GLOBAL BIO-SURVEILLANCE AND RESPONSE SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. provisional application 63/044,815, filed on June 26, 2020, which is hereby incorporated by reference in its entirety.

[0002] This application refers to and incorporates by reference in their entirety, the following patent documents: U.S. Application No. PCT/US2014/010016, filed on January 2, 2014; U.S. Application No. PCT/US2014/022948, filed on March 11, 2014; U.S. Application No. PCT/US2014/026010, filed on March 13, 2014; U.S. Application No. PCT/US2015/03092, filed on May 15, 2015; U.S. Application No. PCT/US20/30754, filed on April 30, 2020; U.S. Application No. PCT/US02/20570, filed on June 29, 2002; U.S. Application No. PCT/US03/041241, filed on December 23, 2003; U.S. Application No. PCT/US2006/049049, filed on December 21, 2006; U.S. Application No. PCT/US2010/058913, filed on December 3, 2010; U.S. Application No. PCT/US2014/010182, filed on January 3, 2014; U.S. Application No. PCT/US2016/026242, filed on April 6, 2016; U.S. Application No. PCT/US2016/043755, filed on July 22, 2016; U.S. Application No. PCT/US2017/014360, filed on January 20, 2017; U.S. Application No. PCT/US2019/032567, filed on May 16, 2019; U.S. Application No. 62/954,961, filed on December 30, 2019; U.S. Application No. 63/025,344, filed on May 15, 2020; U.S. Application No. PCT/US2019/042274, filed on July 17, 2019; and U.S. Application No. 62/964,435, filed on January 22, 2020.

TECHNICAL FIELD

[0003] The present application relates generally to systems, methods, and apparatuses for providing a real-time global bio-surveillance and response solution.

BACKGROUND

[0004] In the face of a biological, chemical, and/or bio-chemical catastrophe, such as a global pandemic, governments, private companies, and private institutions are ill-prepared to quickly detect and mount a rapid and effective response to these events. This is because these entities offer a disparate patchwork of existing public and private clinical diagnostics testing, which is not fully realized or able to respond to a rapidly developing global event or health condition. The current response capabilities of these entities are not able to prevent either the crippling effects these events have on economies, or the resulting dramatic loss of life. Moreover, existing infrastructures are

overrun and overburdened, and undertake reactive testing approach; the vast majority of which occurs after the triggering event has occurred.

[0005] What is required, thus, are systems, methods, and apparatuses that provide a real-time solution with a centralized infrastructure, that is sufficiently funded, stockpiled and staffed, offering an interconnected web and network of testing devices that routinely test for these catastrophic events, and provide an infrastructure to rapidly ramp up and meet global demand for testing and the development of scientific solutions (assay development, vaccine development, etc.) to combat the events and to protect lives and economies. Other examples exist and the solutions disclosed herein are not limited to the problems discussed above.

BRIEF SUMMARY

[0006] Applicants have created systems, methods, and apparatuses (including computer-readable media) for providing a real-time global bio-surveillance and response solution. The systems and apparatuses may include one or more sentinel subsystems and one or more surge subsystems that each include a real-time, cloud-based, distributed, interconnected set of hardware, software, and/or firmware for comprehensive surveillance, complete detection, and immediate response various to biological, chemical, and/or bio-chemical anomalies, for example, a new or emerging pathogen. The methods may include providing one or more tests to assess a health condition, including to detect pathogens, such as infectious agents and toxins, of both natural origin and biowarfare or bioterrorism agents, and host biomarkers of disease, including biomarkers associated with infection and toxemia, and biomarkers associated with radiation exposure (biodosimetry), and providing real-time results across a global network of infrastructure that is adapted to provide the testing for and responses to health conditions. In a non-limiting example, the methods may include providing one or more tests to detect a known, unknown, or emerging pathogen, and in response to detecting an unknown or emerging pathogen, providing real-time results across a global network of infrastructure that is adapted to provide the testing for and responses to the unknown or emerging pathogen. In further embodiments, the methods may include a method of tracking a health condition in a population that includes the steps of providing one or more tests to detect a set of one or more markers relating to said health condition, and providing real-time results across a global network of infrastructure (e.g., a plurality of sentinel surveillance testing systems and a plurality of surge surveillance testing systems) that is adapted to identify and respond to a known, unknown, or emerging risk to health.

[0007] A computer readable storage medium storing a program of instructions executable by a machine to perform one or more methods described herein also may be provided.

[0008] In an embodiment, a global bio-surveillance and response system is provided. The global bio-surveillance and response system includes a first subsystem configured to perform monitoring of one or more health conditions; a second subsystem configured to perform one or more scientific functions in response to the first subsystem's detection of the one or more health conditions; and a networking platform, wherein the networking platform is configured to communicate information in real-time to and/or from one or both of the first and second subsystems.

[0009] In a further embodiment, a method for responding to a known, unknown, or emerging health condition is provided. The method includes providing targeted testing to detect one or more health conditions among a population to obtain targeted results; transmitting the targeted results to a system monitoring subsystem, wherein the targeted results are transmitted in real-time across a distributed network of infrastructure; responsive to the targeted results, performing one or more of the following steps: increasing the rate of testing among the population to detect the presence of the one or more health conditions, and increasing the number of individuals tested among the population to detect the presence of the one or more health conditions.

[0010] In a further embodiment, a method of allocating resources within a global bio-surveillance and response system to be carried out by at least one server having at least one processor is provided. The method includes receiving information from a farm status module relating to one or more available resources of a network of laboratories configured to monitor one or more health conditions in real-time; analyzing the information via an inventory module and/or a load balancing module of the at least one server based at least in part on one or more selection criteria; and balancing, via the load balancing module and according to the analyzing, sample processing loads and inventory loads across the network of laboratories, the load balancing module further including a logical collection of services and software configured to balance the sample processing loads and the inventory loads across the network of laboratories; and causing, via the load balancing module, a routing of one or more of equipment, test samples, instruments, supplies, and/or personnel to a selected laboratory among the network of laboratories responsive to analyzing the received information and based on the one or more selection criteria, the routing including: engaging a delivery service and scheduling a pick-up and delivery of the one or more

of equipment, test samples, instruments, supplies, and/or personnel; printing shipping labels; and paying shipping charges.

[0011] In a further embodiment, a method for responding to a health-related triggering event is provided. The method includes providing targeted testing to detect the presence of one or more health conditions among a population exhibiting a defined set of symptoms to obtain targeted testing results; transmitting the targeted testing results in real-time to a distributed infrastructure network; providing one or more scientific detection tools configured to analyze the one or more health conditions responsive to the targeted testing results; and developing a scientific diagnostic tool responsive to analysis of the targeted testing results from the one or more scientific diagnostic

tools; and distributing one or more of test equipment, scientific detection tools, and scientific diagnostics tools to at least one location within the network of infrastructure responsive to providing the one or more scientific detection tools or developing the scientific diagnostic tool.

[0012] In a further embodiment, a device for managing a global bio-surveillance and response system, comprising at least one processor configured to execute software instructions is provided. The software instructions are configured to provide an information subsystem configured to receive information from at least one subsystem and to facilitate the analysis of the information for providing a response to a health condition in a population; and a command subsystem configured to provide commands to the at least one subsystem for carrying out the response, wherein the information subsystem and the command subsystem are configured to receive real-time communications from the at least one subsystem through a web-based platform.

[0013] In a further embodiment, a global bio-surveillance and response system is provided. The system includes a subsystem configured to perform monitoring of one or more health conditions, wherein the subsystem includes a plurality of portable testing devices distributed among a geographical area; a system monitoring subsystem configured to: receive inputs from the subsystem and send outputs to the subsystem in real-time, facilitate analysis of the inputs, and determine the outputs, responsive to the inputs; and a networking platform configured to communicate with a plurality of the portable testing devices in real time.

[0014] In a further embodiment, a global bio-surveillance and response system is provided. The system includes a first subsystem configured to perform one or more scientific functions in response to a detection by a second subsystem of one or more health conditions, wherein the subsystem includes a plurality of scientific diagnostic equipment; a system monitoring subsystem configured to: receive inputs from the first subsystem and the second subsystem and sending outputs to the first subsystem and the second subsystem in real-time, and facilitate analysis of the inputs to determine the outputs to send to the first subsystem; and a networking platform, wherein the networking platform is configured to communicate with the scientific diagnostic equipment in real time.

[0015] In a further embodiment, a method of minimizing the spread of a health condition in a population is provided. The method includes providing targeted testing to detect one or more health conditions among a population within a geographical area, wherein the health conditions are at least one of biological, chemical, and biochemical; confining the population within that

geographical area for a finite period of time responsive to the detection of the one or more health conditions within that geographical area; performing additional testing of individuals within the geographical area within the finite period of time; and allocating additional resources to the geographical area for which the one or more health conditions were detected.

[0016] In a further embodiment, a global laboratory network is provided. The network includes a plurality of networked laboratories having a geographical distribution and configured to provide continuous monitoring of populations, targeted testing, and/or scientific functions, wherein each one of the plurality of networked laboratory is configured to communicate with one or more other ones of the plurality of networked laboratories; and a system monitoring subsystem configured to: receive inputs from the plurality of networked laboratories, and send outputs to one or more of the plurality of networked laboratories in real-time, allocate resources among the plurality of networked laboratories based at least in part on the inputs from the or more laboratories.

[0017] In a further embodiment, a method of pandemic preparedness is provided. The method includes providing one or more tests to detect a known, unknown, or emerging pathogen; and providing, responsive to detection of an unknown or emerging pathogen, real-time results across a global network of infrastructure, the global network of infrastructure being configured to provide testing for the unknown or emerging pathogen and respond to the unknown or emerging pathogen.

[0018] In a further embodiment, a method of tracking a health condition in a population is provided. The method includes providing one or more tests to detect a set of one or more markers relating to the health condition; obtaining results from the one or more tests; and providing the results in real-time across a global network of infrastructure configured to identify and respond to a known, unknown, or emerging risk to health.

[0018a] In a further embodiment, a method of allocating resources within a global bio-surveillance and response system is provided. The method includes obtaining, from a plurality of networked laboratories of the system, a plurality of scorecards indicative of laboratory status, the plurality of scorecards each providing scores relating to one or more available resources of the networked laboratories, and an operational status of each networked laboratory; determining, according to the plurality of scorecards, that a first laboratory of the plurality of networked laboratories has a resource deficiency of one or more resources; determining, according to the

plurality of scorecards, that a second laboratory of the plurality of networked laboratories has a resource surplus of one or more resources; and causing, via a load balancing module, a routing of one or more resources from the second laboratory to the first laboratory, responsive to the determining that the first laboratory has the resource deficiency, the routing including: engaging a delivery service and scheduling a pick-up and delivery of the one or more resources; printing shipping labels; and paying shipping charges.

[0019] Further features as well as the structure and operation of various embodiments are described in detail below with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The following figures form part of the present specification and are included to further demonstrate certain aspects of the present invention. The invention may be better understood by reference to one or more of these figures in combination with the detailed description of specific embodiments presented herein.

WHAT IS CLAIMED IS:

1. A method of allocating resources within a global bio-surveillance and response system to be carried out by at least one server having at least one processor, the method comprising:

receiving information from a farm status module relating to one or more available resources of a network of laboratories configured to monitor one or more health conditions in real-time;

analyzing the information via an inventory module and/or a load balancing module of the at least one server based at least in part on one or more selection criteria;

balancing, via the load balancing module and according to the analyzing, sample processing loads and inventory loads across the network of laboratories, the load balancing module further including a logical collection of services and software configured to balance the sample processing loads and the inventory loads across the network of laboratories; and

causing, via the load balancing module, a routing of one or more of equipment, test samples, instruments, supplies, and/or personnel to a selected laboratory among the network of laboratories responsive to analyzing the received information and based on the one or more selection criteria, the routing including:

engaging a delivery service and scheduling a pick-up and delivery of the one or more of equipment, test samples, instruments, supplies, and/or personnel;

printing shipping labels; and

paying shipping charges.

2. The method of claim 1, wherein the one or more available resources include testing capacity, current inventory, current supplies, and/or a total number of instruments of a networked laboratory.

3. The method of claim 1, wherein the routing caused by the load balancing module further includes re-routing one or more of the equipment, test samples, instruments, supplies, and/or personnel that have been previously routed based on the one or more selection criteria.

4. The method of claim 1, further comprising scheduling one or more of testing, personnel allocation, and/or sample transportation within laboratories of the network of laboratories.

5. The method of claim 4, wherein scheduling further comprises receiving commands for establishing rules to allocate resources and/or schedule tasks on a global scale via a global scheduler.

6. The method of claim 4, wherein scheduling further comprises receiving commands for establishing rules to allocate resources and/or schedule tasks on a regional scale via a regional scheduler.

7. The method of claim 6, wherein the regional scheduler further includes allocating resources and/or scheduling tasks within one or more farms of instruments.

8. The method of claim 4, further comprising receiving as an input one or more of a type of test results to be processed and/or frequency to be performed by one or more test sites when determining how to allocate resources and/or schedule tasks.

9. The method of claim 4, further comprising receiving as an input one or more of staffing schedules and/or performance metrics of one or more facilities and/or sites when determining how to allocate resources and/or schedule tasks.

10. The method of claim 4, further comprising receiving and managing an allocation of customer orders for equipment, supplies, and/or other resources within the network of laboratories.

11. The method of claim 1, further comprising dispatching one or more of supplies, test samples, equipment, and/or samples within the network of laboratories.

12. The method of claim 11, wherein dispatching further includes procuring and/or

distributing inventory and/or equipment between the network of laboratories.

13. The method of claim 1, wherein the load balancing module employs a combination of real-time algorithms and human analysis to optimize resource allocation and/or task scheduling within the network of laboratories.

14. The method of claim 13, wherein the real-time algorithms evaluate one or more of staff levels, supply inventory levels, and/or testing throughput of one or more laboratories and/or other facilities to optimize resource allocation and/or task scheduling within the network of laboratories.

15. The method of claim 13, wherein the load balancing module further includes minimizing workloads of operators at one or more testing facilities.

16. The method of claim 13, wherein the load balancing module further includes predicting timing for inventory replenishment of one or more laboratories and/or other facilities within the network of laboratories.

17. The method of claim 13, wherein the load balancing module further includes optimizing resource allocation and/or task scheduling based on considerations of proximity of resources to laboratories and/or other facilities.

18. The method of claim 13, wherein the real-time algorithms further include adjusting dynamically based on a change of circumstances, including a site being taken off line and/or a region being made temporarily unavailable.

19. The method of claim 1, wherein monitoring the one or more health conditions includes monitoring for one or more biological, chemical, and biochemical anomalies.

20. The method of claim 19, wherein the monitoring further includes performing luminescence testing.

21. The method of claim 20, wherein the luminescence testing includes chemiluminescence testing.

22. The method of claim 20, wherein the luminescence testing includes electrochemiluminescence testing.

23. A method of allocating resources within a global bio-surveillance and response system, the method comprising:

obtaining, from a plurality of networked laboratories of the system, a plurality of scorecards indicative of laboratory status, the plurality of scorecards each providing scores relating to one or more available resources of the networked laboratories, and an operational status of each networked laboratory;

determining, according to the plurality of scorecards, that a first laboratory of the plurality of networked laboratories has a resource deficiency of one or more resources;

determining, according to the plurality of scorecards, that a second laboratory of the plurality of networked laboratories has a resource surplus of one or more resources; and

causing, via a load balancing module, a routing of one or more resources from the second laboratory to the first laboratory, responsive to the determining that the first laboratory has the resource deficiency, the routing including:

engaging a delivery service and scheduling a pick-up and delivery of the one or more resources;

printing shipping labels; and

paying shipping charges.

24. The method of claim 23, wherein the one or more resources include one or more of equipment, test samples, instruments, supplies, consumables and personnel.

25. The method of claim 23, further comprising routing one or more resources from a manufacturing facility to the first laboratory.

26. The method of claim 23, wherein determining that the first laboratory has the resource deficiency is further performed according to an amount of samples scheduled for processing at the first laboratory.

27. The method of claim 26, wherein determining that the first laboratory has the resource deficiency includes determining a future resource deficiency based on the amount of samples scheduled for processing at the first laboratory.

28. The method of claim 1, wherein the information received from the farm status module includes a plurality of load balancing scorecards, each associated with a networked laboratory and including information defining an operational status of the associated networked laboratory.

29. The method of claim 1, wherein analyzing the information further includes projecting future sample processing times and future inventory needs according to enroute resources.

30. The method of claim 1 wherein routing caused via the load balancing module of the at least one server is performed to address inventory management issues identified across regional deployments of the network of laboratories, and to facilitate inventory management across multiple regions.

31. The method of claim 1, wherein the at least one server is a global services server.