



Research Article

A Multiagent-Based Model for Tracing Symptoms of Infectious Diseases

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Abstract

Symptoms associated with infectious diseases are very complex to detect and sometimes time-consuming to easily bring together by medical experts as most of them are very relative to the other being symptomatic and some being asymptomatic too. This has resulted in ineffective diagnosis that leads to pointing to one thing but later turns out to be another thing entirely as likened to the Covid-19 era, where symptom tracing was a major menace and unidentified infected persons could transmit to other people in a matter of split seconds. The aim of this research is to build a multiagent-based model to identify the symptoms of infectious diseases using fuzzy logic technique. The dataset used for the study was obtained from the University of Port Harcourt as well as the test set for the proposed system. The methodology adopted is Object-Oriented System Analysis and Design (OOSAD). The findings achieved reveal that contact tracing was done and performed efficiently. Further, by comparing the existing and proposed systems based on some performance metrics, including speed of user validation, number of methods adopted, number of algorithms used, number of machine learning techniques adopted, and number of databases used, it is evident that the new system performs better than the existing one, with speed in user validation now reduced to 11% value better than 32% in existing which obviously consumes more time. The study has been able to come up with an effective model that will help in dealing with uncertainty and the process of guessing in human health issues hence saving lives, time, and stress.

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I. INTRODUCTION

The idea of an intelligent agent is a notion derived from the domain of artificial intelligence, where the definition of the discipline of artificial intelligence is given in terms of the analysis and design of single entities with the capability of smart behavior. Thus, it is perceived that a smart agent should understand its environment, think about how to achieve its goals, follow the path of rationality to achieve them, and work with other intelligent agents, which are either machine or human [2].

In particular, vast-agent systems are a particular aspect of the distributed system, and mainly, the multi-agent system is based on the reason that the elements of the system are single and self-centered, with the aim of fulfilling their autonomous goals. Furthermore, the multi-agent systems are also particular due to the fact that they are open systems without any central design. In line with the concept of Distributed AI (DAI), the vast-agent system is “a loosely grouped network

of problem-solving agents for the purpose of working together to solve problems that could not be solved by an individual agent” [10].

There are numerous agents in the multi-agent systems, and they are familiar with each other’s purpose. Additionally, agents also interact with each other either by assisting the achievement of the goal of the individual agent or to prevent the achievement of the goal of the agent in rare cases. It is considered to be an enabler of wide applications that involve the distributed parallel processing of data, and the routine of the agent is also single in a complex and dynamic pool; therefore, it has generated great concern and attention in different fields of the study [8]. MAS comprises many single entities that have the following generic properties: Each of the agents has fewer capabilities to solve the challenge.

1. There is no global control
2. Uncentralized data
3. Asynchronous

The multi-agent system (MAS), as a system, has a lot to give in simple as well as vast models; hence, it can be utilized for distributed as well as centralized systems. For example, in a parallel program, the use of vast agents is made to improve the speed rate of the system. The scalability of the vast-agent system can be seen as another major advantage, which allows the addition of a newer agent to the already existing vast-agent system, and also due to the modularity of the model. The modularity of the multi-agent system makes it very easy, especially when compared to the monolithic system, which requires the addition of some new capabilities [11]. This is because it becomes easier to spot sub-tasks and also control sub-tasks given to various agents rather than working with one agent alone. Therefore, this addresses the challenge of dividing the time of one single agent for different jobs.

II. METHODOLOGY

A. Overview of Multiagent Based System

The study is that of multiagent based systems and is grounded mainly on the achievement of distributed computing, but with new questions arising about the ways in which the agents should discuss with each other to plot their routine and dissolve vast problems. The majority of the study currently being undertaken is centered on the development of the most appropriate mechanisms for the management of merging groups or agents. The programming aspect of intelligent agents still presents wide problems to engineers, not only based on the intricacy of designing concurrent and distributed systems, but also such that the components have architecture with features like reactivity, proactivity, and sociability [1]. This is very hard to program, especially when the said environment is dynamic and very wide. In a bid to get real agent programming, many proposals have now been put forward by several researchers regarding agents' architecture, communication languages, decision-making, and coordination as well.

B. Machine-Learning Algorithms for Contact-Tracing of Infectious Diseases

One of the applications of machine learning is that it has been used to spot and also classify different Android applications. Generally, a normal learning classifier is usually trained on a set of labeled samples and then uses feature vectors which represent syntactic and semantic components of applications. The structure of an Android application is very useful for obtaining syntactic updates like method and package name, permission, and configuration file. Therefore, features that are statically derived can be used to spot and properly classify different types of Android applications [7]. In a world that is inherently filled with data, there is a need to effectively utilize this constantly evolving piece of valuable resource for the discovery of a better way to resolve issues that cannot easily be ascertained. Mining in the actual sense is the process of extraction for the discovery of beneficial hidden natural resources [12]. In most cases, it takes days and months of speculation and preparation before the perceived set of these

natural deposits is excavated so as to enable the team involved to reach their target resource. Data is ubiquitous and everything around us is one form of data or another, but the ability to elicit implicit reliable information from them is of utmost concern to researchers and data scientists. In the same way that effort and expertise are needed for the exploratory and mining processes for natural resources like iron ore, gold, coal, and crude oil, so also it is needed for the mining and retrieval of vital information from data [3].

Thus, the aggregation and grouping of data along with the bid to unearth vital information or patterns of interest within that data, be it structured or unstructured, can be regarded as an act of mining that data. The process of data mining is regarded as "a process to find useful and resourceful patterns within a huge volume of data" [4]. This means that every bit of data has within it some form of value that needs to be mined for it to be of some use or another. It is also regarded as "a process that involves the integration of machine learning, statistics, and database management system to elicit and discover valuable information from big data mostly located in databases."

1. *Complex Systems and MAS*: The research in this field is based on the results obtained in distributed computing, but it asks fresh questions on how agents should flow with each other for smooth coordination and successfully solve complex challenges. The majority of the study focuses on finding appropriate patterns to manage the merging of teams or agents. The programming aspect of intelligent agents is a wide task for system engineers, and apart from the known complexities related to the designing of concurrent and distributed systems, there are also the added complexities that the elements must have as an architecture which incorporates features like reactivity, proactivity, and sociability. All these features remain very difficult to program, especially as there is a robust and wide environment [5]. For real agent programming to be accomplished, many proposals have already been made for the agent architectures, communication languages, decisions, and coordination mechanisms by many researchers.

C. Rule-Based Concept

A rule-based system is one used for storing and manipulation of knowledge in a way that helps to interpret the information. It is normally used in artificial intelligence. One main instance using the rule-based system is that the specific expert system is based on rules in order to make decisions. For instance, the expert system can be used by a specialist to make the right findings based on a group of symptoms or to make decisions in gaming [9].

D. Fuzzy Logic

Fuzzy logic remains a science which is known to incorporate the idea of partial truth. In fuzzy logic, the true value can be partially true and also partially untrue. Fuzzy logic can also

be applicable to control of systems, neural networks, and even AI. Fuzzy logic can also be applied to explain the way in which information is processed in the human brain. For instance, one can argue that humans hardly know the difference between fat and thin. Five people can be fat and not have the same level of being fat. Also, one person can be thin compared to another even while both are fat. Hence, using fuzzy logic, one can assign different values for fatness using logic values which range from 0 to 1 based on the severity of fatness [6].

III. METHODOLOGY

The achievement of this research work on the multiagent symptom tracing model for infectious diseases will be done through the Object-Oriented Analysis System Design (OOASD).

A. Existing System

The existing model in the study is depicted in Figure 1. This system was developed for the purpose of Patient Monitoring (PM) and contact tracing, which consequently resulted in the delivery of health care to the elderly in a cheap and efficient manner. In addition, the existing system is founded on the technology of the Remote Patient Monitoring System (RPMS). MAS works in real time, and the major characteristics include the analysis of remotely gathered continuous or intermittent life signs of the patient in a discreet manner provided by health services. The existing model functions in heterogeneous environments in order to facilitate, and also assist caregivers in providing care mainly to patients in diagnosis and treatment. The Global Positioning System (GPS) offers significant support in a wider spectrum of healthcare services. Sites and time services operate in RPM after disaster recovery to achieve a new level of personal security [8]. RPMS register patients, coordinates regularly with GPS, and uses genotyped mapping to monitor active sites to assist caregivers and patients in an emergency.

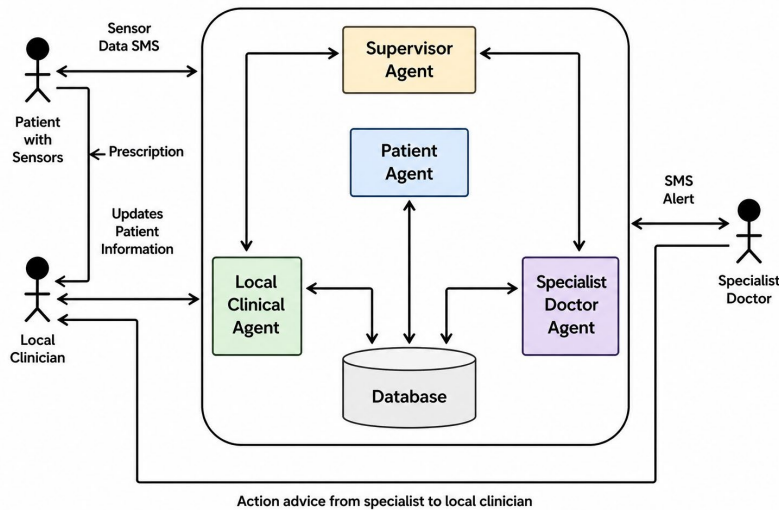


Fig.1 Existing System Architecture (Source: Rameshkumar & Viswanathan, 2023)

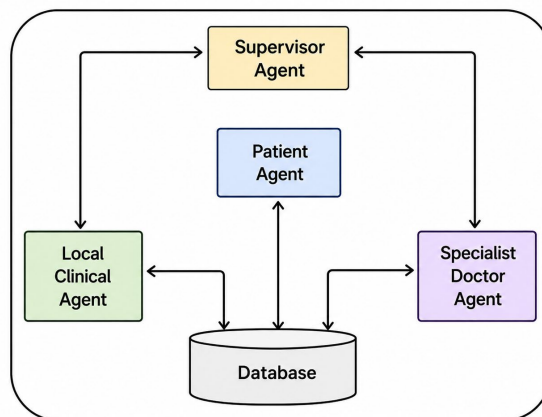


Fig.2 Multiagent Component of the Existing System Architecture

This component is a computerized model for health services to the elderly, and it is made up of multiple interacting intelligent agents that include a supervisor agent, a patient agent, a local clinical agent, a specialist doctor agent, and a relational database management system.

B. Design of the New System

The proposed model is an enhanced version of the existing architecture as depicted in Figure 3 below. The new system

is an improved multiagent-based model for contact tracing of infectious diseases. The new model makes use of the rule-base and fuzzy logic learning core concepts for contact tracing. This is done because the main aspect of the contact tracing process is the preparation of data, which includes selecting input data, the problem formulation, and then the system representation, which are rules, decision trees, regression trees, etc. Once the said data is prepared, the search algorithms for the parameters of the model that are more appropriate for the specific used for training.

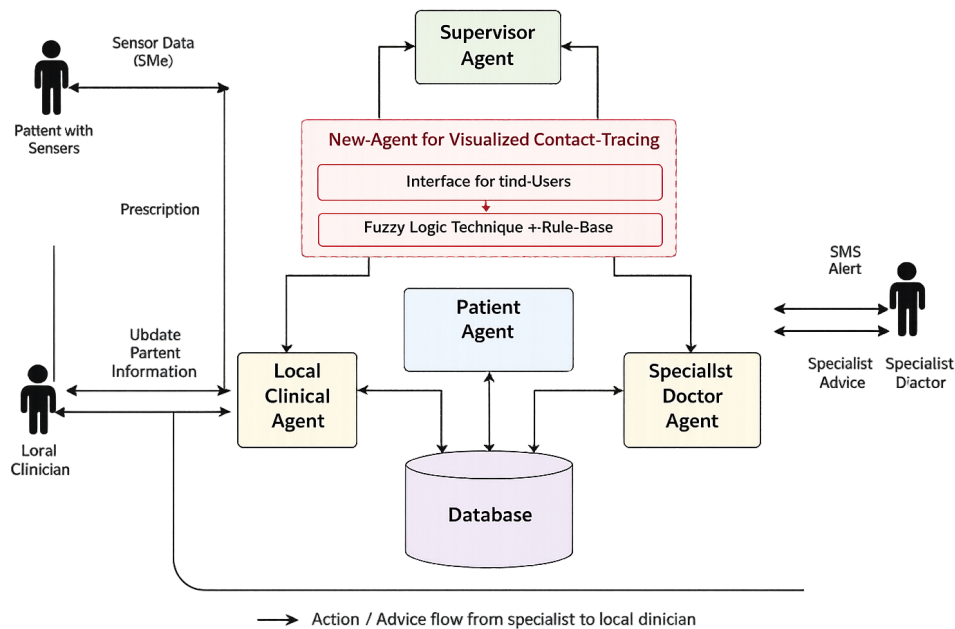


Fig.3 Proposed System Architecture

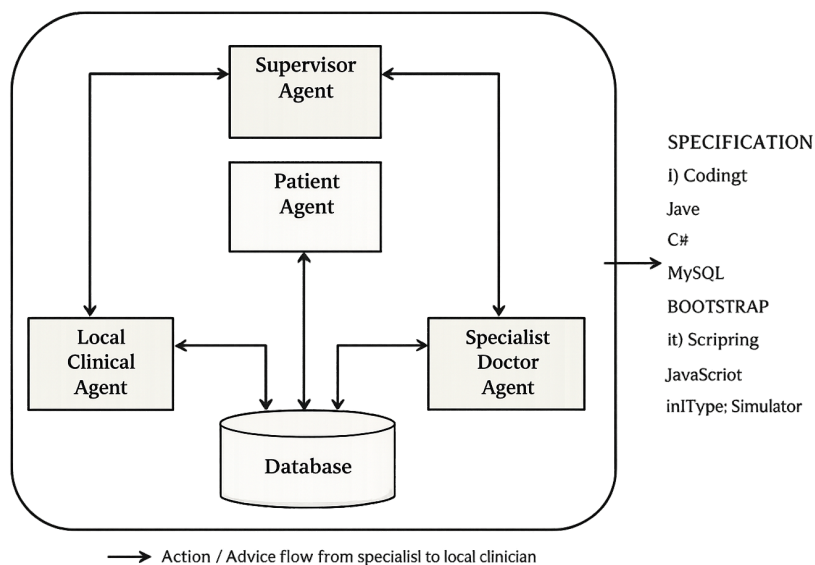


Fig.4 Multi-Agent Component of the Proposed System Architecture

This component represents a computerized model for health services to the elderly and comprises several intelligent agents that interact with one another and include the role of a

supervisor agent, a patient agent, a local clinical agent, a specialist doctor agent, and a relational database management system.

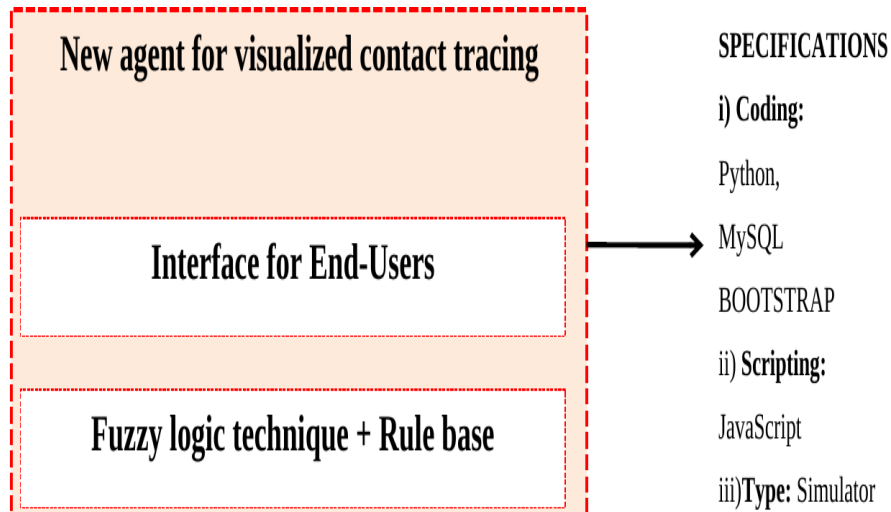


Fig.5 New Agent for the New System Architecture

The component in this case represents the newly added improvement in the existing system. This component comprises a unique interface for the end-users and the rule base and fuzzy logic technique. The interface mainly helps the end-users interact with the system in the best way

possible. The rule base helps in the storage of logical rules for the automatic updating of the system in the long run, whereas the fuzzy logic technique helps in the visualization process in the context of machine learning.

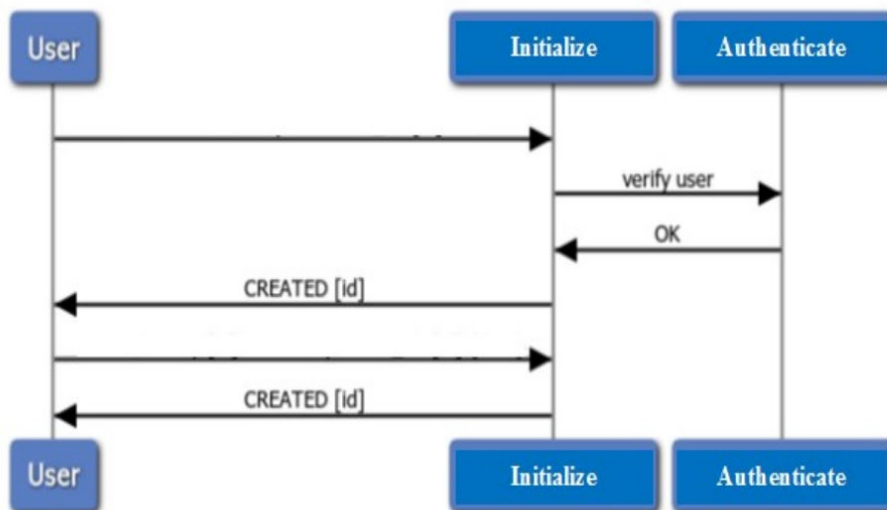


Fig.6 New System High Level Activity Diagram

C. Datasets

SN	Name	Gender	Date of Diagnosis	No. of observed symptoms	Symptoms breakdown	Most recent travel history	Isolation status
1	Mafuzu Obinna	Male	24/09/2020	3	Cold, hotness of body, Loss of smell	Lagos	Isolated
2	Sarah Johnson	Female	12/7/2021	1	Loss of taste	Abuja FCT	Isolated
3	Olivia Wency	Female	7/10/2021	2	Fever and cold	London (United Kingdom)	Isolated
4	Hannah Thompson	Female	3/10/2020	2	Loss of smell and hotness of body	United States	Isolated
5	Megan Paul	Female	20/7/2021	1	Loss of taste	Kaduna	Isolated
6	Chi Oe Agbo	Female	12/10/2021	1	Loss of taste	Greece	Isolated
7	Ibikunle Paul	Male	17/01/2020	3	Headache, loss of taste, loss of smell	Jos	Isolated
8	Caitlin Dimgba	Female	2/12/2020	2	headache and hotness of body	Etche	Isolated
9	Tallulah Osodoba	Male	23/05/2021	2	loss of taste and smell	Italy	Isolated
10	Ammaarah Sam	Male	10/9/2020	2	Loss of smell and taste	Lagos	Isolated
11	Michelle Abraham	Female	24/09/2020	3	Cold, hotness of body, Loss of smell	Lagos	Isolated
12	Jenna Lucy	Female	12/7/2021	1	Loss of taste	Lagos	Isolated
13	Haajarah Okoli	Male	7/10/2021	2	Fever and cold	Abuja FCT	Isolated
14	Emma Dikadi	Male	3/10/2020	2	Loss of smell and hotness of body	Lagos	Isolated
15	Tanja Yusuf	Male	20/7/2021	1	Loss of taste	Ahnada	Isolated
16	Zoe Johnson	Male	12/10/2021	1	Loss of taste	Buguma	Isolated
17	Maria Akpan	Female	17/01/2020	3	Headache, loss of taste, loss of smell	London (United Kingdom)	Isolated
18	Leah Mfoniso	Female	2/12/2020	2	headache and hotness of body	Lagos	Isolated

Fig.7 Screenshot of Test-Sets for the New System (Source: UPTH, 2021)

IV. RESULTS

Fig.8 User Registration Page

Fig.9 Test-Set Input Page

RESULT OF THE IMPROVED MULTI-AGENT SYSTEM

EXIT

YEAR	2021
SYSTEM VERDICT	Isolation Required
DETAILS	Mobile and Identification details from recent travel history matched with Tanja Yusuf; a diagnosed covid-19 patient

Fig.10 Contact-Tracing Result

TABLE I COMPARISON OF THE EXISTING AND NEW SYSTEM

S.No.	Existing System Parameters	Values	New System Parameters
1	Speed in Validating Registered Users	32 11	Speed in Validating Registered Users
2	Number of Adopted Methods	1 1	Number of Adopted Methods
3	Number of Adopted Algorithms	1 1	Number of Adopted Algorithms
4	Number of Adopted Tools	1 4	Number of Adopted Tools
5	Number of Created Databases	1 1	Number of Created Databases

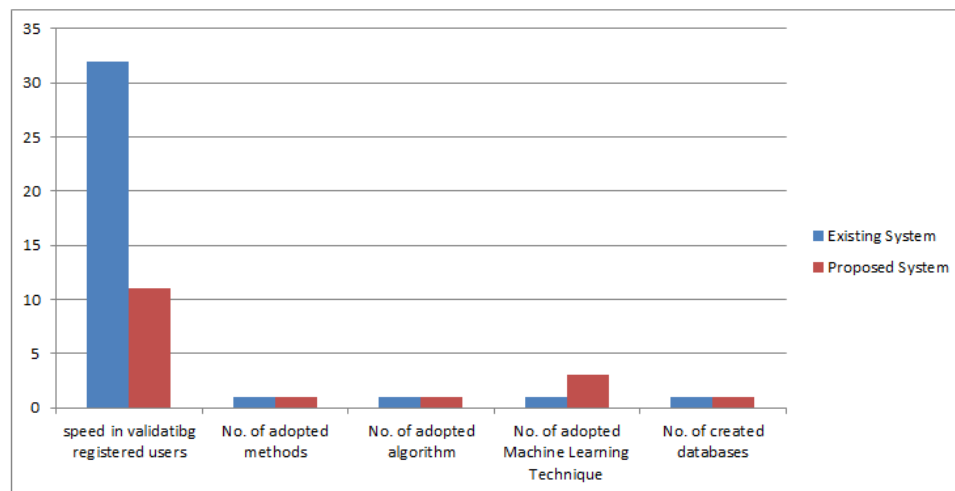


Fig.11 Comparative Analysis Chart (Source: Table I)

A. Discussion

Figure 8 above shows the user registration form/page, which is the form/page the new user who has not signed up before is using to register or sign up. Figure 9 above depicts the test input page, and is the form which the user gets after registering, and a sample of the user is being tested. Figure 10 above shows the results obtained after the user is asked to provide the required information to the multi-agent-based system. Table I above shows the results obtained from the new system, which include the number of end-users who tested the system, as well as the rate of the infectious disease detected. In addition, enough comparative analysis was done on the new system, especially in terms of the speed taken to validate registered users, the actual number of adopted algorithms, the known number of machine learning techniques, and also the number of created databases. The

Existing System has the following values for the parameters above-mentioned: 32, 1, 1, 1, and 1, whereas the New System has obtained the following values for the parameters above-mentioned: 11, 1, 1, 4, and 1. This clearly indicates that the performance of the proposed model is far better than the already existing model. Figure 11 depicts that the accuracy and precision of the new system have been achieved through machine learning-oriented techniques. Moreover, the machine learning-oriented technique can also be viewed as a regression model, which proves the final outcome and impact of the decision tree. The multiagent-based technique is considered an area of machine learning, which is used to determine the partial truth of the computing process with the help of the Boolean value, which has 0 and 1. The algorithm of the multiagent-based technique is used to solve the problem by considering all the data, and then the best possible decision is taken to solve the problem.

V. CONCLUSION

The study has successfully developed the multiagent-based symptom tracing model with the data sets gotten from the University of Port Harcourt Teaching Hospital (UPTH). The study further emphasized that in the event of uncertainty and avoidance of guesswork in human health, the symptom tracing helps in saving time and stress since the whole importance of work is for human health and the betterment of wellbeing. Thus, in summary, the special multi-agent-based system aid for optimizing trust and security of health data in the medical field is also useful for building an improved system for properly tracking the health status of a suspected disease carrier anywhere.

Declaration of Conflicting Interests

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Use of Artificial Intelligence (AI)-Assisted Technology for Manuscript Preparation

The authors confirm that no AI-assisted technologies were used in the preparation or writing of the manuscript, and no images were altered using AI.

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