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Waterborne Zoonotic Diseases and Antimicrobial Resistance: Indian Policy and Onehealth Approach

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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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 an integrated approach to the 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 overuse of the antibiotics.

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

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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 (Water power), Uttarakhand Jal Sansthan, Uttarakhand Renewable Energy Development Agency (UREDA) and Central Water Resource Ministry and biogas scheme/ non renewable energy department needs to 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 the 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 Animal origin pathogens livestock have been rising recently such as Bird flu i.e. Avian and Swine flu causing a global scare [1]. Onehealth approach emerging recently is a new concept of integrated approach to both animal and human health (https://www.who.int/health-topics/one-health).

The livestock production (milk, eggs, meat) is rising rapidly with the rising economy and affluence vide NABARD report Fig. 1, Birthal [2]. 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 the schematic diagram of animal to human disease transmission. The pathogen *Escherichia coli* responsible for diarrhoea in humans and calves and may transfer from the livestock to humans via milk or water pollution due to the cattle dung. Conversely, it may affect cattle drinking the river water if humans defecate in the open, thus passing on the infection.

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/).

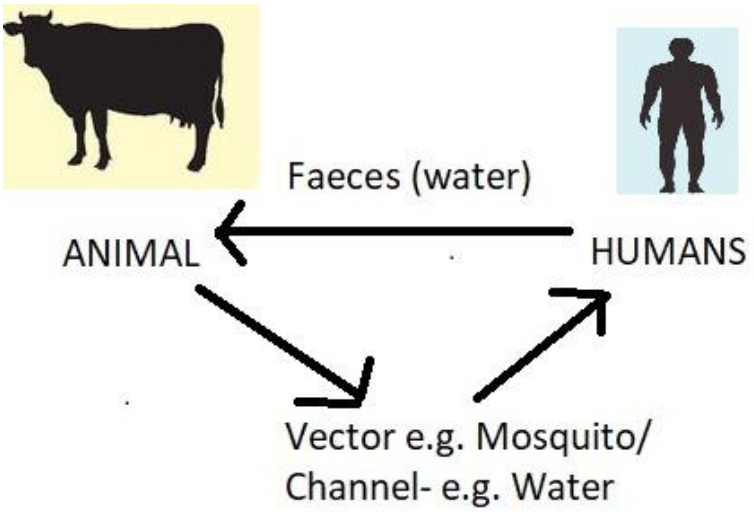

Fig. 1. Zoonotic diseases transmission

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 [3]. Zoonotic pathogens *Escherichia coli* & *Salmonella* both cause diarrhoea, among others, and affect- dairy & poultry causing mastitis & paratyphoid disease respectively [4]. We studied the Pune city environs at first to pilot the study approach as we are based there 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. Waterborne zoonotic diseases have wide spectrum [5] but we focussed on only these 2 taxa for understanding the system and approach in this pilot study.

2. OBJECTIVES

The study intended to include map the subject status and identify gaps and to suggest suitable remedial measures in terms of stakeholders mapping and inclusion. Government of India has recognized the importance of the subject & has initiated national integrated disease surveillance programme (IDSP) and training of veterinarians under it [6]. 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 [7]. We did the stakeholder analysis & prioritization in and vide another study.

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 [8]. We also studied as "standard protocol" of biosecurity the topic 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. It's an industrial setting with systems established as "reference". Fig. 2 depicts the study areas. Uttarakhand state has only about 2,600 factories while Maharashtra state has 10 times more, though withonly 6 times larger area, indicating higher density of factories [9].

Fig. 2. The Study area- Dehradun, Uttarakhand state

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 by consulting the experts and attending a policy workshop at Pune in January 2024 besides inviting policy makers at project review workshop at Dehradun in February 2024.

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 [10]. 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. Table 1 depicts the data collection effort.

5. RESULTS

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) was unaware of the issues and precautionary measures needed such as WASH tools. The farmers had no 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 which may lead to develop AMR. This practise needs to be avoided and sensitisation meetings are needed across districts for the veterinarians regarding rational prescription to reduce the AMR risk. Indian Government did ban some antibiotics earlier e.g. Colistin for poultry to contain AMR [11].

Table 1. Stakeholders consulted

Category Wise			**Category & Sub-Category**	
			Doctors	No
SN	CATEGORY	No	Human	7
1	National	21	Veterinary	5
	Uttarakhand			
2	Govt. Officers	10	BUSINESS	NO
3	Doctors	12	Physicians	7
4	R&D experts	25	Veterinary	5
5	Business	51	Hotel	20
6	Community	57	Meat shops	12
	Pune		Vegetable vendors	5
7	Policymakers	5	Poultry	8
8	Farmers	3	Dairy	6
9	Entrepreneurs	5		
	Total	189	Farmers	No
			Livestock owners	25
			Vegetable farmers	32

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

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 becomes 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 farm manure and is hardly collected by the municipality nor sold/ used for biogas etc. The poultry units, dairy or meat shops need to be monitored. There is acute need of official abattoir/ slaughter house under the state Government. Its absence 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 full coverage of (1) the piped water and (2) sanitation, (3) 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 investigation officer can send the sample for testing at National Laboratory at Bhopal, Madhya Pradesh state 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 charge reports on the monthly basis 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. 3 depicts the bio-surveillance system design. Table 2 illustrates the difference in the bio-surveillance system in the developed (Maharashtra) vis a vis under-developed state (Uttarakhand).

5.2 Monitoring and Livestock Waste Management

The full scale bio surveillance system sketched above is weak in Uttarakhand due to its hilly, forested terrain, low penetration by industries and the primitive economy. Hence, the system needs to improve with industry participation as client or donor as 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, as these have high prevalence of water borne diseases such as diarrhoea, cholera, typhoid. Vaccines are developed for the pathogens of cholera, typhoid but more research is needed to develop vaccines against other causative bacteria as its far more complex and challenging than viruses so preventive measures such as hygiene is the key to their management [12].

Table 2. The difference in bio-security surveillance in developed and developing state

	Maharashtra	Uttarakhand
Water sample testing	++	+++
Animal pathology testing	+++	+
Animal fitness certificate	+	-
Animal product testing#	+	-
Industry involvement	+++	-
Animal waste reuse	+++	*

**- present in subsistence, self use mode, not commercial yet. #- milk, egg, meat*
Note no of “+” marks indicates the strength of the initiative

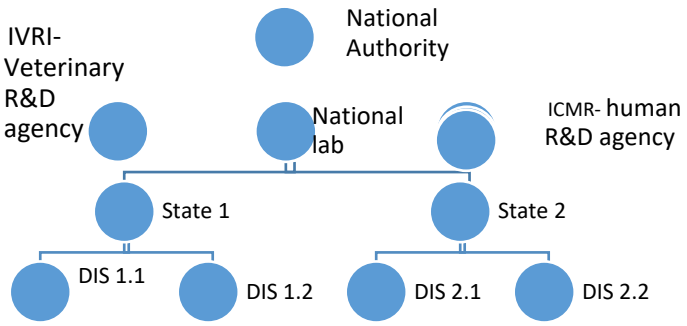

Fig. 3. Livestock disease monitoring system in India
DIS- Disease investigation section

This declining trend in waterborne diseases is continued and intensified recently due to the increase awareness in the cleanliness and hygiene countrywide, especially rural areas, to provide toilets under the Swatch Bharat (Clean India) Mission (SBM) and Jaljeevan (clean drinking water) mission both started from 2014 by the Indian government [13]. 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 mentions that the 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 [14]. Further, 55% drop in the acute diarrhoea disease (ADD) outbreaks is reported post 2015 due to SBM [13]. Muzembo et al. [15] 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* [16], and especially the later [17,18]. Similar pattern is noted in other south Asian countries also and is a cause for concern due to the future pandemic prospects [19].

5.3 Policy Scenario

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 Safety act, 2006,
- Livestock Health & Disease Control scheme, GoI (n.d.),
- Bioenergy Programme, 2021 (for biogas to manage livestock waste),
- Antimicrobial resistance (AMR) plan, 2017 [20].

Indian government has announced draft one health mission through the Principal Scientific Advisor to the Prime Minister [21,22]. 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, [23]. 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 [7]. Uttarakhand state included in the one health project supported by Bill & Melinda Gates foundation (BMGF, https://www.ohsu.in/) may also include it on priority. Table 3 depicts the current policy plays included in the draft National Onehealth Mission of India [22] and suggestiosn to add more players to address the waterborne zoonotic diseases.

Table 3. Stakeholders in the Onehealth mission and additions suggested

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

**- for comprehensive biogas coverage in all villages and bio-CNG in suture.*
Note- marked departments have their parent ministry included in the central government committee, indicated in the similar mark in the left column.

6. DISCUSSION

Literature survey shows the decline in the Diarrhoea DALYs rate (per 100,000 population) by age in India from 1990 to 2019 as depicted in Table 4 [24]- 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.

We highlight that the “water” channel is ignored as a medium for zoonotic diseases transmission in the present Onehealth mission draft despite diarrhoea being common across India. Water resource ministry is absent in the national Onehealth mission (draft) steering committee composition [22] 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 implementation of the protocols of Animal health inspection and tracking system in the socio-economically backward states/ regions; due to low budgets, limited human resources of infrastructure gaps (laboratories, chemicals, machinery). Hence, awareness the “biosecurity” system appears limited to the few industrial belts around metros such as Pune-Mumbai. Here, the industry/processing houses regularly sends veterinarian staff with medicines to detect disease profile and medication to the poultry or dairy entrepreneurs to maintain the animal safety. 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 needs to improve in the 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 need to be followed in the 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.

Table 4. Diarrhoea intensity trend in India

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

*#- mortality, *- 2019 data **- Sachu [25]*

Engaging Industry and CSO (Civil Society Organisations) 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 [26]. Traditional and/ or herbal medicines use for humans and animals (ethno-veterinary) as prophylactic may be considered [27]. This is demonstrated in case of *E.coli* in the calf by the Indian National Dairy Research Institute [28] and *In vitro* [29] and for *Salmonella* in China [30]. Herbs operate in multiple modes e.g. inhibiting bacterial growth or regeneration or biofilm. Herbal ingredients are being mixed recently to reduce the AMR [31].

Asaaga et al. [32] focussed on Kyasanur Forest Disease (zoonotic, but not waterborne) in Kerala state and discussed 3 channels of stakeholder engagement as below is useful to pursue in the future roadmap [33]-

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 also needs 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 the 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.

SUPPLEMENTARY MATERIALS

Supplementary materials available in this link: https://journalijpr.com/index.php/IJPR/libraryFiles/downloadPublic/7

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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