

Claris Siyamambo¹, Edith Phalane¹, Refilwe Nancy Phaswana-Mafuya¹

¹South African Medical Research Council/University of Johannesburg (SAMRC/UJ) Pan African Centre for Epidemics Research (PACER) Extramural Unit, Faculty of Health Sciences, South Africa.

The majority of the studies reporting on HIV and the application of the fourth industrial revolution (4IR) were conducted in Southern Africa (n=11) followed by East Africa (n=10); West Africa (n=6) and Central Africa had the least number of studies (n=1). The commonly used 4IR methods/tools were AI and ML approaches to analyse secondary data. Supervised ML was the most popular 4IR technology, with the random forest being the most preferred followed by XGBoost, logistic regression, and other ML models and algorithms. Artificial intelligence models and algorithms can be used to diagnose and predict HIV, develop prediction tools, and identify HIV clusters. However, more needs to be done including further validation of outcomes with different data or settings to support the superiority of the 4IR approaches.

BACKGROUND

- The review focused on studies that reported on the application of Fourth Industrial Revolution (4IR) technologies in the diagnosis and management of HIV among key populations (KPs) in Sub-Saharan Africa (SSA).
- Artificial intelligence (AI), including machine learning (ML) models and algorithms, are 4IR technologies that can generate AI systems to diagnose and manage HIV.
- 4IR approaches can provide convenient, and quick ways to allow KPs sufficient access to health services as they bear a disproportionate burden of HIV.
- Sub-Saharan Africa carries a disproportionately high burden of HIV, with a significant prevalence and incidence across the region and within individual countries.
- This study aimed to understand the extent to which 4IR technologies have been applied to improve HIV diagnosis and management as well as describe the successes, gaps, opportunities, and limitations thereof among KPs in SSA.

METHODS

- The review was done according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines and registered in the International Prospective Register of Systematic Reviews (PROSPERO) database ID number CRD42023468734.
- A systematic search of the literature was conducted using databases such as PubMed, Google Scholar, SCOPUS, Web of Science, Sabinet, and Science Direct were conducted from August 2023 to May 2024.
- The search included published and unpublished documents made available from the year 2015 and onwards.
- The inclusion and exclusion criteria were guided by the "Population, Intervention, Comparison, and Outcome" (PICO) framework.
- The population considered studies involving adults - 15 years and above for prospective primary studies and all age groups for retrospective studies, key and general populations from SSA.
- The interventions looked at studies that employed 4IR approaches comparing traditional approaches with 4IR or comparing different 4IR methods.

RESULTS CONTINUED

Based on Figure 2, South Africa, Ethiopia, and Zimbabwe were the most researched on the application of 4IR in HIV diagnosis and management.



Figure 2: Number of studies per country

Table 2: Successes and Barriers of the 4IR approaches in the diagnosis and management of HIV

Successes	Barriers
1. AI/ML models improve early HIV detection through data analysis	Limited access to high-quality datasets
2. AI/ML can predict HIV infection risks, virological failure, interruptions in treatment, clinic visits, and viral load suppression.	Lack of standardized data collection procedures, leading to inconsistency in model performance.
3. Classification and interpretation of images of HIV self-testing results using AI.	High costs of advanced AI technologies and infrastructure,
4. Identifying HIV clusters and HIV uptake factors	
5. HIV diagnosis accuracy	

Figure 3 shows that most of the reports emanated from 13 countries from Southern Africa and East Africa and the least from seven countries, of which six were from West Africa and one from Central Africa.

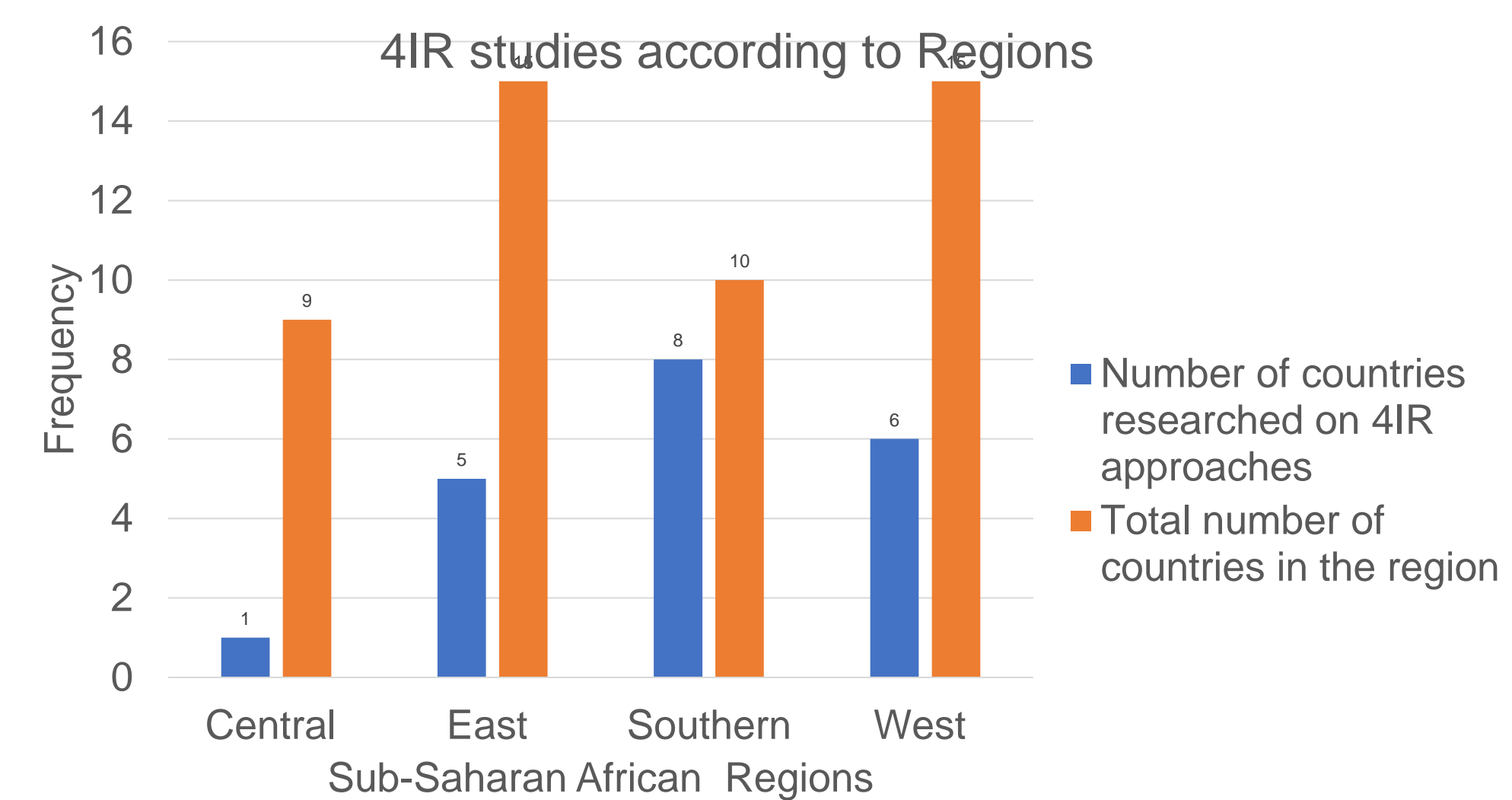


Figure 3: Distribution of 4IR studies per region in Sub-Saharan Africa

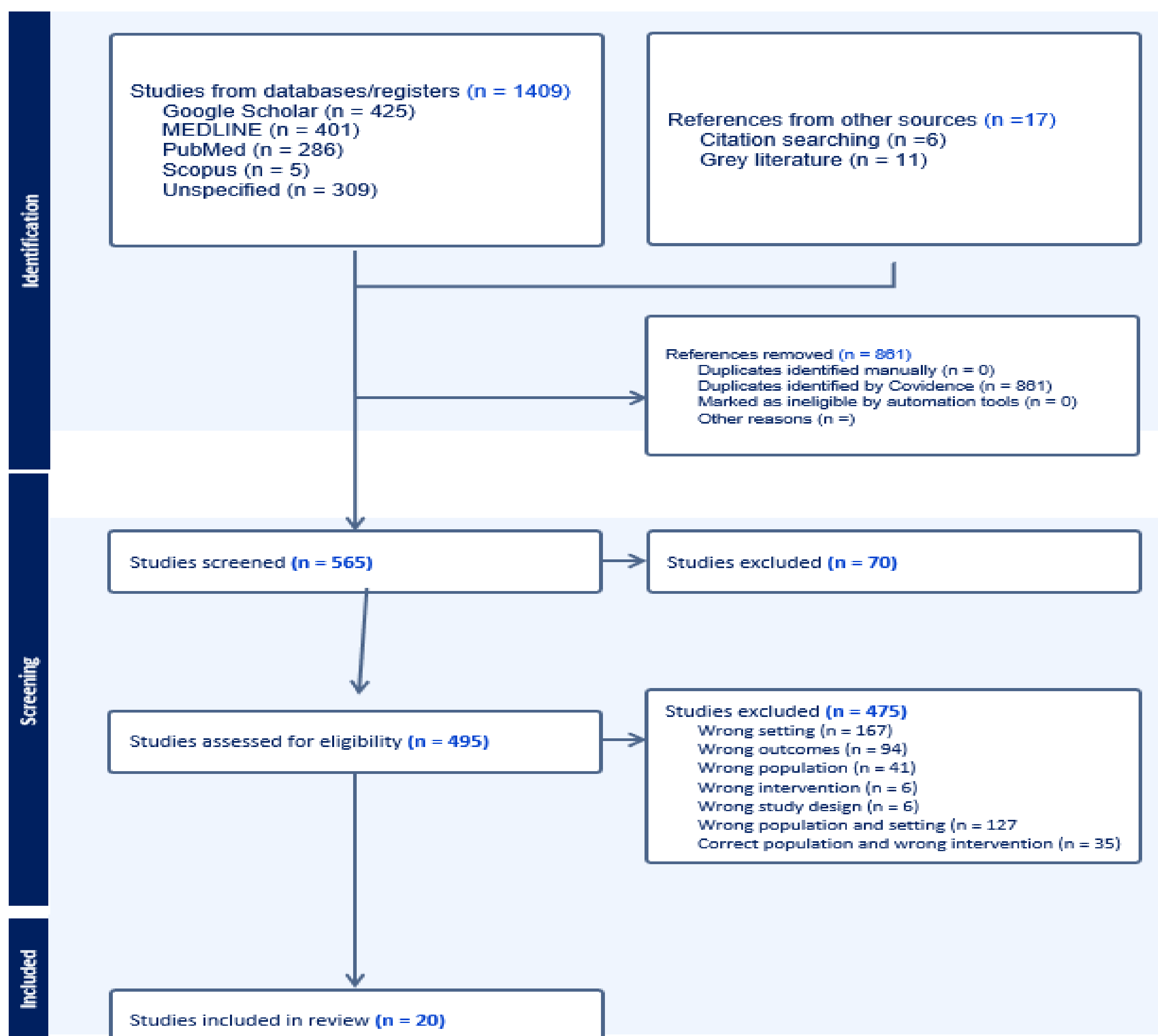


Figure 1 The Preferred Reporting Items for Systematic Reviews and Meta-Analysis flow diagram (Ludwig-Walz et al., 2023).

RESULTS

- The study characteristics of extracted full-text studies were guided by the inclusion and exclusion criteria following the PICO framework.
- Artificial intelligence models can analyze volumes of medical data to help with early detection, diagnosis, and monitoring of HIV, as well as predicting HIV and identifying large-scale public health patterns.
- Furthermore, AI/ML approaches can help with providing point-of-care diagnosis, and conversation agents to allow interactions with patients and management of HIV.

Table 1: Summary of the 4IR approaches and their application in HIV diagnosis and management in Sub-Saharan African countries

4IR approach	Application of the 4IR approaches
1. Random forest	Predicting virological failure, clinic visits, and viral load suppression and visualizing HIV Index Testing.
2. XGBoost	Predicting the likelihood of HIV, enhancing HIV positivity identification, predicting HIV status, predicting and visualizing HIV index testing
3. Logistic regression	Diagnosis and prediction of HIV infection accuracy, HIV status
4. Machine learning models	HIV acquisition risk identification, predicting interruptions in treatment.
5. AI agent	HIV counseling and testing
6. AI algorithm	HIV testing
7. DL Models	HIV status prediction
8. J48 Decision tree	HIV detection
9. LASSO Model	Identifying HIV testing uptake factors
10. Unsupervised ML approaches	Identifying male and female HIV clusters

CONCLUSIONS

- The 4IR approaches have proven more effective and convenient than traditional methods in HIV diagnosis and management.
- However, there are challenges including ethical concerns, quality data availability, and the expertise needed for proper implementation.
- The 4IR technologies can utilize existing data to build models for STI diagnosis and care, potentially improving diagnostic and management strategies.
- These technologies can enhance primary healthcare, mobile health, and self-assisted approaches, benefiting KPs who face segregation and unsensitized medical practitioners.
- By reducing misdiagnosis, improving timely precision, and lowering HIV mortality rates, 4IR approaches could help address the rising burden of HIV highlighting the need for their adoption.

ACKNOWLEDGMENTS

I thank the SAMRC/UJ PACER Extramural Unit team for sponsoring me to attend the WCE conference.

FUNDING

The work reported herein was made possible through funding by the South African Medical Research Council (SAMRC) through its Division of Research Capacity Development under the Mid-Career Scientist Program using funding received from the South African National Treasury (Project Code number: 57035 [SAMRC File ref no: HD18528/KR/202]). This work was conducted under the guidance of SAMRC/University of Johannesburg (UJ) Pan African Centre for Epidemics Research (PACER) Extramural Unit. The content herein is the authors' sole responsibility and does not necessarily represent the official views of SAMRC or UJ. This paper also forms part of a postdoctoral study by Dr Claris Siyamambo, whose studies are funded by the Global Excellence Stature (GES) 4.0 Scholarship at UJ.

SELECTED REFERENCES

- Ludwig-Walz, H., Dannheim, I., Pfadenhauer, L. M., Fegert, J. M., & Bujard, M. (2023). Anxiety among children and adolescents during the COVID-19 pandemic in Europe: a systematic review protocol. *Systematic Reviews*, 12(1), 64.
- Met, İ., Kabukçu, D., Uzunoğulları, G., Soybal, Ü., & Dakdevir, T. (2020). Transformation of business model in finance sector with artificial intelligence and robotic process automation. *Digital Business Strategies in Blockchain Ecosystems: Transformational Design and Future of Global Business*, 3-29.
- Arora, R., Chauhan, S., & Kaur, H. (2023). 1 Role of Machine Learning. *Combating Women's Health Issues with Machine Learning: Challenges and Solutions*.

AUTHOR'S CONTACT INFORMATION

clarismahambo@gmail.com
+27655812871

