to control dog population in Punjab?	Yes	45	25.70
	No	130	74.30
Do you think impounding of stray dogs in dog shelters will be the most appropriate method to control dog population in Punjab?	Yes	42	24
	No	133	76.60
Do you think sterilization of stray dogs by operation will be the most appropriate method to control dog population in Punjab?	Yes	47	26.9
	No	128	73.1
Do you think killing of stray dogs will be the most appropriate method to control dog population in Punjab?	Yes	60	34.30
	No	115	65.70

4.5.2 Univariable analysis

For livestock owners, the variables age, gender, and the level of education were found significantly associated with the knowledge score ($p < 0.05$). For pet owners, age and the level of education were found to be significantly associated with the knowledge score ($p < 0.05$). Results of univariable linear regression for livestock and pet owners are presented in Tables 22 and 23.

Table 22: Univariable linear regression analysis demonstrating the influence of explanatory variables (demography) on the outcome variable (Knowledge Score) in dairy animal owners in Punjab during 2016-2017

Variable	St. β	P-value	Adjusted R^2	Overall p value
Dependent variable: knowledge score				
Age (referent group: Less than 25)				
25—37	1.037	0.110	0.072	0.002
37-51	1.68	0.0037		
More than 51	2.20	0.0003		
District (referent group Amritsar)				
Barnala	0.881	0.575	0.0079	0.39
Bathinda	-0.656	0.6250		
Faridkot	0.611	0.682		
Fatehgarh	-0.833	0.610		
Fazilka	-0.33	0.838		
Nawansheher	-1.208	0.429		
Firozpur	-0.547	0.727		
Gurdaspur	0.433	0.800		
Hoshiarpur	-2.833	0.099		
Jalandhar	0.72	0.628		
Kapurthala	-2.16	0.186		
Ludhiana	-0.33	0.827		

Variable	St. β	P-value	Adjusted R²	Overall p value
Mansa	0.166	0.913		
Moga	-2.40	0.128		
Mohali	0.166	0.927		
Mukatsar	0.766	0.654		
Pathankot	-0.33	0.855		
Patiala	0.803	0.576		
Ropar	-0.458	0.764		
Sangrur	1.541	0.313		
Taran Taran	-1.26	0.423		
Family size (referent group: less than equal to 5 members)				
more than 5 members	-0.13	0.764	-0.0057	0.7644
Presence of pet animal at home	-0.565	0.224	0.0030	0.2235
Gender	2.061	0.000105	0.084	0.000105
Education (reference group : illiterate)				
5 th class	-0.40	0.554	0.0878	0.0016
8 th class	1.158	0.150		
10 th class	1.51	0.032		
12 th class	0.559	0.411		
Graduate/undergraduate	-1.486	0.035		
Type of area	0.957	0.281	0.001	0.281

Table 23: Univariable linear regression analysis demonstrating the influence of explanatory variables on the outcome variable (knowledge score) in pet owners in Punjab, India during 2016-2017

Variable	St. β	P-value	Adjusted R ²	Overall p value
Dependent variable: knowledge score				
Age (Referent group: Less than 25)				
25—37	0.193	0.765	0.1541	<0.001
37-51	0.003	0.996		
More than 51	3.305	<0.001		
District (referent: Amritsar)				
Barnala	4.600	0.040	0.0083	0.386
Bathinda	1.037	0.515		
Faridkot	1.266	0.528		
Fatehgarh	1.600	0.410		
Fazilka	2.100	0.449		
Nawansheher	0.671	0.67		
Firozpur	0.400	0.809		
Gurdaspur	1.100	0.621		
Hoshiarpur	-1.900	0.393		
Jalandhar	4.100	0.066		
Kapurthala	0.600	0.787		
Ludhiana	0.7600	0.640		
Mansa	1.850	0.406		
Moga	0.200	0.924		
Mohali	1.400	0.504		
Mukatsar	-1.400	0.613		
Pathankot	0.600	0.828		
Patiala	4.800	0.023		
Ropar	0.350	0.875		
Sangrur	3.600	0.322		
Taran Taran	0.600	0.828		

Variable	St. β	P-value	Adjusted R ²	Overall p value
House hold size (referent group: less than equal to 5 members)				
more than 5 members	0.280	0.613	-0.0042	0.613
Gender	0.148	0.448	-0.0024	0.448
Education (referent group : illiterate)				
5 th class	-0.200	0.837	0.099	0.0003
8 th class	3.344	0.019		
10 th class	2.928	0.004		
12 th class	0.433	0.665		
Graduate/undergraduate	-0.136	0.872		
Type of area	0.709	0.159	0.0057	0.158

4.5.3 Multivariable analyses

The results of multivariable linear analysis are presented in Table 24 and 25. The age, gender and level of education were significantly associated with the rabies knowledge in livestock owners. Overall, 20.3% variation in knowledge score of dairy animal owners were explained by these variables. The age, and level of education were significantly associated with the rabies knowledge in pet owners. Overall, only 18.5% of variation in knowledge score of pet owners was explained by the current model.

Table 24: Multivariable linear regression analysis demonstrating the influence of explanatory variables on the outcome variable in dairy animal owners during 2016-2017

Variable	St. β	P-value	Adjusted R ²	P value
Dependent variable: Knowledge score				
Age (referent: less than 25 year)				
More than 51 year	2.01	0.0064	0.2037	<0.001
Education(referent no education level) 8 th	1.626	0.037		
Education(referent no education level) 10 th	1.82	0.009		
Education(referent no education level) 12 th	1.59	0.032		
Gender (referent: female) male	1.75	0.0067		

Table 25: Multivariable linear regression analysis demonstrating the influence of explanatory variables on the outcome variable in pet owners during 2016-2017

Variable	St. β	P-value	Adjusted R^2	P value
Dependent variable: Knowledge score				
Age (referent: less than 25 year)				
More than 51 year	2.69	<0.001	0.185	<0.001
Education (referent no education level) 10 th	2.56	0.009		

This is the first systematic analysis of knowledge, attitude and practices of the dairy and pet animal owners related to rabies in Punjab state of India. The results indicate that the dairy farmers and pet owners should be targeted to improve health-seeking behavior and rabies control practices. The majority of study participants (more than 99%) were aware of rabies as a disease and its transmission through dog bite. Similar results have also been reported from other parts of the country (Singh and Choudhary 2005 and Sangral *et al* 2015). Jemberu *et al* (2013) also found high level of awareness (98%) about rabies in Gondar Zone, Ethiopia.

However, there was a lack of comprehensive knowledge about rabies prevention methods, such as the importance of wound washing with soap and running water. Many respondents believed that traditional therapeutic measures could help prevent rabies. Similarly, Shah *et al* (2012) found that majority (72.5%) of animal bite cases did not washed their wounds with soap and water, and 52.6 % patients used indigenous products for wound treatment. Furthermore, it was found that there was a poor knowledge about the fatal nature of rabies once the symptoms arise, suggesting that human deaths are likely occur due to a lack of disease prevention and control knowledge.

In current study, 72.6% pet owners respond that they do vaccinate their pets and 65.70% dairy animal owners reported that they practice to protect their livestock from contact with stray dogs.

Majority of the respondents believed that stray dogs are a problem for their community. However, 38.50% dairy animal owners and 34.30% pet owners

considered killing of dogs as a suitable strategy to control the dog population followed by sterilization of dogs. In contrast, Muthunuwan *et al* (2017) reported that people in Sri Lanka prefer vaccination and sterilization of dogs to control rabies in the stray dog population and only a small group of respondents (17.5%) considered killing of dogs as a suitable strategy. There is a need to educate the animal owners in Punjab that humane measures are equally effective in the control of dog population rather than killing. Univariable and multivariable linear regression analysis showed significant association of age, gender, and level of education with knowledge about rabies in dairy animal owners. The age and level of education also showed a significant association with pet owner's knowledge.

Therefore, persons with low levels of education and involved in animal rearing should receive additional rabies disease educational programs. Public health education programs/health education campaigns should be developed to educate animal owners on issues such as the first aid measures after dog bites, how to judge a behavior of dog and how to avoid getting bitten by dogs. The animal owners should be made aware of the occupational health hazards such as rabies.

CHAPTER V

SUMMARY AND CONCLUSIONS

Rabies is a devastating zoonotic disease of mammals that results in encephalitis and death. In India, rabies is endemic with an estimated 20,000 human deaths every year (one-third of the annual global rabies burden). The magnitude of animal rabies in India is unknown.

The current study was carried out in Punjab state of India. We prospectively followed canine and livestock populations residing in four sub-district(s) in Punjab state of India. These populations were followed for a year starting from August 15, 2016 to August 14, 2017. The detailed demographic, clinical and laboratory data relating to the suspected cases were collected. Probability distributions were applied to account for uncertainty and variability in the data and the sensitivity analyses were conducted on important input parameters. The annual disease incidence in the canine and livestock populations was extrapolated at the state and country level from the sub-district level data.

The annual canine rabies incidence was estimated to be 4.51 (95% UI 0.066-21.88) per 10,000 population in pet dogs and 4.89 (95% UI 0.141-69.97) per 10,000 stray dogs in India. For livestock species, the disease incidence in domestic cattle populations was estimated to be 0.62 (95% UI 0.0034-4.21) per 10,000 domestic cattle in India. A disease incidence of 19.8 (95% UI 0.27-158.4) per 10,000 stray cattle was estimated. We estimate that annually 8,851 (95% UI 256-126,600) stray dogs, 5,270 (95% UI 77-25,540) pet dogs, 10,290 (95% UI 143-82,200) stray cattle, 11,980 (95% UI 65-80460) domestic cattle, 7,777 (95% UI 33-45,790) buffalo, and 867 (95% UI 0-1,745) equines suffer from rabies in India. .

The overpopulation of stray animals is a serious public health and animal welfare concern in India. Stray dogs serve as an important reservoir for human rabies in the country.

Stray dog and cattle count was carried out during August 2016 to November 2017 in the selected villages/wards in the Punjab state of India. For the rural areas, 22 sub-district(s) representing each district were randomly selected followed by the purposeful selection of one village each from the selected sub-district(s). For urban

areas, 3 towns (<100,000 human population) and 2 large cities (>100,000 human population) were randomly selected followed by purposeful selection of two wards each from the selected town(s)/cities. We used a mark-re-sight procedure with slight modifications to estimate the stray animal populations. The recapture probabilities were also estimated. The data was extrapolated based on the number of wards and villages covered, total adult human population residing in the surveyed areas and the residential (built-up) areas covered in the study so as to estimate number of stray dogs residing in the Punjab state of India. The probability distribution(s) were applied to account for uncertainty and variability in the data. Sensitivity analyses were also carried out for important input parameters. The analyses were conducted in R-statistical program (R statistical package version 3.4.0, R Development Core Team (2015), <http://www.r-project.org>).

Based on the number of villages and wards in the state, we estimate there are a median of 672005 (95% CI: 241802, 1198024) stray dogs in Punjab state, comprising of 470366 (95% CI: 165606, 881597) and 191326 (95% CI: 53063, 374020) stray dogs residing in the rural and urban areas, respectively, a ratio of 2.5:1. There were 384787 (95% CI: 146030, 662358) male and 313417 (95% CI: 146046, 543176) female stray dogs (ratio 1.2:1). There were 527463 (95% CI: 184364, 934583) adult and 164860 (95% CI: 62973, 296231) young stray dogs (ratio 3.2:1). Based on the adult human population residing in the surveyed areas, we estimated that there are a median of 607095 (95% CI: 269059, 1106020) stray dogs in Punjab state of India, comprising of 332463 (95% CI: 162137, 526434) dogs in the rural and 262805 (95% CI: 69818, 618278) stray dogs residing in the urban areas. Based on the number stray dogs per built-up area, we estimated that there are a median of 883504 (95% CI: 399529, 1445014) stray dogs in Punjab state of India, comprising of 577421 (95% CI: 284621, 932650) dogs in the rural and 295271 (95% CI: 71436, 567758) stray dogs residing in the urban areas.

Similarly, we estimated that there are a median of 679, 071 stray cattle based on the number of wards and villages, 354, 858 based on the adult human population residing in the surveyed areas and 435, 042 based on the residential (built-up) areas in Punjab.

The knowledge, attitude and practices of school students (6th to 10th) and animal owners (pet and livestock owner) of Punjab related to rabies were recorded. Overall, 65% of the students had a rabies knowledge score more than 50%. Most of the respondents (84.70%) were aware that rabies is a fatal disease and believed (91.70%) that rabies can be prevented in human beings. However, 57.20% students did not know that bite wound should be washed with soap and water and 34.80% students believed that rabies can be prevented using traditional therapeutic approaches. Further, more than 86.30% students informed that they play with stray dogs, even against their parent's advice (95.50%). For animal owners, more than 95% of the dairy animal and pet owners were aware that rabies can be transmitted from animal to humans. However, 19.9% (31/130) dairy animal owners and 21.7% (38/137) pet owners believed that rabies can be prevented by traditional therapeutic methods and less than 50% of the respondents were aware that bite wound should be washed with soap and water. Age and the level of education were significantly associated with the rabies knowledge in livestock and pet owners.

Conclusions

1. The results indicate high annual incidence of rabies in animal as compared to human population.
2. The results indicate high animal incidence of rabies in stray as compared to domestic animal population.
3. Existing stray animal populations are a serious concern for Punjab (India). We estimated important parameters necessary for stray dog and cattle control programs and animal welfare.
4. Lack of knowledge on rabies prevention and control measures were recorded in the target populations such as students and animal owners.

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**School of Public Health and Zoonoses
GADVASU, Ludhiana**

APPENDIX I

Identification Code Date.....

PART I: FOR OWNER

A.PERSONNEL INFORMATION

1. Name and village/town/city of the owner _____

2. Gender of the owner Male Female

3. Age of the respondent: _____ years

4. Education level/qualification of the respondent`

No formal education Primary Middle Matriculation

Secondary Undergraduate Graduate

5. Members in the house (house hold size)?

	Male	Female
Number of children (less than 18 years old)		
Number of Adults (above 18 years old)		

6. Number of person involved in animal (livestock/pet) care?

7. Do you keep an additional livestock attendant at your farm?

Yes No

8. Total number of animals reared by your family?

Dog Cat Cow Buffalo

Sheep Goat Horse Pig

Other

B. CASE INFORMATION (SUSPECTED FOR RABIES)

1. Date when first cl. sign noticed Date of death

2. Address/Location Where Found:

3. Stray Wild Domestic

4. Species and breed of animal

5. Gender Male Female

6. Age (Rough estimate for stray/wild) Months Years

7. Cause of Death Euthanized Died in quarantine Killed how?

8. Clinical signs

<input type="checkbox"/> Intake of inedible object	<input type="checkbox"/> Salivation	<input type="checkbox"/> Cough
<input type="checkbox"/> Diarrhoea	<input type="checkbox"/> Vomiting	<input type="checkbox"/> Fever
<input type="checkbox"/> Snapped at people/object	<input type="checkbox"/> Persons Bitten	<input type="checkbox"/> Circling
<input type="checkbox"/> Behavioural change	<input type="checkbox"/> Recognized owner	<input type="checkbox"/> Off feed
<input type="checkbox"/> Difficulty in standing/ walking	<input type="checkbox"/> Paralysis	<input type="checkbox"/> Difficult intake

Any other relevant information

9. Clinical Impressions

Dumb Furious Found died Other

10. Was the complete course of vaccination completed, before exposure to rabid animal?

Yes No Do not know

If **yes**, do you vaccinate with a booster doses of rabies every year?

Yes No Do not know

11. Was there any history of exposure from any rabid animal? If Yes, answer below:

	Yes	No	Not sure
Through bite			
Direct contact of fresh wound with infectious saliva			
Direct contact of mucosal (eye, nose, mouth) surface with infectious saliva			
Direct contact of scratches or abrasions without bleeding with infectious saliva			
Consumption of raw milk of rabid animal (In case of young animals)			

If **yes, exposed** from which animal?

12. How much time before your animal got exposed from suspected rabid animal?

13. If you noticed animal bite/exposure to your animal from rabid animal, did you informed to veterinary hospital for post prophylaxis? Yes No

If, **yes** how much doses were given?

14. Did you observed wound /scratch/lameness in your animal?

Yes No Not sure

15. Did you notice any bite wound on your animal?

Yes No Not sure

16. Was your animal escaped from house for one or two days?

Yes No

17. Did your animal was ever bitten by dog/ cat/ mongoose (wild animal)?

Yes No Not sure

If **Yes**, did you reported to veterinary hospital. Yes No

18. If you don't know about questions **8-14**, what do you think was the reason of rabies at your farm?

C. HUSBANDRY PRACTICES

19. Was a Rabies case reported on your farm since last 5 years? Yes No

If **yes**, species of the animal

20. How did you keep your livestock/pet?

a) Free to roam around the house compound, village/ town? Yes No

If **Yes** for how much time (hours)? 0-6 12-18 12-18 18-24

b) Tie outside in open area (e.g. street, open land etc.)? Yes No

If **Yes** for how much time (hours)? 0-6 12-18 12-18 18-24

c) Free to roam inside a well-marked boundary wall area? Yes No

If **Yes** for how much time (hours)? 0-6 12-18 12-18 18-24

d) Tie inside in well boundary wall area? Yes No

If **Yes** for how much time (hours)? 0-6 12-18 12-18 18-24

e) Tie inside a partial boundary wall/fencing? Yes No

If **Yes** for how much time (hours)? 0-6 12-18 12-18 18-24

E. RISK OF HUMAN EXPOUSORE

27. Did you, your family member or other person come in contact with rabid animal? Yes No

(If No, do not go for next Questions)

28. How many person came in contact with rabid animal?

29. Detail information related to exposed humans? **(Please provide detailed information)**

Detail Performa for exposed human (M=Male, F=Female)																	
Sr. No.	Young		Adult								Chose type of contact*	No. of Post-Prophylaxis vaccination doses consumed	Rabies immunoglobulin consumed				
	M	F	Male		Female				Working	Yes			No				
			Working	Pregnant		Breast feeding											
				Yes	No	Yes	No	Yes						No			
1.																	
2.																	
3.																	
4.																	
5.																	
6.																	
7.																	
8.																	
9.																	
10																	

* Mention type of contact	Number
Touching or licks on intact skin	1
Nibbling of uncovered skin, minor scratches or abrasions without bleeding	2
Direct contact of abrasions without bleeding or scratches with infectious saliva	3
Direct contact of mucosal (eye, nose, mouth) surface with infectious saliva	4
Direct contact of fresh wound with infectious saliva	5
Single or multiple transdermal bites when the animal was provoked	6
Single or multiple transdermal bites without provoking the animal	7
Consumption of raw milk of rabid animal	8

30. Name and address of exposed persons?

PART II: FOR VETS / PARAVETS

PERSONAL INFORMATION

Owner Information ID (if any):

1. Name

2. Name of CVH / CVD

3. Pin code

4. Designation?

Veterinary doctor

Pharmacist (VI)

5. Age

_____ years

6. Gender

Male

Female

7. Years in veterinary practice?

8. How many cases of rabies you seen in your veterinary practice?

9. Did you ever get exposure of rabies?

Yes

No

If, yes **Chose type of contact***

* Mention type of contact	Number
Touching or licks on intact skin	1
Nibbling of uncovered skin, minor scratches or abrasions without bleeding	2
Direct contact of abrasions without bleeding or scratches with infectious saliva	3
Direct contact of mucosal (eye, nose, mouth) surface with infectious saliva	4
Direct contact of fresh wound with infectious saliva	5
Single or multiple transdermal bites when the animal was provoked	6
Single or multiple transdermal bites without provoking the animal	7
Consumption of raw milk of rabid animal	8

B. QUESTIONS RELATED SUSPECTED RABID ANIMAL

10. Species of animal

11. Age

_____ years

12. Sex

Male

Female

13. Cause of Death Euthanized Died in quarantine Killed how?

14. Clinical signs

- | | | |
|--|---|---|
| <input type="checkbox"/> Intake of inedible object | <input type="checkbox"/> Salivation | <input type="checkbox"/> Cough |
| <input type="checkbox"/> Diarrhoea | <input type="checkbox"/> Vomiting | <input type="checkbox"/> Fever |
| <input type="checkbox"/> Snapped at people/object | <input type="checkbox"/> Persons Bitten | <input type="checkbox"/> Circling |
| <input type="checkbox"/> Behavioural change | <input type="checkbox"/> Recognized owner | <input type="checkbox"/> Off feed |
| <input type="checkbox"/> Difficulty in standing/ walking | <input type="checkbox"/> Paralysis | <input type="checkbox"/> Difficult intake |

Any other relevant information

15. Clinical Impressions

Dumb Furious Unknown Other

16. Based on clinical symptoms, do you think it is a case of rabies?

Yes No Not sure

If, **not sure** do you think it could be due to any other disease? Yes No

If, Yes which disease it could be?

C. RELATED TO OCCUPATIONAL EXPOSURE

17. Are you vaccinated for rabies? Yes No

18. Do you take booster doses of rabies vaccine every year? Yes No

19. Have you ever checked your antibody titre for rabies antibodies? Yes No

20. Do you take personal protective equipment while handling a suspected rabies case? Yes No

If, **yes** chose one or more personal protective equipment

Gloves Gloves Protective goggles
 Gowns or Lab. coats Other equipment
 None of these

21. Did you come in contact with the current rabid animal? Yes No

If, yes **Chose type of contact***

* Mention type of contact	Number
Touching or licks on intact skin	1
Nibbling of uncovered skin, minor scratches or abrasions without bleeding	2
Direct contact of abrasions without bleeding or scratches with infectious saliva	3
Direct contact of mucosal (eye, nose, mouth) surface with infectious saliva	4
Direct contact of fresh wound with infectious saliva	5
Single or multiple transdermal bites when the animal was provoked	6
Single or multiple transdermal bites without provoking the animal	7
Consumption of raw milk of rabid animal	8

12. How rabies can be transmitted from rabid animal to human?

Route of transmission	Yes	No
Through bite		
Direct contact of fresh wound with infectious saliva		
Direct contact of mucosal (eye, nose, mouth) surface with infectious saliva		
Direct contact of scratches or abrasions without bleeding with infectious saliva		

13. Do you know that rabies is a fatal disease? Yes No

14. Do you know that rabies can be transmitted from one animal to another animal? Yes No

15. Please mention the transmission route of rabies from rabid animal to another animal?

Route of transmission	Yes	No
Through bite		
Direct contact of fresh wound with infectious saliva		
Direct contact of mucosal (eye, nose, mouth) surface with infectious saliva		
Direct contact of scratches or abrasions without bleeding with infectious saliva		

16. Do you know rabies can be prevented? In human Yes No
In animal Yes No

17. Do you believe that rabies can be prevented using traditional methods? Yes No

18. Do you know that rabies can be prevented by post prophylaxis?
In human Yes No
In animal Yes No

19. Are you aware that dog bite wound should be washed with soap and water? Yes No

20. Do you know that suspected animal rabies cases have to be confirmed using laboratory tests? (take brain sample to the laboratory and do laboratory test) Yes No

21. Do you think clinical rabies can be treated? In human Yes No
In animal Yes No

PART III - ATTITUDE RELATED TO RABIES

22. What will you do if you see a suspected rabid animal?

Type of animal	Kill the animal	Report to Vet/Paravet	Inform to your neighbors	Move away from that animal
Stray dog				
Pet dog				
Livestock animal				
Stray animal (cow, Pig etc)				

23. Will you report to the hospital for treatment, if

Type of bite	Yes	No
You are bitten by stray dog		
You are bitten by owned dog		
You are bitten by stray cat		
You are bitten by owned cat		
You are scratched by stray dog		
You are bitten by wild animals		
You are bitten by dog in other countries		

PART IV - PERCEPTIONS RELATED TO RABIES

24. Are the stray dogs a problem for your community? Yes No

25. Do you believe it is important to control dog population in Punjab? Yes No

26. What do you think would be the most appropriate method to control dog population in Punjab?

Vaccination Impounding in dog shelter
 Sterilization (by operation) Kill

PART V- PRACTICES RELATED TO RABIES

27. Do you play with stray dogs? Yes No

28. Did your parents/guardians advise you to be careful and not to play with stray dogs? Yes No



**School of Public Health and Zoonoses
GADVASU, Ludhiana**

APPENDIX III

Identification Code

Date.....

PART I - Personnel Information (Demography)

1. Name and village/town/city of the respondent
2. District
3. Locality Urban Rural
4. Gender of respondent Male Female
5. Age of respondent _____ years
6. Education level/qualification of the respondent`
 No formal education Primary Middle Matriculation
 Secondary Undergraduate Graduate
7. Number of members in the house (house hold size)
8. Types of animals owned by your family?
 Pet (Dog/Cat) Dairy animal (cow/buffalo)

PART II - KNOWLEDEGE RELATED TO RABIES

9. Do you believe that rabies can be transmitted from animals to humans? Yes No
10. How rabies can be transmitted from rabid animal to human?

	Yes	No
Through bite	<input type="checkbox"/>	<input type="checkbox"/>
Direct contact of fresh wound with infectious saliva	<input type="checkbox"/>	<input type="checkbox"/>
Direct contact of mucosal (eye, nose, mouth) surface with infectious saliva	<input type="checkbox"/>	<input type="checkbox"/>
Direct contact of scratches or abrasions without bleeding with infectious saliva	<input type="checkbox"/>	<input type="checkbox"/>

11. Do you know that rabies is a fatal disease? Yes No
12. Do you know that rabies can be transmitted from one animal to another animal? Yes No
13. Please mention the transmission route of rabies from rabid animal to another animal?

Route of transmission	Yes	No
Through bite		
Direct contact of fresh wound with infectious saliva		
Direct contact of mucosal (eye, nose, mouth) surface with infectious saliva		
Direct contact of scratches or abrasions without bleeding with infectious saliva		

14. Do you know rabies can be prevented? In human Yes No
In animal Yes No
15. Do you believe that rabies can be prevented using traditional methods? Yes No
16. Do you know that rabies can be prevented by post prophylaxis? In human Yes No
In animal Yes No
17. Are you aware that dog bite wound should be washed with soap and water? Yes No
18. Do you know that suspected animal rabies cases have to be confirmed using laboratory tests? (take brain sample to the laboratory and do laboratory test) Yes No
19. Do you think clinical rabies can be treated? In human Yes No
In animal Yes No

PART III - ATTITUDE RELATED TO RABIES

20. What will you do if you see a suspected rabid animal?

Type of animal	Kill the animal	Report to Vet/Paravet	Inform to your neighbors	Move away from that animal
Stray dog				
Pet dog				
Livestock animal				
Stray animal (cow, Pig etc)				

21. Will you report to the veterinary hospital for treatment, if,

	Yes	No
Your animal / pet is bitten by stray dog		
Your animal/pet is bitten by owned dog		
Your animal /pet is bitten by stray cat		
Your animal /pet is bitten by owned cat		
Your animal/pet is scratched by stray dog		
Your animal/pet is bitten by wild animals		

PART IV - PRACTICES RELATED TO RABIES

22. Do you protected your livestock from contact with stray dogs? Yes No

23. Is your dog vaccinated against rabies? (during last year or this year) Yes No

PART V - PERCEPTIONS RELATED TO RABIES

24. Are the stray dogs a problem for your community? Yes No

25. Do you protected your livestock from contact with in Punjab? Yes No

26. What do you think would be the most appropriate method to control dog population in Punjab?

Vaccination Impounding in dog shelter
 Sterilization (by operation) Kill

VITA

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