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Risk profiling of livestock anthrax through knowledge, attitudes, and practices related to anthrax and animal care in Bevinahalli village of Tumakuru district in Karnataka: A case-control study

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Abstract
This study explores anthrax-related knowledge, attitudes, and practices (KAP) among 49 participants, divided into anthrax-experienced (37%) and anthrax-non-experienced (63%) groups. Gender disparities are evident, with a male predominance in both groups, potentially linked to sheep farming. Anthrax-experienced individuals show diverse ages, while non-experienced participants are concentrated in the 41-50 age range. Varied education and farming experiences highlight potential correlations with anthrax exposure. Livestock holdings indicate higher risk for smaller-scale farmers, and migration patterns raise questions about their role in anthrax transmission. The KAP survey reveals significant disparities. Anthrax-experienced participants demonstrate higher awareness (100%) and understanding of the disease (61.11%) than non-experienced individuals. While clinical signs in animals are universally known among the anthrax-experienced (100%), a gap exists in understanding zoonotic transmission (55.55%). Limited awareness of clinical signs in humans is observed in both groups. Higher attendance in vaccination awareness programs is noted among the anthrax-experienced (94.44%). Attitudinally, the anthrax-experienced group displays heightened vigilance, immediate action, and belief in preventive measures. Practices such as examining animal health and veterinary visits are universal, but disinfection and quarantine practices are more rigorously followed by those with anthrax experience. Both groups unanimously avoid high-risk dead animal meat/undercooked meat. The mean risk of attitude and practices indicates a low level of anthrax occurrence risk in both groups. These findings underscore the impact of first-hand exposure on anthrax-related KAP, emphasizing the need for targeted educational interventions in communities with limited anthrax exposure, contributing valuable insights to public health strategies.

Keywords: Anthrax, knowledge, attitude, practice, risk, management

1. Introduction
Anthrax is a neglected tropical zoonotic disease that holds economic and public health significance (WHO, 2008) [1]. The causative agent of anthrax is *Bacillus anthracis* (*B. anthracis*), and it primarily infects herbivores, with humans being secondarily affected (Hugh-Jones and Blackburn, 2009; Joyner *et al*., 2010, Indrabalan *et al*., 2022) [8, 9, 10]. Livestock anthrax, in particular, is a major concern in agricultural communities, where the disease can have severe economic implications and public health repercussions. This disease in livestock is characterised by fever and sudden death. Cattle, sheep and goats are the most susceptible species and are frequently found dead, which may lead to the diagnosis being confused with lightning strike, snakebite, or acute poisoning (Fukao, 2004; Tuchili *et al*., 1993) [6, 24]. The most common source of infection for ruminants is pasture contaminated with anthrax spores (Dragon and Rennie, 1995; Mongoh *et al*., 2008; Ndiva Mongoh *et al*., 2008) [4, 11, 13]. The spore-forming nature of the bacterium makes it resilient and capable of surviving in various environments, creating challenges for effective control and prevention. Additionally, animals may contract the disease through concentrated feed (Davies and Harvey, 1972) [3].
The occurrence of anthrax outbreaks in a specific location is typically influenced by a combination of factors. These include distinctive characteristics of the bacterium itself, environmentally related features, animal densities, and human activities (Blackburn *et al*., 2010; Hugh-Jones and De Vos, 2002, Sushma *et al*., 2021; Suresh *et al*., 2022; Suma *et al*., 2017) [1, 7, 21, 19, 18].

Anthrax outbreaks have been linked to a range of factors encompassing ecological, demographic, climatic, and sociocultural elements (Muturi *et al*., 2018; Sitali *et al*., 2018, Bylaiah *et al*., 2022; Sushma *et al*., 2022; Sagar *et al*., 2023; Suresh *et al*., 2023) [12, 17, 2, 22, 20, 16]. Understanding the interplay of these various factors is crucial for effectively managing and preventing anthrax outbreaks in a given area. The prevalence of anthrax underscores the importance of addressing its impact on both livestock and human populations, especially in regions where surveillance and reporting systems may be lacking. The study focuses on understanding the factors contributing to the underreporting of anthrax cases, aiming to improve disease awareness, farmer attitudes, and practices for better livestock health management in Bevinahalli Village, situated in the Sira Taluk of the Tumakuru District. In Bevinahalli, suspected cases of anthrax have been observed, but due to inadequate knowledge, awareness, and reporting practices among farmers, only a few cases are officially confirmed and reported. This study aims to address this gap by assessing the knowledge, attitude, and practices (KAP) of farmers in Bevinahalli concerning anthrax.

2. Material and Methods

2.1 Study area

Tumakuru possesses a substantial sheep population, ranking second in sheep holdings after Chitradurga district in Karnataka (DAHD 20th livestock census). Sheep farming is a crucial source of food and income for many rural communities in Tumakuru. In particular, Bevinahalli, a village located 80 kilometers north of the Tumakuru district headquarters and with the highest sheep population in the district (Fig.1). This village, situated at an altitude of 802 meters above sea level, is a significant hub for sheep farming, contributing to the livelihoods of 937 families. The village's demographics reveal a population of 4,500 residents, with 2,301 males and 2,199 females. The literacy rate in Bevinahalli is lower than the state average, standing at 65.95% in 2011.

Covering an area of approximately 3404.98 hectares, Bevinahalli has a varied landscape with both irrigated and un-irrigated areas. The village relies heavily on agriculture, with a substantial portion of the land dedicated to cultivation. Livestock, especially sheep, play a pivotal role in the village's economy, with a total livestock population of 21,727, including 19,678 sheep (Table 1). However, despite the economic importance of livestock, diseases, particularly anthrax, pose a significant challenge to their well-being.

2.2 Study sample

A case-control approach was followed to assess the outbreak risk factors for responsible for anthrax through KAP component. A case was defined as any farmer/shepherd resident of Bevinhalli, who lost their sheep due to sudden unexplained death or anthrax consistent signs and reported to a veterinary doctor and confirmed by laboratory diagnosis. A control was defined as any neighbour resident who did not lose their sheep to anthrax.

2.3 Data collection

A standard questionnaire comprised of 21 questions developed with face validity, content validity, and keystrokes identified for capturing data as per requirements of the study was used. The questionnaires captured information on socio-demographic variables, knowledge, attitudes and practices regarding anthrax. The questionnaire consisted of three segments: (1) items regarding the respondent and socio-demographic information (age, gender, education level, occupation, experience in farming, Livestock holdings and migration details); (2) questions related to the knowledge and perception of anthrax; and (3) questions related to attitudes and practices towards its control activities. The questionnaire was prior tested to improve clarity and interpretation. Key informant interviews (KII) method was followed and farmers with livestock holdings (cattle, sheep and goat) and previous history of anthrax cases on their farm (Case- anthrax experienced) and without anthrax cases (Control- anthrax non-experienced) were considered as subjects of the study. Local Veterinary Doctor serves as rapport person for reaching farmers for data collection purposes.

2.4 Data analysis

A knowledge scale was developed by summing together the scores (0 = No or 1 = Yes) from seven questions regarding the shepherd's knowledge of anthrax in animals, its clinical signs and zoonotic potential. An attitude and practice scale was developed from 7 questions in each category using the Likert scale scoring Low, Medium, and High based on their responses for risk profiling. A higher score indicates a greater overall knowledge of anthrax and a higher percentage on a low scale, indicates their positive attitude and usage of appropriate practices towards the management of anthrax.

At the end of each day of data collection, all questionnaires were handed over and reviewed by the investigator to ensure that all variables had been correctly filled. Data from household questionnaires were entered into an Excel spreadsheet, scored and further exported to SPSS for descriptive analysis. Data collected through key informant interviews was analysed using thematic analysis procedures. The data were used to complement and elaborate quantitative findings and clarify relevant aspects of anthrax-related practices and behaviour.

3. Results and Discussion

3.1 Demographic details of participants

The study comprised 49 participants, with 18 individuals (37%) having experienced anthrax and 31 individuals (63%) classified as anthrax non-experienced. In terms of gender distribution, the majority of the anthrax-experienced participants were male (88.89%), while among the anthrax-non-experienced group, the majority were also male (70.97%). Regarding age, the anthrax-experienced group had a diverse distribution, with the highest percentage of 27.78% observed in each age category of 31-40, 41-50 and 51-60 years. In contrast, the anthrax non-experienced group showed a broader age distribution, with the highest percentage in the 41-50 age range (29.03%). Educational levels varied among the participants, with the anthrax-experienced group having a higher percentage of individuals with primary education (38.89%), while the anthrax-non-experienced group had a higher percentage with high school education (45.16%). Regarding farming experience in livestock handling, the anthrax-experienced group had a notable proportion with 21-30 years of experience (38.89%), while the anthrax non-experienced group showed a more even distribution across

different experience levels with the highest 35.48% in 10-20 years category. Livestock holdings also exhibited differences, with the anthrax-experienced group having a higher percentage of individuals with 0-100 livestock holdings (38.89%), while the anthrax-non-experienced group had a higher percentage in the 101-200 livestock holdings category (64.52%). Migration patterns were evident in both groups, with a substantial majority of anthrax-experienced individuals engaging in migration (88.89%), compared to a lower but significant percentage in the anthrax-non-experienced group (51.61%) (Table 2). The observed results in this study provide valuable insights into the potential associations between demographic variables and anthrax experience among the 49 participants. Notably, the gender distribution suggests that males were more prevalent in both anthrax-experienced (88.89%) and non-experienced (70.97%) groups. This may indicate that males are more likely to engage in activities related to sheep farming. This study also suggests that educational background could play a role in anthrax exposure, potentially due to differences in occupation, awareness, or preventive practices. Farming experience suggests a potential correlation between long-term farming activities and KAP towards anthrax exposure. Livestock holdings imply that smaller-scale farmers may face higher risks, possibly due to closer proximity to livestock or limited resources for disease prevention. Migration patterns raise questions about the role of migration in anthrax transmission, and future studies should explore the specific aspects of migration that contribute to anthrax exposure.

3.2 Knowledge of participants towards anthrax

The results of the survey on anthrax knowledge and awareness among participants reveal significant disparities between the anthrax-experienced and non-experienced groups (Table 3). In the anthrax-experienced group, all participants (100.00%) demonstrated full awareness of the disease, showcasing a comprehensive understanding. Conversely, in the anthrax non-experienced group, approximately three-quarters of participants (74.19%) were aware of anthrax, indicating a notable knowledge gap. Notably, a higher percentage of the anthrax-experienced participants understood the cause of the disease (61.11%) compared to the non-experienced group (25.11%). The awareness of clinical signs and symptoms in animals was universally high among those with anthrax experience (100.00%), emphasizing the importance of this knowledge for early detection and prevention. However, a smaller percentage in the anthrax-experienced group (55.55%) and non-experienced groups (22.58%) understood the zoonotic transmission of anthrax to humans, suggesting a need for targeted education on this aspect. Only a smaller proportion of (22.22%) participants in the anthrax-experienced group were knowledgeable about clinical signs in humans, and none of the participants in the anthrax-non-experienced group possessed this information, indicating a potential gap in understanding the human dimension of anthrax even among those with prior exposure. The higher attendance in vaccination awareness programs among the anthrax-experienced group (94.44%) highlights the positive correlation between awareness initiatives and proactive health measures. These findings reveal that the anthrax-experienced group exhibited higher knowledge and awareness towards anthrax compared to the non-experienced group. Overall, these findings underscore the need for targeted educational interventions to bridge knowledge gaps and enhance awareness, especially among populations with limited anthrax exposure. Similar findings from a study reported that on an 8-point knowledge scale, cases having an animal with anthrax had a 1.31 times greater knowledge score compared to all controls (Traxler *et al*., 2019) [23]. Continuous efforts in public health education can contribute significantly to anthrax prevention and control strategies. Our results corroborate with the findings from a study on Knowledge, attitude and practice towards anthrax in northern Ethiopia 62% of the community respondents said that they were aware of anthrax while 38% of them did not. There was no consistent understanding of the disease among the participants. The study also revealed that the participants did not receive consistent, adequate, and continuous education regarding the disease (Romha and Girmay, 2020) [15]. A study from India in tribal communities of Odisha, Eastern India for the assessment of socio-behavioural correlates and risk perceptions regarding anthrax disease also mentioned that the community members had poor knowledge of the cause, symptoms, transmission and prevention of anthrax disease which may be improved by a One Health approach (Pattnaik *et al*., 2022) [14].

3.3 Attitude and Practice of Respondents towards anthrax

The survey results illuminate distinctive attitudes and practices related to anthrax between individuals with anthrax experience and those without (Table 4). In terms of attitudes, individuals with anthrax experience consistently exhibit a high level of vigilance and immediate action when suspecting anthrax in animals (100%). They base their suspicion on clinical signs in their farm more significantly (88.89%) compared to the Anthrax non-experienced group (29.03%). The prompt consultation with a doctor after anthrax infection is a prevalent practice among the anthrax-experienced (94.44%) and the Anthrax non-experienced (90.32%). Belief in the preventive role of animal vaccination against anthrax is high in both groups, with a notably higher percentage in the anthrax-experienced group (94.44%). Similarly, recognizing the importance of personal safety measures while treating anthrax-infected animals is acknowledged by both groups, though slightly more by those with anthrax experience (88.89%). In the unfortunate event of family members being infected with anthrax, both groups universally take immediate action to address the situation. Regarding perceptions of edaphic/soil factors in anthrax outbreaks, the anthrax-experienced group demonstrates a significantly higher awareness (83.33%) compared to the anthrax-non-experienced group (19.35%).

In terms of practices, individuals with anthrax experience engage more actively in examining the health condition of animals before selling (72.22%) compared to the anthrax non-experienced group (54.84%). Regular visits to veterinary authorities for the maintenance of animal health are universal in both groups (100%). Disinfection practices of equipment and machinery are more rigorously followed by the anthrax-experienced group (61.11%) compared to the anthrax-non-experienced group (48.39%). The practice of quarantining or isolating anthrax-suspected animals is more prevalent among those with anthrax experience (50%) than the Anthrax non-experienced group (45.16%). Both groups unanimously avoid

consuming the meat of dead animals or undercooked meat. The awareness of the frequency of vaccination programs against anthrax conducted by veterinarians in their village is higher in the anthrax-experienced group (88.89%) compared to the anthrax-non-experienced group (74.19%).

The mean risk of attitude exhibited a low level of risk of anthrax occurrence in terms of their attitude towards anthrax management in both the anthrax-experienced (82.54%) and anthrax non-experienced group (77.87%). The mean risk of practices also exhibited a low level of risk of anthrax occurrence in terms of their practices towards anthrax management in both the anthrax-experienced (62.05%) and anthrax non-experienced group (62.67%). These findings suggest that individuals with anthrax experience demonstrate a more proactive approach, marked by heightened vigilance, prompt healthcare-seeking behaviour, and stronger adherence to preventive practices. The observed differences underscore the impact of direct exposure on attitudes and practices related to anthrax, highlighting the need for targeted educational interventions to enhance awareness and proactive measures, especially among those with limited anthrax exposure. These results are corroborated by a recent study on KAP related to anthrax and animal care in Georgia, which revealed that cases were more knowledgeable of anthrax and had better anthrax prevention practices compared to control(Traxler *et al*., 2019) [23]. Another study from Bangladesh indicated that the community members had average knowledge on causes, symptoms, transmission and prevention of anthrax. Veterinary and Medical health planners should design and implement interventions for awareness building on anthrax under One Health (OH) approach for educating the community people on anthrax control and prevention (Dutta *et al*., 2021) [5].

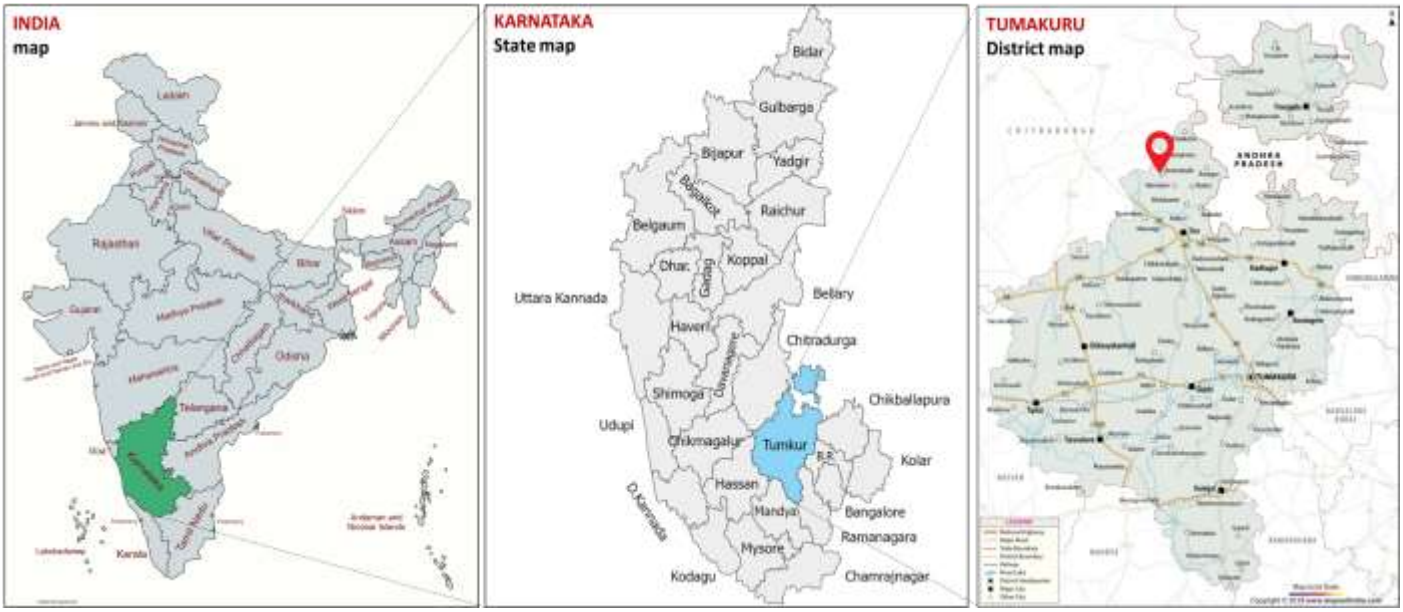

Fig 1: Map of Study area. Indicates-Bevinhalli, Sira taluk, Tumakuru district

Table 1: Demographic, ecological and livestock population details of Bevinahalli

Demographic details	
Area	3404.98 ha
Latitude	13.8967° N
Longitude	76.8425° E
Altitude	802 MSL
Families	937
Population	4500
Literacy rate	65.95%
Ecological conditions	
Average annual Temperature	16-36 ℃
Average annual Rainfall	150-200 mm
Average annual Rainfall days	40-75 days
Average annual wind speed	10-25 kmph
Average annual pressure	1006-1014 mb
Livestock Population	
Cow	55
Buffalo	28
Sheep	19678
Goat	1966

Table 2: Demographic details of participants in the study area

Variable	Categories	Anthrax Experienced (n=18)	Percent (%)	Anthrax non-experienced (n=31)	Percent (%)
Number of participants	(n=49)	18	0.37	31	0.63
Gender	Male	16	88.89	22	70.97
	Female	2	11.11	9	29.03
Age level (Years)	20-30	1	5.56	8	25.81
	31-40	5	27.78	8	25.81
	41-50	5	27.78	9	29.03
	51-60	5	27.78	4	12.90
	>60	2	11.11	2	6.45
Education level	Illiterate	6	33.33	6	19.35
	Primary	7	38.89	14	45.16
	High school	4	22.22	6	19.35
	PUC	0	0.00	3	9.68
	Degree	1	5.56	2	6.45
Experience in farming (Years)	0 to 10	2	11.11	7	22.58
	11 to 20	6	33.33	11	35.48
	21 to 30	7	38.89	7	22.58
	>30	3	16.67	6	19.35
Livestock holdings (Number)	0-100	7	38.89	20	64.52
	101-200	6	33.33	7	22.58
	201-300	3	16.67	2	6.45
	>300	2	11.11	2	6.45
Migration	Migration	16	88.89	16	51.61
	No migration	2	11.11	15	48.38

Table 3: Knowledge of anthrax among respondents

Statement	Anthrax experienced (n=18) (%)		Anthrax non-experienced (n=31) (%)	
	Yes	No	Yes	No
Do you know a disease called anthrax?	18 (100)	0 (0.00)	23 (74.19)	8 (25.81)
Do you know about the cause of the disease?	11 (61.11)	6 (33.33)	8 (25.81)	22 (70.97)
Do you know about the clinical signs/symptoms of an animal with anthrax?	18 (100)	0 (0.00)	17 (54.84)	14 (45.16)
Do you know that anthrax is transmitted among animals?	18 (100)	0 (0.00)	19 (61.29)	12 (38.71)
Do you know that anthrax is transmitted from animals to humans?	10 (55.55)	8 (44.44)	7 (22.58)	24 (77.42)
Do you know about the clinical signs/symptoms of a person with anthrax?	4 (22.22)	13 (72.22)	0 (0.00)	31 (100)
Have you attended any vaccination awareness programs?	17 (94.44)	1 (5.56)	19 (61.29)	12 (38.71)

Table 4: Risk profiling based on Attitude and Practices of Farmers towards Anthrax

Questions	Anthrax experienced (n=18)			Anthrax non-experienced (n=31)		
	Risk level (%)					
Statement	Low	Medium	High	Low	Medium	High
Attitude						
What actions you take, if you suspect anthrax in animals?	100	0.00	0.00	96.77	3.23	0.00
On what basis you suspect anthrax infection in your farm?	88.89	0.00	11.11	67.71	3.23	29.03
How many days after anthrax infection, you consult doctor?	94.44	0.00	5.56	90.32	0.00	9.68
Do you think that vaccination of animals can help to prevent anthrax in animals?	94.44	5.56	0.00	80.65	19.35	0.00
How important it is to follow personal safety measures while treating anthrax infected animal?	88.89	11.11	0.00	90.32	9.68	0.00
What action do you take, if any family members are infected with anthrax?	100	0.00	0.00	100	0.00	0.00
Do you think edaphic /soil factors play crucial role in anthrax outbreak?	11.11	83.33	5.56	19.35	70.97	9.68
Mean	82.54	14.29	3.18	77.87	15.21	6.91
Practices						
How often you examine health condition of animals before selling?	16.67	72.22	11.11	19.35	54.84	25.81
How often you visit veterinary authorities in maintenance of animal health?	100.00	0.00	0.00	100.00	0.00	0.00
How often do you perform disinfection of equipment's & machineries?	0.00	38.89	61.11	0.00	48.39	51.61
Do you quarantine /isolate anthrax suspected animal?	50.00	33.33	16.67	45.16	32.26	22.58
Do you prefer eating meat of dead wild or domestic animals?	100.00	0.00	0.00	100.00	0.00	0.00
Do you have habit of eating undercooked meat?	100.00	0.00	0.00	100.00	0.00	0.00
How often vaccination program against anthrax is being taken up by veterinarians in your village?	88.89	11.11	0.00	74.19	22.58	3.23
Mean	65.08	22.22	12.70	62.67	22.58	14.75

4. Conclusion

The study's findings hold significant importance for authorities tasked with establishing prevention and control measures in regions prone to anthrax outbreaks. The farmers' Knowledge, Attitude, and Practices (KAP) towards anthrax are rated as moderate, potentially contributing to the weakness observed in the reporting surveillance system. In light of these observations, several recommendations are suggested: prioritize timely animal vaccination, intensify health education on Anthrax transmission from livestock to humans, advise health and livestock agencies to discourage

activities such as handling properly disposed dead animals, skinning, and using hides; and strengthen a comprehensive health approach for early intervention in zoonotic diseases. Implementing these measures could enhance overall preparedness and response to anthrax outbreaks in affected regions.

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6. Authors Contribution
Conceptualization of topic and Methodology: K.P.S.; Questionnaire development: K.P.S. J.A. R.R. data collection, curation and formal analysis: J.A., R.R; writing original draft: J.A.; review and editing: K.P.S., S.S.P. supervision: K.P.S.; visualization: J.A., R.R. All authors have read and agreed to the published version of the manuscript.

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