Development of Cattle Disease Diagnosis Expert System (CaDDES): A web application for the diagnosis of cattle diseases

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ABSTRACT

In the present study, an attempt was made to develop an expert system for the diagnosis of cattle diseases under field conditions by Veterinarians. A questionnaire tool was developed and used for collecting the scores for symptoms or signs of 13 cattle diseases for diagnosis. The tool was tested for face validity by pilot survey with experts and content validity by calculating Aiken's value index. The scores for the signs or symptoms were collected from 178 field veterinarians from different states in India. The scores obtained were tested for reliability and consistency by using the split-half test [88.7%] and Cronbach's alpha coefficient [92.7%], respectively. The weighted matrix was calculated for the 51 signs or symptoms obtained for 13 cattle diseases. The CaDDES, a web application was developed using PHP, HTML, JavaScript, and MySQL computer programming languages. This web application contains Home, Introduction, About CaDDES, Disease Diagnosis, Development Team, and Contact pages. The Veterinarians need to enter the basic details of cattle and select the signs or symptoms observed in the particular cattle under field conditions. The results page will display the three probable diseases diagnosed for the selected signs or symptoms. Further, the necessary samples to be collected for laboratory confirmation and preventive measures to be undertaken were also provided. This web application will be useful for field level diagnosis of cattle diseases by Veterinarians and later by farmers. It may also be useful as a surveillance application, which will improve cattle disease reporting in the future.

Keywords: Cattle, Diagnosis, Disease, Symptoms, Veterinarians, Web application

Diagnosing animal disease quickly and accurately has economic value. The expert system for animal disease diagnosis can help the farms with urgent needs of veterinary experts since there are very few experts at the farms (Wan and Bao 2010). An expert system is a computer system that emulates the decision-making ability of a human expert (Peter 1998). The intention of creating an expert system is to make use of the expert's knowledge which can be used by many people. An expert system simulates the judgment and behaviour of a human that has expert knowledge and experience in a particular field. It consists of inbuilt facilities to write the rules that build the knowledge base. Nowadays, people are very conscious about their health as well as the health of their animals. The owner of the cattle has to observe the daily routine of the animals and check for any changes in their routine or behaviour. Animal owners take the help of books or other experienced animal owners or Veterinarians, which appears to be a very time consuming and costly job as reported (Saurkar and Watane 2012).

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India has a total bovine population of 302.79 million as per the 20th Livestock Census (BAHS 2019) and also ranks first in the combined cattle and buffalo milk production in the World. The number of veterinary hospitals/polyclinics, veterinary dispensaries, and veterinary aid centers were 12,076, 25,571, and 28,168, respectively in India (BAHS 2019). The total number of registered Veterinarians in India was 67,784, out of which approximately 26,821 Veterinarians are working in Government veterinary institutions. The average Veterinarian to cattle ratio, i.e. one Veterinarian available for 4,616 units of cattle in India. The Jharkhand state has the lowest cattle to Veterinarian ratio with 15,704 cattle units per Veterinarian and the highest in Puducherry with one Veterinarian for 170 cattle units (Singh 2022). The number of Veterinarians needed to take care of the health of the available cattle population has to be increased. Dairy cattle are suffering from various diseases and are considered a major problem in dairy farming. The veterinary care for dairy animals in India is still at large due to fewer Veterinarians available for disease diagnosis and to provide advice on the management of the affected cattle. Most of the systems developed so far are based on animal disease surveillance to improve disease analysis, early warning, and prediction of disease emergence and spread (Patil *et al.* 2012). The expert system will be useful

for the animal owners for the healthcare of his/her animals and also for the veterinary doctors to take advice from this system as it is an expert and knowledge based system. There is a need for the development of an expert system for the diagnosis of cattle diseases to meet the shortage of expert Veterinarians in the diagnosis of cattle diseases. However, a duck diseases expert system (Divayana 2014) and a mobile expert system for diagnosing endometritis in cattle (Suharjito *et al.* 2017) were available in Indonesia. No expert system is available for the diagnosis of cattle diseases in India. Hence, an attempt was made in the present study to develop a methodology to develop an expert system for the diagnosis of cattle diseases by Veterinarians in field conditions.

MATERIALS AND METHODS

The cattle diseases and their symptoms or signs were selected based on a literature search and discussion with cattle disease experts and field Veterinarians. The Likert scale of 1 to 10 was considered for the scoring of the symptoms or signs of cattle diseases. The questionnaire tool for collecting the scores for symptoms/signs of 13 cattle diseases was prepared. The questionnaire was evaluated for face validity and the suitability of the symptoms/signs for a particular disease by using the symptoms/signs given in the literature and determined by cattle disease experts. The questionnaire tool was assessed for content validity, also known as logical validity. It refers to the extent to which a measure represents all facets of a given social construct. The normally accepted quantitative index for content validity was Aiken's value index. This index was used to quantify the scores given by the veterinarians for evaluating the items in the questionnaire. Aiken's value index for content validity is given as (Aiken 1985):

$$V = \frac{S}{[n*(c-1)]}$$

Where, n, Veterinarians rate the degree to which symptoms/signs help in the diagnosis of a particular disease of cattle on a 1 to 10 (c) on the Likert-scale, where 'c' is the maximum score in a grading scale (c=10); lo, the lowest possible validity rating (usually, this is 1 on the Likert scale); r, the score given by the veterinarian; s = r – lo; S, the sum of s for the n raters.

The range of scores was from 1 to 10. The scores for each cattle disease's symptoms or signs were obtained from field Veterinarians from many states in India and depends on the possible importance, frequency observed, and pathognomonics for a cattle disease. The highest score will be given to frequently observed, important symptoms, and less score for rarely observed symptoms based on the experience of the Veterinarians. The Aiken's value obtained for each symptom or sign was used for ranking the symptoms or signs. The ranks and values obtained were used for calculating the weighted matrix for each symptoms or signs within each disease. The questionnaire was further tested for reliability and consistency by using a split-half test (Bolarinwa 2019) and Cronbach alpha coefficient (Cronbach 1990), respectively.

The web application was prepared by using open source computer programming languages including PHP (hypertext preprocessor), HTML (hypertext markup language), JavaScript, and MySQL (structured query language) for coding. The source code was prepared for the web application and submitted for obtaining copyright under the Literary Works – software category from the Copyright Office, Government of India with Dairy no. 2989/2022-CO/SW dated 11th February 2022. The web application was validated in the field conditions with Veterinarians and their feedback was obtained by online Google forms.

RESULTS AND DISCUSSION

The 13 diseases considered for scoring were anaplasmosis, anthrax, babesiosis, black quarter, bovine trypanosomiasis, brucellosis, foot and mouth disease, haemorrhagic septicemia, infectious bovine rhinotracheitis, leptospirosis, mastitis, rabies, and theileriosis in cattle. The questionnaire tool was used to collect the data from the Veterinarians after obtaining informed consent from them. The pilot survey of the questionnaire was carried out with experts and field Veterinarians, and slight modifications in the cattle symptoms/signs were incorporated in the final questionnaire tool version 2 was prepared. The details included in the questionnaire tool are shown in Fig. 1. The scores for the symptoms or signs were collected by using a questionnaire from Veterinarians in Assam, AICRP on

Table 1. Details of questionnaire data collected from field veterinarians in India

States/Union territory/Centers name	Number of Veterinarians			Total
	2017-18	2018-19	2019-20	
Assam	5	10	0	15
AICRP on Animal Disease Monitoring and Surveillance centers PI's	14	0	0	14
Chhattisgarh	0	33	0	33
Madhya Pradesh	0	0	31	31
Karnataka	26	2	0	28
Kerala	9	15	0	24
Puducherry	5	0	0	5
Tamil Nadu	11	10	7	28
Total	70	70	38	178

**Questionnaire for collection of data on symptoms/signs for
Cattle disease diagnosis from Veterinarians**

1. Name   :   _____

2. Designation :   _____

3. Gender   :   Male/Female

4. Age in years :   _____

5. Address   :   _____

6. Contact No. :   _____

7. Email   :   _____

8. Experience :   _____

9. Commonly observed cattle diseases in your area:

_____

**Scoring of Cattle diseases signs/symptoms with 0- not seen, with scale of 1- least seen
and ranged to 10 - most commonly seen (Use tick mark in appropriate column)**

No.	Cattle diseases	Clinical Signs/Symptoms	Score (0-Not seen, 1-least seen and ranged to 10-mostly seen)										
			0	1	2	3	4	5	6	7	8	9	10
1	Anaplasmosis	Anaemia											
		Fever											
		Weight loss											
		Breathlessness											
		Jaundice											
		Uncoordinated movements											
		Abortion											
		Death											
		Anorexia and pica											
2	Anthrax	Sudden death											
		Trembling											
		Fever											
		Difficulty in breathing											
		Convulsions before death											
		Bloody discharge from natural orifices											
		Blood may not clot											
3	Babesiosis	Fever											

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Fig. 1. Details of the questionnaire tool used for collecting scores on symptoms or signs of cattle diseases.

Animal Disease Monitoring and Surveillance Principal Investigators, Chhattisgarh, Madhya Pradesh, Karnataka, Kerala, Puducherry, and Tamil Nadu states. The year-wise and the number of respondents interviewed details are given in Table 1. The total number of Veterinarians was 178 included in collecting the questionnaire data. More number of Veterinarians were from Chhattisgarh state and a lesser number were from Puducherry.

The Aiken's value was calculated for the symptoms or signs of 13 cattle diseases and the ranking of the symptoms based on the scores obtained are presented in Table 2. The symptoms or signs were classified based on Aiken's values as less important - < 0.50, slightly important – 0.50-0.70, important – 0.71-0.90, and highly important - > 0.90. The ranks were assigned for each symptoms or signs within each disease. Further, the questionnaire was tested for reliability by using the Split-half test and the value obtained was 88.7% reliable. The consistency of the questionnaire

Table 2. Details of Aiken's value calculated for the 13 cattle diseases with rankings

Cattle diseases	Clinical Signs/Symptoms	Total score	Number of respondent	Aiken's value	Symptoms/ signs ranking
Anaplasmosis	Anaemia	714	107	0.74	2
	Fever	707	103	0.76	1
	Weight loss	443	86	0.57	4
	Breathlessness	241	75	0.36	6
	Jaundice	311	79	0.44	5
	Uncoordinated movements	174	69	0.28	7
	Abortion	113	54	0.23	9
	Death	186	75	0.28	8
	Anorexia, Pica	491	80	0.68	3
Anthrax	Sudden death	669	81	0.92	1
	Trembling	154	39	0.44	6
	Fever	451	61	0.82	4
	Difficulty in breathing	166	37	0.50	5
	Convulsions before death	152	39	0.43	7
	Bloody discharge from natural orifices	645	83	0.86	3
	Blood may not clot	601	74	0.90	2
Babesiosis	Fever	948	123	0.86	1
	Ataxia and incoordination	289	76	0.42	6
	Anorexia	806	117	0.77	3
	Haemoglobinuria	893	121	0.82	2
	Anaemia	761	114	0.74	4
	Nervous signs	244	73	0.37	7
	Jaundice	418	80	0.58	5
Black quarter	Fever	711	90	0.88	3
	Swelling of the limbs	763	95	0.89	1
	Affected limb warm to touch	725	93	0.87	4
	Lameness	747	95	0.87	5
	Crepitating sound in the affected area	802	100	0.89	2
	Affected muscle black in colour	688	93	0.82	6
Bovine Trypanosomiasis	Intermittent fever	559	79	0.79	1
	Anaemia	485	68	0.79	2
	Oedema	176	50	0.39	5
	Lacrimation	180	51	0.39	6
	Swelling of lymph nodes	194	57	0.38	7
	Abortion	125	46	0.30	8
	Loss of appetite	493	75	0.73	3
	Convulsions or uncoordinated movements	481	74	0.72	4
Brucellosis	Abortion	767	102	0.84	1
	Retention of placenta	740	99	0.83	2
	Reduction in milk yield	560	84	0.74	3
	Orchitis	272	53	0.57	4
	Hygroma of Knee	334	77	0.48	5
Foot and Mouth Disease	Vesicles on the nose, tongue, lips, oral cavity, between the toes, hooves, teats, and on the skin	1024	128	0.89	1
	Ulceration of tongue	898	119	0.84	6
	Fever	984	127	0.86	4
	Depression	764	112	0.76	8
	Hyper salivation	999	127	0.87	2
	Loss of appetite	931	121	0.85	5
	Drop in milk production	1013	129	0.87	3
	Limping of fore and hind limbs	715	103	0.77	7

Table 2 continued...

Table 2. *Concluded*

Cattle diseases	Clinical Signs/Symptoms	Total score	Number of respondent	Aiken's value	Symptoms/ signs ranking
Haemorrhagic septicaemia	Fever	847	110	0.86	1
	Salivation and serous nasal discharge	729	103	0.79	3
	Oedematous swelling in pharyngeal/ cervical/ brisket region	734	109	0.75	5
	Congestion of mucous membranes	712	104	0.76	4
	Respiratory distress	797	109	0.81	2
	sudden death	541	88	0.68	6
	Enteritis	233	67	0.39	7
Infectious Bovine Rhinotracheitis	Fever	310	45	0.77	1
	Coughing	268	43	0.69	4
	Loss of appetite	262	41	0.71	3
	Nasal discharge	326	47	0.77	2
	Conjunctivitis	293	47	0.69	5
	Infertility	242	44	0.61	7
	Abortion	279	47	0.66	6
Leptospirosis	Fever	501	72	0.77	1
	Anaemia	432	66	0.73	2
	Haemoglobinuria	382	62	0.68	4
	Jaundice	430	67	0.71	3
	Abortion	259	56	0.51	5
	Meningitis	173	44	0.44	7
	Blood tinged milk	186	42	0.49	6
Mastitis	Swollen udder	1058	134	0.88	1
	Warm, hard, red udder with pain on touching	1063	134	0.88	2
	Milk watery with clots, flakes, or pus	1033	134	0.86	4
	Fever	785	124	0.70	5
	Loss of appetite	660	115	0.64	7
	Reduction in milk yield	919	116	0.88	3
	Fibrosed udder	555	94	0.66	6
Rabies	Sudden change in behaviour	916	115	0.89	1
	Progressive paralysis	681	100	0.76	7
	Hypersensitivity	768	101	0.84	5
	Abnormal bellowing	819	107	0.85	3
	Paralysis of the throat	669	95	0.78	6
	Drooling of Saliva	831	107	0.86	2
	Rectal reflex	420	68	0.69	8
	Maniac behaviour	699	91	0.85	4
Theileriosis	Fever	817	109	0.83	1
	Loss of appetite	743	106	0.78	2
	Swelling of lymph nodes	689	104	0.74	4
	Haemorrhages on the mucous membrane	310	79	0.44	6
	Lacrimation	300	84	0.40	8
	Corneal opacity	240	76	0.35	10
	Nasal discharges	266	79	0.37	9
	Respiratory distress	450	87	0.57	5
	Diarrhoea	323	84	0.43	7
	Anaemia	641	94	0.76	3
	Jaundice	497	86	0.64	4
	Abdominal pain	165	57	0.32	11

was tested by Cronbach's Alpha coefficient and found to be 97.2% consistent. The combined symptoms/signs for 13 cattle diseases were collated and finally, 51 symptoms/ signs were obtained. Further, Aiken's values were used for preparing the weighted matrix of symptoms or signs. The value of each symptom/sign obtained was summed to
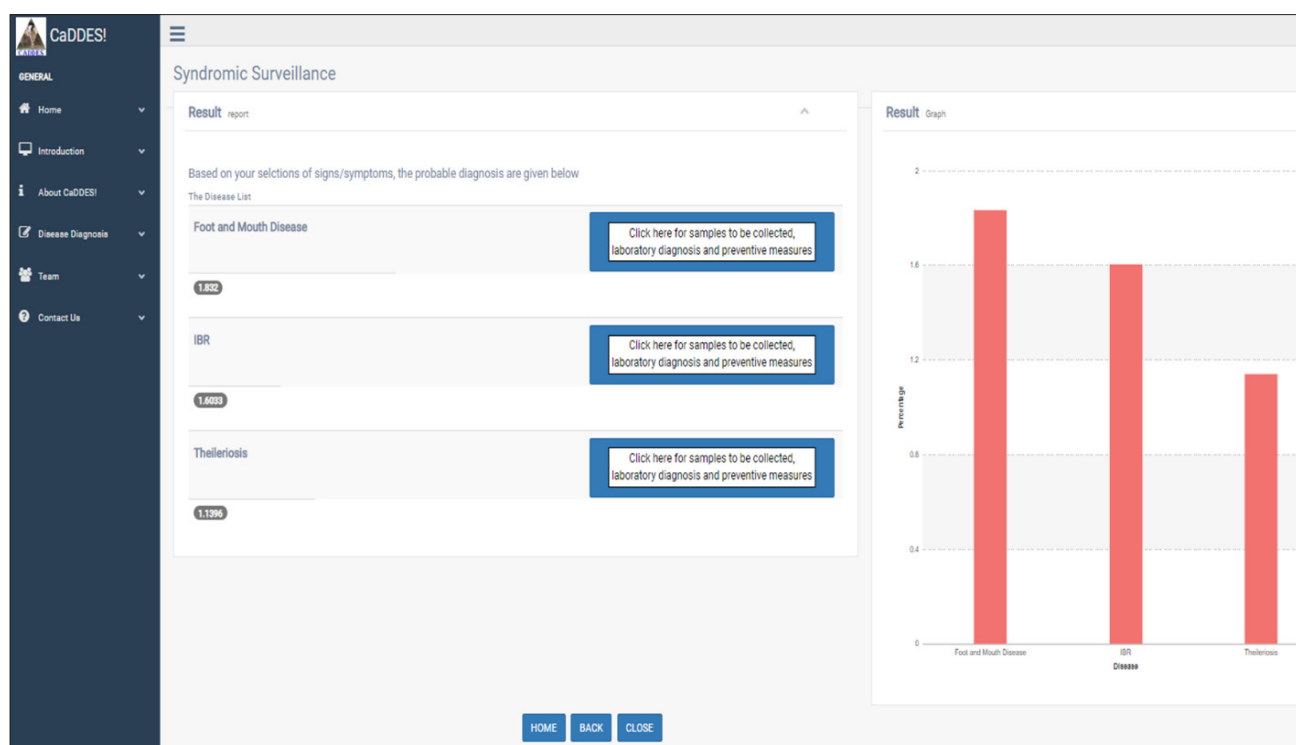
Fig. 2. CADDES Result page with probable diseases based on symptoms selected with samples to be collected for laboratory confirmation.

obtain the probability of three disease diagnoses arranged based on the sum of the symptoms or signs Aiken's value.

The Cattle Diseases Diagnosis Expert System (CaDDES), a web application was developed and is available online (https://nivedi.res.in/nicra/CaDDES/). The web application contains a web page menu including Home, Introduction, About CaDDES, Disease Diagnosis, Development Team, and Contact details. The internal validation of the web application was done by adding one symptom/sign each time to each disease and the percentage obtained for each disease. On the disease diagnosis page, the Veterinarian's and animal details such as cattle or buffalo, breed, age, and sex need to be selected from the drop-down menu before proceeding to the symptoms page. The symptoms or signs observed by the Veterinarian need to be selected on the symptoms page. The details of the results page of the CaDDES web application are shown in Fig. 2. The results page will be displayed with three probable diseases diagnosed based on the symptoms selected with the probability values. However, a mobile expert system using Fuzzy Tsukamoto for diagnosing cattle disease was developed but it was useful in identifying the endometritis disease risk level in cattle at 100% accuracy level (Suharjito et al. 2017) but not available for other diseases. A duck diseases expert system was developed using the alliance method in Bali, Indonesia for providing information to duck breeders, solving complicated problems, and information about duck diseases (Divayana 2014). Further, there are no expert system available for cattle diseases for comparison and may be considered as the first report from India to the best of our knowledge.

In the present expert system, a simple methodology of the sum of assigned values of symptoms or signs selected was used in diagnosing the 13 cattle diseases in India. The use of mobile applications in the endometritis detection and treatment in cattle was efficient, feasible, and easy to use compared to a desktop computer (Suharjito et al. 2017). Similarly, the CaDDES is easy to use and can be used from anywhere in the World. Further, the web application has the features of "samples to be collected for laboratory confirmation" and "preventive measures to be followed for the 13 cattle diseases". The source code of the CaDDES web application received the copyright registration from the Register of Copyrights (RoC) with number SW-15961/2023 dated 6th February 2023. The feedback obtained from 16 Veterinarians revealed the expert system was extremely useful (43.8%), useful (50%), and less useful (6.3%). From this feedback, it is implied that the expert system is useful in diagnosing the 13 cattle diseases.

The expert system will be useful for Veterinarians in the early diagnosis and to implement the preventive measures against cattle diseases. The web application developed is user-friendly and convenient to use in field conditions by Veterinarians. The CaDDES may be used in mobile phones also. It could be improved into a mobile application for better usage by field Veterinarians in near future. This expert system may be used by the farmers with simplified language for the symptoms or signs along with uploading the photographs of the symptoms or lesions observed, for accurate diagnosis of cattle diseases in the future. The early diagnosis using an expert system will help reduce

the disease occurrence and improve the milk production and export trade of buffalo meat in cattle and buffaloes. Thus, the cattle diseases diagnosis and prevention of cattle diseases will eventually result in economic benefits to the dairy farmers.

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