synbiotics, biofilm-based vaccines, bacteriophage therapy, quorum sensing inhibition, RNA interference, and DNA/physicochemical biosensors, have shown great potential as alternatives to traditional chemical treatments. These innovations can maintain productivity while minimizing the risk of antimicrobial resistance. In addition, immunostimulants and antiviral compounds derived from plants, animals, and synthetic sources, when combined with strict disinfection measures, can effectively and safely enhance innate immunity in shrimp, particularly for the control of WSSV. Epigenetic regulation and “trained immunity” represent promising research frontiers, offering the potential to achieve heritable or long-term disease resistance through modulation of immune gene expression. Furthermore, microbiome-based engineering strategies, such as customized probiotics, synthetic microbial consortia, and fecal microbiota transplantation, are expected to become key components of future disease control, although their ecological adaptability, safety, and resilience to climate change require further investigation.

With the rapid development of the Internet of Things (IoT), artificial intelligence (AI), and their integration (AIoT), shrimp health management is increasingly shifting toward precision aquaculture. Sensor- and microcontroller-based monitoring systems can now provide real-time measurements of key water quality parameters, including temperature, pH, salinity, turbidity, total dissolved solids (TDS), and electrical conductivity. These systems enable remote management, anomaly detection, and automated regulation (e.g., aeration and chemical dosing) through cloud platforms and mobile applications. Machine learning models, including regression and classification algorithms, have been successfully applied to predict water quality changes and evaluate production performance with high accuracy, allowing early intervention to reduce mortality and optimize yields. Studies indicate that the integration of AIoT with precision aquaculture enables intelligent decision-making in feed management, disease monitoring, biomass estimation, and environmental regulation through the combination of sensor data, AI analytics, and remote sensing technologies. However, high investment costs, data privacy concerns, and limitations in model generalization remain key challenges. Additionally, emerging “smart dosing systems” can automatically apply probiotics and water quality regulators based on microbial and environmental data, effectively reducing organic load and pathogen levels in biofloc systems while lowering labor costs and improving sustainability.

Overall, existing studies suggest that future shrimp disease control will evolve toward comprehensive systems centered on biosecurity, integrating host, pathogen, environmental, and management factors. Sustainable shrimp aquaculture will depend on high-level biosecure facilities, the use of SPF seedstock and genetically improved disease-resistant strains, and the implementation of efficient pathogen monitoring systems and rapid diagnostic technologies, such as high-throughput sequencing, CRISPR-based detection, and culture-independent biosensors. Current research emphasizes the need to establish dynamic, risk-based management frameworks that integrate physical, biological, and operational biosecurity measures with emerging technologies and multi-stakeholder collaboration. Key future research directions include microbiome-based disease regulation, genetic and epigenetic improvement of disease resistance, detection technologies for emerging pathogens, and the development of climate-resilient aquaculture systems, such as IMTA, RAS, and hybrid models. The integration of green control technologies, precision monitoring, genetic breeding, epigenetic regulation, and comprehensive biosecurity systems will facilitate the transition of shrimp aquaculture from traditional “reactive treatment” to a “prevention-oriented and system-regulated” health management model, thereby ensuring long-term sustainability and contributing to global food security.

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Conflict of Interest Disclosure

The author affirms that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.