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ORIGINAL

Advancing One Health by Integrating Veterinary and Human Vaccines to Address Global Health Challenges

Impulsar una sola salud mediante la integración de vacunas veterinarias y humanas para abordar los desafíos de salud mundial

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ABSTRACT

The increasing frequency of zoonotic outbreaks calls for stronger integration between human and animal health sectors under the One Health framework. Veterinary vaccinology plays an important role in pandemic preparedness and control, demonstrated by how immunization strategies targeting animals—such as dog vaccination for rabies or livestock vaccination for Rift Valley fever—have directly reduced human disease burden. Moreover, veterinary medicine has served as a platform for vaccine innovation, contributing technologies like viral vectors, oil-based adjuvants, and thermostable formulations now applied in human vaccines. Transboundary animal diseases, even when not directly zoonotic, pose risks through ecological disruption and human-animal interface, impacting the economy and reinforcing the need for coordinated surveillance and immunization strategies. Collaborative efforts that bring together veterinary and human health sectors can strengthen disease control, improve research outcomes, and promote fairness in resource-limited environments. Greater medical engagement in One Health is essential to prevent future epidemics and safeguard public health globally.

KEYWORDS

One Health; Innovation; Vaccines; Surveillance.

RESUMEN

La creciente frecuencia de brotes zoonóticos exige una mayor integración entre los sectores de la salud humana y animal en el marco de Una Salud. La vacunología veterinaria desempeña un papel importante en la preparación y el control de pandemias, como lo demuestra la reducción directa de la carga de morbilidad humana por parte de las estrategias de inmunización dirigidas a animales, como la vacunación canina contra la rabia o la vacunación del ganado contra la fiebre del Valle del Rift. Además, la medicina veterinaria ha servido como plataforma para la innovación en vacunas, aportando tecnologías como vectores virales, adyuvantes oleosos y formulaciones termoestables que ahora se aplican en vacunas humanas. Las enfermedades animales transfronterizas, incluso cuando no son directamente zoonóticas, plantean riesgos debido a la perturbación ecológica y la interacción entre humanos y animales, lo que impacta la economía y refuerza la necesidad de estrategias coordinadas de vigilancia e inmunización. Los esfuerzos de colaboración que unen a los sectores veterinario y de la salud humana pueden fortalecer el control de enfermedades, mejorar los resultados de la investigación y promover la equidad en entornos con recursos limitados. Una mayor participación médica en Una Salud es esencial para prevenir futuras epidemias y salvaguardar la salud pública a nivel mundial.

PALABRAS CLAVE

Una Salud; Innovación; Vacunas; Vigilancia.

INTRODUCTION

The rising incidence of zoonotic and transboundary diseases over the past decades has underscored the biological and ecological interconnectedness that links human health to animal populations and the environments we share. Nearly 60 % of known human infectious diseases are zoonotic in origin, and over 70 % of emerging pathogens in humans originate from animals—many of them wildlife.[1,2] These statistics are not merely epidemiological observations; they point to structural weaknesses in our current health systems, which have traditionally operated in disciplinary silos.

The One Health paradigm represents a transdisciplinary, multisectoral framework that systematically addresses the interconnectivity of human, animal, and environmental health (figure 1). It is predicated on the recognition that the majority of emerging and re-emerging infectious diseases are zoonotic in origin, necessitating coordinated surveillance, research, and intervention strategies across traditionally segregated domains.[1,3]

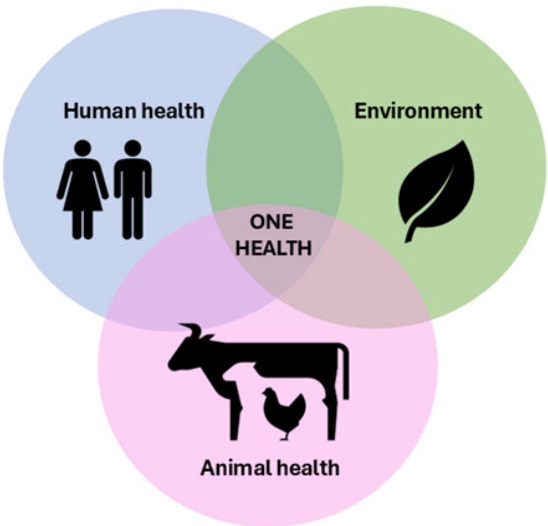

Figure 1. Diagram illustrating the three core domains encompassed by the One Health framework: human, environmental, and animal health

The One Health perspective advocates for a comprehensive approach to addressing challenges within each domain by considering the complex interconnections among them.

Fundamental to the One Health approach are the prevention and control of zoonoses, the containment of antimicrobial resistance (AMR) through integrated stewardship programs, the assurance of food safety via biosecure agricultural systems, and the conservation of ecosystems as determinants of health.[4,5] The One Health approach has gained recognition as a practical and strategic framework to address fragmented health systems. It encourages coordinated actions among professionals in human medicine, veterinary science, and environmental health, aiming to prevent and manage disease risks that arise where people, animals, and ecosystems interact. This paradigm is increasingly recognized as critical for addressing complex global health challenges exacerbated by anthropogenic pressures such as land-use change, biodiversity loss, and climate variability.[6,7]

Veterinary medicine has a long-standing role not only in protecting animal health and productivity, but also in safeguarding human health. Effective control of zoonotic diseases often begins with interventions in animal populations. Rabies, for instance, has been nearly eliminated in many parts of Latin America through mass vaccination of dogs, directly reducing the burden of disease in humans.[8] Similarly, Rift Valley fever (RVF) and brucellosis control strategies have relied on timely livestock vaccination to interrupt transmission to human populations.[9,10] Beyond zoonoses, veterinary science has historically served as a testbed for technologies that later enter human medicine. Innovations such as oil-based adjuvants, thermostable formulations, mucosal delivery systems, and viral-vectored platforms were first validated in animals under field conditions before being adapted for human use. This translational value is particularly relevant when considering vaccine strategies for neglected diseases, pandemic preparedness, and deployment in low-resource settings.

Environmental change—deforestation, climate variability, urbanization, and biodiversity loss—has further intensified interactions between wildlife, domestic animals, and humans, reshaping the dynamics of disease emergence and transmission.[11] These ecological pressures influence not only pathogen spillover but also vector ecology, immunological stress, and vaccine efficacy.[12] As such, any sustainable disease prevention strategy must incorporate environmental stewardship as a core component. One Health encourages early warning systems that integrate animal and environmental surveillance with human health data, enabling earlier detection and response. For medical professionals, this means acknowledging that clinical outcomes and public health interventions are increasingly dependent on upstream factors such as animal disease management and ecosystem integrity. In this context, vaccine development becomes a shared responsibility across sectors—one that demands cross-disciplinary research platforms, harmonized regulatory pathways, and equitable access strategies to ensure global health security.

The growing frequency and impact of zoonotic and transboundary diseases underscore the need for integrated approaches that bridge the traditional boundaries between human and veterinary medicine. Recognizing the interconnectedness of human, animal, and environmental health, the One Health approach has become increasingly important in the field of vaccinology. Transboundary and zoonotic diseases such as rabies, avian influenza, Rift Valley fever, and foot-and-mouth disease (FMD) exemplify how interrelated health threats can affect public health, food security, and global economies. In this context, aligning veterinary and human vaccine development is not only desirable but essential.

Bridging Species to Control Disease

Zoonotic diseases represent over 60 % of all emerging infectious diseases, underscoring the necessity of animal-targeted interventions as a frontline defense for human health.[3,6] Control measures in animal populations often preempt human cases by interrupting transmission at the source. For instance, Latin America's integrated rabies control program, which combines mass canine vaccination with enhanced surveillance, has led to a >95 % reduction in human rabies cases since the 1980s.[8] This success highlights the cost-effectiveness and public health impact of sustained animal vaccination strategies.

Similar approaches have proven successful against RVF in sub-Saharan Africa. In endemic areas, prophylactic immunization of livestock significantly reduces the risk of viral amplification during periods of increased vector activity, thereby preventing spillover into human populations.[13,14] The strategic deployment of veterinary vaccines during high-risk periods, informed by ecological and climatic data, is a cornerstone of outbreak prevention.

More broadly, coordinated One Health vaccination strategies—incorporating livestock, wildlife reservoirs, and, when appropriate, human populations—are essential to control complex multi-host pathogens such as brucellosis, anthrax, and leptospirosis.[15,16] As environmental changes intensify pathogen circulation at the human–animal–ecosystem interface, the alignment of veterinary and human immunization campaigns becomes not only pragmatic but necessary for sustained disease control.

Veterinary Vaccines as Innovation Platforms

Veterinary vaccinology has long been a foundation for technological advancement in human vaccine development. The veterinary sector often serves as an early-stage testing environment for new antigen delivery systems, adjuvants, and formulations due to its faster regulatory pathways and ability to test interventions in natural hosts under field conditions.[17,18]

Adjuvants (Table 1) such as water-in-oil emulsions (e.g., Montanide™) and saponin-based systems (e.g., Quil A and Matrix-M™) were first developed and licensed for use in livestock vaccines, demonstrating strong immune potentiation and thermostability in challenging environments. Matrix-M™, a nanoparticle adjuvant derived from saponins, is now a key component of Novavax's SARS-CoV-2 vaccine approved for human use.[19,20] Similarly, CpG oligonucleotides, TLR agonists, and polymer-based delivery platforms were initially evaluated in veterinary species, particularly in swine and poultry, before being adapted for human vaccines and cancer immunotherapies.

Veterinary mass vaccination campaigns have pioneered alternative delivery systems such as oral vaccines, mucosal routes, edible formulations, and needle-free injectors that reduce stress in animals and improve compliance. These platforms are now being explored for human vaccination to overcome needle phobia, increase coverage, and enhance immune responses. Thermostable formulations and cold-chain-independent technologies, already in use

for livestock vaccines, offer valuable solutions for remote or underserved human populations.
The challenges of vaccine hesitancy, rapid deployment, and infrastructure limitations are shared across both sectors. Integrating lessons learned from veterinary applications can inform the development of more efficient and accessible human vaccines. Tables summarizing current adjuvants and delivery systems in use across species further illustrate this convergence and the potential for broader application.(21)

Focusing on Transboundary Threats

Diseases that cross national borders, including foot-and-mouth disease (FMD), African swine fever (ASF), and peste des petits ruminants (PPR), pose serious threats to global food security, trade, and in some cases, public health. Although not all of these transboundary animal diseases (TADs) are zoonotic, effective control measures are essential to limit pathogen evolution and reduce the risk of transmission between species. For example, the ecology of ASF and FMD includes sylvatic cycles involving wildlife reservoirs that complicate control strategies and increase the potential for viral adaptation.(22,23) Under conditions of ecological stress and increased anthropogenic interface, such cycles may accelerate the emergence of novel pathogens with zoonotic potential.(24)
Veterinary vaccination plays a dual role in controlling endemic circulation and reducing the risk of interspecies transmission. In regions with dense livestock populations and high levels of human–animal contact, such as Southeast Asia or the Sahel region, immunization programs targeting domestic species act as immunological firewalls, limiting pathogen amplification and environmental contamination.(25) This is particularly relevant in the context of One Health surveillance systems, which aim to integrate early warning indicators across species. The strategic deployment of vaccines against TADs can therefore serve both agricultural and public health objectives, especially when integrated into cross-sectoral disease preparedness plans.
Additionally, climate change, land-use conversion, and intensified livestock production are expanding the geographic range of several vector-borne TADs, increasing the probability of new zoonotic interfaces. Coordinated international responses—including antigen banks, regional vaccination campaigns, and risk-based deployment strategies—are essential to preempt the emergence or re-emergence of high-impact zoonoses.(26,27)

Building Cross-Sectoral Collaboration

Effective vaccine development and deployment at the human–animal–environment interface requires institutional mechanisms that support collaboration across disciplines and sectors. Initiatives such as the Global Foot-and-Mouth Disease Research Alliance (GFRA) and the International Veterinary Vaccinology Network (IVVN) exemplify how international platforms can catalyze cooperation between veterinary and medical researchers, regulatory bodies, and national health authorities https://www.intvetvaccnet.co.uk/ . These networks foster innovation by supporting joint research programs, facilitating technology transfer, and building laboratory capacity in low- and middle-income countries.
One of the critical roles of such platforms is to promote the use of veterinary models for preclinical evaluation of new vaccine technologies, particularly for pathogens with shared antigenic targets across species. Veterinary species offer valuable insight into mucosal immunity, maternal antibody interference, and population-scale vaccine efficacy under field conditions—scenarios that often precede human clinical trials.(17) In addition, harmonized regulatory frameworks—such as those promoted by the World Organization for Animal Health (WOAH) and the European Medicines Agency—can accelerate the licensing of platforms applicable to both veterinary and human vaccines, including vector-based technologies and thermostable formulations.(20,29)
Collaborative surveillance systems that integrate animal health data with environmental and human health indicators can also enhance early detection and control of zoonotic outbreaks. Joint simulation exercises, vaccine target product profile (TPP) alignment, and data-sharing protocols contribute to better pandemic preparedness and mutual reinforcement of public and animal health infrastructure.(30,31)

CONCLUSIONS

Animals must be recognized not only as potential reservoirs of disease but also as key partners in disease prevention. Veterinary vaccination strategies have repeatedly demonstrated their capacity to reduce the burden of zoonoses and prevent human infection, as evidenced by the control of rabies and Rift Valley fever. Moreover, veterinary vaccinology has long served as an innovation platform for human vaccine development, with adjuvants, delivery systems, and thermostable formulations often being pioneered in animal health before translation to human medicine.
In an era marked by ecological disruption, emerging infectious diseases, and antimicrobial resistance, siloed approaches to health are no longer sustainable. The One Health approach provides a holistic and coordinated strategy for tackling complex health challenges that arise where human, animal, and environmental systems intersect. Strengthening collaboration across disciplines—through joint surveillance systems, harmonized

regulatory pathways, and shared research infrastructures—can enhance preparedness and promote equity, particularly in resource-limited settings.
Medical professionals have a critical role to play in embracing and advancing One Health. By engaging in veterinary science and environmental health, the medical community can help shape more effective, forward-looking strategies to prevent future pandemics and protect global public health.

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ANNEXES

Table 1. Adjuvants used in vaccines

Adjuvant	Type of Vaccine	Species	Examples (Vaccine / Manufacturer)
Alum (aluminium salts)	Inactivated, protein subunit	Humans, cattle, poultry, swine	Hepatitis B (Engerix-B) FMD vaccines (multiple manufacturers)
MF59 (squalene oil-in-water emulsion)	Inactivated, subunit	Humans (licensed), poultry (experimental)	Human influenza (Fluad, Seqirus) Eimeria vaccines (R&D)
AS03 (squalene + α-tocopherol)	Pandemic influenza, protein subunit	Humans	H1N1 pandemic (Pandemrix, GSK)
Montanide ISA series (oil-based emulsions)	Inactivated, recombinant protein	Cattle, swine, poultry, fish	FMD vaccines (Seppic) ISA 206, ISA 61 (veterinary)
Poly I:C (TLR3 agonist)	Viral vectored, DNA	Cattle, swine (experimental)	PRRSV and FMD vaccines (experimental)
CpG ODN (TLR9 agonist)	DNA, subunit	Humans (licensed), poultry, pigs (experimental)	Heplisav-B (Hep BD, Dynavax) CpG 1018 (human) Swine influenza (R&D)
Quil A / Saponin / ISCOMs	Protein subunit, recombinant	Cattle, horses, poultry, humans (QS-21)	Equilis Prequenza (horses) COVID-19 vaccine (Matrix-M, Novavax)
Emulsigen	Inactivated, recombinant	Swine, poultry, cattle	PRRS Mycoplasma vaccines (veterinary)
Advax (delta inulin)	Inactivated, protein subunit	Humans (clinical trials), swine (experimental)	COVID-19 (Covax-19) veterinary vaccines (R&D)
GEL-based adjuvants (Carbopol, Pluronic F127)	Protein subunit, DNA	Swine, poultry, cattle	FMDV, PRRSV (experimental vaccines)
Nanoparticles (chitosan, liposomes)	Subunit, DNA, mRNA	Fish, poultry, cattle, humans (mRNA)	Comirnaty (Pfizer-BioNTechmRNA)Veterinary (R&D)

Table 2. Alternative vaccine administration systems

Administration System	Type of Vaccine	Species	Examples (Vaccine / Manufacturer)
Needle-free jet injectors	Inactivated, DNA, mRNA	Humans, swine, cattle	FMDV DNA vaccine Influenza, COVID-19 (PharmaJet andnZyCoV-D, Zydus Lifesciences)
Transdermal patches (microneedles)	DNA, mRNA, protein subunit	Humans, swine (experimental)	Human flu (Vaxxas) Infectious diseases (Verndari´s platform, microneedle patch)
Oral vaccines (tablets, gels, liquids)	Live attenuated, recombinant, subunit	Humans, poultry, fish, wild animals	Oral COVID-19 pill (Vaxart) RABORAL V-RG (Boerhringer Ingelheim) Fish diseases (AquaVac, MSD)
Intranasal sprays/drops	Live attenuated, viral-vectored	Humans, poultry, pigs, dogs, cats	Influenza (FluMist, MedImmune Vaccines) IntraNasal PRRSV (experimental) Canine distemper (nasal drops)
Aerosolized vaccines (nebulization)	Live attenuated, vectored	Poultry, pigs, cattle, humans	Newcastle vaccine in poultry BRSV vaccine in cattle RSV human (trials)
Ocular (eye drop)	Live attenuated	Poultry	Newcastle disease vaccines (Asia, Africa, Latin America)
Immersion/bath vaccination	Inactivated, subunit, DNA	Fish (salmon, tilapia)	AquaVac™ IridoV, ERM (MSD) Alphaject® (Zoetis)
In ovo vaccination	Live attenuated, recombinant	Poultry (embryos)	Marek's, Gumboro, NDV vaccines Inovoject® (Zoetis)

Implants or biodegradable pellets	Subunit, recombinant	Cattle, swine (experimental)	GnRH vaccine implants Extended-release antigen (R&D)
Topical (scarification/reams)	Viral-vectored, recombinant	Humans (rare)	Smallpox, scarification (Dryvax) Skin DNA vaccines (experimental)