




# Risk Assessment Tools from the One Health Perspective: A Narrative Review

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**Background:** 61% of the infections around the world that have emerged to date are zoonotic. Evidence warns that the threat posed by zoonoses is on the rise, and the risk of a new pandemic is higher now than ever. Early identification of risk, populations at risk, and risk of transmission are essential steps towards a prevention, preparation and response to outbreaks. This review aims to look at the tools available for identifying and estimating risks and threats from one health perspective and finally propose a list of indicators which could assess the risk of transmission of disease at the humans, animals and the environment intersection.

**Methods:** The databases like PubMed, google scholar, Embase and Scopus were used to extract the relevant articles. A search was carried out using a keyword. A total of 1311 articles were listed initially after the search and reviewed. Out of 1311, only 26 tools which assessed the risk of diseases mainly infectious or were relevant to risk of transmission of any infectious diseases were included in the review.

**Results:** The tools included in this review involve risk assessment at the environmental, animal and human dimensions. The tools are used to evaluate the contamination of the environment due to chemicals or toxins or the risk of transmission of infection due to environmental factors like air contamination, to identify the animal diseases like bovine respiratory disease and foot and mouth disease and to estimate the human health risk at the community or individual levels.

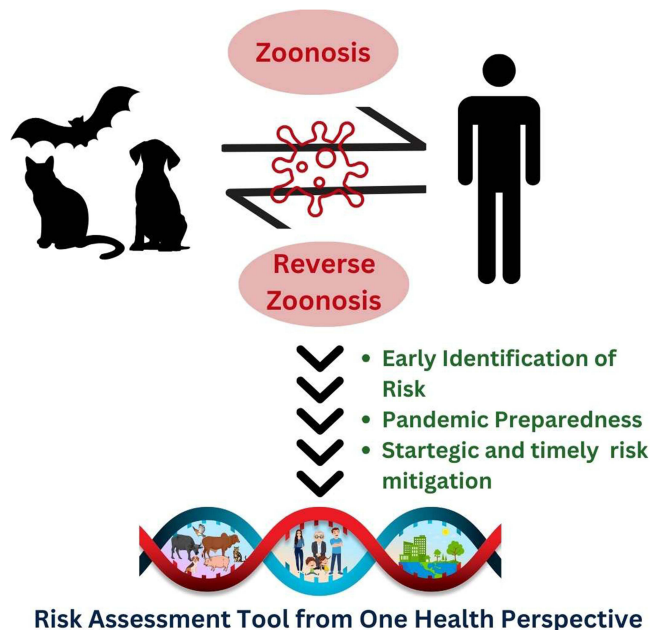
**Conclusion:** Risk assessment tools are an essential part of the prevention of pandemics. These tools are helpful in assessing the risk of transmission of infections either from human to human, between human and animals, between animals and animals and so on. Thus this review gives us an insight into the existing risk assessment tools and the need for a One Health risk assessment tools to prevent outbreaks in future. It also provides a list of factors that can be included in a one health risk assessment tool.

**Keywords:** one health, risk assessment, one health risk assessment

## Introduction

Modern day human activities have accelerated the changes in the environment of our planet, affecting not only human and animal species but also the ecosystem as a whole. Recently there have been instances of inter-species transmission of diseases resulting in the spread of infection in new species. An infectious disease is a disease caused by a pathogen or toxin transmitted from an infected person, animal or inanimate object.<sup>1</sup> In 2013, 45 million years were lost due to disability, and over 9 million deaths occurred due to infectious diseases.<sup>2</sup> In 2019, 13.7 million people worldwide died from infectious diseases.<sup>3</sup> Out of the total infectious agents identified globally to date, 61% are zoonotic and have the potential to be transmitted between humans and animals.<sup>4</sup> According to the World Bank, the global expenses of zoonosis between 2000 and 2010 amounted to around \$20 billion in direct costs and \$200 billion in indirect costs.<sup>5</sup> Experts predict that the risk of Zoonotic disease risks would increase with changes in the environment. The altered climate has led to change in the genomics of the pathogens as well as breeding pattern of the vectors which has impacted the risk of zoonotic diseases.

## Graphical Abstract



Global pandemics such as the recent Covid-19 pandemic have caused global crises. It not only had a high burden on the health system but also brought our lives to a standstill, highlighting that the control and prevention of transmission depend on a comprehensive understanding of the elements that determine it.<sup>6</sup> The administration got into the task of estimating the risk of the covid-19. This included estimating the risk of transmission concerning socio-economic and demographic factors impacting the spread of covid-19, vulnerable populations and coming up with measures to avoid the spread of the infection and keep the populations safe.<sup>7</sup>

Evidence indicates that there is a rise in the threat posed by zoonotic diseases, and the risk of a new pandemic is also very high. Among other approaches, early identification of risk, populations at risk, and risk of transmission are essential steps towards a better response, preparedness, and prevention of outbreaks.

Risk is the probability of having a negative effect on people, systems or assets. Risk is typically depicted as a function of the combined effects of hazards, the assets or people exposed to the hazard and the vulnerability of those exposed elements.<sup>8,9</sup>

The risk assessment identifies actual or potential risks for the population as a whole or a particular section of the population, thereby coming up with measures to reduce those risks. Risk assessment mostly resides within the realm of science, technology, academics, and policymakers.<sup>10</sup> Risk assessment helps identify and estimate risk, thus paving a path for its prevention and helping in policy-related decisions.

The outbreaks of SARS that emerged in the 21st century gave us the idea that novel pathogens could emerge from wildlife. The emergence of H5N1, avian flu and covid-19 proved the need for an effective alert and response system.<sup>11,12</sup> Risk assessment is carried out not only at the human but also at the animal interface. Among the various risk assessment tools available, they identify the risk for the environment as a whole or for the transmission in the community at the community or individual level. Healthcare professionals, researchers, and individuals utilize health risk assessment tools to analyze a person's overall health and determine their risk of contracting specific diseases or ailments. With the use of these instruments, one can discover potential health hazards and determine preventive actions. Some tools are used to decide the method suitable for risk assessment in a particular circumstance.<sup>13</sup> The tools are separate for animals or humans and in case of humans they estimate risk of very varied dimensions; thus, there is no tool to estimate the risk of

zoonosis or transmission of diseases between wildlife and humans. This review aims to look at the tools available for identifying and estimating risks and threats from one health perspective and finally propose a list of indicators which could assess the risk of transmission of disease at the humans, animals and the environment intersection.

## Methods

The review aimed to have an insight on the existing tools that can be used for identification or assessment risk at the human-animal-environment interface. An analysis of the literature regarding risk assessment tools published till November 2022 has been provided in the review. Articles with primary data sources are considered in this literature survey. The tools which assess the risk of transmission of infectious diseases were taken for assessment.

## Operational Definitions

Risk is generally defined as the probability of an outcome having a negative effect on people, systems or assets.

Health risk can be defined as the likelihood that a given exposure or series of exposures may have damaged or will damage the health of individuals.<sup>14</sup>

Human health risk assessment is a process of assessing the risk to an individual or a population as a whole. The risk assessment usually starts with problem formulation and includes steps like hazard identification, hazard characterization, exposure assessment and risk characterization.

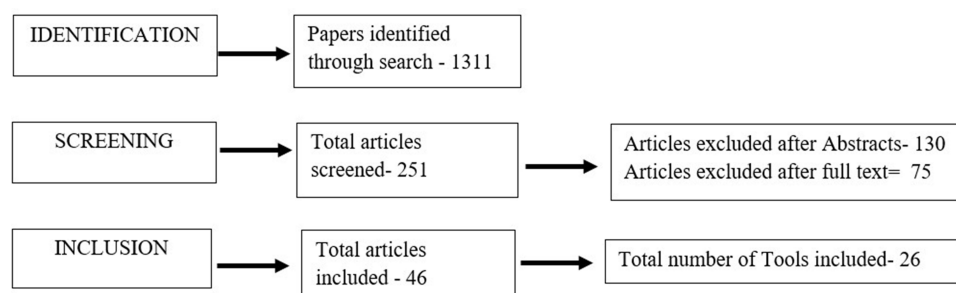
## Search Strategy and Selection Criteria

The review includes tools which estimate or assess the risk of diseases. The databases like PubMed, google scholar, Embase and Scopus were searched for studies. Keywords such as “Risk assessment tools”, “Zoonotic Diseases”, “Infectious diseases”, “One-Health”, “Transmission of infectious diseases”, “Environment”, “Animals”, “Human health”, and “community transmission” were used to conduct the search and documents with risk assessment tools used in the context of infectious diseases or those applicable to the risk of transmission of infectious diseases. All articles were extrapolated, and criteria of risk assessment in the tools were enlisted.

## Data Extraction and Quality Assessment

A total of 1311 articles were initially selected for review, and after review a total of 26 tools were included in the review. The excluded searches include multiple studies using the same tools or studies, including tools that cannot be used for infectious disease risk assessment. The studies that justified the exclusion and inclusion criteria were only included. The data that was extracted included the author details, year of publication, number of study participants, and factors used by the tools for risk assessment.

The PRISMA chart presented in [Figure 1](#) gives an overview of the tools/papers included in the study. The results of this review have been synthesised using the extracted data.



**Figure 1** Prisma Diagram.

## Inclusion and Exclusion Criteria

The studies or documents with the risk assessment tools and elaborating the factors considered in risk assessment mainly dealing with exposure assessment of the risk or which assessed the risk were included. The tools assessing the risk of transmission of infections among humans or animals or the tools estimating the risk of health hazards at the workplace or environmental hazards are included, which can be further used in the context of infectious diseases.

The tools that assessed the risk of NCDs, injuries, falls or other health issues or assessed the severity or impact of a hazard were excluded. Studies that did not elicit the details about the tools or their usage have been excluded. The studies that used the same tools as other studies, those that do not assess the risk of transmission of infectious diseases, or those that cannot be used in the context of infectious diseases have been excluded from the study.

## Results

The 26 tools which deal with the risk of Transmission of infections at workplaces, risk assessment at the environmental levels, animal health risks assessment, and human health risks assessment at the community and individual levels are included in the study. The basic characteristics of the tools have been enlisted in [Table 1](#).

### Assessment Tools to Assess Health Risks Due to Environmental Factors

The tools are used to evaluate the contamination of the environment due to chemicals or toxins or the risk of Transmission of infection due to environmental factors like air contamination, as in the Wells-Riley model, and water contamination like CHWRA or QMRA.

The safety risk assessment toolkit by World Health Organisation (WHO) is helpful in identifying and recognizing the necessary information for evaluating the chemical dangers, levels of exposure, and associated health risks. It collects information on chemical assessment and its impact on human health. The details about the hazard-causing potential of the chemical, impact of the chemical on the population, determination of risk with respect to the amount of exposure, and assessment of Non-Cancer and Cancer risk.<sup>33</sup>

Human Health Risk Assessment (HHRISK) is a tool mainly helpful in assessing the contamination of the environment due to chemicals. The technique incorporates a matrix that considers both space and time to assess the combined risk from numerous exposure paths and the cumulative risk from many sources.<sup>14</sup>

The Wells–Riley model is useful for examining ventilation strategies and their connection to airborne pathogens in clinical settings. This is a rapid assessment of the likelihood of contracting airborne diseases.<sup>18,39</sup> The process entails utilizing a distance index and a ventilation index to precisely measure the effects of social distance and ventilation on the likelihood of infection.<sup>39</sup>

The Community Health and Well-being Risk Assessment (CHWRA) is an online tool used to record the existing health effects experienced in a specific local area. It also collects information on the duration of residency in the region. The CHWRA provides comprehensive and organized evaluations of health risks and potential benefits. This includes identifying the type, scope, and probability of risks. Waterborne illnesses, heat exhaustion, cancer, and related conditions.<sup>37</sup>

Disease Attribute Intelligence System Tool (DAISY) is a tool to assess the spread of infectious disease in an area as well as monitor the risks of other new threats from a country's perspective. The tool assessment depends on four major factors: threats or hazards inherent to the biological agent, vulnerabilities in surveillance and containment, Monitoring of biological agents or infectious diseases, and media or social support. This Tool is useful in case of emerging diseases.<sup>23</sup>

Quantitative microbial risk assessment (QMRA) is a method to ascertain faecal contamination and hydrologic events in water bodies. QMRA may determine the level of safety of water, quantify the degree of variability in safety, and provide a measure of certainty in the safety estimate. This gives an idea about the safety of water from a particular site.<sup>34</sup>

Ecological risk assessment (ECoRA) is a tool useful to predict the potential influences of contaminants of animal, plant or human sources that could affect an area or a locality. The primary focus of this study is on the measurement and quantification of pollutants in soil/sediments, plants, and creatures. It aims to directly assess the exposure of ecological receptors (animals, plants, and microbes) to contaminants present at the site. Additionally, the study collects information about the release, movement, and destiny of these contaminants.<sup>24</sup>

**Table 1** Summary of Risk Assessment Tools with Its Practical Implications, Synthesised Based on the Review

SI No	Name of the Tool	Paper	Author	Risk Identified	Practical Implications
1	A human immunodeficiency virus (HIV) risk assessment tool for pregnant women <sup>15</sup>	A Risk Assessment Tool for Identifying Pregnant and Postpartum Women Who May Benefit From Preexposure Prophylaxis	Jillian Pintye, Alison L. Drake, John Kinuthia, Jennifer A. Unger, Daniel Matemo, Renee A. Heffron, Ruanne V. Barnabas, Pamela Kohler, R. Scott McClelland, Grace John-Stewart	Risk of mother-to-child transmission	Identify pregnant women who would most benefit from pre-exposure prophylaxis (PrEP)
2	EUFROT model (European up-front risk assessment tool) <sup>16,17</sup>	Estimating the risk of dengue transmission from Dutch blood donors travelling to Suriname and the Dutch Caribbean	W Oei, R W Lieshout-Krikke, M E Kretzschmar, H L Zaaier, R A Coutinho, M Eersel, B Jubithana, Y Halabi, I Gerstenbluth, E Maduro, M Tromp, M P Janssen	Estimate the risk of HIV transmission	Estimates the Risk of HIV Transmission by Blood Transfusion among Dutch travelling donors.
3	Wells Riley model <sup>18</sup>	Review and comparison between the Wells–Riley and dose-response approaches to risk assessment of infectious respiratory diseases	G. N. Sze To, C. Y. H. Chao	Estimate the risk of airborne transmission of infectious diseases	Quantitative infection risk assessment of respiratory infectious diseases in indoor premises.
4	Rapid risk assessment tool for communicable diseases in humanitarian emergencies <sup>19</sup>	Rapid risk assessment for communicable diseases in humanitarian emergencies: validation of a rapid risk assessment tool for communicable disease risk in humanitarian emergencies	Charlotte Christiane Hammer, Julii Brainard, Paul R Hunter	Assess the risk of communicable disease outbreaks in humanitarian emergencies	To understand vulnerabilities towards communicable disease outbreaks in humanitarian emergencies other than a disease outbreak
5	Hazard and Operability Studies (HAZOP) <sup>20</sup>	Analysis of the Potential Hazard Identification and Risk Assessment (HIRA) and Hazard Operability Study (HAZOP): Case Study	Bambang Suhardi, Pringgo Widyo Laksono, Andhika Ayu V.E., Jafri Mohd.Rohani, Tan Shy Ching	Identify potential hazards to personnel, equipment, and the environment	Analyse the potential risk due to environmental contamination in the work places and also to indicate potential hazards and operability issues in a complex working system.
6	Risk assessment tool for Bovine respiratory disease <sup>21</sup>	A novel risk assessment tool for bovine respiratory disease in preweaned dairy calves	G.U Maier, B.M Karle, S.A Dubrovsky, D.R Williams, J.D.Champagne, R.J Anderson, J.D. Rowe	Estimate the overall risk of BRD	A comprehensive risk assessment tool for BRD in pre-weaned dairy calves
7	Covid-19 risk assessment tool (RIKA) <sup>10,21</sup>	COVID-19 Risk Assessment Tool: Dual application of risk communication and risk governance	Ranit Chatterjee Sukhreet Bajwaa Disha Dwivedi Repaul Kanji Moniruddin Ahammed Rajib Shaw	Assesses a person's overall risk profile	Estimates risk based on the factors like health, behaviour, exposure and social policy.
8	Joint risk assessment operational tool (JRA OT) <sup>22</sup>	Joint Risk Assessment Operational Tool (JRA OT) An Operational Tool of the Tripartite Zoonoses Guide Taking a Multisectoral, One Health Approach: A Tripartite Guide to Addressing Zoonotic Diseases in Countries	FAO, OIE, WHO	Assess risks due to zoonotic diseases	Helps countries in the identification and prioritization of zoonotic diseases.
9	Risk Assessment Tool (Disease Attribute Intelligence System Tool (DAISY)) For Emerging Human Infectious Diseases <sup>23</sup>	A rapid risk analysis tool to prioritise response to infectious disease outbreaks	Health Analysis & Information For Action (HAIFA) Bruce Adlam	Assess the risk posed by emerging human infectious diseases	Used to profile the daily risk of avian influenza spread into Europe.
10	Human Health Risk Assessment (HHRISK) <sup>14</sup>	HHRISK: A code for assessment of human health risk due to environmental chemical pollution	J,B Nerisa DM, Montalvan Oliveresa F G, Velascoa F H M, Luzardoal O Correi,	Estimate the nature and probability of adverse health effects in humans	Human health risk assessment due to contamination of the environment by chemicals
11	Ecological risk assessment (EcoRA) <sup>24</sup>	Development process and perspective on ecological risk assessment	Chen Qiuying, Liu Jingling	Estimate the likelihood and extent of harm to ecosystems	Actual and predicted potential influences of contaminants on animal and plant populations or communities are evaluated.
12	Hazard Identification and Risk Assessment (HIRA) <sup>14</sup>	Hazard identification and risk assessment in firework industry	S. Ajith, V. Arumugaprabhu, V.Ajith, K. Naresh	Assess risks associated with hazards in occupational settings	Used to quantify risks associated with hazards
13	Egyptian HCV risk screening tool Egyptian HCV risk screening tool (EGCRISC) <sup>25</sup>	Validation of EGCRISC for Chronic Hepatitis C Infection Screening and Risk Assessment in the Egyptian Population	Engy Mohamed El-Ghitany, Azza Galal Farghaly, Shehata Farag, Ekram Wassim Abd El-Wahab	Assess the risk of HCV infection	Screen for HCV infection among the Egypt population

(Continued)

Table 1 (Continued).

SI No	Name of the Tool	Paper	Author	Risk Identified	Practical Implications
14	All Wales COVID-19 Workforce Risk Assessment Tool <sup>26</sup>	All Wales COVID-19 Workforce Risk Assessment Tool	Wales health system	Assess the risk of Covid-19 risk	Assessment of covid-19 Risk among the health care Workforce
15	Public health risk assessment tool (PHRAT) <sup>27</sup>	A Quantitative Public Health Risk Assessment Tool for Planning for At-Risk Populations	Rachel Peters, Thomas J. Hipper, Hilary Kricun, Esther Chernak	Assess Public health risks	Assesses hazard impacts on health care and public health metrics
16	WHO mass gathering COVID-19 risk assessment tool - generic events <sup>28</sup>			Assesses risk covid-19 transmission	Assess the Risk of Transmission of covid-19 infection during a mass gathering
17	Tool for influenza pandemic risk (TIPRA) <sup>29</sup>	Tool for Influenza Pandemic Risk Assessment (TIPRA)	World Health Organisation (WHO)	Assesses risk of influenza infection	Access the risk of influenza viruses with respect to pandemic potential
18	GLEWS+ Risk assessment <sup>30</sup>	SARS-CoV-2 in animals used for fur farming	WHO	Assesses risk of transmission of Covid-19 from humans to animals	Assesses the Risk of Transmission of virus from fur animals to wildlife, Risk of spillover to humans, and Risk of virus transmission among the study sample
19	Influenza risk assessment Tool (IRAT) <sup>31</sup>	Influenza Risk Assessment Tool	CDC	Assess risk of influenza infection	Properties of the virus, "attributes of the population", and "ecology and epidemiology of the virus".
20	Mass gathering risk assessment tools (MGRAT) <sup>32</sup>				Experience of organizers, public transport, and public agencies, and risk of weather, Risk of gatherings or Risk of Transmission
21	Safety risk assessment toolkit by WHO <sup>33</sup>		Smeets, P. W. M. H., Rietveld, L. C., Van Dijk, J. C. and Medema, G. J	Assess risk of chemicals on health	Assessment of chemical and their impact on human health
22	Quantitative Microbial Risk Assessment (QMRA) <sup>34</sup>	Synergy between quantitative microbial source tracking (qMST) and quantitative microbial risk assessment (QMRA): A review and prospectus	QianZhanga, JavierGallard, BaoleiWu, Valerie J. Harwood, Michael J.Sadowsky, Kerry A.Hamilton, WarishAhmed	Assess risk of microbial infection or exposure	Estimates the risk due to faecal contamination and hydrologic events in water bodies
23	Hazard Identification, Risk Assessment, and Control Measures (HIRAC) <sup>35</sup>	Hazard identification and risk assessment in firework industry	S. Ajith, V. Arumugaprabhu, V.Ajith, K. Naresh	Assess risk of injury or infection	Provides assessment on the likelihood of the injury or illness occurring.
24	Hospital occupational safety and health risk assessment (HOSHRA) <sup>36</sup>		Jahangiri, M. et al	Assess risk of health hazards in hospitals	Assess the risk of biological hazards for healthcare workers in a hospital
25	The community health and wellbeing risk assessment (CHWRA) <sup>37</sup>		Bell, E., Turner, P., Meinke, H. and Holbrook, N	Assess risk of disease	Health and wellbeing risk assessment through the use of an electronic tool.
26	FMD risk identification tool <sup>38</sup>		Schijven, J., Rijs, G. B. J. and De Roda Husman	Assess risk of foot and mouth disease in animals	Estimates the spatial variation of risk of infectious animal disease at a national scale

**Abbreviations:** BRD, Bovine Respiratory Disease; CDC, Center for Disease Control; CHWRA, Community Health and Wellbeing Risk Assessment; Covid-19, Coronavirus Disease; DAISY, Disease Attribute Intelligence System Tool EUFRAT, European up-front risk assessment tool ECoRA, Ecological risk assessment; ECGRISC, Egyptian HCV risk screening tool FMD, Foot and Mouth Disease; GLEWS, Global Early Warning and Response System; HCV, Hepatitis C Virus; HIV, Human Immunodeficiency Virus; HAIFA, Health Analysis & Information For Action HAZOP, Hazard and Operability Studies HHRISK, Human Health Risk Assessment HIRA, Hazard Identification and Risk Assessment HIRAC, Hazard Identification; Risk Assessment; and Control Measures HOSHRA, Hospital occupational safety and health risk assessment; IRAT, Influenza risk assessment Tool; JRA-OT, Joint risk assessment operational tool; MGRAT, Mass gathering risk assessment tools PHRAT, Public health risk assessment tool PrEP, Pre-Exposure Prophylaxis QMRA, Quantitative Microbial Risk Assessment TIPRA, Tool for influenza pandemic risk WHO, World Health Organization.

Hazard Identification and Risk Assessment (HIRA) is a tool to quantify risks associated with hazards. This Tool mainly deals with hazard identification and assessment of the risk. This includes hazard identification in construction, operations and natural calamities.<sup>40</sup>

## Risk Assessment Tools to Assess Health Risks Due to Animal Factors

The risk assessment tools are present to identify the animal diseases like bovine respiratory disease and foot and mouth disease. There are specific tools to estimate the risk among a particular section of the animal population, like that of the risk of SARS CoV 2 virus among the animals used for fur farming.

Bovine respiratory disease risk identification tool used to identify the risk of bovine respiratory disease among pre-weaned calves. The tool assessment is based on herd risk profile, maternity pen management like pen density, bedding type, hygiene practices, and quality control; colostrum management includes storage and container type, milk feeding factors or nutrition factors including feeding order, milk source, pasteurization, and quality control, vaccination includes types and frequency of vaccines administered and calf housing factors includes housing material, calf to calf contact, presence of extra shade and manure flush system.<sup>21</sup>

FMD risk identification tool is useful in estimating the spatial variation of risk of infectious animal disease at a national scale. It can be used for diseases like foot and mouth disease. Tool assessment is based on local data, data on cattle type, permeability of virus, potential contact between wildlife and livestock, and level of herd immunity generated by prophylactic vaccination.<sup>38,41</sup>

GLEWS+ The combined OIE/FAO network of experts in animal health conducts risk assessment to ascertain the transmission of the SARs CoV 2 virus among animals involved in fur production. The text explores the transmission risk of viruses from fur animals to wildlife, the risk of spill over to people, and the risk of virus transmission among fur animals. Therefore, it examines the probability and repercussions at the regional or national scale.<sup>30</sup>

The quantitative microbial risk assessment tool calculates the health hazards resulting from the exposure to water polluted with feces and the diseases it carries. The evaluation relies on determining the concentration of certain pathogens at the locations where humans are exposed to the environment. This is commonly done by estimating the presence of pathogens in their sources and using models to predict how the pathogens will move and be distributed to the locations where humans are exposed. This information is then combined with the volume of ingestion to estimate the amount of pathogens that individuals are likely to be exposed to. The computed dosage is utilized alongside a corresponding dose-response model for each exposure pathway/pathogen combination to obtain estimations of health hazards.<sup>34</sup>

## Risk Assessment Tools Due to Human Physiological Factors

The tools found from the search estimate the human health risk at the community or individual levels.

### Risk Assessment Tools Used at the Community Level

Rapid risk assessment tool for communicable disease risk in humanitarian emergencies is helpful to assess disease outbreaks in any humanitarian emergencies like natural calamities or war. The tool includes risk factors like water, sanitation and hygiene practices, health and socio political factors whose scoring is done to predict risk of communicable diseases.<sup>42</sup>

Mass Gathering Risk Assessment Tool (MAGRAT) is a tool helpful in assessment of risk during the planning of a mass gathering event. It collects information on organisers' experience, public transport, public agencies, and risk of weather, gatherings, or Transmission of infectious diseases like Covid-19.<sup>32</sup>

The Influenza Risk Assessment instrument (IRAT) is an external evaluation instrument used to estimate the potential pandemic risk posed by influenza A virus among humans. The Tool gathers data on the "characteristics of the virus", "characteristics of the population", and "ecology and epidemiology of the virus". It provides a perspective on the transmission of the virus from one human to another.<sup>31</sup>

The Public Health System Risk Assessment (PHRAT) evaluates the magnitude of particular risks by considering their effects on human health, healthcare services, community functioning, and the operations of public health agencies. The Healthcare System Risk Assessment analysis evaluates the severity of risks in two domains: human health and healthcare services, as well as the infrastructure of inpatient healthcare facilities.<sup>27</sup>

The Egyptian HCV risk screening tool (EGCRISC) is a tool useful to screen HCV infection among the Egypt population. It estimates risk based on various risk factors like blood product transfusion, rural residence, fatigue h/o jaundice, h/o of PAT, incarceration, unsafe route of sex, contact with jaundice patient, use of barber or beautician tools, substance abuse, living abroad, hospitalization, needle prick, h/o invasive procedures, during intercourse, blood sample, labour and delivery at home.<sup>25</sup>

WHO mass gathering COVID-19 risk assessment tool - generic events is used to assess the risk of a disease due to or during a mass gathering. It is based on the number of people, spacing, ventilation, event duration, travel footprint, travel routes.<sup>28</sup>

### Risk Assessment Tools Used at the Individual Level

“European Up-Front Risk Assessment Tool” (EUFRACT) quantifies the potential for transmission of a newly identified infectious illness through the process of blood transfusion. The Tool calculates the number of individuals that contract an infection by blood transfusion, either during a regional outbreak of an infectious illness or due to donors visiting an area affected by an outbreak. The risk can be estimated using characteristics of the disease whose risk is being calculated and information about the disease and its outbreak, including the incidence rate, duration of the outbreak, infectivity duration and its latent period. It also uses information regarding donor screening and donation testing, blood component production and donor exposure, and susceptibility of the recipient of the blood.<sup>16</sup>

TIPRA tool for Influenza pandemic Risk Assessment is a tool to assess the risk of sustained human-to-human transmission of the virus. The characteristics like properties of the virus, including the receptor binding properties, genomic characteristics of the virus, susceptibility to anti-viral treatments, attributes in human population like human infection, disease severity and population immunity, virus ecology and epidemiology in non-human hosts including geographic distribution of animals, and infections in animals are considered in the Tool to assess the risk of viruses.<sup>29</sup>

The risk assessment tool to detect maternal HIV infections includes scoring the number of sexual partners, behavioural factors like age of sexual debut, number of lifetime sexual partners, trading sex, condomless sex, vaginal washing and drying, and clinical factors like self-reported history of sexually transmitted infections [STIs], laboratory-confirmed *C. trachomatis*, *N. gonorrhoea*, *T. vaginalis*, syphilis, BV, and candidiasis has a good prediction ability to identify the women vulnerable to HIV.<sup>15</sup>

COVID-19 Risk Assessment Tool (RIKA) is a online tool to access individual risk based on the health, behaviours, exposure and social policy parameters. The health parameter includes age, co-morbidities gender, smoking habit. Behaviour parameter includes mask use, hand washing, sanitizing before touching face, practicing social distancing, and anxiety due to the pandemic. The type of residence, occupation, travel history and exposure to mass gatherings comprises exposure parameter. Effectiveness of lockdown, community compliance of social distancing comprises of social policy parameter.<sup>10</sup>

All Wales Covid-19 Risk Assessment tool is a tool to explore the outcomes through self perceived risk. It is a self administered tool to estimate an individuals risk of severe covid-19 infection by scoring personal risk factors. The factors like age, ethnicity, existing health conditions, Obesity and family history of susceptibility to covid-19 are considered in this Tool. It can identified to assess the risk of infectious diseases among the vulnerable population.<sup>26</sup>

### Risk Assessment Tools to Identify Risks Due to Occupation

Hazard Identification, Risk Assessment, and Control measures (HIRAC) is a tool for Occupational Health Assessment. This includes defining hazards characterized by the probability of the risks, frequency, severity of the risk, evaluation of adverse consequences, potential losses and possible injuries. This Tool includes steps like risk identification, analysis, evaluation and treatment. The factors based on which the assessment is done are the likelihood that the injury (or illness) may actually occur and the severity of the injury (or illness) resulting from the hazard.<sup>35</sup>

Hazard and Operability Studies (HAZOP) is also a tool to perform risk identification and assessment in the workplace. It includes classifying potential hazards based on the attitude of the workers, safety measures taken, posture, and physical work environment. This Tool also reflects on the consequences of hazards at the workplace due to environmental



contamination through analysis of operability on the deviations, possible causes, consequences, safeguards, and action required.<sup>20</sup>

Hospital occupational safety, and health risk assessment (HOSHRA) is a tool to assess the risk of biological hazards for health care workers in a hospital. This Tool encompasses various categories of hazards, namely physical hazards (such as electrical, fire/explosion, fall/slip, and radiation), chemical hazards (including exposure to acids and bases, alcohol, ether, ester, formaldehyde, and detergents), biological hazards (such as needle stick and sharp objects, hospital waste, and bloodborne pathogens), ergonomic hazards (related to musculoskeletal disorders and environmental parameters), and psychological hazards (such as violence in the workplace, shift work, and job stress).<sup>36</sup>

## Risk Assessment Tool from the One Health perspective

Joint risk assessment operational tool (JRA OT) is an Operational Tool of the Tripartite Zoonoses Guide to addressing zoonotic diseases by considering a multisectoral approach from One Health perspective. It helps countries in the identification and prioritization of zoonotic diseases. The main assessment is based on various steps and it is mainly conducted when a health event emerges or occurs at the human-animal–environment interface.<sup>22</sup>

## Discussion

The risk assessment tools are essential part of prevention of pandemics. These tools are helpful in accessing the Risk of Transmission of infections either from human to human, between human and animals, between animals and animals and so on. The route of Transmission, the intensity of the risk, and characterization of risk is essential for prevention of Transmission thus thereby preventing an upcoming pandemic. The tools must be collectively used by various fraternities like human health, animal health and environmentalists thereby ensuring the health of the animals, humans and environment and evading the Risk of Transmission of infectious diseases. The dissection of tools from One Health perspective is mentioned in [Table 2](#).

## Factors to Evaluate the Human Health Risks

The demographic information like age, education, marital status, relationship status and duration need to be documented as Age, race and gender are the human attributes which significantly impact an individual's risk of zoonotic diseases. As per ECDC a higher mortality rate is seen among males compared to females due to covid-19. In a study by Jones et al, the risk of infectious diseases is higher among older people than young people. Similarly, it was also seen that gender and race also had a correlation with chance of contacting infection. It was seen that married men had lower frailty than unmarried men, whereas married women had higher frailty than unmarried or widowed women.<sup>43</sup> Educational status plays an important role in awareness and knowledge, which finally helps in the prevention of zoonotic diseases. Education also has a key impact on the habits and behaviour of an individual.<sup>44</sup> The risk of zoonotic diseases increases based on the likelihood of exposure at workplaces. Some zoonotic diseases pose a significant risk for individuals of certain occupations.<sup>45</sup> In a study in Ethiopia, it was seen that the adherence to preventive measures was associated with age, level of education, occupation and knowledge.<sup>46</sup> Thus as considered in risk assessment scales like the human immunodeficiency virus (HIV) risk assessment tool for pregnant women, the Covid-19 risk assessment tool (RIKA) and the All Wales COVID-19 Workforce tool the demographic factors need to be included in the OH Risk assessment tool.

Factors like the likelihood of exposure to disease vectors through systematic surveillance of the pathogen give an accurate idea about human vector contact and the risk of exposure to the pathogen. Similarly, vector density also indicates the risk of human vector contact or animal vector contact, thereby providing with risk of vector-borne diseases.<sup>47</sup> Reluctance to follow disease prevention measures, insufficient nutrient intake, and lack of hygiene are behavioural factors which have a significant impact on the overall health and wellbeing of an individual. Reluctance to follow protective and preventive measures puts an individual at risk of contracting an infection. Similarly, insufficient nutrient intake has effects such as poor growth, impaired intellect, and increased mortality and susceptibility to infection.<sup>48</sup> Lack of hygiene or water, sanitation and hygiene (WASH) increases the risk of diarrheal diseases and compounds the risk of infectious diseases.<sup>42</sup> The history of jaundice, cancer, organ transplantation and other chronic conditions reflects the individual's health status. It was seen that Chronic co-morbidities, including Obesity, hypertension,

**Table 2** Dissecting the Risk Assessment Tools from the One Health Perspective

Tool	Key Factors Currently Used	Environment Risk	Animal Risk	Human Risk	Food Safety	AMR
A human immunodeficiency virus (HIV) risk assessment tool for pregnant women <sup>15</sup>	The data collected includes demographic information such as age, education level, marital status, and duration of the relationship. Additionally, information about the male partner's age and circumcision status is recorded. Behavioral data includes the age at which sexual activity began, the number of sexual partners throughout one's lifetime, engagement in sex trading, frequency of unprotected sex, and practices such as vaginal washing and drying. Clinical characteristics encompass self-reported history of sexually transmitted infections (STIs), as well as laboratory-confirmed cases of <i>C. trachomatis</i> , <i>N. gonorrhoea</i> , <i>T. vaginalis</i> , syphilis, and candidiasis.	xx	xx	√√	xx	xx
EUFRAT model (European up-front risk assessment tool) <sup>16,17</sup>	The recipient's risk of developing the disease will be calculated if the infection is determined to have a chronic phase. Donor screening for possible infections, The total number of reported infections (Ip) over a period of time. The variables in question include the duration of the epidemic (D0), the population size (N), the donor relative risk (RR), the disease features, and the proportion of undiagnosed cases (pu). The duration of infectivity for acute infection (Da), the duration of the latent phase of acute infection (Dia), and the estimated incidence rate in the donor population (I). The frequency of donors who are infectious at the time of their most recent observed infection (Pr), Donor screening and donation testing involve the process of evaluating potential donors and examining donated materials for any potential issues or risks. Donation kind, Number of donors affected, Residual risk of transmission after processing (PIT), Recipient population's specific immunity (PIM) and the proportion of additional problems. Percentage of serious infections and percentage of fatalities.	xx	xx	√√	xx	xx
Wells Riley model <sup>18</sup>	The number of susceptible people in the space, the number of infectious people, the pulmonary ventilation rate of susceptible individuals,	xx	xx	√√	xx	xx
Rapid risk assessment tool for communicable diseases in humanitarian emergencies <sup>19</sup>	Risk of transmission through blood transfusion, Insufficient access to potable water, Insufficient access to sanitation facilities, Insufficient separation between housing and animal waste disposal - Mean separation between housing and human waste disposal, Waste water inundation, Inadequate waste management, Contact with disease-carrying organisms, Inadequate healthcare infrastructure, Inadequate number of healthcare professionals, Inadequate immunization rate, The population's unfavorable health condition, Insufficient availability of pharmaceuticals, Resistance to adhere to illness prevention protocols, Inadequate consumption of essential nutrients, Insufficient health and hygiene practices, Severe destitution and lack of access to sufficient food, Excessive population density, Continuing hostilities, Forced migration	√√	xx	√√	√√	xx
Hazard and Operability Studies (HAZOP) <sup>20</sup>	Operability, deviations in regular functions, possible causes, consequences, safeguards, and action required.	√√	xx	√√	xx	xx
Risk assessment tool for Bovine respiratory disease. <sup>21</sup>	Herd Risk profile, maternity pen management, colostrum management, milk feeding, vaccinations of cattle, a housing of the cattle,	xx	√√	xx	xx	xx

Covid-19 risk assessment tool (RIKA) <sup>10</sup>	Age, co-morbidities, gender, smoking habit, use of mask, hand washing, sanitising before touching the face, practising social distancing, anxiety based on the current situation, trust in government's measures, travel history and mass gathering, occupation, residential type, effective lockdown, community compliance of social distancing and mask use.	xx	xx	√√	xx	xx
Joint risk assessment operational tool (JRA OT) <sup>22</sup>	Number or extent of the situation, target population, geographic location, Outcome, Hazard, source of exposure, and time frame. When a health event emerges or occurs at the human-animal-environment interface, a joint risk assessment focused on risks at the interface is conducted.	√√	√√	√√	xx	xx
Risk Assessment Tool (DAISY) For Emerging Human Infectious Diseases <sup>23</sup>	The key aspects to consider in the analysis of an infection include identifying the specific infection, determining the reservoir of the pathogen, understanding the mode of transmission, calculating the average incubation period, assessing the period of communicability, evaluating susceptibility, determining the effectiveness of treatment, estimating case fatality rate, devising control methods, identifying the nearest affected region, implementing human disease surveillance, conducting vector or source surveillance, implementing disease containment measures, and ensuring human disease surveillance, vector or reservoir, and source control for effective disease containment.,	√√	√√	√√	xx	xx
Human Health Risk Assessment (HHRISK) <sup>14</sup>	The HHRISK code incorporates a novel spatiotemporal matrix for evaluating the combined risk of several exposure paths and the cumulative risk associated with exposure to multiple chemicals.	xx	xx	√√	xx	xx
Ecological risk assessment (EcoRA) <sup>24</sup>	Contaminants, soil/sediments, plants, and organisms are measured directly, quantifying the exposures of ecological receptors (animals, plants and microorganisms) to site contaminants, information about contaminant release, its migration and fate are collected,	√√	√√	√√	xx	xx
Quantitative microbial risk assessment (QMRA) <sup>34</sup>	Quantifying the concentration of Reference pathogen(s) at the specific location(s) of environmental exposure, usually by assessing the amount in the source(s) and predicting the pathogen's behavior and movement to the location(s) of human exposure; this information is then paired with the volume of ingestion to estimate the amount of exposure. The computed dose is utilized alongside a corresponding model for each combination of exposure pathway and pathogen to obtain estimations of health risks.	√√	xx	√√	xx	√√
Egyptian HCV risk screening tool (EGCRISC) <sup>25</sup>	Various risk factors like blood product transfusion, rural residence, fatigue, h/o jaundice, incarceration, unsafe route of sex, contact with jaundice patient, use of barber or beautician tools, substance abuse, living abroad, hospitalisation, needle prick, h/o invasive procedures, merges during intercourse, blood sample, labour and delivery at home	xx	xx	√√	xx	xx
All Wales COVID-19 Workforce Risk Assessment Tool <sup>26</sup>	Age, Sex at birth, ethnicity, existing health conditions or co-morbidities, Obesity, family history of morbidity due to covid-19 infection	xx	xx	√√	xx	xx
Public health risk assessment tool (PHRAT) <sup>27</sup>	The product of the probability and severity of a hazard, as assessed by its influence on five domains: human health, health care services, inpatient health care infrastructure, community health, and public health services.	xx	xx	√√	xx	xx

(Continued)

Table 2 (Continued).

Tool	Key Factors Currently Used	Environment Risk	Animal Risk	Human Risk	Food Safety	AMR
WHO mass gathering COVID-19 risk assessment tool - generic events <sup>28</sup>	No of people, spacing, ventilation, event duration, travel footprint, travel routes.	√√	xx	√√	xx	xx
Tool for influenza pandemic risk (TIPRA) <sup>29</sup>	Properties of virus, including the receptor binding properties, genomic characteristics of the virus, susceptibility to anti-viral treatments, attributes in human population like human infection, disease severity and population immunity, virus ecology and epidemiology in non-human hosts including geographic distribution of animals, and infections in animals	xx	√√	√√	xx	xx
GLEWS+ Risk assessment <sup>30</sup>	Risk of Transmission of virus from fur animals to wildlife, Risk of spillover to humans, and Risk of virus transmission among the study sample	xx	√√	√√	xx	xx
Influenza risk assessment Tool (IRAT) <sup>31</sup>	Properties of the virus, “attributes of the population”, and “ecology and epidemiology of the virus”	xx	xx	√√	xx	√√
Mass gathering risk assessment tools (MGRAT) <sup>32</sup>	Experience of organisers, public transport, public agencies, and risk of weather, Risk of gatherings or Risk of Transmission	xx	xx	√√	xx	xx
Safety risk assessment toolkit by WHO <sup>33</sup>	Assessment of chemicals and their impact on human health	xx	xx	√√	xx	xx
Quantitative Microbial Risk Assessment (QMRA) <sup>34</sup>	Faecal contamination and hydrologic events in water bodies	√√	xx	√√	xx	√√
Hazard Identification, Risk Assessment, and Control Measures (HIRAC) <sup>35</sup>	The probability of the occurrence of the injury (or disease) and the extent of the resulting harm caused by the hazard.	xx	xx	√√	xx	xx
Hospital occupational safety and health risk assessment (HOSHRA) <sup>36</sup>	The hazards can be categorized into five main types: physical hazards (such as electrical, fire/ explosion, fall/slip, and radiation), chemical hazards (including exposure to acids and bases, alcohol, ether, ester, formaldehyde, and detergents), biological hazards (such as needle stick and sharp objects, hospital waste, and bloodborne pathogens), ergonomic hazards (which can lead to musculoskeletal disorders and are related to environmental parameters), and psychological hazards (including workplace violence, shift work, and job stress).	√√	xx	√√	xx	xx
The community health and wellbeing risk assessment (CHWRA)	Identifying the nature, extent and likelihood of risks like waterborne diseases, heatstroke, cancers, and other similar situations	√√	xx	√√	xx	xx
FMD risk identification tool <sup>38</sup>	Data on cattle type, the permeability of virus, potential contact between wildlife and livestock, level of herd immunity generated by prophylactic vaccination	xx	√√	xx	xx	xx

**Abbreviations:** xx, Absent; √√, Present; AMR, Antimicrobial resistance; CHWRA, Community Health and Wellbeing Risk Assessment; Covid-19, Coronavirus Disease; DAISY, Disease Attribute Intelligence System Tool; EUFRAT, European up-front risk assessment tool; ECoRA, Ecological risk assessment; ECGRISC, Egyptian HCV risk screening tool FMD, Foot and Mouth Disease; FMD, Foot and Mouth Disease; GLEWS, Global Early Warning and Response System; HCV, Hepatitis C Virus; HIV, Human Immunodeficiency Virus; HCV, Hepatitis C Virus; HIV, Human Immunodeficiency Virus; HAZOP, Hazard and Operability Studies HHRISK, Human Health Risk Assessment HIRA, Hazard Identification and Risk Assessment HIRAC, Hazard Identification; Risk Assessment; and Control Measures HOSHRA, Hospital occupational safety and health risk assessment; IRAT, Influenza risk assessment Tool; JRA-OT, Joint risk assessment operational tool; MGRAT, Mass gathering risk assessment tools PHRAT, Public health risk assessment tool; QMRA, Quantitative Microbial Risk Assessment RR, Relative Risk; STI, Sexually Transmitted Diseases; TIPRA, Tool for influenza pandemic risk; WHO, World Health Organization.

diabetes, cardiovascular disease, cerebrovascular disease, respiratory disease, kidney disease, and malignancy, are clinical risk factors for a severe or fatal outcome associated with COVID-19.<sup>49</sup> Thus, the details on the likelihood of exposure to disease vectors and information on adherence to preventive measures, insufficient nutrient intake and hygiene practices as documented by the risk assessment tools like A human immunodeficiency virus (HIV) risk assessment tool for pregnant women, rapid risk assessment tool for communicable diseases in humanitarian emergencies, Covid-19 risk assessment tool (RIKA), Risk Assessment Tool (DAISY) For Emerging Human Infectious Diseases and The community health and wellbeing risk assessment (CHWRA) needs to be included in the OH risk assessment tool. But the observatory tool or Tool to access risk at an individual level needs to be tailored appropriately to capture the information regarding the likelihood of exposure at workplaces or residential areas.

The increase in the number and frequency of international travels, migratory flows, health system failures, social inequalities, and geopolitical conflicts are factors that contribute to the emergence and spread of new pathogens in human populations.<sup>50</sup> Health system failure like lack of health facilities, lack of health workers, insufficient vaccine coverage, and Lack of medicines reflects the preparedness of the health system to manage an outbreak. Several initiatives have been rolled out during the covid-19 pandemic towards effective response to the pandemic and alleviating future threats.<sup>51</sup>

### Factors to Evaluate the Animal Health Risks

The factors like Herd risk profile, maternity pen management, colostrum management, milk feeding, cattle vaccinations, and cattle housing are used to estimate the risk of bovine TB. Still, these will also be applicable for zoonotic diseases whose host or reservoirs are cattle or other poultry animals. The health status of animals is an essential component in risk assessment as most zoonotic diseases have emerged at the human-animal interface.<sup>52</sup> The Risk of Transmission of pathogens from wild animals to cattle also needs to be documented as undertaken by GLEWS+ Risk assessment tool. These factors will evaluate the animal health risks. Thus, cattle management and WASH practices mainly associated with handling cattle or pets need to be observed along with the vaccination status of the cattle and the likelihood of Transmission of infection from wild animals to understand the chance of a zoonotic disease.

### Factors to Evaluate the Environmental Health Risks

The causes contributing to the problem include insufficient access to potable water, inadequate sanitation facilities, and a suboptimal distance between homes and the disposal of animal and human waste. Waste water inundation The absence of waste management is seen as a factor in assessing the likelihood of communicable diseases in times of humanitarian crises. These parameters can be applied to a wide range of situations and are valuable for predicting the risk of transmission of zoonotic illnesses in the OH risk assessment tool.

Environmental risk factors include weather and climate factors, such as cold and dust storms, vector habitats, increased contact with animals, and endemic diseases. The environmental factors affect the distributions of zoonotic agents and their Transmission to humans.<sup>53</sup>

The genesis and spread of novel infections in human populations are influenced by factors such as high population density, deforestation, geographic location, climate changes, and the increasing interaction between humans, livestock, and wild animals<sup>50</sup> In tropical regions, the alteration in climatic circumstances has resulted in the extensive proliferation of carriers and vectors of zoonotic viruses, hence augmenting the transmission of viruses from their carriers to animal hosts. Climate-induced alterations, such as variations in temperature and precipitation, can lead to genetic instability in the evolutionary makeup of viruses. This phenomenon has been observed in the case of the West Nile virus (WNV) in North America, where increased temperatures triggered an adaptive mutation that allowed the virus to replicate more efficiently at higher temperatures.<sup>54,55</sup> So, as per the risk assessment tools rapid risk assessment tool for communicable diseases in humanitarian emergencies and Tool for influenza pandemic risk (TIPRA) the factors to estimate the quality of care, environmental factors like deforestation, climate changes, and population density are necessary to estimate the risk of zoonotic diseases.

Mass vaccination of cattle reduces Transmission of diseases like Brucellosis<sup>56</sup>. The presence of wet markets which sell live animals for food are also a source of the emergence of diseases<sup>57</sup> Thus, the presence of wet markets, the vaccination status of cattle also need to be captured to assess the risk due to animals or factors associated with animals.

**Table 3** Summary of Variables Which Could Be Part of the One Health Risk Assessment tool

Factors to be Included in the Proposed One Health Risk Assessment Tool	Name of the standard Risk Assessment tool
Socio-demographic factors like Age, Education, gender, marital status, and occupation	Rapid risk assessment tool, Covid-19 risk assessment tool (RIKA), European up-front risk assessment tool (EUFRAT), All Wales Covid-19 Risk Assessment tool,
Food habits include nutrient intake and habits related to alcohol, tobacco or other harmful substances.	A human immunodeficiency virus (HIV) risk assessment tool for pregnant women Covid-19 risk assessment tool (RIKA), A human immunodeficiency virus (HIV) risk assessment tool for pregnant women
WASH practices- Washing hands, drinking clean water, flooding of water, sanitation and personal hygiene	Rapid risk assessment tool
Obesity	All Wales Covid-19 Risk Assessment tool
Vaccination status	
History of infection	European up-front risk assessment tool (EUFRAT), All Wales Covid-19 Risk Assessment tool
History of co-morbid conditions.	European up-front risk assessment tool (EUFRAT), All Wales Covid-19 Risk Assessment tool
Chance of exposure to risk factors or likelihood of infection in the shared environment	Hazard Identification, Risk Assessment, and Control Measures (HIRAC), Hospital occupational safety and health risk assessment (HOSHRA), Hazard and Operability Studies (HAZOP), Wells-Riley model, Dose-response model, The community health and wellbeing risk assessment (CHWRA), Quantitative Microbial Risk Assessment (QMRA), Safety assessment toolkit, Risk Assessment Tool (Disease Attribute Intelligence System Tool (DAISY)) For Emerging Human Infectious Diseases, Mass gathering risk assessment tools (MAGRAT), rapid risk assessment tool for communicable diseases in humanitarian emergencies, Joint risk assessment operational tool (JRA OT), ecological risk assessment (EcoRA)
Chance of exposure of animals	Bovine respiratory disease risk identification tool, FMD risk identification tool, GLEWS + risk assessment, TIPRA, Risk assessment tool for Bovine respiratory disease
Management of cattle or animals	Bovine respiratory disease risk identification tool, FMD risk identification tool, GLEWS + risk assessment
Vector breeding sites and vector density	Joint risk assessment operational tool (JRA OT), Risk Assessment Tool (DAISY) For Emerging Human Infectious Diseases
Attributes of virus	IRAT, Tool for influenza pandemic risk (TIPRA)
Factors related to the health system	Rapid risk assessment tool for communicable diseases in humanitarian emergencies

**Abbreviations:** CHWRA, Community Health and Wellbeing Risk Assessment; Covid-19, Coronavirus Disease; DAISY, Disease Attribute Intelligence System Tool; EUFRAT, European up-front risk assessment tool; EcoRA, Ecological risk assessment; ECGRISC, Egyptian HCV risk screening tool; FMD, Foot and Mouth Disease; FMD, Foot and Mouth Disease; GLEWS, Global Early Warning and Response System; HCV, Hepatitis C Virus; HIV, Human Immunodeficiency Virus; HCV, Hepatitis C Virus; HIV, Human Immunodeficiency Virus; HAZOP, Hazard and Operability Studies; HHRISK, Human Health Risk Assessment; HIRA, Hazard Identification and Risk Assessment; HIRAC, Hazard Identification, Risk Assessment, and Control Measures; HOSHRA, Hospital occupational safety and health risk assessment; IRAT, Influenza risk assessment Tool; JRA-OT, Joint risk assessment operational tool; MAGRAT, Mass gathering risk assessment tools; PHRAT, Public health risk assessment tool; QMRA, Quantitative Microbial Risk Assessment; RR, Relative Risk; STI, Sexually Transmitted Diseases; TIPRA, Tool for influenza pandemic risk; WHO, World Health Organization; WASH, Water, Sanitation and Hygiene.

## Conclusion

As discussed in the review, many risk assessment tools are available, but they all estimate one aspect of risk in humans, animals, or their shared environment. The tools also sometimes estimated diseases specific risks. Thus, a One Health Risk assessment tool must be developed and validated considering various factors to assess human, animal, and environmental risks. This Tool will also help predict the outbreak of zoonotic diseases. The estimation of likelihood of an outbreak will be helpful in mitigation of risk and decreasing the chances of an outbreak. These estimations can be conducted among the high-risk population at a time interval. Such assessment results will alert us of a future outbreak, which will help us with timely interventions. This will also give us an idea about the recurrent OH risks and help to formulate policy to combat them at a greater level.

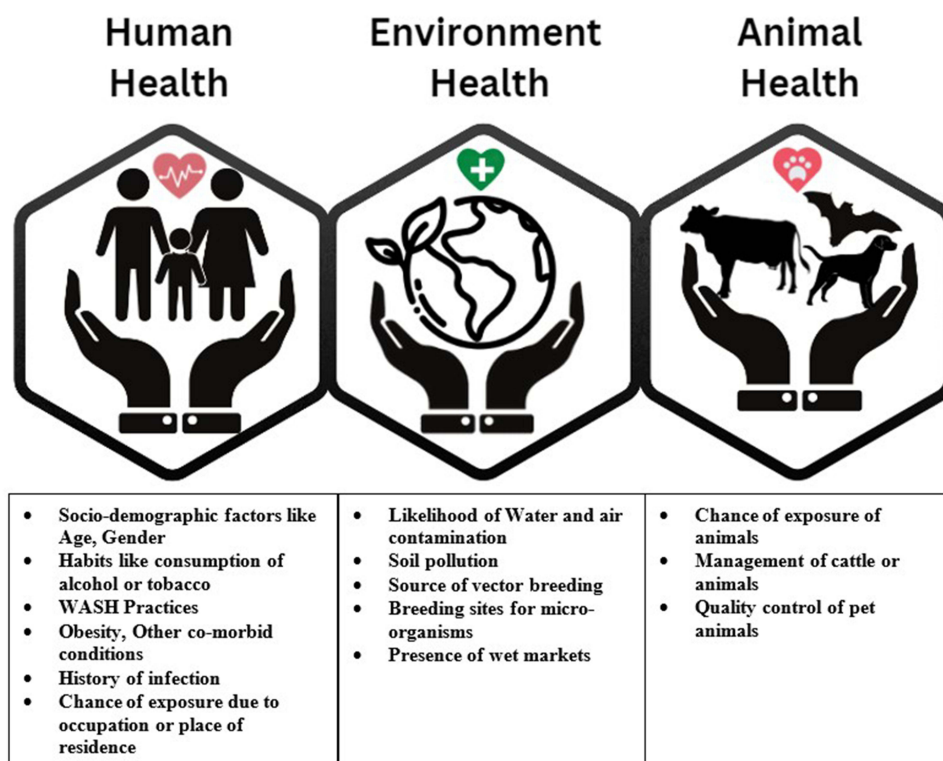
## Future Perspectives

A thorough One Health risk assessment will help us to prepare policies for the betterment of everyone. A tool has to be developed which could be unanimously used by various departments for risk assessment in place of different tools during different contexts. An ideal One Health risk assessment tool must comprise the factors from animal health, human health and environmental well-being. The OH risk assessment will assess the risk of infection as well as the likelihood of an outbreak of disease.

The physical, biological, psychological and environmental factors are important in estimating risk. The physical factors like exposures of ecological receptors (animals, plants and microorganisms) to site contaminants, information about contaminant release, its migration and fate are crucial to detect risk. Similarly, biological factors like age, gender, presence of co-morbidities also predispose to estimation of risk. Psychological factors or behavioural factors like WASH practices, and consumption of alcohol are few factors which increases the risk of diseases. Environmental factors like access to clean water, distance from site of hazard, distance from reservoir also helpful in knowing the risk of zoonotic diseases. Thus, these factors need to be included in the proposed tool for One Health risk assessment.

The existing Joint Risk Assessment operational tool assesses risk on the indicators like Number or extent of the situation, target population, geographic location, Outcome, Hazard, source of exposure, and time frame but it does not look at the factors like likelihood of exposure, likelihood of contamination of environmental factors, and biological and behavioural factors of human which has a crucial role to play in the transmission of zoonotic diseases. Thus, we propose a tool with factors to analyse risk at the human, animal and environmental interface that can help us in early detection and mitigation of risk. The factors that could be included in the One Health risk assessment tool and the tools from which they are obtained are tabulated in Table 3. The factors that can be included in the tool are segregated based on the human, animal, or environmental factors in Figure 2.

Further, this study proposes to implement and validate the suggested one health risk assessment tool in the global and local context for its replicability.



**Figure 2** Proposed future perspectives of the One Health Risk Assessment tool.

## Abbreviations

CHWRA, Community Health and Well-being Risk Assessment; Covid-19, Corona Virus Disease 2019; DAISY, Disease Attribute Intelligence System Tool; ECoRA, Ecological Risk Assessment; ECDC, European Centre for Disease Prevention and Control; EGCRISC, The Egyptian HCV risk screening tool; EUFRAT, European Up-Front Risk Assessment Tool; FAO, Food and Agriculture Organization; FMD, Foot and Mouth Disease; HAZOP, Hazard and Operability Studies; HCV, Hepatitis C Virus; HHRISK, Human Health Risk Assessment; HIRA, Hazard Identification and Risk Assessment; HIRAC, Hazard Identification, Risk Assessment, and Control Measures; HIV, Human Immunodeficiency Virus; HOSHRRA, Hospital Occupational Safety And Health Risk Assessment; IRAT, Influenza Risk Assessment Tool; JRA OT, Joint Risk Assessment Operational Tool; MAGRAT, Mass Gathering Risk Assessment Tool; NCD, Non-Communicable Diseases; OH, One Health; OIE, Office International des Epizooties; PHRAT, The Public Health System Risk Assessment; QMRA, Quantitative Microbial Risk Assessment; RIKA, Risk Assessment Tool; SARS, Severe Acute Respiratory Syndrome; STI, Sexually Transmitted Infections; TIPRA, Tool for Influenza Pandemic Risk Assessment; WASH, Water, Sanitation And Hygiene; WNV, West Nile virus.

## Data Sharing Statement

The datasets used and/or analysed during the current study are available from the corresponding author on request.

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## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

## Disclosure

The authors declare that they have no conflicts of interest in this work.

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