computational power is needed to analyze the collected data. As a result of the effort and power needed, only relatively severe or harmful outbreaks are tracked, leaving many outbreaks untracked.

[0004] In addition to above, medical data related to an outbreak is only entered after an outbreak has been identified. The lag between the outbreak occurring, identification, data gathering, and analysis can result in an outbreak quickly expanding before much is known. As many healthcare professionals believe, the next pandemic (or wave of pandemics) will begin small, in isolated areas such as urban centers or on the fringes of developed areas, and proceed under health radars until a significant portion of the world's population is affected.

SUMMARY

[0005] The present disclosure sets forth a graph database for outbreak tracking and management. In particular, the disclosure describes a method, system, and apparatus for the creation and updating of a graph database to track one or more outbreaks. The method, system, and apparatus disclosed herein may also be configured to compare certain graph database data, patient data, and/or patient medical data to one or more case or cluster rules. Satisfaction of the case or cluster rule causes the method, system, and apparatus to add a case to an outbreak, begin a workflow to ensure the case is properly documented or otherwise managed, and/or transmit notifications to designated clinicians indicative of a presence of a new case. The graph databases incorporate medical, positional, temporal, and/or demographic relationships between nodes according to a predefined structure. The definitions and relationships provided among different types of nodes enable information to automatically be incorporated into the graph database. The disclosed graph database structure enables cases to be analyzed to determine if an outbreak is in the process of occurring. Linkage of cases to an outbreak enable an origin of the outbreak to be tracked to help identify potential solutions and appropriate control measures.

[0005a] In an aspect, the present disclosure refers to an outbreak management server system comprising:

a memory device storing (i) case rules each specifying at least one condition for satisfying the respective case rule, and (ii) instructions therein, the instructions defining a graph database structure for disease outbreak tracking, the instructions specifying for a given host that:

a host node is created, the host node being associated with host parameters,

an episode node is connected to the host node via a ‘case’ link, the episode node being associated with episode parameters that are related to a disease classification of the host, and

a rule node is connected to the episode node via a ‘found’ link, the rule node being associated with a case workflow, an assignment, and a notification; and

an outbreak management server configured to:

receive patient data related to the host,

store at least some of the received patient data to the graph database at one or more parameters of at least one of the host node or the episode node based on contents of the at least some of the received patient data matching parameter definitions of the respective node,

compare parameters of the host node and the episode node to the conditions of the case rules, and

for a case rule having at least one condition that first matches the parameters of the host node and episode node, create a link between the rule node and the episode node, the linkage causing a case workflow of the case rule to be added for the episode node, the episode node to be assigned to an individual or a team, and a notification to be generated regarding association with the case rule.

[0005b] In an aspect, the present disclosure refers to an outbreak management method comprising:

storing, in a memory device, (i) case rules each specifying at least one condition for satisfying the respective case rule, and (ii) a graph database structure for disease outbreak tracking, the graph database structure configured, for a given host, such that:

when a host node is created, the host node is associated with host parameters,

when an episode node is connected to the host node via a ‘case’ link, the episode node is associated with episode parameters that are related to a disease classification of the host, and

when a rule node is connected to the episode node via a 'found' link, the rule node is associated with a case workflow, an assignment, and a notification;

receiving, in an outbreak management server, patient data related to the host;

storing, via the outbreak management server, at least some of the received patient data to the graph database at one or more parameters of at least one of the host node or the episode node based on contents of the at least some of the received patient data matching parameter definitions of the respective node;

comparing, via the outbreak management server, parameters of the host node and the episode node to the conditions of the case rules; and

for a case rule having at least one condition that first matches the parameters of the host node and episode node, creating, via the outbreak management server, a link between the rule node and the episode node, the linkage causing a case workflow of the case rule to be added for the episode node, the episode node to be assigned to an individual or a team, and a notification to be generated regarding association with the case rule.

[0006] Examples of the subject matter described herein may be useful alone or in combination with one or more other examples described herein. Without limiting the foregoing description, in a first example of the present disclosure, an outbreak management server apparatus includes an outbreak management server system including a memory device storing (i) case rules each specifying at least one condition for satisfying the respective case rule, and (ii) instructions therein. The instructions define a graph database structure for disease outbreak tracking. The instructions specify for a given host that a host node is created, the host node being associated with

host parameters, an episode node is connected to the host node via a ‘case’ link, the episode node being associated with episode parameters that are related to a disease classification of the host, and a rule node is connected to the episode node via a ‘found’ link, the rule node being associated with a case workflow, an assignment, and a notification. The outbreak management server apparatus also includes an outbreak management server configured to receive patient data related to the host and store at least some of the received patient data to the graph database at one or more parameters of at least one of the host node or the episode node based on contents of the at least some of the received patient data matching parameter definitions of the respective node. The outbreak management server apparatus is also configured to compare parameters of the host node and episode node to the conditions of the case rules, and for a case rule having at least one condition that first matches the parameters of the host node and episode node, create a link between the rule node and the episode node, the linkage causing a workflow of the case rule to be added for the episode node, the episode node to be assigned to an individual or a team, and a notification to be generated regarding association with the case rule.

[0007] In a second example of the present disclosure, which may be combined with any other example, or portion thereof, described herein, the case rules are arranged in an order or hierarchy, and the outbreak management server is further configured to sequentially compare the one or more conditions of each of the case rules to the parameters of the host node and episode node until there is a match to one case rule.

[0008] In a third example of the present disclosure, which may be combined with any other example, or portion thereof, described herein, the case workflow defines a sequence of steps specified by objects for obtaining documentation related to the case of the episode node or managing a disease associated with the episode node.

[0009] In a fourth example of the present disclosure, which may be combined with any other example, or portion thereof, described herein, the outbreak management server is further configured to use the assignment of the case rule to create a leakage between the episode node and a node of an individual or a team via an ‘assigned’ link.

[0010] In a fifth example of the present disclosure, which may be combined with any other example, or portion thereof, described herein, the notification identifies one or more individuals or organizations that should receive a message indicative of the case rule being satisfied for the host node and the episode node.

[0011] In a sixth example of the present disclosure, which may be combined with any other example, or portion thereof, described herein, the case rule includes guidance information for treating the case, the guidance information being included within the message that is related to the notification.

[0012] In a seventh example of the present disclosure, which may be combined with any other example, or portion thereof, described herein, each of the case rules are data structures or files that include the one or more conditions, assignment information, a link to the case workflow, and notification information.

[0013] In an eighth example of the present disclosure, which may be combined with any other example, or portion thereof, described herein, after the case workflow is completed, the outbreak management server is further configured to connect an outbreak node to the episode node via a 'part of' link to indicate that the host has become part of an outbreak of the disease when a result of the workflow is indicative that the case is associated with the outbreak. The outbreak node is connected to a definition node via a 'defined as' link, the definition node specifying disease parameters of the disease that are related to the outbreak node.

[0014] In a ninth example of the present disclosure, which may be combined with any other example, or portion thereof, described herein, the disease parameters include at least one of a name of the disease, a background of the disease, a time/place related to the disease, clinical criteria for the disease, laboratory criteria for the disease, modes of transmission for the disease, criteria for determining a 'suspected' classification, criteria for determining a 'probable' classification, and criteria a determining the 'confirmed' classification.

[0015] In a tenth example of the present disclosure, which may be combined with any other example, or portion thereof, described herein, the server is further configured to connect the host node to the outbreak node via the episode node after determining at least some of the patient data matches at least some of the disease parameters of the definition node.

[0016] In an eleventh example of the present disclosure, which may be combined with any other example, or portion thereof, described herein, the host parameters include at least one of a name of the host, a patient classification flag, a clinician classification flag, a person classification flag, an animal classification flag, a fomite classification flag, an object classification flag, patient demographic data, or patient medical data.

[0017] In a twelfth example of the present disclosure, which may be combined with any other example, or portion thereof, described herein, the episode parameters include at least one of a start of a case number for the host, a 'possible' classification for the disease for the host, a 'probable' classification for the disease for the host, a 'confirmed' classification for the disease for the host, an immunization status of the host, an immunization type of the host, a flag indicative that the host acquired the disease in a medical facility, or death information related to the host.

[0018] In a thirteenth example of the present disclosure, which may be combined with any other example, or portion thereof, described herein, the outbreak management server is further configured to generate a case number for the respective episode parameter of the episode node after determining a 'confirmed' or a 'probable' classification for the host.

[0019] In a fourteenth example of the present disclosure, which may be combined with any other example, or portion thereof, described herein, the outbreak management server is further configured to receive at least one of a geographic location or a journey associated with the host node, create an activity map that is related to the host node for the at least one geographic location or journey, and create stay nodes linked to the host node via a 'stayed' link and location nodes linked to one of the stay nodes via an 'in' link for the at least one geographic location or journey.

[0020] In a fifteenth example of the present disclosure, which may be combined with any other example, or portion thereof, described herein, an outbreak management method includes storing, in a memory device, (i) case rules each specifying at least one condition for satisfying the respective case rule, and (ii) a graph database structure for disease outbreak tracking, the graph database structure configured, for a given host, such that when a host node is created, the host node is associated with host parameters, when an episode node is connected to the host node via a 'case' link, the episode node is associated with episode parameters that are related to a disease classification of the host, and when a rule node is connected to the episode node via a 'found' link, the rule node is associated with a case workflow, an assignment, and a notification. The method also includes receiving, in an outbreak management server, patient data related to the host, storing, via the outbreak management server, at least some of the received patient data to the graph database at one or more parameters of at least one of the host node or the episode node based on contents of the at least some of the received patient data matching parameter definitions of the respective node, comparing, via the outbreak management server, parameters of the host node and the episode node to the conditions of the case rules, and for a case rule having at least one condition that first

matches the parameters of the host node and episode node, creating, via the outbreak management server, a link between the rule node and the episode node, the linkage causing a case workflow of the case rule to be added for the episode node, the episode node to be assigned to an individual or a team, and a notification to be generated regarding association with the case rule.

[0021] In a sixteenth example of the present disclosure, which may be combined with any other example, or portion thereof, described herein, the case rules are arranged in an order or hierarchy, and the method further comprises sequentially comparing, via the outbreak management server, the one or more conditions of each of the case rules to the parameters of the host node and episode node until there is a match to one case rule.

[0022] In a seventeenth example of the present disclosure, which may be combined with any other example, or portion thereof, described herein, the case workflow defines a sequence of steps specified by objects for obtaining documentation related to the case of the episode node or managing a disease associated with the episode node.

[0023] In an eighteenth example of the present disclosure, which may be combined with any other example, or portion thereof, described herein, the method further comprises using, via the outbreak management server, the assignment of the case rule to create a leakage between the episode node and a node of an individual or a team via an 'assigned' link.

[0024] In a nineteenth example of the present disclosure, which may be combined with any other example, or portion thereof, described herein, the notification identifies one or more individuals or organizations that should receive a message indicative of the case rule being satisfied for the host node and the episode node, and the case rule includes guidance information for treating the case, the guidance information being included within the message that is related to the notification.

[0025] In a twentieth example of the present disclosure, which may be combined with any other example, or portion thereof, described herein, the method further includes connecting, via the outbreak management server, an outbreak node to the episode node via a 'part of' link to indicate that the host has become part of an outbreak of the disease when a result of the workflow is indicative that the case is associated with the outbreak. The outbreak node is connected to a definition node via a 'defined as' link, the definition node specifying disease parameters of the disease that are related to the outbreak node.

[0026] In accordance with a twenty-first example of the present disclosure, any of the structure and functionality illustrated and described in connection with FIGS. 1 to 32 may be used

in combination with any of the structure and functionality illustrated and described in connection with any of the other of FIGS. 1 to 32 and with any one or more of the preceding examples.

[0027] In light of the examples above and the disclosure herein, it is accordingly an advantage of the present disclosure to provide graph database with case rules that define workflows, assignments, and notifications that are added to each case.

[0028] It is another advantage of the present disclosure to provide a system that creates graph databases according to a predefined data structure to enable a source of an outbreak to be determined using one or more care or cluster rules.

[0029] It is further advantage of the present disclosure to provide a system that creates graph databases according to a predefined data structure to identify potential or susceptible individuals to an outbreak.

[0030] Additional features and advantages are described in, and will be apparent from, the following Detailed Description and the Figures. The features and advantages described herein are not all-inclusive and, in particular, many additional features and advantages will be apparent to one of ordinary skill in the art in view of the figures and description. Also, any particular embodiment does not have to have all of the advantages listed herein and it is expressly contemplated to claim individual advantageous embodiments separately. Moreover, it should be noted that the language used in the specification has been selected principally for readability and instructional purposes, and not to limit the scope of the inventive subject matter.

BRIEF DESCRIPTION OF THE FIGURES

[0031] Figs. 1 to 3 show example embodiments of an example outbreak tracking and management system including an outbreak management server, according to example embodiments of the present disclosure.

[0032] Fig. 4 shows a diagram of the outbreak management server of Figs. 1 to 3, according to an example embodiment of the present disclosure.

[0033] Fig. 5 shows a diagram of an example patient electronic medical record, according to an example embodiment of the present disclosure.

[0034] Figs. 6 and 7 show diagrams of graphical representations of outbreak conditions, according to example embodiments of the present disclosure.