Journey towards National Institute of One Health in India

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Background & objectives: Issues such as emerging and re-emerging infectious diseases, antimicrobial resistance, food security, biosafety and biosecurity are associated with changes in land use, population growth, urbanization, global travel and trade and climate change. As a result, a trans-disciplinary approach among human, animal and environmental health disciplines gained support. The Indian Council of Medical Research (ICMR) and Indian Council of Agricultural Research (ICAR) decided to establish a National Institute of One Health at Nagpur, Maharashtra, India. In this context, two collaborative research projects, funded by the ICAR and ICMR were initiated to conduct the epidemiological surveillance of selected zoonotic diseases in Central India.

Methods: Disease surveillance and molecular detection employing standard techniques like enzyme linked immunosorbent assay (ELISA), immuno-fluorescent assay (IFA), standard tube agglutination test (STAT), Rose Bengal plate test (RBPT) and polymerase chain reaction (PCR) were undertaken based on the disease to be screened.

Results: In animals, the seropositivities for listeriosis (7.66%) and brucellosis (11.69%) were recorded. The occurrence of tuberculosis (3.8%) and leptospirosis (6.33%) was detected by PCR. Through cross-sectional studies from suspected human population with associated risk factors for zoonotic diseases, the seropositivity of brucellosis (1.83-11%), listeriosis (1.01-10.18%), leptospirosis (8.14-12.67%) and scrub typhus (1.78-20.34%) was recorded. The investigations on scrub typhus indicated bimodal pattern during the months of pre-monsoon and post-monsoon season with a peak in post-monsoon in human cases. Ornithonyssus bacoti mites were identified from the rodents as a vector harbouring Orientia tsutsugamushi. The bovine tuberculosis was detected in 1.43 per cent human cases employing molecular assay.

Interpretation & conclusions: The data indicated the occurrence of important zoonotic diseases adversely affecting the livestock health and human wellbeing. The scientific collaboration between veterinary and medical faculties has set an example for effective implementation of One Health (OH) programme for the establishment of National Institute of OH.

Key words Brucellosis - listeriosis - One Health - scrub thypus - surveillance - zoonotic diseases
The public health challenges in today’s world such as emerging and re-emerging infectious diseases, antimicrobial resistance, food security, biosafety and bio-security are associated with the changes in land use, population growth, urbanization, global travel and trade and climate change. As a result, a trans-disciplinary approach among human, animal and environmental health disciplines has gained support and visibility. On July 6, 2010 in Nagpur, India, the experts and scientists from medical and veterinary sciences in a national conference organized by the National Association of Welfare of Animals and Research in collaboration with Indian Medical Association (Nagpur Chapter) conceived the concept of establishing of a National Institute for Zoonoses (NIZ) at Nagpur. Since then, deliberations were held at the levels of the Indian Council of Medical Research (ICMR) and Indian Council of Agricultural Research (ICAR). Both the apex organizations were committed towards creating this imperative facility at Maharashtra Animal and Fishery Science University (MAFSU), Nagpur. Discussion on the setting up a dedicated facility was initiated. Subsequently, in March 2019, the ICMR declared to establish ‘Centre for One Health (OH)’, a satellite centre under National Institute of Virology, Pune in Nagpur. It is contemplated to be an independent institute though nomenclature may change from the NIZ to the National Institute for OH (NIOH). As a step towards activities of the institute, two research projects, funded by ICAR entitled ‘Centre for Zoonoses under Niche Area of Excellence’ to Nagpur Veterinary College (NVC), Nagpur, and another by ICMR to Mahatma Gandhi Institute of Medical Sciences (MGIMS), Sewagram, and Central India Institute of Medical Research (CIIMS), Nagpur, were sanctioned.

Material & Methods

The study was conducted under the projects ‘Centre for Zoonoses’ sanctioned by the ICAR and ICMR to NVC and CIIMS, Nagpur, and MGIMS, Sewagram, during 2015 to 2019. The zoonotic diseases namely brucellosis, listeriosis, tuberculosis, leptospirosis and scrub typhus were studied at the Centre for Zoonoses at NVC, Nagpur. the MGIMS, Sewagram, was assigned brucellosis, leptospirosis and scrub typhus, CIIMS worked on brucellosis, listeriosis and bovine tuberculosis. The research work with respect to disease surveillance and molecular detection of the pathogens was undertaken.

These studies were approved by the Institutional Ethics Committees (vide reference No. NVC/IAEC/19; MGIMS/IEC/MICR/118/2014 and 01/CIIMS/ICMR/09/14) of NVC, CIIMS and MGIMS. The samples were collected with prior consent of the animal owners and with written consent from human participants.

The team from the NVC, over a period of four years, collected the clinical samples from livestock (blood, serum, nasal swabs and vaginal swabs), other animals (blood and serum) and their human contacts (blood and serum) from different regions of Central India (Maharashtra, Madhya Pradesh, Chhattisgarh and Telangana). The samples were collected randomly. Further the number of samples included for screening for particular disease was based on the clinical symptoms. The details of clinical samples are presented in Table I.

At MGIMS, Sewagram, of the 3454 individuals, 1726 (49.97%) suspects with acute undifferentiated fever (AUF) were recruited from a tertiary care hospital. From the community, out of 10,000 population belonging to seven villages, 98 individuals were recruited by house-to-house visits over a period of one and a half year. Further, 166 individuals were selected from 8808 patients attending a rural hospital. The blood samples (2.5 ml) collected from these individuals were screened for seropositivity for brucellosis, leptospirosis and scrub typhus. The CIIMS, Nagpur, collected clinical blood samples from Central Indian population having animal–human interface. A total of 7026 blood samples were collected through cross-sectional studies from suspected populations with associated risk factors for seroprevalence against brucellosis, listeriosis and bovine tuberculosis.

The seroprevalence of listeriosis was studied by in-house standardized listeriolyisin-O based indirect IgG ELISA. Screening for brucellosis was conducted on the basis of the detection of antibodies against Brucella spp. by using in-housed standardized indirect IgG ELISA against lipopolysaccharide (LPS). Standard tube agglutination test (STAT) and Rose Bengal plate test (RBPT) were performed according to the procedure described by the World Organization for Animal Health (OIE). The samples from animals were screened for tuberculosis and leptospirosis by targeting the IS1160 gene and secY gene, respectively.

Scrub typhus among various occupationally exposed patients, abattoir workers, sanitary workers
and livestock owners was detected employing IgM-ELISA (InBios International, USA) and Immuno Fluroscent assay (IFA) (Fuller Laboratories, USA) as per the manufacturer’s instructions. The samples from rodents (blood and tissue) and vectors were investigated for the 56 and 47 kDa outer membrane protein genes of *Orientia tsutsugamushi*.

**Results**

**Brucellosis**: Of 9855 serum samples collected from animals, a total of 1152 (11.69%) and 898 (9.12%) samples were found to be positive for brucellosis by ELISA and by RBPT, respectively. Of the 3051 human serum samples tested, 56 (1.83%), 43 (1.40%) and 12 (0.39%) were positive by ELISA, RBPT and STAT, respectively (Table II). The antibodies for brucellosis were detected in 6.31 per cent samples collected from the human cases of AUF attending a tertiary care centre. In the samples collected from seven villages to central India, the occurrence of brucellosis was 11 per cent. Through the hospital-based observational retrospective studies, in suspected human cases with associated neurological morbidities, the presence of neurobrucellosis was found to be 8.4 per cent.

**Listeriosis**: In the present investigation, seropositivity for *Listeria* IgG was observed to be 7.66 per cent among animals (755/9855), whereas, of the 3346 human serum samples, 1.01 per cent were found to be positive. Of the 88 samples from women with spontaneous abortion, five (5.68%) were positive. Among the 98 samples collected from Central Indian human population, 9.3 per cent were positive for *Listeria*.

**Leptospirosis**: From endemic regions of leptospirosis, namely Konkan region and East Vidarbha of Maharashtra and Telangana, animal (1783) and human (1252) blood samples were tested. The *secY* gene was detected in 113 (6.33%) and 102 (8.14%) samples, respectively (Tables II and III). Among the 1726 human cases of AUF attending a tertiary care centre, 12.67 per cent (218 were positive for leptospirosis. Among the community of seven villages, the positivity for leptospirosis was seven per cent.

**Tuberculosis**: A total of 8363 samples from animals were screened for tuberculosis by targeting the *IS6110* gene, wherein 318 (3.8%) were found to be positive. Among the Central Indian human population who were in contact with animals; the overall occurrence of tuberculosis was 1.43 per cent and the hospital-based observational retrospective studies showed 12.3 per cent human cases of tuberculous meningitis.

**Scrub typhus**: A study on scrub typhus among various occupationally exposed patients, abattoir workers, sanitary workers and livestock owners was carried out. Of the, 462 serum samples, 94 (20.34%) were found to be positive by IgM-ELISA and 24 (5.14%) samples turned out to be positive by IFA (Tables II and III). The IFA could identify the infection of *O. tsutsugamushi* at strain level, viz. Karp, Gilliam, Kato and Boryong.

Blood and tissue samples of rodents trapped from different locations in Central India were processed for the detection of scrub typhus. The 56 kDa outer membrane protein gene of *O. tsutsugamushi* was detected from 10 of 59 samples, and the 47 kDa
protein gene was detected from four of 59 samples by nested-PCR. *Ornithonyssus bacoti* mites from the rodents were identified as a vector harbouring *O. tsutsugamushi*. The seasonal variations in the occurrence in *O. tsutsugamushi* in rodents and mites were studied by PCR detection targeting the 56 and 47 kDa genes. During pre-monsoon season, *O. tsutsugamushi* was detected in 12 and 10 per cent samples, whereas during post-monsoon season, the respective detection rates were 13.33 and 26.66 per cent predicting a bimodal pattern during the months of pre- and post-monsoon season with a peak in post-monsoon. The study conducted on the human cases having AUF attending a tertiary care centre indicated 15.79 per cent cases of scrub typhus. In the community of seven villages, four per cent positivity for scrub typhus was recorded.

### Table II. Region wise per cent positivity to targeted diseases in humans and animals

| Region     | Brucellosis | Listeriosis | Leptospirosis | Mycobacterium bovis | Mycobacterium tuberculosis | Rickettsia |
|------------|-------------|-------------|---------------|---------------------|--------------------------|-----------|
|            | Animals     | Human       | Animals       | Human               | Animals                  | Human     |
| Nagpur     | 5.91        | 0.42        | 6.29          | 0.66                | 65.38                    | 40.83     |
| Amravati   | 5.26        | 0.00        | 0.62          | 0.00                | 0.00                     | 0.00      |
| Nashik     | 21.71       | 5.66        | 11.43         | 0.00                | 25.28                    | 3.93      |
| Pune       | 13.05       | 3.36        | 6.98          | 3.66                | 0.00                     | 0.00      |
| Aurangabad | 9.95        | 0.92        | 0.00          | 0.00                | 0.00                     | 0.52      |
| Konkan     | 13.13       | 1.98        | 4.53          | 0.00                | 60.99                    | 92.30     |
| Chhattisgarh| 16.36       | 1.14        | 15.03         | 0.98                | 0.00                     | 0.00      |
| MP         | 12.07       | 7.41        | 18.15         | 10.18               | 0.00                     | 0.00      |
| Telangana  | 3.23        | 21.84       | 4.76          | 0.00                | 0.00                     | 0.00      |

### Table III. Species-wise per cent positivity to targeted diseases

| Species     | Brucellosis | Listeriosis | Leptospirosis | Tuberculosis | Rickettsia |
|-------------|-------------|-------------|---------------|--------------|------------|
| Human       | 3.64        | 1.01        | 45.86         | 1.04         | 5.92       |
| Cattle      | 26.95       | 10.67       | 23.52         | 4.83         | -          |
| Buffalo     | 10.90       | 1.40        | 45.61         | 0.61         | -          |
| Goat        | 7.39        | 5.56        | -             | 1.26         | -          |
| Sheep       | 10.32       | 3.56        | -             | 0.36         | -          |
| Pig         | 0.00        | 0.00        | -             | 0.00         | -          |
| Dog         | -           | -           | 80.00         | -            | -          |
| Rodent      | -           | -           | 69.23         | -            | 6.95       |
| Other       | 0.00        | 0.00        | 0.00          | 0.00         | 1.00       |

### Discussion

The global threats of zoonotic diseases are well known. Surveillance data help to identify areas and populations at increased risk for infection, improving ability to direct and prioritize health interventions, to monitor the effectiveness, timeliness and cost-effectiveness of prevention and control efforts and to identify gaps and new prevention strategies. In recent years, the OH approach to manage endemic and emerging/re-emerging zoonotic diseases has been promoted by international human and animal Health agencies. The presence of important zoonotic diseases, viz. listeriosis, brucellosis, tuberculosis, leptospirosis and scrub typhus, recorded in the present collaborative research was in accordance with Indian reports\(^1,6-21\). The study on vectors revealed novel findings, especially in scrub typhus and listeriosis.
Listeria monocytogenes has potential to infect humans and animals, resulting into septicaemia, gastroenteritis, meningitis, meningio-encephalitis, still birth and abortions\textsuperscript{22,23}. The Listeria strains have been isolated from women with poor obstetric history and premature births\textsuperscript{24}, buffaloes with reproductive disorders\textsuperscript{22,25} and foods of animal and fish origin\textsuperscript{26}. The present study reported 7.66 and 1.01 per cent seropositivity in animals and humans for Listeria IgG, respectively, along with 5.6 per cent cases of spontaneous abortions in women and 9.3 per cent of Listeria meningitis in human patients.

The seropositivities for brucellosis in animals by ELISA and RBPT were 11.69 and 9.12 per cent, respectively. Earlier investigations reported 6.5 per cent prevalence in organized farms\textsuperscript{32}; flock-wise incidence rate in sheep and goats was around 50 per cent\textsuperscript{2} and 17.8-55.5 per cent in occupationally exposed veterinarians\textsuperscript{28,29}. Although brucellosis in animals is involved in orchitis, arthritis, still births and late abortions, the most human cases exhibit undulant fever, headache, back pain, myalgia and arthralgia. Occupationally exposed people have more chances of getting infected during animal handling and care. Higher positivity was recorded among the individuals from the regions where livestock farming was intensified\textsuperscript{29}.

Tuberculosis has been a challenge to healthcare system. Our explorations indicated 1.43 and 3.80 per cent positivity of M. bovis in humans and farm animals, respectively. High occurrence of bovine tuberculosis was recorded in the persons living in tuberculosis-endemic region. These patients lived in poorly ventilated houses and exhibited similar symptoms to M. tuberculosis\textsuperscript{30}. Our reports in animals contradicted with earlier finding reporting 15-28 per cent infection of M. tuberculosis in animals\textsuperscript{31}; however, 0.4-51.2 per cent prevalence was recorded in different studies\textsuperscript{32}.

The occurrence of leptospirosis was reported from paddy areas where there are water logging conditions, soil pH is alkaline and rodent population is high\textsuperscript{33}. Our findings from animal in the endemic regions of Konkan and East Vidarbha and Telangana recorded 6.33 and 8.14 per cent occurrence in animals and humans, respectively, along with 12.67 per cent among the human cases of AUF attending a tertiary care centre. Additionally, seven per cent positivity was reported in human population of seven selected villages from Central India. Significant reduction in positivity was reported earlier in a tertiary health care centre in north India from 26.90 per cent in 2000-2010 to 6.47 per cent in 2015-2018\textsuperscript{34}. Leptospiral antibodies were found in 19.7 per cent rodents and dogs from Mumbai, India of which only 5.93 per cent samples showed the presence of the pathogen as confirmed by quantitative PCR and isolation\textsuperscript{35}.

Rickettsiosis has been reported from almost all parts of India\textsuperscript{36}. We reported 20.34 per cent seropositivity of scrub typhus among various occupationally exposed patients, abattoir workers, sanitary workers and livestock owners of Central India with involvement of O. tsutsugamushi in 5.14 per cent cases. O. tsutsugamushi was detected in rodents, ticks and O. bacoti mites from the study area\textsuperscript{37}. Our study demonstrated that the O. bacoti mites harboured this pathogen which could be transmitted among rodent population via bites and rodents might further perpetuate the infection to human being. Earlier, flea-borne rickettsiosis was reported in human from the Western Himalayan region\textsuperscript{38}.

The major highlight of the study was the collaborative work conducted which provided important links towards strengthening of the One Health approach that linked human and animals for prevention and control of zoonotic infections and their drivers through holistic and interdisciplinary approaches. The infrastructure and technical expertise developed at the Centre for Zoonoses at NVC could be utilized for addressing the public health issues. The training programmes could develop skilled workforce in the various aspects of zoonoses wherein participants from veterinary, medical and other allied fields would participate as a part of capacity building programmes.

In conclusion, the present study indicated the occurrence of important zoonotic diseases that affected both animal and human health. The upcoming NIOH will be developed to serve as national leader in zoonoses and the think tank devoted to One Health involving animals, human, wild life and environment by providing inter-sectoral and inter-disciplinary approach for surveillance, response, research, capacity building and advocacy/communication for prevention and control of zoonotic diseases.

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Conflicts of Interest: None.

References
1. Chaudhari SP, Malik SV, Banu RG, Barbuudhe SB. Detection of anti-listeriolysin-O and Listeria monocytogenes in experimentally infected buffaloes (Bubalus bubalis). Trop Anim Health Prod 2001; 33 : 285-93.
2. Barbuudhe SB, Chaudhari SP, Malik SV. The occurrence of pathogenic Listeria monocytogenes and antibodies against listeriolysin-O in buffaloes. J Vet Med B Infect Dis Vet Public Health 2002; 49 : 181-4.
3. Somekar CP, Kale S, Bhoyar S, Paliwal N, Shinde SV, Awandkar SP, et al. Brucellosis in migratory sheep flock from Maharashtra, India. Trop Anim Health Prod 2018; 50 : 91-6.
4. World Organization for Animal Health. Manual of Diagnostic Tests and Vaccines for Terrestrial Animals. Paris: OIE; 2008. p. 624-59.
5. Osman AL, Saeed NS, Elhassan MM. Polymerase chain reaction targeting insertion sequence IS6110 for the diagnosis of pulmonary tuberculosis among Sudanese children and young adults. Int J Mycobacteriol 2014; 3 : 252-8.
6. Ahmed A, Grobusch MP, Klatsner PR, Hartkeerl RA. Molecular approaches in the detection and characterization of Leptospira. J Bacteriol Parasitol 2012; 3 : 133.
7. Furuya Y, Yoshida Y, Katayama T, Yamamoto S, Kawamura A Jr. Serotype-specific amplification of Rickettsia tsutsugamushi DNA by nested polymerase chain reaction. J Clin Microbiol 1993; 31 : 1637-40.
8. Banu Rekha G, Malik SV, Chaudhari SP, Barbuudhe SB. Listeriolysin O based diagnosis of Listeria monocytogenes infection in experimentally and naturally infected goats. Small Rum Res 2006; 66 : 70-5.
9. Malik SV, Barbuudhe SB, Chaudhari SP. Listeric infections in humans and animals in the Indian subcontinent: A review. Trop Anim Health Prod 2002; 34 : 359-81.
10. Behera SK, Das D, Balasubramani K, Chellapan S, Rajaram K, Kumar Mohanta H, et al. Seroprevalence and risk factors of brucellosis in livestock in the wildlife and livestock interface area of Similipal Biosphere Reserve, India. Vet World 2020; 13 : 465-70.
11. Mantur BG, Amarnath SK. Brucellosis in India - A review. J Biosci 2008; 33 : 539-47.
12. Renukaradhya GJ, Isloor S, Rajasekhar M. Epidemiology, zoonotic aspects, vaccination and control/eradication of brucellosis in India. Vet Microbiol 2002; 90 : 183-95.
13. Bojiraj M, Porteen K, Gunaseelan L, Sureshkannan S. Seroprevalence of leptospirosis in animals and its public health significance. Int J Livestock Res 2017; 7 : 220-6.
14. Bojiraj M, Porteen K, Gunaseelan L, Kannan S. Diagnosis of leptospirosis in animals and human by dark field microscopy and polymerase chain reaction. Int J Livestock Res 2018; 8 : 172-83.
15. Balamurugan V, Thirumalesh SR, Sridevi R, Mohandoss N, Govindaraj G, Hemadri D, et al. Seroprevalence of bovine leptospirosis in Odisha, India. World J Vet Sci 2013; 1 : 1-7.
16. Balamurugan V, Thirumalesh SR, Veena S, Alamuri A, Nagalingam M, Sridevi R, et al. Investigation on the distribution of Leptospira serovars and its prevalence in bovine in Konkan region, Maharashtra, India. Adv Anim Vet Sci 2016; 4 : 19-26.
17. Uska K, Kumar E, Uska K, Kumar BS, Chaudhry A, Sai Gopal DV. Molecular detection of scrub typhus in Tirupati, Andhra Pradesh. Indian J Vector Borne Dis 2015; 52 : 171-4.
18. Srinivasan S, Menon T. Molecular detection of Orientia tsutsugamushi from suspected scrub typhus cases. Indian J Pathol Microbiol 2017; 60 : 70-3.
19. Nautiyal S, Jauhari S, Goel N, Mahawal BS. Incidence of scrub typhus in a tertiary care hospital in Uttarakhnad. Int J Adv Res 2016; 4 : 1.
20. Phaniraj K, Jayaramu GM, Sanganal J, Naveen Kumar GS. Incidence of tuberculosis in and around Bangalore. Vet World 2010; 3 : 161-4.
21. Thakur A, Sharma M, Kotch V, Dhar P, Kotch R. A study on the prevalence of bovine tuberculosis in farmed dairy cattle in Himachal Pradesh. Vet World 2010; 3 : 409-14.
22. Graves LM, Helsel LO, Steigerwalt AG, Morey RE, Daneshvar MI, Roof SE, et al. Listeria marthii sp. nov., isolated from the natural environment, finger lakes national forest. Int J Syst Evol Microbiol 2010; 60 : 1280-8.
23. Guillet C, Join-Lambert O, Le Monnier A, Leclercq A, et al. Incidence of pulmonary tuberculosis among dairy cattle in Konkan region, Maharashtra, India. Vet World 2010; 3 : 136-8.
24. Dhanshree B, Otta SK, Kanunasaragi I, Goebel W, Karunasaragi I. Incidence of Listeria spp. in clinical and food samples in Mangalore, India. Food Microbiol 2003; 20 : 447-53.
25. Shakuntala I, Malik SV, Barbuudhe SB, Rawool DB. Isolation of Listeria monocytogenes from buffaloes with reproductive disorders and its confirmation by polymerase chain reaction. Vet Microbiol 2002; 117 : 229-34.
26. Karunasaragi I, Kanunasaragi I. Listeria in tropical fish and fishery products. Int J Food Microbiol 2000; 62 : 177-81.
27. Mehr A, Dhansher NS, Chaturvedi VK. Sero-positivity of brucellosis in bovines of Madhya Pradesh. Indian Vet J 2000; 77 : 571-3.
28. Patil NB, Damle AS, Bhakare JB, Irvane JA, Khaparkhuntkars MN, Gajbiye PS. Positivity of brucellosis in veterinarians. J Glob Infect Dis 2013; 5 : 87-8.
29. Yohannes M, Gill JP. Seroepidemiological survey of human brucellosis in and around Ludhiana, India. Emerg Health Threats J 2011; 4 : 7361.
30. Bapat PR, Renuka S, Dodkey RS, Shekhawat SD, Husain AA, Nayak AR, et al. Prevalence of zoonotic tuberculosis and associated risk factors in Central Indian populations. *J Epidemiol Glob Health* 2017; 7: 277-83.

31. Prasad HK, Singhal A, Mishra A, Shah NP, Katoch VM, Thakral SS, et al. Bovine tuberculosis in India: Potential basis for zoonosis. *Tuberculosis (Edinb)* 2005; 85: 421-8.

32. Srinivasan S, Easterling L, Rimal B, Nilu XM, Conlan AJ, Dudas P, et al. Prevalence of bovine tuberculosis in India: A systematic review and meta-analysis. *Transbound Emerg Dis* 2018; 65: 1627-40.

33. Shivkumar S. Leptospirosis – Current scenario in India. *Med Update* 2008; 18: 799-809.

34. Agrawal SK, Chaudhry R, Gupta N, Arif N, Bhadur T. Decreasing trend of seroprevalence of leptospirosis at All India Institute of Medical Sciences New Delhi: 2014-2018. *J Family Med Prim Care* 2018; 7: 1425-8.

35. Patil D, Dahake R, Roy S, Mukherjee S, Chowdhary A, Deshmukh R. Prevalence of leptospirosis among dogs and rodents and their possible role in human leptospirosis from Mumbai, India. *Indian J Med Microbiol* 2014; 32: 64-7.

36. Tilak R, Kunwar R, Tyagi PK, Khera A, Joshi RK, Wankhade UB. Zoonotic surveillance for rickettsiae in rodents and mapping of vectors of rickettsial diseases in India: A multi-centric study. *Indian J Public Health* 2017; 61: 174-81.

37. Bhate R, Pansare N, Chaudhari SP, Barbuudhe SB, Chaudhary VK, Kurkure VV. Prevalence and phylogenetic analysis of *O. tsutsugamushi* in rodents and mites from Central India. *Vector borne Zoonotic Dis* 2017; 17: 749-54.

38. Chahota R, Thakur SD, Sharma M, Mittra S. Detection of flea-borne Rickettsia species in the Western Himalayan region of India. *Indian J Med Microbiol* 2015; 33: 422-5.

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