5th African International Conference on Industrial Engineering and Operations Management, Johannesburg/Pretoria, South Africa, April 23 - 25, 2024
Publisher: IEOM Society International, USA
Published: April 23, 2024 DOI: 10.46254/AF05.20240213

Literature Review on Airborne Pathogen Detection Systems at Airports

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Abstract

In recent years, the emergence of airborne pathogens has posed significant challenges to public health, especially in high-traffic environments like airports. Early detection of these pathogens is crucial for effective containment and prevention of outbreaks. This literature review examines the current state of airborne pathogen detection systems deployed in airports. Through an analysis of methodologies, technologies, challenges, and advancements, this review aims to contribute to a deeper understanding of the efficacy and limitations of existing systems, as well as to identify areas for further research and development. The observation came about after the world was affected by covid 19 and the cholera outbreak affecting Zambia. The traditional methods, often lab-based and time-consuming, hinder swift responses. Real-time airborne disease detection technologies offer a game-changer, promising rapid on-site results. This review dives into the cutting-edge of real-time detection, exploring diverse technologies and their potential applications. The researcher discusses the challenges and opportunities associated with these advancements, paving the way for future research and development. The system will be monitored in real time taking advantage of emerging technologies such as Artificial Intelligence, Cloud Computing. The results will be noted and analysed giving outputs that will be used to act or ignore. The conclusions, recommendations will be made, and indications of where the system needs improvement for future engineering and technical developments.

Keywords
Disease Detection, Pathogens, Diagnostics, Biosensors, Airports

1. Introduction

The rapid spread of airborne pathogens, including viruses and bacteria, presents a constant threat to global public health, with airports serving as potential hotspots for transmission due to the high volume of travelers passing through these facilities. Detecting and monitoring airborne pathogens in airport environments is essential for early intervention and containment of infectious diseases. In this literature review, the researcher is going to explore the landscape of airborne pathogen detection systems in airports, focusing on the methodologies, technologies, challenges, and advancements in this critical field. By synthesizing existing research and empirical evidence, this review aims to provide insights into the current state of airborne pathogen detection in airports and to outline future directions for research and innovation. Technological innovation has resulted in the emergence of various new concepts such as cyber-physical systems (CPSs), the Internet of Things (IoT), artificial intelligence (AI), big data, and cloud computing. These new technologies have cleared the path for new inventive opportunities and greater socioeconomic development. The driving force was intensified competition by leading health monitoring systems like in the first world countries, which can help in preparedness in the health industry for standards around the world. The research aims to reduce human errors and thus improve the time a person can be helped before they succumb to the disease. Safety and mitigation in the health sector cannot be overstated because they are critical and mandatory requirements. Airborne disease pathogen detection is critical for any country to prevent and minimize an outbreak or pandemic, which are the main causes of death. Aside from death which can be caused if detection of air pathogens is not done, economic meltdown and terror which also have a significant impact on the country's financial benefits can also result. Zimbabwe's health sector has a nightmare of disease mitigation due to shortage of advanced technologies throughout the entire system. This results in most mitigation activities becoming an independent function rather than process sub-function due to lack of reference. For a long period of time, operations, safety and security of health in Zimbabwe have been affected by lack of exerting measures on entry points, thereby making grave mistakes on how to stop a disease before it spreads. The inherent development in technology together with the industrial sectors, disease mitigation should be flexible and easy to adapt to the new pathogens found everyday in the air present. For such proactive world-class airborne pathogen detector system to be achieved there is need for computer-based support.

1.1Objective

The objective of the study is to review airborne pathogen detector systems for airport entry points.

1.2 Background

Airports serve as critical Points in the worldwide transportation grid, facilitating the movement of the day, millions of passengers and goods traverse international borders. (Smith et al., 2020; Jones et al., 2018). Yet, the dense population and continuous flow of travelers render airports vulnerable to the transmission of infectious diseases, including respiratory viruses. (Smith et al., 2020). The significance of efficient disease surveillance and containment measures within airport settings has been highlighted by outbreaks of respiratory illnesses like influenza and COVID-19. Conventional approaches to airport disease surveillance have predominantly centered on assessing passengers for symptoms and potential risk factors upon their arrival. Nevertheless, such measures might overlook asymptomatic carriers or individuals in the initial stages of infection, potentially creating gaps in detection and containment strategies. Additionally, relying solely on symptom-based screening may prove inadequate for detecting airborne pathogens transmitted through respiratory droplets or aerosols. To address these challenges, there's a growing interest in developing and integrating airborne pathogen detection systems within airports. These systems are designed to continuously monitor air quality within airport terminals and promptly identify the presence of respiratory viruses or other infectious agents in real-time. By offering early alerts regarding potential health risks, airborne pathogen detection systems empower airports and public health authorities to implement timely interventions, thus curbing the spread of infectious diseases. Studies conducted by researchers such as Smith et al. and Jones et al. contribute significantly to this emerging field by assessing various airborne pathogen detection technologies in airport settings. Smith et al.'s longitudinal investigation sheds light on the distribution of respiratory viruses within airport terminals, identifying areas with high passenger traffic as potential transmission hotspots. Conversely, Jones et al.'s study concentrates on evaluating a novel bioaerosol sampler tailored for detecting influenza viruses, demonstrating its efficacy in capturing viral particles with high sensitivity and specificity. The collective findings from these studies emphasize the critical role of airborne pathogen detection systems in bolstering the surveillance and containment of infectious diseases within airport environments. By gaining a deeper understanding of the distribution and dynamics of airborne pathogens within airports, stakeholders can devise targeted strategies to mitigate transmission risks and safeguard the health and well-being of passengers and airport personnel (Figure 1).

Figure 1. Travelers file into the north security complex in the main terminal at Denver International Airport Thursday morning, Dec. 22, 2022.*Hart Van Denburg/CPR News*

2. Methodology

For this literature review, an exhaustive search was carried out across multiple academic databases, including PubMed, IEEE Xplore, ScienceDirect, and Google Scholar. Keywords like "airborne pathogen detection," "airport," "bioaerosol monitoring," and "airborne disease surveillance" were employed to pinpoint pertinent studies published in the past ten years. Peer-reviewed articles, conference papers, and reports were selected based on their relevance to airborne pathogen detection systems within airport environments, methodological soundness, and their contribution to advancing knowledge in this domain.

3. Literature Review

Detection of airborne pathogens in airport environments is a multifaceted challenge owing to various factors, including the intricate dynamics of airflows, the diverse array of potential sources of contamination, and the imperative for rapid and dependable detection methodologies. Traditional approaches to pathogen detection, such as culture-based methods and polymerase chain reaction (PCR) assays, though commonly utilized, exhibit notable limitations in terms of sensitivity, specificity, and real-time monitoring capabilities (Hassan et al., 2019).Culture-based methods, which involve isolating and cultivating pathogens from environmental samples, are time-consuming and labor-intensive. Additionally, they may fail to detect viable but non-culturable microorganisms or those with slow growth rates, leading to false negatives and underestimation of pathogen prevalence (Smith et al., 2020). PCR assays, while highly sensitive and specific, require specialized laboratory equipment and trained personnel, making them less suitable for on-site detection in airport environments (Jones et al., 2018).Moreover, the dynamic nature of airflows within airport terminals presents challenges for effective pathogen detection. Airflows can vary significantly depending on factors such as ventilation systems, passenger movements, and outdoor environmental conditions, leading to complex dispersion patterns of airborne contaminants (Wang et al., 2021). This variability makes it difficult to predict the spatial distribution of pathogens within the airport environment and to identify high-risk areas for targeted surveillance and intervention. The diversity of potential sources of contamination further complicates airborne pathogen detection in airports. In addition to human passengers, airports accommodate a wide range of activities and facilities, including retail outlets, food courts, and baggage handling areas, each of which may contribute to the dissemination of airborne pathogens (Li et al., 2019). Contaminants can originate from respiratory secretions, contaminated surfaces, or fomites, making it challenging to distinguish between sources and pathways of transmission. Furthermore, the high throughput of passengers and goods passing through airports presents logistical challenges for implementing comprehensive surveillance systems. The sheer volume of people and cargo moving through airport terminals daily necessitates efficient and scalable detection methods that can accommodate large-scale screening without disrupting normal airport operations (Tang et al., 2020). Traditional surveillance approaches, such as manual sampling and analysis, may be inadequate for monitoring such high traffic volumes and may result in delays in detection and response to potential health threats. Addressing these challenges requires the development of innovative detection technologies and surveillance strategies tailored to the unique requirements of airport environments. Advanced sensor technologies, such as optical particle counters and next-generation sequencing (NGS) platforms, offer promising avenues for real-time monitoring of airborne pathogens with high sensitivity and specificity (Zhang et al., 2021). Integration of sensor networks with data analytics and machine learning algorithms can enable predictive modeling of pathogen transmission dynamics and facilitate early warning systems for disease outbreaks (Zhou et al., 2020). Furthermore, collaboration among airport authorities, public health agencies, and research institutions is essential for implementing effective surveillance programs and coordinating response efforts. Standardization of protocols and best practices for airborne pathogen detection in airport environments can enhance interoperability and ensure consistency across different jurisdictions and airport facilities (World Health Organization, 2017). By overcoming these challenges, airports can enhance their capacity to detect and mitigate the spread of airborne pathogens, thereby safeguarding public health and safety.

4. Case Studies and Research Findings

4.1 Dubai International Airport

Figure 2. Dubai Airport arrival hall

Upon arrival, passengers pass through thermal camera checkpoints. These cameras capture temperature readings and flag individuals with readings exceeding predetermined thresholds, indicating a potential fever. Passengers flagged by the cameras may be directed to separate screening areas for further identification (Figure 2). Trained personnel then visually assess them for other symptoms like coughing or fatigue. All passengers, regardless of camera readings, must complete health questionnaires**.** Electronic or paper forms are available in multiple languages. Questions about recent travel history, current symptoms, and potential exposure to infectious diseases are to be answered. Trained personnel review completed questionnaires for potential risks. Passengers with concerning answers might be directed for further assessment These forms inquire about recent travel, potential disease exposure, and any present symptoms. Based on the combined information from cameras, visual inspection, and questionnaires, trained health professionals determine the next steps. This could involve further medical assessment If symptoms warrant, passengers may undergo additional tests like rapid diagnostic tests for specific diseases like COVID-19. Individuals confirmed or suspected of having an infectious disease are promptly isolated and medical assistance is provided. Passengers deemed symptom-free and with completed questionnaires are allowed to proceed. The thermal cameras are highly calibrated and constantly monitored for accuracy. Infrared cameras detect minute differences in body temperature, displayed as colored heat maps. Strategic locations like arrival/departure halls, immigration counters, and baggage claim areas. Passengers pass through the camera's field of view. Cameras capture temperature readings and send them for analysis. If a reading exceeds a set threshold (typically around 100.4°F or 38°C), an alert is triggered. Trained medical staff stationed at key points throughout the airport. Staff visually assess passengers for signs of illness, like fever, cough, fatigue, or difficulty breathing. Non-intrusive observation, avoiding physical contact unless necessary. Staff can refer passengers for further medical evaluation based on their observations. Dedicated teams of trained healthcare professionals conduct visual inspections and questionnaire assessments. They are equipped with personal protective equipment to ensure their safety. Data from cameras, questionnaires, and medical assessments is securely stored and analyzed to identify potential outbreaks and inform response measures. This allows for rapid communication and coordination with public health authorities. Regular and thorough disinfection of high-touch surfaces like counters, kiosks, and restrooms. Provision of easily accessible hand sanitizer dispensers and masks for passengers and staff. Enhanced cleaning and disinfection protocols for aircraft after each flight. Comprehensive training for airport staff on recognizing potential symptoms, reporting procedures, and maintaining hygiene protocols.

4.2 Effectiveness & Challenges

Combining various methods increases the chance of detecting potential cases. Thus prompt identification and isolation can help contain outbreaks. Visual inspection and assessment rely on trained personnel, subject to potential human error. Thermal cameras may not detect fevers in individuals taking fever-reducing medications. Individuals without symptoms may still carry and transmit the disease, posing a challenge. DXB works closely with the UAE Ministry of Health and Prevention for disease surveillance and response. Information on suspected cases is shared with relevant authorities for further investigation and containment measures, DXB's disease detection system, while not perfect, represents a comprehensive and proactive approach to safeguarding public health in a globally connected world.

4.3 Singapore Changi Airport (SIN)

Singapore Changi Airport (SIN) stands as a global frontrunner in disease prevention, employing a multi-layered approach that also adds an extra layer of defense, which is rapid influenza diagnostic testing. Changi leverages thermal cameras to scan arriving passengers for elevated temperatures, a potential indicator of infection. Passengers also complete mandatory health questionnaires to gather travel history and symptom information. The Changi AdvantageWhere SIN truly sets itself apart is its on-site rapid diagnostic testing for influenza, a common and potentially serious respiratory illness. This swift testing, with results within minutes, allows for Identifying influenza cases quickly is crucial for isolating individuals and preventing onward transmission within the airport and on flights. Prompt confirmation facilitates appropriate medical care and management of confirmed cases. Changi, prioritizes meticulous disinfection of high-touch surfaces and aircraft cabins. Passenger awareness is also key, with clear signage and announcements promoting hand hygiene, respiratory etiquette, and available health resources. Changi staff receive comprehensive training on identifying potential health risks, reporting procedures, and proper handling of suspected cases. This empowers them to act swiftly and effectively should a situation arise. Passengers arriving at SIN undergo thermal camera screening and complete health questionnaires. Individuals with elevated temperatures or concerning symptoms are directed for further evaluation. Rapid influenza tests are offered to those exhibiting flu-like symptoms. Confirmed or suspected cases are promptly isolated and managed by healthcare personnel. Continuous disinfection and passenger education remain integral to preventive efforts. red approach, combined with the rapid testing advantage, has earned it international acclaim for its effective disease prevention measures. This proactive approach significantly minimizes the risk of disease transmission, solidifying SIN's position as a safe and healthy travel hub. Singapore Changi Airport's disease detection system exemplifies a proactive and comprehensive approach to safeguarding the health of passengers and staff. By incorporating rapid diagnostic testing alongside established methods like thermal screening and questionnaires, Changi demonstrates a commitment to public health that transcends borders, setting a high standard for airports worldwide.

4.4 Abu Dhabi International Airport

The rapid COVID-19 testing system implemented at Abu Dhabi International Airport in 2020 likely involved the use of antigen tests, which are designed to detect specific proteins on the surface of the SARS-CoV-2 virus, the virus that causes COVID-19. The program was launched in partnership with Pure Health and Tamouh Healthcare. All arriving passengers, except those in transit, were mandated to undergo the test, regardless of their nationality or origin. This comprehensive approach aimed to identify potential cases early on, even if asymptomatic. The testing was free of charge, minimizing barriers for travelers. Results were delivered via SMS, WhatsApp, and the Alhosn mobile application, facilitating easy access and quick action. Upon arrival at the airport, passengers are directed to designated testing areas where trained personnel collect samples from the passengers. The most common method for sample collection is through nasal or nasopharyngeal swabs. It was a Real-Time Polymerase Chain Reaction (RT-PCR) test, considered the gold standard for COVID-19 detection at the time. While the original 2020 announcement mentioned 10-minute results, later reports indicated a timeframe of approximately 90 minutes. This is still incredibly fast compared to standard PCR tests that could take several hours. The testing was conducted through a dedicated on-site laboratory within the airport, eliminating the need for external processing and further speeding up the process. The collected samples are then processed using rapid antigen test kits. These kits contain reagents that react with viral proteins present in the sample. The antigen test detects the presence of specific proteins associated with the SARS-CoV-2 virus. The rapid antigen test kits typically utilize lateral flow immunoassay technology. This technology involves applying the collected sample to a test strip, which contains antibodies that bind to the viral proteins if present in the sample. If the virus is detected, it triggers a visible signal, often a coloured line, indicating a positive result. After a brief incubation period, usually around 10-15 minutes, the test results are interpreted based on the appearance of lines or other indicators on the test strip. A positive result indicates the presence of viral antigens in the sample, suggesting an active COVID-19 infection, while a negative result suggests the absence of detectable viral antigens. Passengers receive their test results promptly, typically within minutes of undergoing the test. Depending on the result, passengers may be directed to proceed with their travel plans or be advised to undergo additional testing, quarantine, or medical evaluation as per the airport's protocols and public health guidelines. This rapid testing system enables airports like Abu Dhabi International Airport to quickly screen arriving passengers for COVID-19, helping to identify and isolate infected individuals and mitigate the spread of the virus within the airport and the broader community.

Even seemingly healthy individuals boarding a plane can develop symptoms of SARS mid-flight. This risk is higher for diseases like SARS with short incubation periods. Long-distance flights create a particularly concerning situation. For instance, a passenger who contracted SARS just before boarding could develop symptoms within 10-12 hours on the plane. Once symptomatic, they become contagious and pose a threat to others. Therefore, allowing a potentially infected individual to continue their journey depends on two key factors Longer flights increase the risk of symptom development and potential transmission. Understanding the incubation period (time from infection to symptoms) and contagious period (duration of infectivity) is crucial for assessing the risk. Considering these factors, specific decisions regarding a potential SARS case on board would need to be made based on the individual's symptoms, flight duration, and the latest public health guidelines for managing infectious diseases in air travel settings.

4.5 Zambia International Airport

The Kenneth Kaunda International Airport (KKIA), also known as Zambia International Airport, implements several measures to detect and prevent the spread of infectious diseases Passengers are required to fill out health declaration forms disclosing any potential symptoms or recent travel to high-risk areas. Trained health officials visually screen departing passengers for signs of illness. All arriving passengers undergo thermal screening using infrared cameras. Individuals with elevated temperatures are referred for further assessment. Health officials monitor arriving passengers for any visible signs of illness, such as coughing, sneezing, or difficulty breathing. A designated health facility is available at the airport for passengers requiring medical attention or additional screening. Regular disinfection of high-touch surfaces like doorknobs, handrails, and counters is conducted throughout the airport. Hand sanitizer dispensers are readily available at various locations within the airport. Formation posters and announcements educate passengers about infectious disease prevention practices like handwashing and respiratory etiquette. It's important to note that these measures are not foolproof, and some infectious diseases may not present with immediate symptoms. Additionally, resource constraints can sometimes limit the effectiveness of these systems.The Zambian government is exploring the implementation of more advanced technologies like rapid diagnostic tests and non-invasive pathogen detection systems for improved efficiency and accuracy.

4.6 Robert Gabriel Mugabe International Airport

The Zimbabwe International Airport is one of the busiest airports in Southern Africa, and as such, it is important to have measures in place to detect and prevent the spread of airborne pathogens. The airport has implemented several measures thus all passengers arriving at the airport are screened using thermal cameras. If a passenger has a fever, they will be directed to a healthcare professional for further evaluation. The airport continuously monitors the air quality in its terminals and other facilities. If there is a spike in the levels of airborne pathogens, the airport will take steps to improve air quality, such as increasing ventilation. The airport regularly disinfects its terminals and other facilities using EPA-registered disinfectants. This helps to kill any airborne pathogens that may be present. The airport provides information to passengers about how to prevent the spread of airborne pathogens, such as by washing their hands frequently and wearing a mask. In addition to these measures, the Zimbabwe Civil Aviation Authority (CAAZ) is also working on developing new technologies for airborne pathogen detection. For example, the CAAZ is testing a new system that uses ultraviolet light to kill airborne pathogens.

5. Results

5.1 Effectiveness and Limitations of Existing Technologies

The study has shown that the thermal screening method is widely used by the aviation industry to screen passengers for diseases. Disinfection and questionnaires are also widely methods implemented by airports. Studies evaluating the effectiveness of similar systems in detecting infectious diseases have shown mixed results. While thermal screening can identify individuals with fevers, it cannot definitively diagnose specific diseases. Additionally, factors like environmental temperature and individual variations can influence readings. Studies have shown limitations in accuracy, with a high number of false positives and negatives. Additionally, ethical concerns surround its potential for misidentification, discrimination based on perceived health status, and invasion of privacy The effectiveness of hand hygiene and disinfection practices is well-established in preventing the spread of pathogens when implemented correctly and consistently. However, their reliance on individual compliance and adherence to proper procedures can limit their overall effectiveness in an airport environment with high passenger volume and constant movement. Well-maintained ventilation systems play a crucial role in diluting and removing airborne pathogens. However, their efficacy depends on various factors, including airflow rates, air filtration efficiency, and the specific characteristics of the pathogen. Sensitivity and specificity remain major challenges, often requiring large sample volumes and extensive validation for different pathogens. Additionally, cost-effectiveness for large-scale airport deployment necessitates further research and development. Air Sampling and PCR Analysis offers high accuracy for pathogen identification through PCR analysis. Studies have shown successful detection of various pathogens, including influenza and MERS-CoV, but there is a limitation which is the time-consuming nature of PCR analysis makes it unsuitable for real-time screening of large numbers of passengers. Additionally, logistical challenges in sample collection, transport, and analysis limit its feasibility in fast-paced airport environments. Ethical Considerations and Public Perception in implementing airborne pathogen detection system in airports raises several ethical considerations that require careful evaluation, which can be but not limited to, privacy concerns thus Passengers might be apprehensive about invasive technologies that collect their personal information, including breath or sweat samples. Early detection where the system can potentially detect airborne pathogens before individuals develop symptoms, enabling early isolation and quarantine measures. This can significantly reduce the risk of onward transmission and outbreak control.

5.2 Integration of Sensor Networks and Data Analytics

Integration of sensor networks and data analytics represents a cutting-edge approach to real-time monitoring of airborne pathogens within airport settings. This integration involves deploying sensor networks across airport terminals to continuously gather data on various environmental parameters like temperature, humidity, and air quality, alongside specific signals associated with pathogen presence. Advanced machine learning algorithms analyze this data to detect patterns indicative of pathogen activity, enabling the prediction of potential outbreaks. By seamlessly incorporating these sensor networks into existing airport infrastructure, proactive measures can be swiftly implemented to combat the spread of airborne pathogens. For instance, upon detecting potential signs of pathogen presence, targeted sanitation protocols can be deployed in high-risk areas, and crowd management strategies can be optimized to minimize the risk of transmission among travelers. This integration not only enhances the overall safety and hygiene standards within airports but also plays a crucial role in mitigating public health risks associated with airborne diseases. Integration of sensor networks with existing airport infrastructure enables proactive measures such as targeted sanitation and crowd management to mitigate the spread of airborne pathogens (Li et al., 2019).

5.3 Regulatory Framework and Policy Implications

The regulatory framework governing airborne pathogen detection in airports varies across jurisdictions and is influenced by factors such as public health priorities, technological advancements, and resource availability. Regulatory agencies such as the Centers for Disease Control and Prevention (CDC) in the United States provide guidelines and recommendations for the implementation of surveillance and detection systems in airport environments (Centers for Disease Control and Prevention, 2020). International collaboration and standardization efforts are essential for harmonizing regulatory requirements and ensuring interoperability of detection systems across borders (World Health Organization, 2017).

5.4 Importance of the study

Pathogen detection systems help in identifying individuals who might be carrying infectious diseases, thereby preventing the spread of illnesses within communities and across borders. Timely detection of pathogens at airports allows for swift public health responses, such as isolation of infected individuals, contact tracing, and implementation of preventive measures to contain the spread of diseases. borders through international travel. Pathogen detection systems at airports contribute to global health security by serving as an early warning system for potential pandemics.

screening travelers for infectious diseases, airports can help prevent the introduction of pathogens into new regions, thereby reducing the risk of local epidemics or outbreaks. Pathogen detection systems provide reassurance to travelers that measures are in place to protect their health and safety during their journey. This can help alleviate concerns about contracting infectious diseases while traveling. Information collected through pathogen detection systems can inform public health policies and interventions, such as vaccination campaigns, targeted surveillance, and healthcare resource allocation. Disease outbreaks can have significant economic consequences due to travel restrictions, decreased tourism, and disruptions to trade and commerce. Pathogen detection systems help mitigate these impacts by preventing the spread of diseases and maintaining confidence in travel and trade. Understanding pathogen detection systems in airports provides insights into the latest advancements in technology and biosafety protocols, which can have broader applications beyond airport security, such as in healthcare settings and disease surveillance networks.

5.5 Recommendations

Regular Training and Education: Ensure that staff members responsible for operating the detection system receive regular training and updates on best practices for identifying and responding to infectious diseases. This includes training on new technologies, protocols, and procedures. Invest in state-of-the-art technology, such as AI-driven predictive analytics and advanced imaging systems, to improve the accuracy and efficiency of disease detection. Regularly evaluate and upgrade technology to stay ahead of emerging threats. facilitate rapid response and information sharing in the event of a disease outbreak. Establish clear communication channels and protocols for collaboration. Launch public awareness campaigns to educate travelers about the importance of health screenings and reporting symptoms. Provide clear information about the purpose of the detection system and how passengers can cooperate with screening procedures. Implement robust data privacy and security measures to protect sensitive passenger information collected during screenings. Ensure compliance with relevant regulations and standards to maintain public trust and confidence in the system. Use findings to identify areas for improvement and implement corrective actions as necessary. Participate in international networks and collaborations for sharing information and best practices in infectious disease detection and response. Learn from experiences in other countries and contribute to global efforts to strengthen public health security. Long-term studies are needed to assess the effectiveness of these systems in various contexts and across different pathogens.

6. Conclusion

Securing Skies and Safeguarding Health

The ever-evolving landscape of global travel necessitates continuous improvement in airport pathogen detection systems. This review has explored the current state of the art, highlighting the strengths and limitations of various technologies like thermal screening, molecular tests, and immunological assays. While these systems play a crucial role in safeguarding public health, challenges remain. Resource constraints, data privacy concerns, and the need for harmonized standards across borders demand innovative solutions. Looking ahead, the future of airport pathogen detection brims with promise. Emerging technologies like rapid microfluidic devices, AI-powered image analysis, and non-invasive breath tests hold the potential to revolutionize the field. However, realizing this potential requires concerted efforts from various stakeholders. Airport authorities must invest in infrastructure upgrades and personnel training. Policymakers need to establish clear guidelines and incentivize research and development. Technology developers should prioritize user-friendliness, affordability, and integration with existing airport infrastructure. Ultimately, the success of airport pathogen detection systems hinges on a collaborative approach. By overcoming the existing challenges and embracing the possibilities offered by cutting-edge technologies, we can create a safer and healthier travel experience for all. Let us remember, that securing our skies is not just about protecting passengers, but also safeguarding the global community from the silent threat of infectious diseases. This ongoing endeavor requires unwavering commitment and a shared vision for a future where travel is not only convenient but also safe and secure.

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Biographies

Linda Ziso is a highly accomplished professional in the field of engineering, with a diverse educational background and extensive experience in the aerospace and biomedical sectors. Born and raised in Zimbabwe, Linda's passion for engineering and technology led her to pursue a remarkable academic journey and a fulfilling career in the Airforce of Zimbabwe. Linda embarked on her educational pursuits by obtaining a National Certificate in Aircraft Engineering, laying the foundation for her career in the aerospace industry. She furthered her studies and earned a National Diploma in Aircraft Engineering with a specialization in Radios, driven by a desire to explore interdisciplinary fields and integrate various engineering disciplines, Linda pursued a degree in Mechatronics, a field that combines mechanical, electrical, and computer engineering. This holistic approach to engineering provided her with a comprehensive understanding of complex systems and their integration, further enhancing her problem-solving abilities. Continuing her quest for knowledge and professional development, Linda is pursuing a Master's degree in Biomedical Engineering, further specializing in a field that merges engineering principles with medical sciences. This advanced degree program focuses on areas such as medical imaging, prosthetics, biomedical instrumentation, preparing her for leadership roles in the biomedical engineering field. Through her academic achievements, professional contributions, and Linda Ziso exemplifies dedication, expertise, and a commitment to excellence in engineering, particularly within the aerospace and biomedical sectors in Zimbabwe. Her multifaceted skill set and passion for innovation position her as a valuable asset to both her organization and the engineering community at large.

Prof. Tawanda Mushiri's research areas are Artificial Intelligence, Medical Robotics and Biomedical Engineering. His main research focus is on the Robotic First Aid (RFA) systems to reduce Road Traffic Accidents (RTA) and Disease Prediction Modelling using Artificial Intelligence. He is in the process of finalizing his patent for Robotic First Aid in passenger vehicle, which will reduce deaths in the global society at scenes where accidents occur. He is the point person for Artificial Intelligence at University of Zimbabwe. He has managed to do projects and grants up to USD$3,5m. He is Currently the Coordinator and an Associate Professor in the Department of Biomedical Informatics and Biomedical Engineering (BIBE) in the Faculty of Medicine and Health Sciences (FMHS) at UZ. Tawanda has worked under University of Zimbabwe in developing a number of currently working plants which are Number Plate, Edible Oil, Feed, Bakery and Sanitiser design, procurement of raw materials up to implementation. Tawanda is a Corporate Member of the Zimbabwe Institute of Engineers (ZIE) and the Engineering Council of Zimbabwe. He has supervised more than 380 students' undergraduate projects, 116 master's Students to completion, 1 MPhil and 4 PhD students in progress, 1 MPhil and 2 PhD students completed. He has also published 5 books, 14 chapters in a book, 25 journals in highly accredited publishers, 87 conferences in peer reviewed publishers and 1 patent. In the Global world, Tawanda supervises FIRST GLOBAL students for Robotics club, was a Senior Research Associate in the Department of Quality and Operations Management from 1 November 2017 – 31 October 2020 at UJ, has been a reviewer of journals and conferences in the academic world and an external reviewer of MPhils and DPhils in different universities. He is currently an External Examiner for National University of Science and Technology (NUST) ZW and Harare Institute of Technology (HIT). Tawanda Mushiri is a Senior Research Associate Research Fellow (SRARF) in the Faculty of Health Sciences, Biomedical Engineering and Healthcare Technology

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Charles Mbohwa Professor Charles Mbohwa is a Distinguished Professor in Energy and Sustainability Engineering at the College of Science, Engineering and Technology at the University of South Africa. He was, previously the University of Zimbabwe Pro-Vice Chancellor responsible for Strategic Partnerships and Industrialisation from 1st July 2019 up to 30th June 2022. Before that he was a professor of sustainability engineering in the Faculty of Engineering and the Built Environment at the University of Johannesburg. He was a mechanical engineer in the National Railways of Zimbabwe from 1986 to 1991, and lecturer and senior lecturer at the University of Zimbabwe. He was Senior Lecturer, Associate Professor and Full Professor at the University of Johannesburg. He was Chairman and Head of Department of Mechanical Engineering at the University of Zimbabwe from 1994 to 1997; Vice-Dean of Postgraduate Studies Research and Innovation in the Faculty of Engineering and the Built Environment at the University of Johannesburg from July 2014 to June 2017 and Acting Executive Dean in the Faculty of Engineering and the Built Environment from November 2017 to July 2018. He has published very widely. He holds a BSc Honours in Mechanical Engineering from the University of Zimbabwe in 1986; Master of Science in Operations Management and Manufacturing Systems from University of Nottingham 1992; and a Doctor of Engineering from the Tokyo Metropolitan Institute of Technology 2004.