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Assessment of Emergency Preparedness and Response Using One Health Approach in Juba, South Sudan

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Abstract

Emerging and re-emerging public health threats such as zoonotic diseases, outbreaks, and environmental hazards continue to challenge South Sudan's fragile health system. This study, titled "Assessment of Emergency Preparedness and Response Using One Health Approach in Juba, South Sudan," evaluates the extent to which the One Health (OH) framework integrating human, animal, and environmental health, has been applied to strengthen emergency preparedness and response (EPR) capacities in Juba, Republic of South Sudan. A mixed-methods approach was employed, combining quantitative data from structured questionnaires administered to 378 respondents across key sectors (human health, animal health, and environment) with qualitative data from 20 key informant interviews and document reviews of national preparedness plans. Results revealed that while awareness of the OH approach was moderate (67%), its operationalization within emergency preparedness structures remained limited due to fragmented coordination, inadequate funding, and weak intersectoral collaboration. Surveillance and laboratory capacities improved, yet joint outbreak investigations and data sharing remained inconsistent. However, the study found positive trends in multisectoral training initiatives and policy alignment efforts supported by international partners. The study concludes that adopting a fully functional One Health model could significantly enhance South Sudan's emergency preparedness and response (EPR) systems. Strengthening institutional coordination, capacity building, and resource mobilization across sectors is critical for building resilience against health emergencies in Juba and beyond.

Keywords: Emergency Preparedness, Juba, One Health, Response, South Sudan, Zoonotic Diseases.

Introduction

South Sudan (SSD), with a population of 12.44 million based on the 2018 census and South Sudan National Bureau of statistic 2024 projection, faces substantial challenges impacting prevention, preparedness, and response to disease outbreaks, due to its complex geo-political, socio-economic, and environmental landscape. Operational conditions are severely affected by damaged infrastructure and logistical challenges, particularly during the rainy season, which hampers the delivery of health services. The country's susceptibility to climate change has led to repeated severe droughts and floods since 2011, causing extensive fatalities, displacement, and livestock losses [29]. These events critically affect livelihoods and compound the difficulty of improving health infrastructure. The country faces numerous public health challenges, including outbreaks of both zoonotic and non-zoonotic diseases [2].

The country continues to face recurrent public health emergencies **[Figure 1]** such as disease outbreaks, floods, protracted humanitarian crises, and cross-border health

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threats [30]. The capital city of South Sudan Juba, as the political and economic center, remains particularly vulnerable due to its dense population, high mobility, weak urban health infrastructure, and close interaction between humans, animals, and the environment [20], The One Health approach integrating human, animal, and environmental health sectors provides an effective framework for strengthening emergency preparedness and response capacities [17], This assessment examines existing systems, identifies gaps, and evaluates the effectiveness of One Health coordination multisectoral coordination mechanism in Juba.

South Sudan faces a multitude of zoonotic and non-zoonotic diseases, largely due to porous borders and uncontrolled movement between neighboring countries [12]. With a ranking of 185 out of 195 countries in the Global Health Security Index, scoring only 21/100 points, the country is particularly vulnerable [23]. This susceptibility is compounded by poor socio-economic conditions, political instability, and climate change-induced flooding and population displacement, which contribute to downstream health effects such as waterborne diseases. Furthermore, the proximity of wildlife to human population centers increases the risk of animal-to-human disease transmission. These challenges strain an already fragile health system, emphasizing the need for a robust and resilient system to prevent, prepare for, and respond to epidemic threats. Over 75% of emerging and re-emerging infectious diseases are attributed to zoonotic pathogens from both domestic and wildlife sources, with 60% of infectious diseases in humans linked to pathogens transmitted between wildlife and humans [10]. Additionally, pathogens with non-human animal hosts pose threats to human health by impacting food production and supply, as approximately 20% of animal production is lost due to disease. Recognizing these interconnected risks, One Health efforts are being undertaken worldwide at the human-animal-environment interface to manage and mitigate the emergence of infectious diseases with both local and global implications. One Health is an integrated approach that aims to sustainably balance and optimize the health of humans, animals, plants, and ecosystems. It mobilizes multiple sectors, disciplines, and communities to foster well-being and tackle threats to health and ecosystems while addressing collective needs for clean water, energy, air, safe and nutritious food, climate action, and sustainable development. In South Sudan, where emerging diseases are a known hotspot, increasing commitment to institutionalizing multi-sectoral collaboration for the One Health agenda is evident. Such collaboration is essential for identifying additive versus competing uses for limited resources in a country whose health, livestock, agriculture, and other systems have been repeatedly challenged by insecurity and disasters. Zoonotic diseases pose significant public health threats in South Sudan, with major concerns including Ebola Virus Disease, Yellow Fever, Anthrax, Brucellosis, Bovine Tuberculosis, Highly Pathogenic Avian Influenza, Rabies, and Rift Valley Fever. Antimicrobial resistance is also emerging due to the unregulated use of antimicrobials in humans and animals, compounded by the lack of surveillance systems to monitor antimicrobial susceptibility trends. Strengthening coordination and communication between relevant sectors is crucial for developing policies, strategies, plans, and guidelines to ensure optimal operational readiness and response to zoonotic diseases across South Sudan. Refers to the organized actions taken to anticipate, plan for, and manage the impacts of emergencies or disasters [figure 2]. This can range from natural disasters such as floods, earthquakes, and pandemics to man-made crises such as conflicts, industrial accidents, or public health emergencies. The goal of EPR is to reduce risks, minimize

damage, and enhance recovery efforts, ensuring the safety and well-being of affected populations.

Emergency Preparedness and response were stated by researchers to be not constant but to change as social contexts shift, requiring revisions and modifications [11]. For instance, caregiving or medical considerations may affect the household's needs temporarily or permanently. Proper household emergency preparation is a substantial strategy to reduce the impact of a disaster [15]. Identifying the dangers specific to a region, developing a contingency plan, and providing a home survival kit with 72 hours of food, water, and medical supplies for sheltering in place are all part of emergency preparedness. In addition to drafting a contingency plan and understanding emergency housing and evacuation tactics for public response, the American Red Cross says that preparation often includes practising the plan with family members [28]. Public Safety Canada emphasizes the interconnectedness and necessity for continuity throughout all phases of a crisis: prevention, preparedness, response, and recovery [13]. According to Tanner and Doberstein (2015), approximately 30% of college students carry emergency kits [1]. However, any disaster preparedness supplies that student may have, are purely coincidental because they are common household stuff [9], over half of students had at least three days' worth of food and a first- aid kit, but less than a third had a radio, generator, or extra supply of medication [14], argues that there's a lack of emergency planning training and education [26]. Estimates indicate that between 28% and 73% of colleges participate in emergency drills [25]. If successful, training exercises demonstrate readiness, while failure reveals areas for growth [22]. During student orientation, however, just about half of the students receive information or training on disaster preparedness [8]. Videos about emergency preparedness could be an effective way to raise awareness of emergency planning. Adopting and integrating the One Health approach into plans and policies, both at national and international levels, requires a radical change of strategy in terms of governance, capacity building, training and research to overcome the current fragmentation and barriers and to allow the required interaction, collaboration and coordination across sectors and disciplines.

Problem Statement

South Sudan's emergency management landscape suffers from several systemic and operational challenges: Fragmented coordination between human health, animal health, environmental sectors, and disaster management authorities; Limited early warning and surveillance systems especially in some sectors, leading to delayed detection of outbreaks; Weak laboratory capacity for rapid diagnosis of zoonotic and other priority diseases; Insufficient emergency response resources, including trained personnel, logistics, and response funding; Poor risk communication mechanisms that hamper timely dissemination of public health information; Rapid urbanization and environmental degradation that increase the risk of zoonotic spillover. To solve these problems there is a need to fully operationalize one health approach by establishing a fully functional.

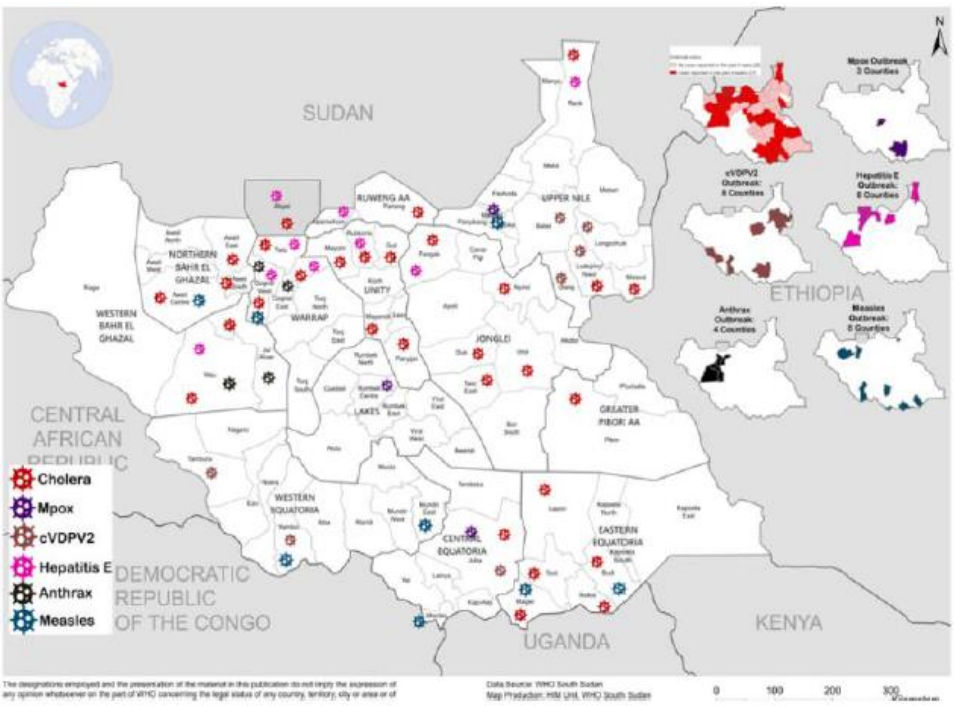

Figure 1. Major Ongoing Outbreaks in South Sudan

South Sudan, a country marked by recurrent public health emergencies including infectious disease outbreaks, in which 80% are zoonotic diseases, natural disasters, and conflicts, faces significant challenges in ensuring effective emergency preparedness and response. The convergence of human, animal, and environmental health threats in the region has underscored the need for integrated strategies that recognize the interconnectedness of these domains. Despite efforts by national and international organizations to bolster emergency response systems, gaps in coordination, resource allocation, and policy implementation persist. The fragmented healthcare infrastructure limited veterinary and environmental services, and the complex socio-political landscape further exacerbate these challenges, leading to delayed responses and increased morbidity and mortality during emergencies.

The One Health approach, which emphasizes collaboration across human, animal, and environmental health sectors, has emerged as a comprehensive framework for addressing such multifaceted public health challenges. However, there has been limited systematic evaluation of how well South Sudan's emergency preparedness and response mechanisms align with One Health principles. This knowledge gap raises critical questions about the capacity of the country's health system to effectively anticipate, prevent, and respond to public health emergencies in an integrated and sustainable manner.

This research seeks to assess South Sudan's emergency preparedness and response capabilities through the lens of the One Health approach. By identifying existing strengths, weaknesses, and areas for improvement, this study aims to contribute to the development of more holistic, coordinated, and resilient public health strategies in South Sudan. The findings will inform policy recommendations and capacity-building initiatives to enhance the country's ability to respond to current and future public health threats.

The One Health concept is not well established in South Sudan Health policy. There needs to be increased awareness of the benefits of a One Health approach, training and education, across the human health, animal, and environmental sectors. The One Health concept should be more consistently covered in the

medical curriculum. The government should invest in One Health research and incorporate evidence based One Health approaches into policies, programs, and services especially the department of emergency preparedness and response (EPR) in the Ministry of Health, Republic of South Sudan.

Several mechanisms and interventions currently exist to support emergency preparedness and response: such as Public Health Emergency Operations Center (PHEOC) at national level supporting coordination and incident management; National One Health secretariat and One Health multisectoral coordination mechanism bringing together line ministries: such as Ministry of Health (MoH), Ministry of Livestock and fisheries (MoLF), Ministry of Environment and Forestry (MoEF), and partners. The existing Integrated Disease Surveillance and Response (IDSR) system for routine surveillance and reporting. Event-Based Surveillance (EBS) and community-level alerts.

The One Health Approach through strengthened Public Health Emergency Operation Center (PHEOC) coordination emerges as the most effective solution because: includes Its integrates multisectoral expertise in real time to prepare, prevent and response to public health emergencies using one health approach; It ensures joint risk assessment, information sharing, and unified response; It increases efficiency by pooling resources and avoiding duplication; It aligns with international frameworks including International Health Regulations (IHR 2005), Global Health Security Agenda (GHSA), and African Union (AU) One Health strategy; It enables early detection of zoonotic spillovers and environmental triggers. Thus, a fully functional multisectoral emergency preparedness and response (EPR and public health emergency operation center (PHEOC) with decentralized linkages to states provides the strongest foundation for emergency resilience.

Limitations

Despite progress, key limitations remain: Limited funding for one health preparedness and emergency rapid response activities; Inadequate integrated surveillance across human, animal, and environmental sectors; Human resource gaps, including shortages of epidemiologists, veterinarians, lab technologists, and emergency managers; Poor interoperability of digital surveillance platforms; Weak enforcement of environmental and animal health regulations; Dependence on external partners, risking sustainability and Limited laboratory networking, leading to diagnostic delays. Significant progress has been made, including but not limited to Establishment and operationalization of the National public health emergency operation center (PHEOC) with trained incident management teams; Development of the 2nd edition of the National Action plan for health security (NAPHS), One Health strategic plan (OHSP), and multiple hazard-specific preparedness plans; Increased integrated diseases surveillance and response (IDSR) reporting coverage and improved outbreak detection; Formation of a National One Health secretariat enhancing coordination; Successful responses to priority outbreaks such as cholera, anthrax, measles, and hepatitis E; Capacity building through trainings on Event and Indicator Based Surveillance (EBS&IBS), Rapid Response Teams (RRTs), laboratory diagnostics, and emergency management; Strengthened risk communication during emergencies like COVID-19 and flooding events [21].

Conceptual Framework of the Study

South Sudan's susceptibility to emerging infectious diseases, particularly zoonotic ones, stems from its environmental conditions, exemplified by extensive 2022 flooding attributed to climate change, as reported in the South Sudan Monthly Humanitarian Situation Report. A key driver of zoonotic disease

transmission is the close proximity of many South Sudanese to animals, including livestock and wildlife, due to the prevalence of rural living conditions. Cultural practices like consuming raw milk and animal blood, along with poaching, further exacerbate the transmission of pathogens between humans and animals. With approximately 34.2% to 45% of its land covered by forests, as outlined in the National Environmental Policy 2015-2025, South Sudan boasts rich biodiversity [27]. However, this biodiversity also serves as a reservoir for disease hosts, including wildlife, due to activities such as commercial hunting, logging, shifting cultivation, and settlements, which have become more common in the post-conflict period. Encroachment on wildlife habitats, driven by illegal logging and mining, has heightened the risk of human-wildlife interaction, particularly with species like the pygmy hippopotamus and non-human primates. Weaknesses in the health system exacerbate the challenge of disease detection and containment. Surveillance systems for animal diseases remain rudimentary, with limited personnel and resources dedicated to monitoring and reporting. Additionally, the importation of livestock and poultry, sometimes without prior documentation, increases the risk of introducing infectious diseases into South Sudan. Despite local guidelines, high levels of inappropriate antibiotic use persist in hospitals, contributing to the emergence of antibiotic-resistant infectious diseases, although precise data on the burden of antimicrobial resistance (AMR) in South Sudan are limited [5]. In summary, South Sudan's vulnerability to emerging infectious diseases arises from a combination of environmental factors, cultural practices, encroachment on wildlife habitats, weak health systems, and inappropriate antibiotic use. Addressing these challenges requires a multifaceted approach encompassing improved surveillance, public awareness campaigns, strengthened regulations, and enhanced healthcare infrastructure.

Emerging Infectious Disease in South Sudan

Infectious Diseases in Humans

South Sudan boasts a substantial livestock population, exceeding 36.5 million, comprising 12.1 million sheep, 12.4 million goats, and 12 million cattle. With over 70 percent of the population relying on the livestock sector for their livelihoods, communities in both subsistence agro pastoral and pastoral production systems play pivotal roles in maintaining approximately 47 percent and 43 percent of this livestock population, respectively. Despite its significance, livestock production in South Sudan predominantly follows an extensive, low-input system, contributing an estimated 15 percent to the national Gross Domestic Product. However, the sector faces challenges stemming from endemic livestock diseases, low animal production and productivity, minimal investment in value chains, and the adverse effects of climate change-related floods, particularly since 2019. South Sudan grapples with several endemic zoonotic diseases, including Rabies, Anthrax, Brucellosis, Bovine Tuberculosis, Rift Valley Fever (RVF), Yellow Fever, and Sudan Ebolavirus species. Additionally, the country has witnessed a rise in environmentally related diseases such as malaria, typhoid, and watery diarrhea, largely attributed to widespread water contamination from urban surface runoff and inadequate environmental sanitation. The absence of a robust surveillance system and environmental laboratories exacerbate these challenges. To address priority zoonotic diseases, South Sudan has implemented surveillance through the Integrated Disease Surveillance and Response (IDSR) and Early Warning, Alert, and Response Systems (EWARS) strategies, developed by the WHO Regional Office for Africa. In 2022, the IDSR system detected and responded to five outbreaks of human-related diseases, including various zoonoses [31]. Notable outbreaks

included Hepatitis E, Cholera, Meningitis, Anthrax, Mpox, and Measles. For instance, in 2022, South Sudan reported 72 suspected cases of Anthrax, resulting in four deaths (with a Case Fatality Rate [CFR] of 5.6%). Similarly, the cholera outbreak in Bentiu recorded a cumulative total of 424 suspected cases, with one death (CFR of 0.24%) [19].

Infectious Disease in Animals

In South Sudan, the emergence of diseases among domestic and wild animals, as well as plants, presents a significant concern. Crop losses due to pests and diseases, both pre- and post-harvest, are estimated at 40%-50%, with livestock losses expected to be similarly substantial. Notably, between 2019 and 2022, documented disease outbreaks among animals include Anthrax, Rabies, Rift Valley Fever, Foot and Mouth Disease, Lumpy Skin Disease, Peste des Petits Ruminants, Brucellosis, Bovine Tuberculosis, Contagious Bovine Pleuropneumonia (CBPP), Sheep and Goat Pox, Newcastle Disease, and Avian Influenza in poultry. Given South Sudan's heightened vulnerability to zoonotic diseases, it is imperative to strengthen national multisectoral capacities for cross-sectoral surveillance, response, and control systems. This entails early detection and rapid containment of zoonoses to minimize illness and fatalities. Commitment to collaborative efforts aimed at enhancing the control of zoonoses and threats at the human-animal-environment interface, particularly within high-risk populations in South Sudan, is crucial. Recognizing the urgency of this issue, the draft South Sudan National Livestock Development Policy (2021), along with the Animal Health Bill (2019), Veterinary Council Bill (2019), and Meat Control and Slaughter Facility Bill (2019), acknowledges the endemic or frequently occurring status of several priority diseases designated by the World Organization for Animal Health (OIE) [7]. These transmissible diseases, characterized by their potential for rapid and severe spread across national borders, include Foot and Mouth Disease, Peste des Petits Ruminants, Contagious Bovine Pleuropneumonia, Lumpy Skin Disease, Classical Swine Fever, Newcastle Disease, Rinderpest, Sheep Pox, and Goat Pox. Efforts to address these challenges must be multifaceted, encompassing robust surveillance, effective response mechanisms, and comprehensive policy frameworks to safeguard animal health and mitigate the risks posed by infectious diseases.

Factors Contributing to Emergence of Infectious Diseases in South Sudan

South Sudan's susceptibility to emerging infectious diseases, particularly zoonotic ones, stems from its environmental conditions, exemplified by extensive flooding in 2022 attributed to climate change, as reported in the South Sudan Monthly Humanitarian Situation Report [4]. A key driver of zoonotic disease transmission is the close proximity of many South Sudanese to animals, including livestock and wildlife, due to the prevalence of rural living conditions. Cultural practices like consuming raw milk and animal blood, along with poaching, further exacerbate the transmission of pathogens between humans and animals. With approximately 34.2% to 45% of its land covered by forests, as outlined in the National Environmental Policy 2015-2025, South Sudan boasts rich biodiversity [6]. However, this biodiversity also serves as a reservoir for disease hosts, including wildlife, due to activities such as commercial hunting, logging, shifting cultivation, and settlements, which have become more common in the post-conflict period. Encroachment on wildlife habitats, driven by illegal logging and mining, has heightened the risk of human-wildlife interactions, particularly with species such as the pygmy hippopotamus and non-human primates. Weaknesses in the health system exacerbate the challenge of detecting and containing disease. Surveillance systems for

animal diseases remain rudimentary, with limited personnel and resources dedicated to monitoring and reporting. Additionally, the importation of livestock and poultry, sometimes without prior documentation, increases the risk of introducing infectious diseases into South Sudan. Despite local guidelines, high levels of inappropriate antibiotic use persist in hospitals, contributing to the emergence of antibiotic-resistant infectious diseases, although precise data on the burden of antimicrobial resistance (AMR) in South Sudan are limited. In summary, South Sudan's vulnerability to emerging infectious diseases arises from a combination of environmental factors, cultural practices, encroachment on wildlife habitats, weak health systems, and inappropriate antibiotic use. Addressing these challenges requires a multifaceted approach encompassing improved surveillance, public awareness campaigns, strengthened regulations, and enhanced healthcare infrastructure.

Other Public Health Threats in South Sudan

Beyond infectious diseases, South Sudan faces a spectrum of environmentally driven public health hazards stemming from inadequate regulation of human activities. These threats encompass a range of issues, including industrial chemical spills, substandard waste management practices, recurring flooding, and associated safety concerns. Gold mining operations in South Sudan employ cyanide leaching, a widely used method for gold recovery worldwide, which can recover approximately 83% of gold [18]. However, without stringent regulation and monitoring, the chemicals present in the wastewater used for gold processing, such as Hydrochloric acid and cyanide, pose significant risks. Leakage from mining sites can contaminate nearby water sources, leading to exposure among both humans and animals, and causing adverse environmental impacts. Moreover, inadequate waste management practices contribute to public health risks as waste accumulates in market and residential areas, serving as potential breeding grounds for disease-carrying vectors and contaminating local water supplies. As shown in **Table 1**, the distribution of priority zoonotic diseases varies across states.

Table 1. List of Other Public Health Threats in South Sudan

S/N	Public Health Threat	Geographical Location affected
1	Road accident especially in urban areas	Juba - Nimule Road, Juba - Terekeka, Juba - Bor, and Juba Nadapal Road. (countrywide)
2	Drought and famine	Kapoata, Northern Bahr El Ghazal, Ruweng, Greater Pibor Administrative Area (GPAA) Greater Upper Nile.
3	Fire hazard	Eastern Equatoria, parts of Central Equatoria etc.
4	Oil spills	Major Towns and Unity, Upper Nile, and Ruweng A. Area
5	Volcano eruption /Earthquake	Juba, Eastern Equatoria
6	Food poison	From the imported food items abroad
7	Insecurity	Fringes of major towns and some states
8	Cattle rustling	All over the country

9	Over poaching/fishing	Protected Areas, The Sudd Wetland, game park and national reserves
10	Deforestation/Soil degradation	Country (among cattle keeping communities)
11	Lightening (thunderstorm)	Juba, Yei, Ruweng, Torit, (countrywide)
12	Landmine	Yei, Lasu, Magwi, Rokon, contested areas
13	Poor land use Planning	Juba, Bor, Torit, (countrywide)
14	Lack of environmental impact assessment	Juba-Bor Road, Juba - Rumbek - Wau Road oil Fields
15	Air pollution	Major towns (e.g. Juba, Wau, Malakal etc.) and oil produce states (Ruweng Administrative area, Unity, Upper Nile state)
16	Landslide/ Flood	Unity State, Jonglei State, Upper Nile, Ruweng, Warrap, Torit, Pibor, Central Equatoria
17	Extensive use of fertilisers	Renk County
18	Overuse of drug/ alcohol	Illicit drug use among the youth (urban towns)
19	Human wildlife conflict	Protected areas (badingilo, boma etc.)
20	Desert locust invasion	Budi county, kapoeta, magwi, chukudum
21	Air-crafts accidents	Akobo, Juba, old Fangak,
22	High population displacement	Some of the state including three administrative area, almost 10 states are living in the POCs.
23	Poor distribution of healthcare services	At least 1 Doctor is attending 1000 persons in a day.
24	Poor socio-economic	Every 1 person in South Sudan is living below 0.0001% in a day
25	Lack of a healthcare registration policy	All operational pharmacies and private clinics have no clear registration and follow-up policy.
26	Severe food shortage	Due to mass migration and Insecurity out of the country, the impact of climate change, flood, drought and outbreaks of crop pest diseases, such as fall armyworm, desert locust, whiteflies, and cross-border cattle migration, such as Amboro herders crossing to the northern part of Aweil and Wau in western Equatoria.
27	Inadequate health care services	Due to destruction and closure due to war and maintenance
28	High prevalence of HIV/AIDS,	dengue fever, meningococcal meningitis, bacterial and protozoal diarrhoea, rabies, hepatitis A and E, typhoid fever and many more.
29	Widespread outbreaks of diseases	Such as cholera, Malaria, measles and other communicable diseases
30	Persistent cholera outbreaks	From 2014-2017 and Currently 2023.

Source South Sudan Public Health Emergency operation center (PHEOC) 2024.

Schematic Diagram\ Graphical Abstract

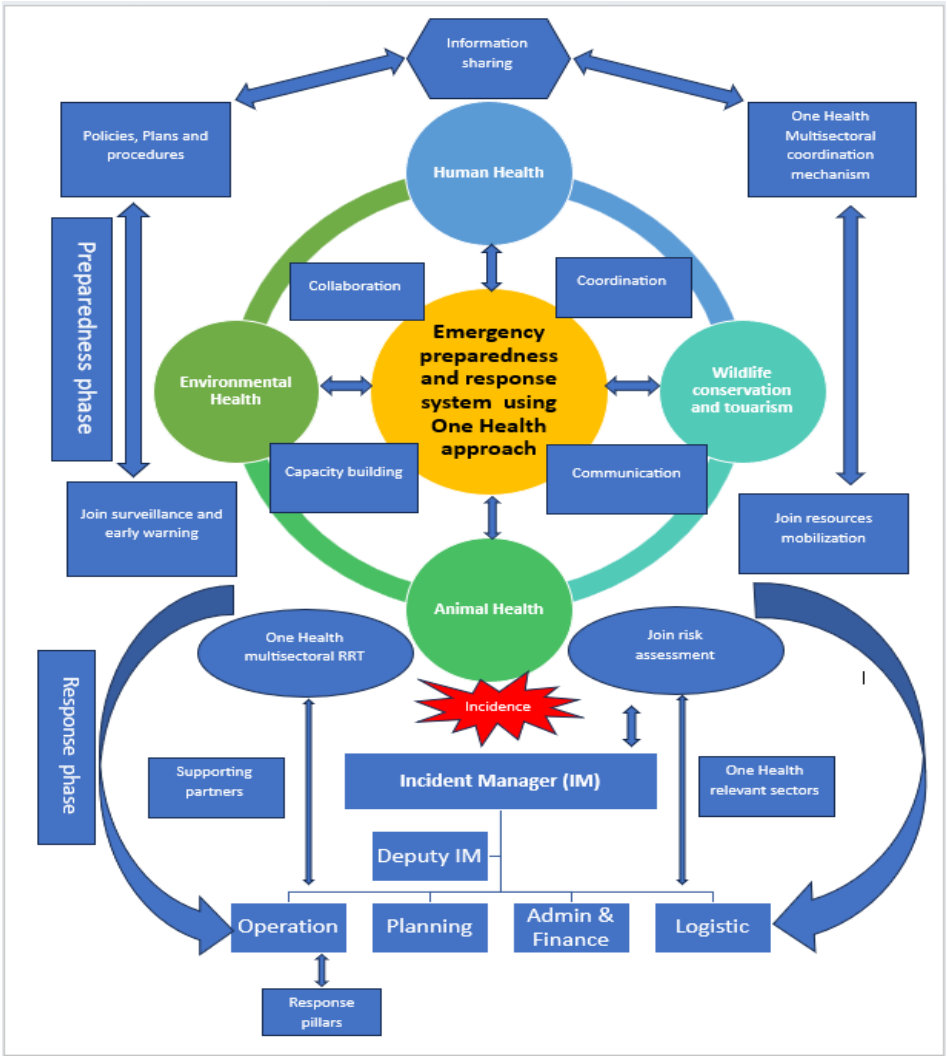

Figure 2. Conceptual Framework by Author 2024

Figure 2 shows the principal investigator newly proposed conceptual framework for effective inclusion of One health approach in South Sudan Emergency Preparedness and Response framework.

Research Questions

1. What is the current level of One Health approach and the Emergency Preparedness and Response capacity in South Sudan, specifically in the context of zoonotic diseases and other public health threats?
2. How does the collaboration, coordination and communication (Information sharing) between human, animal, and environmental health and other sectors impact the effectiveness of emergency preparedness and responses to public health outbreaks in South Sudan?
3. How effectively is the One Health approach integrated into emergency preparedness and response systems in South Sudan?
4. What are the key challenges and barriers to implementing the One Health approach in emergency preparedness and response in South Sudan?
5. What is the impact of One Health Interventions on Public Health Outcomes in the past emergencies from 2019 to 2025

The major objective for this study is to assess the Emergency Preparedness and Response

(EPR) system using the One Health approach to identify how effective is the integration and functionality of One Health approach in Emergency Preparedness and system in Juba, South Sudan. Specifically, 1. To evaluate the Current Integration of One Health approach in Emergency Preparedness and response Frameworks in South Sudan. 2. To examine the Role of Cross-Sectoral Collaboration in Emergency preparedness and Response Systems. 3. To assess the Effectiveness of One Health-Based Surveillance Systems in South Sudan emergency preparedness and response. 4. To identify Resource Gaps and Challenges in Implementing One Health-Based Emergency Preparedness. And 5. To analyze the Impact of One Health Interventions on Public Health Outcomes in Past Emergencies preparedness and response 2019 to 2025.

This study provides the first comprehensive One Health–focused assessment of emergency preparedness in Juba. It integrates multi-sectoral insights from human, animal, environmental, and disaster management authorities. It introduces a novel cross-sector emergency preparedness scoring framework tailored to South Sudan. It outlines an interoperable surveillance and response model adapted to the country's context. It contributes evidence to guide future policy, NAPHS updates, strategic plans, and donor investment.

Methodology

Research design is the structured approach followed by researchers to answer a particular research question [7]. The research design involves a plan, structure and strategy of the study. These three research design concepts guide a researcher in writing the research questions, conducting the project, and in analyzing and evaluating the data [16]. This study is a descriptive cross sectional study design, applying both qualitative and quantitative approaches. The quantitative approach provided a method to collect statistical data for analysis and reporting [16], are of the view that the main purpose of scientific research is to explore the association among primary variables to gain a better understanding of the phenomena under study. The principal researcher also has a qualitative approach which is more subjective in nature and involves examining and reflecting on the less tangible aspects of a research subject, e.g. values, attitudes, perceptions. A cross-sectional based design using quantitative and qualitative approaches were employed in this study to assess emergency preparedness and response using one health approach in Juba, Republic of South Sudan. Information on socio-demographic characteristics, the role of collaboration, effectiveness of surveillance system, gaps and challenges of implementing one health will be collected using a pretested structured interview schedule questionnaire. Cross-sectional study or survey will be used because it employs exploratory and descriptive approaches to assess Emergency Preparedness and Response using One Health approach, and this is particularly useful in informing the planning and allocation of health resources. Both exploratory and descriptive designs were used to assess Emergency Preparedness and Response using one health approach. This study utilized a mixed-methods research design to comprehensively assess emergency preparedness and response capacities within a One Health framework. The study was conducted between January and July 2025 in Juba City. The target population comprised personnel from the Ministry of Health, Ministry of Livestock and Fisheries, environmental authorities, academic institutions, and humanitarian organizations engaged in emergency response. Quantitative data were collected using a structured questionnaire administered to 150 respondents selected through purposive and stratified sampling to ensure balanced representation from the three One Health sectors. The questionnaire gathered information on awareness, coordination, surveillance systems,

laboratory capacity, and operational readiness. Qualitative data were collected through 20 key informant interviews with senior officials and technical staff responsible for policy formulation, surveillance, laboratory services, and outbreak response. These interviews followed a semi-structured guide exploring multisectoral collaboration, implementation of One Health (OH) approach in South Sudan, challenges, and sector-specific roles in emergencies. Document review included national guidelines such as National Action Plan for Health Security (NAPHS), the One Health Strategic Plan, Public Health Emergency Operation Center (PHEOC) Standard Operating Procedures (SOPs), and outbreak reports [33]. The assessment incorporated relevant indicators from the WHO Joint External Evaluation (JEE) tool and the OIE Performance of Veterinary Services (PVS) framework to benchmark national capacities. Quantitative data were analyzed using descriptive statistics, while qualitative transcripts underwent thematic content analysis. Triangulation enhanced the reliability and validity of the findings.

At the first step, all the data sheets were checked manually for any mismatches and was corrected accordingly. Later, the data were also cleaned using computerized cleaning process. After the data collection the data will also enter Epi Data software, version 3.1. for rechecking rechecked for the purpose of the data validation. After, that data were imported to SPSS software, version 23 for analysis. The hard copies of the filled interview schedules and consent forms were kept in the locked chamber under custody of the personal information (PI). The privacy and the confidentiality of the study participants are being strictly maintained. Analysis was done using Statistical Package for Social Sciences (SPSS) software version 23. Bivariate analysis was used with outcome variables, Statistical tests was also be done and for all the tests, p-value of <0.05 was considered as significant. For adjustment of possible interaction and confounding factors, multiple logistic regression analysis was performed to arrive at a final model. Predictor variables that will have p-value < 0.1 in bivariate analysis was considered for multiple logistic regression analysis. The net bearing effect of different predictor variables was explained in terms of odds ratio (OR) with 95% of confidence interval (CI).

To ensure legal processes a clearance was obtained from Taxila American University Prior to data collection. Permission was also obtained from the Ministry of Health Research Ethics Review Board, Government of South Sudan. Written informed consent for participating in the study was developed and signed by the participants. Participants were given full freedom of either accepting or refusing to participate, and for withdrawing participation at any time of the study without any explanation and consequences. Respondents were informed regarding the voluntary nature of participation, study objectives, and the potential benefits and risks of participation. Utmost ease was given to protect the privacy and confidentiality of the participants. Personal information about the participants was not shared with anyone not involved in the study. The researcher (principal investigator) used codes and not respondent's names, so that the respondents would not be identifiable. Two boxes were provided in each grade. One for the signed consent forms, which will be sealed once all the forms have been placed in the box. Another box will be provided for questionnaires, which will also be sealed after the respondents have completed all the questionnaires, and the same way will be followed for the semi-structured interview schedule. The National Ministry of Health will give permission to the researchers to conduct the study and data collection. The researcher further requests that the in-charge of those institutions where data will be collected should be present at the beginning of the data collection. The head of units in the different

departments will also be notified orally before data collection.

Research Design

Research design is the structured approach followed by researchers to answer a particular research question [7]. The research design involves a plan, structure and strategy of the study. These three research design concepts guide a researcher in writing the research questions, conducting the project, and in analyzing and evaluating the data [16].

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Research methodology refers to the steps, procedures and strategies for gathering and analyzing the data [24]. This section discusses the study setting, population and sample selection.

Study Setting and Period

Juba city the Capital of the Republic of South Sudan will be the study setting. It was chosen because it is the largest population city and the capital city of South Sudan with a population of Juba County is an administrative area located in Central Equatoria State (CES), Population 690,918 base on National Bureau of Statistics, 2021. In addition, Juba is the capital city of South Sudan where all national Government institutions are hosted such as Ministries, teaching hospitals, Public Health Emergency Operations Center, Public Health Laboratory and many others.

Study Population

A study population is an aggregate of elements sharing some common set of criteria [3]. The population is described in terms of the target population, inclusion criteria, and sampling method.

1. Public health officials: Include officials from ministries of health, WHO, or local public health agencies.
2. Healthcare providers: Doctors, nurses, and emergency health workers who are directly involved in emergency preparedness and response.
3. Disease surveillance officers: Personnel working on disease detection and reporting systems.
4. Members of the Rapid Response Team: such clinicians, epidemiologist, risk and crisis and community engagement officers, Infection prevention and control experts, laboratory technologist.
5. Veterinarians and animal health workers: Involved in monitoring zoonotic diseases (those transmitted from animals to humans) and outbreaks in animal populations.

6. Animal disease surveillance officers: Those responsible for animal disease monitoring and reporting.
7. Environmental health officers: Officials or organizations responsible for monitoring environmental factors that impact health (e.g., water safety, sanitation, air quality).
8. Environmental monitoring agencies: These might include agencies that deal with land management, wildlife conservation, and ecosystem health.
9. Community leaders: Chiefs, elders, or influential members of communities who are important in organizing response efforts during emergencies.
10. Local farmers and pastoralists: Especially in areas dependent on livestock, these individuals may be affected by zoonotic diseases and environmental factors.
11. General public: Individuals affected by emergencies like disease outbreaks or natural disasters.
12. Ministry of Health: Officials responsible for policy and coordination of health-related emergency responses.
13. Ministry of Agriculture and Livestock: Key for understanding animal health and how it integrates into emergency responses.
14. Ministry of Environment and Forestry: Important for environmental health aspects in the context of emergencies.
15. UN agencies (WHO, FAO, OIE): Engaged in emergency preparedness and response, especially in public health, veterinary, and environmental sectors.
16. NGOs: Organizations focused on emergency relief, humanitarian assistance, and development in the areas of health, environment, and food security.
17. Researchers in public health, veterinary science, and environmental health: Those involved in One Health-related studies, particularly in emergency preparedness and disease control.
18. Considerations for the Study Population:
19. Geographic Location: Focus on regions in South Sudan that are prone to health emergencies (e.g., areas with frequent zoonotic disease outbreaks, floods, etc.).
20. Diversity in Sectors: Ensure representation from all three core areas of One Health (human, animal, environmental health).
21. Role in Emergency Response: Focus on those actively involved or impacted by preparedness and response efforts.

Ethical Approval

Ethical approval for this study was obtained from the Ministry of Health Research Ethical Review Board (RER) of South Sudan and also approval was obtained from Texila American University prior to the commencement of data collection (Approval reference number MOH/RERB/A-81/2024). Administrative clearance to conduct the study was also granted by the Central Equatoria State Ministry of Health and relevant authorities in Juba County. The study was conducted in accordance to internationally recognized ethical standards for research involving human participants. Participation in the study was voluntary, and written informed consent was obtained from all respondents before data collection. Participants were adequately informed about the purpose of the study, procedures involved, potential risks and benefits, confidentiality of the information provided, and their right to withdraw from the study at any stage without any penalty. Confidentiality and anonymity of participants were strictly maintained. No personal identifiers were collected, and all data were securely stored and used solely for academic and research purposes. The study involved minimal risk and did not include any invasive procedures.

Inclusion Criteria

1. Sector-specific: People who work or are involved in human, animal, or environmental health.
2. Experience in emergencies: Individuals who have been part of emergency preparedness or response efforts (e.g., health workers during disease outbreaks, farmers impacted by zoonotic diseases).
3. Geographic relevance: Participants from areas in South Sudan affected by emergencies (e.g., regions prone to floods, droughts, or disease outbreaks).
4. Community involvement: Local leaders and community members actively participating in response activities.
5. Employee status: officially employed or on short contract with government or partners and working in a facility in different human, animal and environmental medical professions (laboratory technicians, clinical officers and theatres assistant).

Exclusion Criteria

1. Lack of relevant experience: Individuals not directly involved in emergency preparedness or response efforts.
2. Age group (under age): any person below 18 and above 80 years are excluded, the eligible age group targeted in this study is between 19 and 75 years old.

Samples Size Determination

Sample Size

The determined sample size was an outcome estimated of multisectoral and multidiscipline professionals and others providing health services especially emergencies preparedness and response. The sample size was determined by using the Krejcie & Morgan [34] [Table 2].

Table 2. Determining Sample Size [34]

Given population (N)	Sample size (S)	Given population (N)	Sample size (S)
10	10	300	169
20	19	320	175
30	28	340	181
40	36	360	186
50	44	380	191
60	52	400	196
70	59	420	201
80	66	440	205
90	73	460	210
100	80	480	214
110	86	500	217
120	92	550	226
130	97	600	234
140	103	650	242
150	108	700	248
160	113	750	254
170	118	800	260
180	123	850	265
190	127	900	269
200	132	950	274

210	136	1,000	278
220	140	1,100	285
230	144	1,200	291
240	148	1,300	297
250	152	1,400	302
260	155	1,500	306
270	159	1,600	310
280	162	1,700	313
290	165	1,800	317
2,000	322	1,900	320
2,200	327	8,000	367
2,400	331	9,000	368
2,600	335	10,000	370
2,800	338	15,000	375
3,000	341	20,000	377
3,500	346	30,000	379
4,000	351	40,000	380
4,500	354	50,000	381
5,000	357	75,000	382
6,000	361	100,000	383
7,000	364	1,000,000	384

This table provides recommended sample sizes (S) for given population sizes (N) at a 95% confidence level and ±5% margin of error, assuming a population proportion of 0.5.

The total number of respondents voluntarily participated in the study was 387 respondents.

This group was taken with the assumption that it is close to and representative of the group health care professional and noon professionals providing health care services in emergency preparedness and response.

Using a 95% confidence level of certainty (α=0.05) as an assumption, the computed actual sample size for the study used one sample proportion formula as indicated below (Joubert & Ehrlich 2007:347). 80% was the expected power (1-β) for the study because it could allow good generalization since this level is the probability that a test will produce a significant difference at a given significance level if there is in fact a difference (Joubert & Ehrlich 2007:346).

The Equations

$$n = \frac{(\boldsymbol{Z\alpha/2})^{\mathbf{2}}\, \boldsymbol{p}\, (\mathbf{1}-\boldsymbol{p})}{\boldsymbol{d}^{\mathbf{2}}}$$

$$n = \frac{(1.96)^2(0.093 * 0.907)}{(0.03)^2} = 360$$

$Adding\ 5\%\ non-response\ rate$

$Total\ sample\ size\ = 360 + 18$

$= 378\ respondents$

$Where$:

$n = the\ required\ minimum\ sample\ size.$

$Level\ of\ confidence\ 95\%, which\ gives\ the\ percentile\ of\ n$

$/2 = 1.96.$

$D\ = (margin\ of\ error)\ = 0.03.$

$P\ = proportion\ of\ being\ tested\ = 0.093.$

$1-p\ = proportion\ of\ not\ being\ tested$

$= 0.907.$

$Estimated\ non$

$-response\ rate\ in\ school\ youth\ = 5\%.$

Based on the above assumptions, a total of 378 (with flexibility) students will be required for the study.

Data Analysis

The findings of research assessing emergency preparedness and response using the One Health approach in Juba, South Sudan. The analysis is based on both quantitative and qualitative data collected from stakeholders in human health, animal health, and environmental and other sectors. The aim was to evaluate the current state of multisectoral preparedness, identify gaps, and determine the extent of collaboration and coordination during emergencies. Descriptive statistics, thematic content analysis [Figure 4], and comparative frameworks were employed to interpret the data.

A total of 378 respondents participated in this study through structured interviews and questionnaires. These participants were drawn from key sectors of the One Health spectrum namely human health (38.8%), animal health (26.5%), environmental health (18.4%), and multisectoral coordination offices (16.3%). Respondents included government officials, healthcare workers, veterinarians, environmental officers, Noon Governmental Organisation NGO/ United Nations agencies representatives and the private sector.

The One Health approach recognizing the interconnection between human, animal, and environmental health has emerged as a critical strategy in addressing public health emergencies. The findings of this study indicate that the level of knowledge and understanding of One Health principles among health professionals and key stakeholders in South Sudan is still developing but shows significant promise, especially in areas exposed to zoonotic outbreaks and in cross-sectoral collaboration.

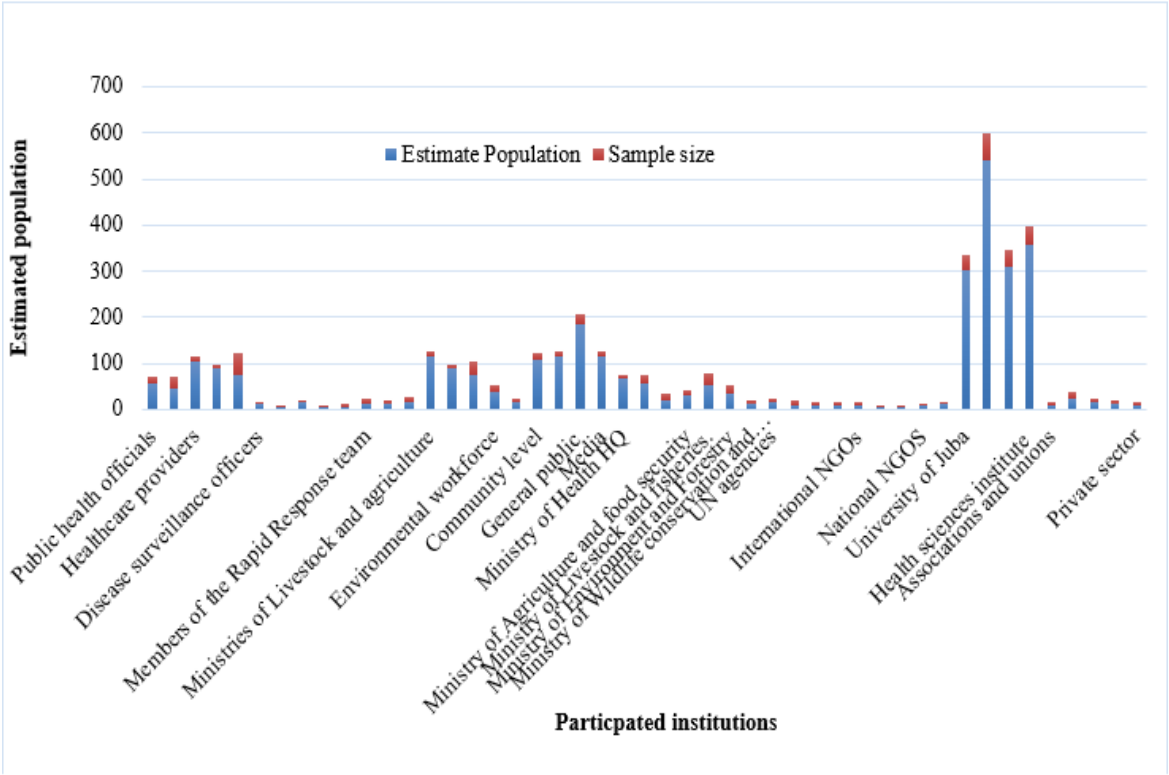

Figure 3. Estimated Population and Sample Size Determination

Figure 3 summarizes the institution participated in this study and sample size by author 2025.

Results

Findings showed moderate awareness of the One Health approach among the respondents, with 67% demonstrating good conceptual understanding. However, practical operationalization of OH principles remained limited. Coordination between sectors was described as ad hoc and reactive, often activated only during outbreaks. Formalized OH structures existed at national level but lacked consistent funding and operational functionality. Surveillance systems for human health were relatively stronger compared to animal and environmental sectors. Cross-sectoral data sharing was inconsistent, and joint outbreak investigations were rarely conducted, despite their necessity for zoonotic diseases. Laboratory capacity showed gradual improvement through partner support, but challenges persisted, including inadequate equipment maintenance, limited molecular diagnostic capacity, and shortages of trained personnel. Qualitative interviews revealed systemic gaps such as weak intersectoral communication, limited budget allocation, and absence of routine multisectoral simulation exercises. Nevertheless, respondents acknowledged positive developments, including improved national policy alignment, establishment of a national One Health platform, and increased multisectoral training activities supported by partners such as World Health Organization (WHO), Food and Agriculture Organization of United nation (FAO), and Africa Center for Diseases Control and Prevention (Africa CDC).

Discussion

The findings highlight that although the One Health concept is widely recognized in South Sudan's public health discourse, its operational integration into emergency preparedness and response remains insufficient. The moderate awareness observed among stakeholders aligns with regional trends, where One Health is conceptually supported but constrained by structural and resource limitations.

Weaknesses in coordination mirror previous Joint External Evaluation (JEE) and National Action Plan for Health Security (NAPHS) evaluations, indicating that multisectoral coordination and collaboration remains reactive rather than proactive and institutionalized. The inconsistent participation of animal health and environmental actors during surveillance and response activities undermines efforts to control zoonotic threats. Laboratory challenges further limit the country's capacity to detect and respond rapidly to emerging and re-emerging diseases. The relevance of One Health in emergency preparedness and response is evident in its ability to promote multisectoral coordination, early warning systems, and rapid response mechanisms. This research demonstrated several key ways in which the One Health approach enhances preparedness and response. The new proposed coordination framework between human, animal, and environmental sectors is presented in [**Figure 2]**. Early Detection of Zoonotic Outbreaks; In areas where One Health structures exist, there was earlier detection of outbreaks due to shared information between veterinary and public health sectors. This was particularly evident in Rabies surveillance and recent Anthrax outbreaks, where animal health alerts enabled human health systems to prepare or respond promptly [21]. Joint Risk Assessment and Planning; The existence of multisectoral One Health multisectoral Coordination Mechanism (OH MCM) platforms allowed for more comprehensive risk assessments, which led to more context-specific and integrated emergency preparedness and response plans [32]. However, in many regions, this practice is not institutionalized, making preparedness reactive rather than proactive. Resource Sharing and Coordination; One Health

facilitates resource pooling across sectors logistics, laboratory services, surveillance teams especially during emergency response. For instance, during recent suspected and confirmed zoonotic outbreaks, coordination among ministries led to more effective deployment of One Health multisectoral Rapid Response teams. Risk, crisis communication and Community Engagement: The approach fosters trust and better communication with communities, especially in rural and pastoralist settings where animals are integral to livelihoods. Community-based surveillance systems that engage both human and animal health workers have shown to be effective early-warning mechanisms. The analysis of response core capacities in One Health sectors is shown in **[figure 4].** However, the presence of foundational structures such as the national One Health platform and Public Health Emergency Operation Centre (PHEOC) suggests significant opportunities. Strategic investment in joint surveillance, simulation exercises, integrated training, and resource mobilization could substantially improve South Sudan's health security architecture.

Conclusion

1. Emergency Preparedness is Inadequate and Fragmented: The overall assessment revealed that while individual institutions within the human, animal, and environmental sectors have made efforts toward emergency preparedness, the lack of coordination significantly undermines effectiveness. Preparedness remains fragmented, with limited multisectoral planning and joint simulations.
2. Emergency Response is often Delayed and Sector-Specific: The study found that response actions are often delayed beyond the critical 48-hour window, particularly for zoonotic and environmental emergencies. This delay is exacerbated by the absence of coordinated rapid response teams, interoperable systems, and joint contingency plans.
3. One Health Coordination Mechanisms Exist but Are Weakly Operationalized: The presence of a national One Health platform is a positive development; however, its activities are poorly institutionalized, underfunded, and inadequately communicated to operational stakeholders. Engagement across sectors is uneven, and collaboration is mostly reactive rather than strategic.
4. Laboratory and Surveillance Capacities are Underdeveloped: While some functional surveillance systems exist in human health, the integration with animal and environmental sectors is limited. Laboratory infrastructure is weak, with insufficient equipment, human resources, and joint protocols for testing and reporting zoonotic diseases.
5. Risk, crisis communication and Community Engagement (RCCE) is Minimal: A major gap identified is the minimal involvement of communities in preparedness and response. The absence of risk communication, early warning dissemination, and involvement of local leaders limits the ability to detect and respond to threats early.

Recommendations

This study assessed the application of the One Health approach in emergency preparedness and response in Juba, South Sudan, revealing both progress and persistent gaps within the multisectoral health security system. While awareness of the One Health concept among stakeholders was moderate [Table 3], its operationalization remained limited and largely reactive, particularly during outbreak events. Coordination between human, animal, and environmental health sectors lacked formalized structures, consistent engagement, and predictable financing, undermining effective joint planning and response. Surveillance and laboratory

capacities showed notable improvements through partner support; however, these gains were uneven across sectors, with veterinary and environmental systems remaining significantly under-resourced.

Despite these challenges, the presence of national frameworks such as the One Health Strategic Plan, NAPHS, and the PHEOC offers an important foundation for strengthening integrated preparedness. Enhancing collaboration, institutionalizing multisectoral platforms, investing in diagnostic capacity, and promoting joint simulation exercises are critical steps for advancing a functional One Health ecosystem. The findings underscore the need for sustained political commitment, resource mobilization, and capacity building across all sectors. A fully integrated One Health approach will significantly improve South Sudan's ability to prevent, detect, and respond to public health threats, thereby contributing to national resilience and global health security.

1. Strengthen One Health Governance, leadership and Institutional Frameworks
    - Develop a national One Health policy with legal and operational frameworks.
    - Establishment of One Health act, with the aim of making one health as semi-autonomous institution also known as One Health commission.
    - Develop one health strategic plan to guide the full operationalization of OH approach in 10 states and 3 administrative areas.
    - Establishment and formulization of One Health Multisectoral Coordination Mechanism launching of One Health Multisectoral Coordination Mechanism (OH MCM) at national and subnational level (10 state and three administrative areas) with clear governance structure and terms of reference.
    - Institutionalize the One Health Multisectoral Coordination Mechanism within key ministries, with defined roles and responsibilities.
    - Allocate domestic resources to support routine activities of the One Health platform such training, simulation exercises, joint deployment and outbreak investigations etc.
2. Establish or strengthen One Health Multisectoral Coordination Mechanism (OH MCM) and One Health secretariat
    - Finalize the establishment of Health security, Surge Capacity development and One Health to support fully functionality of OH approach at all levels.
    - Finalize the establishment of One Health secretariat to coordinate One Health activities across the country.
    - Establish the South Sudan One Health HQs office with the Ministry of Health to support secretariat work at all level.
    - Procurement of emergency deployment vehicles and logistic to support rapid joint deployment and coordination across sectors at all level.
    - Conduct regular training, capacity building and supportive supervision for effective functionality of OH MCM at all levels.
    - Finalize the rollout of one health multisectoral coordination mechanism (OH MCM) to the remaining states.

Table 3. % of One Health Multisectoral Coordination Mechanism Stakeholders' Engagement

Sector	**Regular Engagement (%)**
Human Health	52%
Animal Health	41%
Environmental	28%

Wildlife	16%
Water resources and irrigation	13%
Agriculture and food security	12%
National bureau of standard	09%
Juba city council	07%
Academia	05%

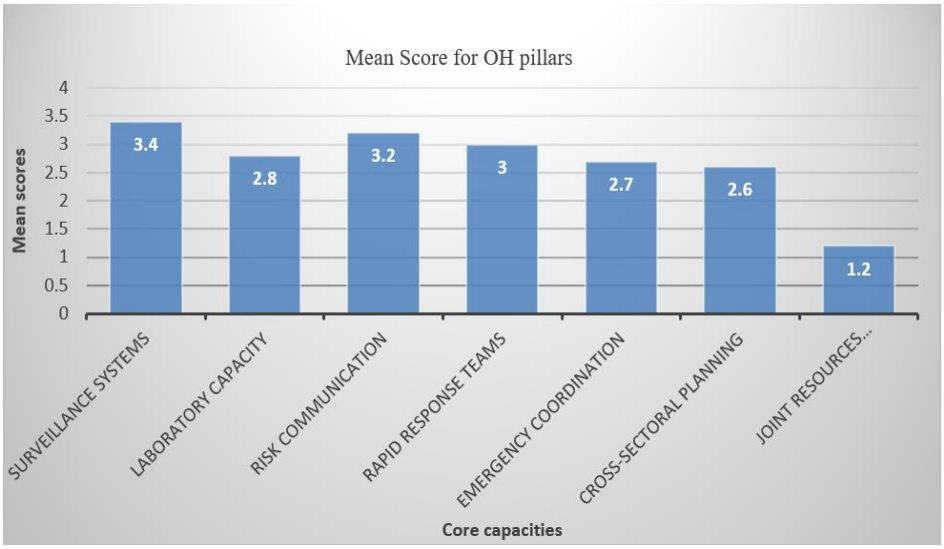

Figure 4. Analysis of Response Core Capacities in One Health Sectors.

Figure 4 shows one health thematic areas (pillars) capacities in sectors by author 2025.

Conflict of Interest

The author declares that there is no conflict of interest associated with the conduct, analysis, or publication of this study. No financial, personal, or institutional relationships influenced the research process or the interpretation of the findings.

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Author Contribution Statement

The author conceptualized the study, designed the methodology, and conducted the data collection and analysis. The author drafted the manuscript, revised all sections critically for important intellectual content, and approved the final version for submission. The author agrees to be accountable for all aspects of the work, ensuring that any questions related to the accuracy or integrity of the study are appropriately investigated and resolved.

Future Research

This study, titled assessment of Emergency Preparedness and Response Using One Health Approach in Juba, South Sudan has equipped principal investigator with broad knowledge of the dynamic and challenges faced by the public health emergency preparedness and response using one health approach in Juba, South Sudan and also identify the research gabs in the area as follow: There is need for father detailed research and study, to evaluate protection aspect to gain an understanding of the political context of the crisis, including who gains and losses from the conflict, and how this impacts on Public health activate delivery in Humanitarian setting.

Data Availability Statement

The data supporting the findings of this study, *Assessment of Emergency Preparedness and Response Using One Health Approach in Juba, South Sudan*, are available from the corresponding author upon reasonable request. The datasets include survey responses, key informant interview records, and document review materials collected during the study period. Due to ethical considerations, confidentiality agreements, and institutional restrictions, the raw data are not publicly available to protect the privacy of participants and the sensitive nature of emergency preparedness information.

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