Waterborne zoonotic diseases- Indian scenario and antimicrobial resistance: Onehealth approach

Abstract

Waterborne zoonotic diseases such as Diarrhoea, gastroenteritis, Brucellosis cause heavy loss to the livestock farmers and cause growing health risk to the citizens and economy as exemplified by the recent COVID-19 pandemic.

The global Onehealth initiative aims to map and reduce the risk of zoonotic i.e. animal borne microbial diseases through integrated approach of human & livestock health. Preventive strategies such as water, sanitation and hygiene (WASH) are vital and even herbal medicines can address the antimicrobial resistance (AMR), due to the antibiotics overuse.

We studied such integrated approach in the India focussed on 2 bacterial pathogens- *Escherichia coli&Salmonella enterica,* causing diarrhoea and gastroenteritis respectively at Pune city and in Dehradun District, Uttarakhand state. Our study using stakeholder consultations and literature survey indicated that (a) India has established draft national Onehealth mission, and is gearing up to meet the challenge, including initiatives such as by the Kerala state, (b) surveillance mechanism needs to be improved especially animal and water testing, reporting and tracking, in the less developed states such as in the Himalayas or central and eastern Indian forests, (c) public awareness campaign on WASH and AMR is needed for enhanced biosecurity as is observed at Pune, (d) Ministry of Jal Shakti, Uttarakhand Jal Sansthan, Uttarakhand Renewable Energy Development Agency (UREDA) and Central Water Resource Ministry and biogas scheme/ non renewable energy department may be involved in livestock waste reuse for circular economy and reduce contamination risk.

Keywords: aquatic, livestock, pathogens, epidemic, health, antibiotic

1. INTRODUCTION

The sudden emergence of COVID-19 as the pandemic and loss of millions of lives, social fabric and economy during 2020-22 globally alerted the world to prepare for addressing and reducing the risk of future health risks from microbes. Zoonotic diseases i.e. from the Animal origin pathogens livestock have been rising recently such as Bird flu i.e. Avian and Swine flu causing a global scare (Libera et al, 2022). The livestock production (milk, eggs, meat) is rising rapidly with the rising economy and affluence vide NABARD report (Fig. 1,Birthal, 2022). The sector recorded an unprecedented growth rate of 7.6% per year during 2011-20, which is twice the agricultural sector growth rate. The livestock sector is the new agricultural growth engine, raising its to 30% in the agricultural gross value added (GVA) and over 50% in the agri-growth (https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1935628). But this implies higher risk of zoonotic diseases and we present a snapshot of it with focus on selected waterborne diseases as illustrative of the segment here. Fig. 1 represents that schematic diagram of animal to human disease transmission. A pathogen such as *Escherichia coli* responsible for diarrhoea in humans and calves may transfer from the livestock to humans via milk or water pollution due to cattle dung. Conversely, it may affect cattle drinking the river water if humans defecate in the open, thus passing on the infection.

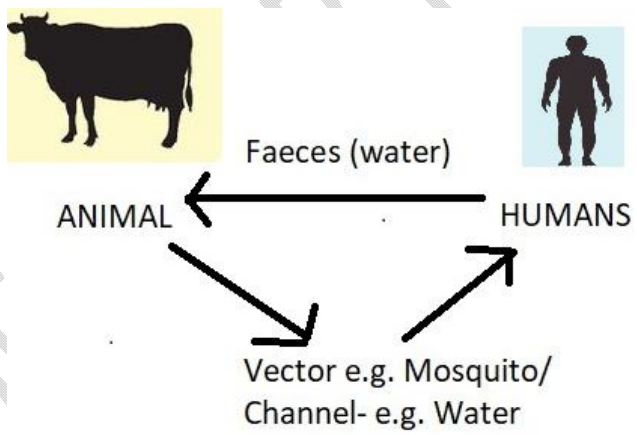


Fig. 1**- Zoonotic diseases transmission**

We got the opportunity to study the waterborne zoonotic disease monitoring and reporting, management system in a project under the Onehealth project of Consultative Group of International Agriculture Research (CGIAR, https://www.iwmi.cgiar.org/2023/10/water-amplifying-impact-through-the-cgiar-initiative-on-one-health/).

Uttarakhand state is selected for the study as it has the highest diarrhoea at 17% of sample detection among the children below 5 years age which is 2 times the national average (9.2%) vide data from the National Family Health Survey-IV (NFHS-4) data of India, 2015–16 (Ghosh et al, 2021). Zoonotic pathogens *Escherichia coli&Salmonella* both cause diarrhoea, among others, and affect- dairy & poultry causing mastitis & paratyphoid disease

in respectively (Dubal et al, 2014). We studied the Pune environs first to pilot the study approach as we are based at Pune and this helped to finalize the respondent's questionnaire and stakeholders' identification (policymakers, managers, livestock farmers, dairy and poultry entrepreneurs etc.) to identify the status of the subject and gap analysis at the policy and programme level.

2. OBJECTIVES

The study intended to include map the subject status and identify gaps and to suggest suitable remedial measures. Government of India has recognized the importance of the subject & has initiated national integrated disease surveillance programme (IDSP) and training of veterinarians under it (NCDC, 2015). This research aims to complement the policy initiatives so as to strengthen it further.

There are many stakeholders of waterborne zoonotic diseases ranging from the villagers who drink or use stream water at the river origin in the mountains to water management officers in Government of India, New Delhi or international agencies such as the World Bank that has recently funded "Onehealth" support project in 5 Indian states. We did the stakeholder analysis & prioritization in and vide another study (World Bank, 2023).

3. STUDY AREA

The study area is Song river basin near Dehradun capital city in Uttarakahand state in India where the water quality poor due to both biotic and chemical pollution with water borne diseases being common in the past e.g. diarrhoea, cholera, malaria, Japanese encephalitis, hepatitis, dengue, enteric fever (Uniyal et al, 2022). We also studied the subject at Uralikanchan village cluster, 40 km off Pune, a megacity with 7 million population in the western India, close to Mumbai metropolis, which is the economic capital of India.

4. METHODOLOGY

The following research tools were used to analyze the situation-

a) Desk research,
b) Stakeholder interviews,
c) Expert consultations.
d) Secondary data (literature survey).

We conducted policy analysis of the topic through literature search and consulting experts and attending policy workshop at Pune besides inviting policy makers as project inception workshop at Dehradun.

We also conducted stakeholders mapping to identify the linkages and any gaps in it. Stakeholders are defined as groups of people that could be affected by the implications of a decision and that can directly or indirectly influence (Ahmadi et al, 2019). Here, they include-

a) Policymakers- Drinking Water, Health, Animal Husbandry, Food Safety, Pollution, Bio-energy department higher officials (director/ secretary/ commissioner).

b) Others (Policy influencers/ affected sections/ contributors)- R&D agencies, Industry, Agri-universities, bio-energy enterprises, Media, Veterinarians, Farmers, Meat shops, dairy, hotels, community.

We sampled representatives of each stakeholder types using “Epicollect app” in handheld mobile phones, to know the current diseases status, trends &stakeholder perceptions about the issue.

5. RESULTS

Table 1- **Stakeholders consulted**

CATEGORY WISE

SN	CATEGORY	No
1	National	21
	Uttarakhand	
2	Govt. Officers	10
3	Doctors	12
4	R&D experts	25
5	Business	51
6	Community	57
	Pune	
7	Policymakers	5
8	Farmers	3
9	Entrepreneurs	5
	TOTAL	189

CATEGORY & Sub-Category

DOCTORS	NO
Human	7
Veterinary	5

BUSINESS	NO
Physicians	7
Veterinary	5
Hotel	20
Meat shops	12
Vegetable vendors	5
Poultry	8
Dairy	6

FARMERS	NO
Livestock owners	25
Vegetable farmers	32

Note- Stakeholders interviewed are enlisted in the supplementary data file uploaded.

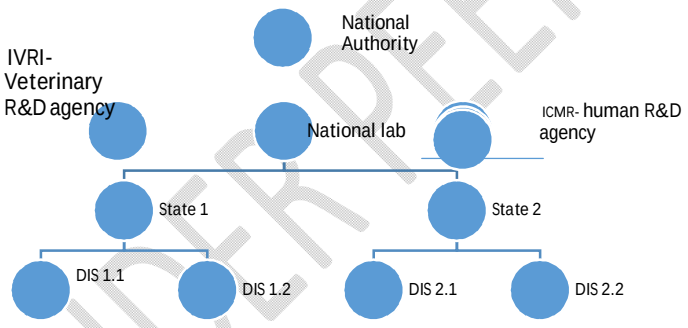
5.1 Awareness & monitoring system

The government officials, R&D agencies were aware of zoonotic diseases and management strategies, but school, colleges had only partial knowledge. Community- farmers, citizens were unaware of the issues and precautionary measures needed such as WASH strategies. The farmers had poor idea of AMR issues and gave antibiotics as prescribed by their regular visiting veterinarians. R&D agencies, scientists said that the antibiotics prescribed were often higher grade or in higher dosage than optimal to show quick results to the farmer. However, this lead to AMR development in many cases. This practise needs to be curbed and sensitisation meetings need to be conducted at the district level for veterinarians rational prescription to reduce the AMR risk. Indian Government did ban some antibiotics earlier e.g. Colistin for poultry to contain AMR (Mutua et al, 2022).

A major gap identified in Uttarakhand is the lack of regular testing of cow herds, dairy, poultry by the Govt. veterinary staff with meagre strength. Farmers call private veterinary practitioners only if they realize that the animal become sick (stops giving milk/ eggs/ prominent disease symptoms noticed such as mastitis/ Ranikhet disease). The milk/ eggs/ animals are sold locally in retail and few organized dairy or poultries exist. Cow dung is used as a farm manure and hardly collected by municipality or sold or used for biogas etc. The poultry units, dairy or meat shops are needs to be monitored. There is acute need of official abattoir/ slaughter house under the state Government. Absenceof this s has led to flourishing of the illegal/ sometimes unscrupulous animal culling and disposal. This needs to be regularized for biosecurity and consumer health.

The situation is better in industrial/ commercial settings like Pune city where waterborne pathogenic diseases such as Cholera, Typhoid etc. have long vanished/ are extremely rare due to the piped water and sanitation full coverage, robust biosecurity system. Here, most farmers keep cattle/ poultry with some industry tie up for marketing. The industry sends their veterinary physician each week for animal health monitoring. Any medications are provided instantly if s/he notices any health upset and collects blood/ urine/ dung samples for testing at the company lab/ Govt. lab as and when required. They send samples to the disease investigation section laboratory (set up 1/ district by the animal husbandry, DIS, https://ahd.maharashtra.gov.in/en/dis-dis). Its mandate is to check continually for any risk assessment. The disease can send the sample for testing at National Laboratory at Bhopal in case of doubt/ confirmation of sensitive cases e.g. pathogen with epidemic risk/ advisory by the Government. Industries in Pune city such as dairy or poultry regularly send samples of blood/ tissues/ water to DIS for testing to detect any risk and its part of their routine vigilance for "biosecurity" i.e. "biosafety" protocol in the urban livestock industry. The DIS in chare reports the monthly to state authority and national authority gathers monitoring reports from all state nodal officers. This minimizes the epidemic risk and can be managed as successfully done before in case of bird flu or swine flu etc. notwithstanding some scare and some disturbance caused at the farmer level. Fig. 2 depicts the bio-surveillance system.

Fig. 2- Livestock disease monitoring system in India



DIS- Disease investigation section

5.2 Monitoring and livestock waste management

The full scale bio surveillance system sketched above is week in Uttrakhand due to hilly, forested terrain, low penetration by industries and primitive economy. Here the system needs to improve with industry participation as client or donor in the CSR- corporate social responsibility (CSR) project. One such example is Krishnanyan Gaushala, Haridwar in Uttarakhand (https://www.krishnayangauraksha.org/). It shelters hundreds of cows and runs many welfare activities including bio-CNG (compressed natural gas) unit supported by

Indian Oil Corporation CSR (https://www.krishnayangauraksha.org/csr.html). Similar efforts are needed elsewhere in the state and other Himalayan states besides poor, hilly, forested states in central India such as Chhattisgarh, Bihar and Orissa, among others as these have high prevalence of water borne diseases such as diarrhoea, cholera, typhoid. There are vaccine for cholera, typhoid but more research and needs to develop vaccines against other causative bacteria as its far more complex and challenging than viruses so preventive measures such as hygiene is the financially cheap key to management (Osterloh, 2022).

This declining trend in waterborne diseases is continued and intensified recently due to the increaseawareness in the cleanliness and hygiene countrywide, especially rural areas, to provide toilets under the Swatch Bharat (Clean India) Mission and andJaljeevan (clean drinking water)mission both started from 2014 by the Indian government(Dandabathula et al, 2019). More than 14 million DALYs (Disability-Adjusted Life Years) are estimated to be avoided (diarrhoea and protein-energy malnutrition) between 2014 and October 2019 (WHO, n.d.). The same brief SBM - Grameen (rural) could have averted more than 300 000 deaths (diarrhoea and protein-energy malnutrition) between 2014 and October 2019. This success been ascribed to the coverage of toilets to all families and sanitation improvement besides piped drinking water supply country wide (Hussain and Das, 2023). Further, 55% drop in the acute diarrhoea disease (ADD) outbreaks is reported post 2015 due to SBM (Dandabathula et al, 2019).Muzembo et al (2022) have similarly recorded 40% reduction in the number of cholera outbreaks across the country during 2016-2020 (347) compared to 2011-2015 (218), another waterborne disease. However, increasing broad spectrum/ multi-drug resistance (MDR) is noted in both E. coli and Salmonella (Taneja and Sharma, 2019), and especially the later (Balaji, 2018, Jacob, 2020). Similar pattern is noted in other south Asian countries also and is a cause for concern due to the future pandemic prospects (Talukder et al, 2023).

5.3 Policy

We reviewed policy linked to water and contamination also for long term, systemic change. The following policies regarding the Onehealth topic are noted-

- Water Pollution control act, 1974,
- Food Saftey act, 2006,
- Livestock Health & Disease Control scheme, GoI (n.d.),
- Bioenergy Programme, 2021 (for biogas to manage livestock waste),
- Antimicrobial resistance (AMR) plan, 2017 (Ranjalkar et al, 2019).

Indian government has announced draft one health mission through the Principal Scientific Advisor to the Prime Minister (Bhatia, 2021, PSA, 2023). It has the 9 departments included in its steering committee but it can add another 7 ministries/ department as below to cover waterborne zoonotic disease aspect, including recycling of animal waste through biogas. Kerala state leads the country in bringing out Onehealth state policy, 2021 involving the panchayat (3 tier governance council system- local to state level, Suhail et al, 2023). Other states may follow this, starting with Assam, Karnataka, Maharashtra, Odisha, and Madhya Pradesh states, included in the recently started project of the World Bank (2023). Uttarakhand state included in the onehealth project supported by Bill & Melinda Gates foundation (BMGF, https://www.ohsu.in/) may also include it on priority.

Table 2- Stakeholders in the Onhealth mission and need for additions

INCLUDED	TO CONSIDER FOR ADDITION
1. Agriculture Department 2. Animal Husbandry 3. Indian Council of Medical Research (ICMR) 4. Science and Technology department 5. Environment, Forest and Climate Change 6. Health and Family Welfare 7. Biotechnology 8. Principal Scientific Adviser to the PM, GoI **9.** Disaster Management Authority (DMA)	**1.** Water resource Ministry **2.** Drinking water & sanitation department* 3. Pollution Control Board (PCB) **4.** State Renewable Energy Development Agency* **5.** Central Pollution Control Board, **6.** Food Safety and Standards Authority of India **7.** Indian Veterinary Research Institute (IVRI)

*- for comprehensive biogas coverage in all villages and bio-CNG in suture.

Note- underlined departments have their parent ministry included in the central government committee.

6. DISCUSSION

Literature survey shows the decline in the Diarrhoea DALYs rate (per 100,000 population) by age in India from 1990 to 2019 (Behera and Mishra, 2022)- All ages: The DALYs rate has been declined from 6544 in 1990 to 1446 in 2019 (70% decline in 29 years, Under – 5 year age: DALYs declined from 27,351 in 1990 to 4283 i.e. 85% decline). This could be attributed to the economic development, literacy, awareness and modern housing.

Table 3- **Diarrhoea intensity trend in India**

	Diarrhoea mortality #
2010	64
2015	51
2020*	49
% decline in 10 years	22%

#- mortality, *- 2019 data **- Sachu, 2023.

We highlight that "water" channel is ignored as a medium for zoonotic diseasestransmissiondespite diarrhoea being common across India.Water resource ministry is absent in the national Onehealth mission (draft) steering committee composition (PSA, 2023) and needs to be included. In particular, drinking water and sanitation department in it is crucial as it is responsible for rural and urban water supply to be clean, potable. It is also entrusted with family/ community biogas unit scheme towards the recycling/ circular economy goal.

The 2nd lacunae evident is the limited Animal health inspection and tracking system/ protocols that are sound on paper butbut needs to be practice socio-economically backward states/ regions due to low budgets, limited human resources of infrastructure gaps (laboratories, chemicals, machinery). Hence, due to awareness the "biosecurity" system appears sound in industrial belts around metro cities such as Pune-Mumbai. Here, the industry/processing houses regularly sends veterinarianstaff with medicines to detect disease profile and service the poultry or dairy entrepreneurs in the safe limits. They also report the same to the local Government authorities (Animal disease inspection unit) and get animal/ water samples tested regularly. Such robust disease tracking system is needs to improve backward states such as in the Himalayan mountains, north eastern and central Indian hill forests (Orissa, Chhattisgarh, Jharkhand states). Animal disease surveillance and facilities, human resources here need rapid increase to reduce the future risks of waterborne zoonotic disease outbreaks.

The food safety guidelines issues by FSSAI are followed in metros but needs to follow in case of petty vendors of meat/ vegetables or roadside small hotels/ canteens etc. There is acute need to establish abattoirs in states such as Uttarakhand for instance, raising public health risk. This department needs higher budget, more staff & machinery, monitoring-review effort for the better health of the society. .

Engaging Industry and CSO to larger extent in the onehealth mission including CSR (corporate social responsibility) programmes can be useful to address the above gaps. Veterinary associations and livestock farmers also need to be involved in raising awareness and austerity in prescribing antibiotics or preventive measures regarding Antimicrobial resistance (AMR) for its effective control. Multiple strategies need to be promoted to reduce the over indulgence in the antibiotics, including herbal medicines in humans and in the livestock (Chaughule and Barve, 2022). This is demonstrated in case of E.coli in the calf by the Indian National Dairy Research Institute (Rai et al, 2023) and in vitro (Venugopal et al, 2009) and for Salmonella in China (Shu et al, 2022). Herbs operate in multiple modes e.g. inhibiting bacterial growth or regeneration or biofilm. Herbal ingredients are being mixed recently to reduce the AMR **(**Naeemasa et al, 2015).

Asaaga et al (2022) with focus on Kyasanur Forest Disease(zoonotic, but not waterborne) in Kerala discussed 3 channels of stakeholder engagement as below is useful to pursue in the future roadmap-

a) Research, education- Knowledge generation,
b) Govt. Line departments - integrated management, disease reporting, tracking.
c) Community, grassroots workers (e.g.) farmers- awareness, preventive action.

7. CONCLUSIONS

We identified “water resource ministry” and particularly drinking water and sanitation department in it is crucial to involve in onehealth mission steering committee. For, it is responsible for rural and urban water supply to be clean, potable and is also entrusted with family/ community biogas unit scheme.Food safety system alsoneeds to get higher budget, sufficient staff and machinery and monitoring-review effort. Finally, veterinary associations and livestock farmers, industry & CSOs need to be engaged for effective Anti microbial resistance (AMR) control including public awareness and herbal drugs.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during writing or editing of manuscripts.

REFERENCES

1. Ahmadi, A., Kerachian, R., Rahimi, R., & Emami Skardi, M. J. . Comparing and combining Social Network Analysis and Stakeholder Analysis for natural resource governance. *Environmental Development*, 2019; *32*. https://doi.org/10.1016/j.envdev.2019.07.001
2. Asaaga FA, Young JC, Srinivas PN, Seshadri T, Oommen MA, et al. Co-production of knowledge as part of a OneHealth approach to better control zoonotic diseases. PLOS Global Public Health, 2022; 2(3):e0000075.

https://doi.org/10.1371/journal.pgph.0000075

3. Balaji V., Kapil A., Shastri J., Pragasam A. K., Gole G., Choudhari S. et al.. Longitudinal Typhoid Fever Trends in India from 2000 to 2015. *Am. J. Trop. Med. Hyg.,* 2018; *99 (Suppl 3),* pp. 34–40. doi:10.4269/ajtmh.18-0139
4. Behera, D.K., Mishra, S. The burden of diarrhoea, aetiologies, and risk factors in India from 1990 to 2019: evidence from the global burden of disease study. *BMC Public Health,* 2022; **22**, 92. https://doi.org/10.1186/s12889-022-12515-3.
5. Bhatia, R.. National Framework for One Health. New Delhi, FAO, 2021. https://doi.or.10.4060/cb4072en
6. Birthal P. S.. Livestock, Agricultural Growth and Poverty Alleviation. NABARD Research and Policy Series,2022; No. 7/2022. Mumbai.
7. Chaughule R., Barve R.Role of herbal medicines in the treatment of infectious diseases.*Vegetos,*2024; 37:41–51. https://doi.org/10.1007/s42535-022-00549-2
8. Dandabathula G, Bhardwaj P, Burra M, Rao PVVP, Rao SS. Impact assessment of India's Swachh Bharat Mission - Clean India Campaign on acute diarrheal disease outbreaks: Yes, there is a positive change. *J Family Med Prim Care.*; 2019; 8(3): 1202-1208. doi: 10.4103/jfmpc.jfmpc_144_19.
9. Dubal Z B, Barbuddhe S B and Singh N P. Important Zoonotic Diseases: Prevention and control. Technical Bulletin No. 39. ICAR Research Complex for Goa (Indian Council of Agricultural Research), Old Goa- 403 402, 2014; Goa, India.
10. Ghosh K., Chakraborty A. S., Mog M. . Prevalence of diarrhoea among under five children in India and its contextual determinants: A geo-spatial analysis Clinical Epidemiology and Global Health 2021; 12: no. 100813, pp. 7. https://doi.org/10.1016/j.cegh.2021.100813
11. Husain Z., Das P. Reducing child diarrhoea in India: Shifting policy focus from source of water to quality, Water Resources and Economics, 2023; Volume 42, no. 100221,https://doi.org/10.1016/j.wre.2023.100221.

12. Jacob J., Solaimalai D., Sethuvel D.P. , Rachel T., Jeslin P. , Anandan S., Veeraraghavan B. A nineteen-year report of serotype and antimicrobial susceptibility of enteric non-typhoidal *Salmonella* from humans in Southern India: changing facades of taxonomy and resistance trend. Gut Pathog, 2020; 12 (1) (2020), pp. 1-9.doi : 10.1186/s13099-020-00388-z
13. Libera, K, Konieczny K., Grabska, J., Szopka, W., Augustniak, A., Pomorska-Mol, M. Selected Livestock-Associated Zoonoses as a Growing Challenge for Public Health. Infect Dis Rep. 2022 Feb; 14(1): 63–81.doi: 10.3390/idr14010008
14. Mutua F, Sharma G, Grace D, Bandyopadhyay S, Shome B, Lindahl J. 2020. A review of animal health and drug use practices in India, and their possible link to ntimicrobial resistance. Antimicrob Resist Infect Control. 2020; Jul 8; 9(1):103. doi: 10.1186/s13756-020-00760-3.
15. Muzembo B A, Kitahara K, Debnath A., Ohno A.,Okamoto K., Miyoshi S-I.. Cholera Outbreaks in India, 2011–2020: A Systematic Review. Int J Environ Res Public Health. 2022 May; 19(9): 5738. doi: 10.3390/ijerph19095738
16. Naeemasa, M., Alaw Qotbi, A.A., Seidavi, A., Norris, D., Brown, D., Ginindza, M. Effects of coriander (*Coriandrum sativum* L.) seed powder and extract on performance of broiler chickens. *South African Journal of Animal Science*, 2015; *45*(4), 371-378. https://dx.doi.org/10.4314/SAJAS.V45I4.3
17. NCDC . Integrated Disease Surveillance Programme (IDSP)- Training Manual for Veterinary Consultants under IDSP. National Centre for Disease Control (NCDC), Ministry of Health & Family Welfare, Govt. of India, 2025; New Delhi.
18. Osterloh A.. Vaccination against Bacterial Infections: Challenges, Progress, and New Approaches with a Focus on Intracellular Bacteria. Vaccines (Basel). 2022; May10; 10(5):751. doi: 10.3390/vaccines10050751
19. PSA. National Onehealth Mission (draft), Office of the Principle Scientific Advisor to the Prime Minister, Government of India, 2023; New Delhi. https://www.psa.gov.in/innerPage/psa-initiatives-covid/one-health/4053/4053
20. Rai S, Kumar M. Jas R. Mandal G. P. Samanta I. RajendarM et al.. Antibacterial effect of kitchen herbs against pathogenic multidrug- resistant *E. coli* isolates from calf diarrhoea.*Tropical Animal Health and Production.* 2023; *55:211*.https://doi.org/10.1007/s11250-023-03628-x.
21. Ranjalkar J, Chandy SJ. India's National Action Plan for antimicrobial resistance - An overview of the context, status, and way ahead. J Family Med Prim Care. 2019 Jun;8(6):1828-1834. doi: 10.4103/jfmpc.jfmpc_275_19
22. Sachu A. Prevalence and antimicrobial susceptibility pattern of Salmonella and Shigella in stool among patients presenting with diarrhea in a tertiary caretertiary care centre in south India. *Iran. J. Microbiol*.2023; 15 (2): 236-242.doi : 10.18502/ijm.v15i2.12475
23. Shu J, Liu H, Liu Y, Chen X, Yu Y, Lv Q, et al. Tannic Acid Inhibits *Salmonella enterica Serovar Typhimurium* Infection by Targeting the Type III Secretion System. *Front. Microbiol.* 2022; 12:784926. doi: 10.3389/fmicb.2021.784926.
24. Suhail, M. K., Hannis, D., Armstrong, A., & Rhodes, A. Implementation of 'One Health' approach in Kerala state, India – A systematic review. *Veterinary Medicine and Science*, 2023; *9,* 2625–2633. doi: https://10.1002/vms3.1307

25. Talukder, H., Roky, S.A., Debnath, K. *et al.* Prevalence and Antimicrobial Resistance Profile of *Salmonella* Isolated from Human, Animal and Environment Samples in South Asia: A 10-Year Meta-analysis. *J Epidemiol Glob Health,* 2023; **13**, 637–652. https://doi.org/10.1007/s44197-023-00160-x
26. Taneja N, Sharma M.. Antimicrobial resistance in the environment: The Indian scenario. Indian J Med Res2019.; 149(2):119-128. doi: 10.4103/ijmr.IJMR_331_18.
27. Uniyal D.P., Khatri S, Dobhal R, Aswal J.S. Chander V, Singh, P, Sinha V S. Prevalence of waterborne diseases and drinking water quality in the tribal areas of Garhwal Himalayas Uttarakhand, India: An awareness programme and mitigation approaches. *Jr. Sci. Temper*, 2021; 9 (3-4): 184-206. DOI: https://10.56042/jst. v9i3-4.67114.
28. Venugopal A., Dasani S., Rai S. Antibacterial Effect of Herbs and Spices Extract on *Escherichia coli***.** *Electronic Journal of Biology,* 2009, Vol. 5(2): 40-44
29. WHO, 2018. https://www.who.int/india/news/detail/27-07-2018-health-gains-from-the-swachh-bharat-initiative
30. World Bank, 2023.Onehealth project in India in the livestock sector.https://www.worldbank.org/en/news/press-release/2023/05/10/world-bank-approves-82-million-for-prevention-of-zoonotic-endemic-diseases-in-india