[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 analyze the graph database to provide for outbreak management and outbreak predictions. 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 enables information to automatically be incorporated into the graph database. Further, the definitions and relationships enable an origin of an outbreak to be located for identifying a cause and potential solutions for an outbreak.

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

a node processor; and

a memory device storing machine-readable instructions, which when executed by the node processor, cause the node processor to:

receive, via an interface, patient data related to patients,

create an outbreak tracking graph database by:

comparing the patient data to disease parameters of different diseases, the disease parameters specifying conditions for a 'possible' classification for the respective disease, a 'probable' classification for the respective disease, and a 'confirmed' classification for the respective disease, and

for each patient in which at least one of the 'possible', 'probable', and 'confirmed' classification is determined for one of the diseases, add the patient to the outbreak tracking graph database that is associated with an outbreak of the determined disease by

creating a host node for the patient,

creating an episode node that is connected to the host node via a 'case' link, the episode node being associated with episode parameters that are related to the 'possible', 'probable', or 'confirmed' disease classification of the host, and

creating an outbreak node that is connected to the episode node via a 'part of' link to indicate that the host has become part of the outbreak for the determined disease, the outbreak node being connected to a definition node via a 'defined as' link, the definition node specifying the disease parameters of the disease that is related to the outbreak node, and

analyze, via a database analyzer, the outbreak tracking graph database that is associated with the outbreak of the determined disease to display for identification at least one of (i) an index patient as a possible source of the outbreak or (ii) relationships among the patients.

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

a memory device storing instructions therein, the instructions defining a graph database 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, the disease classification including one of a 'possible' classification, a 'probable' classification, or a 'confirmed' classification for a disease for the host, and

an outbreak node is connected to the episode node via a 'part of' link to indicate that the host has become part of an outbreak of the disease, the outbreak node being connected to a definition node via a 'defined as' link, the definition node specifying disease parameters of the disease that is related to the outbreak node; and

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, the episode node, or the outbreak node based on contents of the at least some of the received patient data matching parameter definitions of the respective node,

wherein the server is 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.

[0006] Aspects of the subject matter described herein may be useful alone or in combination with one or more other aspect described herein. Without limiting the foregoing description, in a first ~~aspect~~ example of the present disclosure, an outbreak management server apparatus includes a node processor; and a memory device storing machine-readable instructions, which when executed by the node processor, cause the node processor to: receive, via an interface, patient data related to patients, create an outbreak tracking graph database. The node processor creates the outbreak tracking graph database by comparing the patient data to disease parameters of different diseases, the disease parameters specifying conditions for a 'possible' classification for the respective disease, a 'probable' classification for the respective disease, and a 'confirmed' classification for the respective disease. For each patient in which at least one of the 'possible', 'probable', and 'confirmed' classification is determined for one of the diseases, the node processor adds the patient to the graph database that

is associated with an outbreak of the determined disease by creating a host node for the patient, creating an episode node that is connected to the host node via a 'case' link, the episode node being associated with episode parameters that are related to the disease classification of the host, and creating an outbreak node that is connected to the episode node via a 'part of' link to indicate that the host has become part of the outbreak for the determined disease, the outbreak node being connected to a definition node via a 'defined as' link, the definition node specifying the disease parameters of the disease that is related to the outbreak node, and analyze, via a database analyzer, the graph database that is associated with the outbreak of the determined disease to display for identification at least one of an index patient or relationships among the patients.

[0007] In accordance with a second example ~~aspect~~ of the present disclosure, which may be used in combination with any other aspect listed herein unless stated otherwise, the node processor is configured to use at least a portion of the patient data to create epidemiological links between at least some of the host nodes that are linked to the same outbreak node.

[0008] In accordance with a third example ~~aspect~~ of the present disclosure, which may be used in combination with any other aspect listed herein unless stated otherwise, the database analyzer is configured to receive a request, from a user device, to view relationships of a designated host that is associated with a particular disease that is specified by a related outbreak node, determine epidemiological links between the designated host and at least one of (i) other hosts that are connected to the same related outbreak node, or (ii) persons that have been in a same location at the same time as the host, and cause a user interface to be displayed on the user device that graphically shows the designated host connected to the other hosts to show potential contacts that are at risk of contacting the particular disease that is associated with the host.

[0009] In accordance with a fourth example ~~aspect~~ of the present disclosure, which may be used in combination with any other aspect listed herein unless stated otherwise, the node processor is configured to determine the 'possible', 'probable', or 'confirmed' classification for at least some of the other hosts, and the database analyzer is configured to provide a graphical indication of the 'possible', 'probable', or 'confirmed' classification in the user interface for the at least some of the other hosts.

[0010] In accordance with a fifth example ~~aspect~~ of the present disclosure, which may be used in combination with any other aspect listed herein unless stated otherwise, the epidemiological

links include at least one of an ‘airborne’ link, an ‘animal reservoir’ link, an ‘environmental reservoir’ link, a ‘food and drinking water’ link, an ‘insect bite’ link, an ‘animal-to-person contact’ link, a ‘contaminated object’ link, a ‘droplet spread’ link, or a ‘person-to-person contact’ link, and each of the other hosts are at least one of a patient, a clinician, a person, an animal, a fomite, or an object.

[0011] In accordance with a sixth example ~~aspect~~ of the present disclosure, which may be used in combination with any other aspect listed herein unless stated otherwise, the node processor is configured to, for each host node in which specimen data is available within the patient data for the respective patient create a specimen node that is linked to the respective host node via a specimen link, the specimen node being associated with specimen parameters that indicate a time or status of a specimen acquired from the patient, create an isolate node that is linked to the specimen node via an isolate link, the isolate node being associated with isolate parameters that specify an isolate in specimen results that are related to the acquired specimen, and create an organism node that is linked to the isolate node via an organism link, the organism node being associated with organism parameters that specify at least one organism that was found in an isolation routine.

[0012] In accordance with a seventh example ~~aspect~~ of the present disclosure, which may be used in combination with any other aspect listed herein unless stated otherwise, the node processor is configured to determine, as a first set of hosts, hosts that have the same organism specified in the respective organism parameter of the organism node, determine as a second set of hosts from the first set of hosts, hosts that are linked to the same outbreak node, and display a graphical representation that shows connections between the organism node and the outbreak node for the second set of hosts to show a spread of the disease and a biologic that is responsible for the outbreak of the disease.

[0013] In accordance with an eighth example ~~aspect~~ of the present disclosure, which may be used in combination with any other aspect listed herein unless stated otherwise, the node processor is configured to, for each host node in which location data is available within the patient data for the respective patient create a stay node that is linked to the respective host node via a stayed link, the stay node being associated with stay parameters that specify a date/time that the host node was in a particular location, and create a location node that is linked to the stay node via an

'in' link, the location node being associated with location parameters that specify the particular location.

[0014] In accordance with a ninth example ~~aspect~~ of the present disclosure, which may be used in combination with any other aspect listed herein unless stated otherwise, the particular location includes at least one of a hospital bed identifier or node, a room identifier or node, a corridor identifier or node, a ward identifier or node, a level identifier or node, a wing identifier or node, a hospital identifier or node, a structure identifier or node, a building identifier or node, a street identifier or node, a site identifier or node, an area identifier or node, a state identifier or node, a country identifier or node, or GPS coordinates.

[0015] In accordance with a tenth example ~~aspect~~ of the present disclosure, which may be used in combination with any other aspect listed herein unless stated otherwise, the interface is configured to receive the patient data from at least one of an Electronic Medical Record ("EMR") server or a third-party server, and wherein the patient data includes at least one of patient medical data, social media data, location data, or demographic data.

[0016] In accordance with an eleventh example ~~aspect~~ of the present disclosure, which may be used in combination with any other aspect listed herein unless stated otherwise, an outbreak management system comprises a memory device storing instructions therein, the instructions defining a graph database 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 an outbreak node is connected to the episode node via a 'part of' link to indicate that the host has become part of an outbreak of the disease, the outbreak node being connected to a definition node via a 'defined as' link, the definition node specifying disease parameters of the disease that is related to the outbreak node. The system 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, the episode node, or the outbreak node based on contents of the at least some of the received patient data matching parameter definitions of the respective node.

[0017] In accordance with a twelfth example ~~aspect~~ of the present disclosure, which may be used in combination with any other aspect listed herein unless stated otherwise, the server is

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.

[0018] In accordance with a thirteenth example ~~aspect~~ of the present disclosure, which may be used in combination with any other aspect listed herein unless stated otherwise, 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.

[0019] In accordance with a fourteenth example ~~aspect~~ of the present disclosure, which may be used in combination with any other aspect listed herein unless stated otherwise, the episode parameters include at least one 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.

[0020] In accordance with a fifteenth example ~~aspect~~ of the present disclosure, which may be used in combination with any other aspect listed herein unless stated otherwise, 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 the 'suspected' classification, criteria for determining the 'probable' classification, and criteria for determining the 'confirmed' classification.

[0021] In accordance with a sixteenth example ~~aspect~~ of the present disclosure, which may be used in combination with any other aspect listed herein unless stated otherwise, the server is configured to determine a case classification for the episode node for the host node by comparing at least some of the patient parameters to the criteria for determining the 'suspected', 'probable', and 'confirmed' classifications in the disease parameters, and store at the respective episode parameter of the episode node at least one of the 'suspected', 'probable', or 'confirmed' classification for the disease based on the comparison.

[0022] In accordance with a seventeenth example ~~aspect~~ of the present disclosure, which may be used in combination with any other aspect listed herein unless stated otherwise, the server is configured to generate the case number for the respective episode parameter of the episode node after determining the 'confirmed' or 'probable' classification for the host.

[0023] In accordance with an eighteenth example ~~aspect~~ of the present disclosure, which may be used in combination with any other aspect listed herein unless stated otherwise, the instructions specify for the given host that a role node is connected to the episode node via a role link, the role node being associated with role parameters that specify whether the host is a patient, a clinician, a family member, or an individual.

[0024] In accordance with a nineteenth example ~~aspect~~ of the present disclosure, which may be used in combination with any other aspect listed herein unless stated otherwise, the instructions specify for the given host that a symptom node is connected to the host node via a 'has symptom' link, the symptom node being associated with one or more symptom parameters that specify at least one of a start date of a symptom, an end date of a symptom, and a symptom identifier corresponding to a symptom experienced by the host.

[0025] In accordance with a twentieth example ~~aspect~~ of the present disclosure, which may be used in combination with any other aspect listed herein unless stated otherwise, the instructions specify for the given host that the host node is connected to another host node via an epidemiological link, and the epidemiological link includes at least one of an 'airborne' link, an 'animal reservoir' link, an 'environmental reservoir' link, a 'food and drinking water' link, an 'insect bite' link, an 'animal-to-person contact' link, a 'contaminated object' link, a 'droplet spread' link, or a 'person-to-person contact' link.

[0026] In accordance with a twenty-first example ~~aspect~~ of the present disclosure, any of the structure and functionality illustrated and described in connection with FIGS. 1 to 20 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 20 and with any one or more of the preceding aspects.

[0027] In light of the aspects above and the disclosure herein, it is accordingly an advantage of the present disclosure to provide graph database that provides for the tracking and management of outbreaks.

CLAIMS

1. An outbreak management server apparatus comprising:

a node processor; and

a memory device storing machine-readable instructions, which when executed by the node processor, cause the node processor to:

receive, via an interface, patient data related to patients,

create an outbreak tracking graph database by:

comparing the patient data to disease parameters of different diseases, the disease parameters specifying conditions for a 'possible' classification for the respective disease, a 'probable' classification for the respective disease, and a 'confirmed' classification for the respective disease, and

for each patient in which at least one of the 'possible', 'probable', and 'confirmed' classification is determined for one of the diseases, add the patient to the outbreak tracking graph database that is associated with an outbreak of the determined disease by

creating a host node for the patient,

creating an episode node that is connected to the host node via a 'case' link, the episode node being associated with episode parameters that are related to the 'possible', 'probable', or 'confirmed' disease classification of the host, and

creating an outbreak node that is connected to the episode node via a 'part of' link to indicate that the host has become part of the outbreak for the determined disease, the outbreak node being connected to a definition node via a 'defined as' link, the definition node specifying the disease parameters of the disease that is related to the outbreak node, and

analyze, via a database analyzer, the outbreak tracking graph database that is associated with the outbreak of the determined disease to display for identification at least one of (i) an index patient as a possible source of the outbreak or (ii) relationships among the patients.

2. The apparatus of Claim 1, wherein the instructions further cause the node processor ~~is configured~~ to use at least a portion of the patient data to create epidemiological links between at least some of the host nodes that are linked to the same outbreak node.

3. The apparatus of Claim 2, wherein the instructions further cause the node processor, via the database analyzer, to:

receive a request, from a user device, to view relationships of a designated host that is associated with a particular disease that is specified by a related outbreak node;

determine epidemiological links between the designated host and at least one of (i) other hosts that are connected to the same related outbreak node, or (ii) persons that have been in a same location at the same time as the host; and

cause a user interface to be displayed on the user device that graphically shows the designated host connected to the other hosts to show potential contacts that are at risk of contacting the particular disease that is associated with the host.

4. The apparatus of Claim 3, wherein the instructions further cause the node processor to determine the 'possible', 'probable', or 'confirmed' classification for at least some of the other hosts; and

wherein the instructions further cause the node processor, via the database analyzer, to provide a graphical indication of the 'possible', 'probable', or 'confirmed' classification in the user interface for the at least some of the other hosts.

5. The apparatus of Claim 3, wherein the epidemiological links include at least one of an 'airborne' link, an 'animal reservoir' link, an 'environmental reservoir' link, a 'food and drinking water' link, an 'insect bite' link, an 'animal-to-person contact' link, a 'contaminated object' link, a 'droplet spread' link, or a 'person-to-person contact' link, and

wherein each of the other hosts are at least one of a patient, a clinician, a person, an animal, a fomite, or an object.

6. The apparatus of Claim 1, wherein the instructions further cause the node processor to, for each host node in which specimen data is available within the patient data for the respective patient:

create a specimen node that is linked to the respective host node via a specimen link, the specimen node being associated with specimen parameters that indicate a time or status of a specimen acquired from the patient;

create an isolate node that is linked to the specimen node via an isolate link, the isolate node being associated with isolate parameters that specify an isolate in specimen results that are related to the acquired specimen; and

create an organism node that is linked to the isolate node via an organism link, the organism node being associated with organism parameters that specify at least one organism that was found in an isolation routine.

7. The apparatus of Claim 6, wherein the instructions further cause the node processor to:

determine, as a first set of hosts, hosts that have the same organism specified in the respective organism parameter of the organism node;

determine as a second set of hosts from the first set of hosts, hosts that are linked to the same outbreak node; and

display a graphical representation that shows connections between the organism node and the outbreak node for the second set of hosts to show a spread of the disease and a biologic that is responsible for the outbreak of the disease.

8. The apparatus of Claim 1, wherein the instructions further cause the node processor to, for each host node in which location data is available within the patient data for the respective patient:

create a stay node that is linked to the respective host node via a stayed link, the stay node being associated with stay parameters that specify a date/time that the host node was in a particular location; and

create a location node that is linked to the stay node via an ‘in’ link, the location node being associated with location parameters that specify the particular location.

9. The apparatus of Claim 8, wherein the particular location includes at least one of a hospital bed identifier or node, a room identifier or node, a corridor identifier or node, a ward identifier or node, a level identifier or node, a wing identifier or node, a hospital identifier or node, a structure identifier or node, a building identifier or node, a street identifier or node, a site identifier or node, an area identifier or node, a state identifier or node, a country identifier or node, or GPS coordinates.

10. The apparatus of Claim 1, wherein the interface is configured to receive the patient data from at least one of an Electronic Medical Record ("EMR") server or a third-party server, and wherein the patient data includes at least one of patient medical data, social media data, location data, or demographic data.

11. An outbreak management system comprising:

a memory device storing instructions therein, the instructions defining a graph database 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, the disease classification including one of a 'possible' classification, a 'probable' classification, or a 'confirmed' classification for a disease for the host, and

an outbreak node is connected to the episode node via a 'part of' link to indicate that the host has become part of an outbreak of the disease, the outbreak node being connected to a definition node via a 'defined as' link, the definition node specifying disease parameters of the disease that is related to the outbreak node; and

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, the episode node, or the outbreak node based on contents of the at least some of the received patient data matching parameter definitions of the respective node,

wherein the server is 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.

12. The system of Claim 11, wherein 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.

13. The system of Claims 11 or 12, wherein the episode parameters include at least one 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.

14. The system of Claim 13, wherein 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 the 'suspected' classification, criteria for determining the 'probable' classification, and criteria for determining the 'confirmed' classification.

15. The system of Claim 14, wherein the server is configured to:

determine a case classification for the episode node for the host node by comparing at least some of the patient parameters to the criteria for determining the 'suspected', 'probable', and 'confirmed' classifications in the disease parameters; and

store at the respective episode parameter of the episode node at least one of the 'suspected', 'probable', or 'confirmed' classification for the disease based on the comparison.

16. The system of Claim 15, wherein the server is configured to generate the case number for the respective episode parameter of the episode node after determining the 'confirmed' or 'probable' classification for the host.

17. The system of Claims 11, 12, or 16, wherein the instructions specify for the given host that a role node is connected to the episode node via a role link, the role node being associated with role parameters that specify whether the host is a patient, a clinician, a family member, or an individual.

18. The system of Claims 11 or 17, wherein the instructions specify for the given host that a symptom node is connected to the host node via a ‘has symptom’ link, the symptom node being associated with one or more symptom parameters that specify at least one of a start date of a symptom, an end date of a symptom, and a symptom identifier corresponding to a symptom experienced by the host.

19. The system of Claims 11 or 18, wherein the instructions specify for the given host that the host node is connected to another host node via an epidemiological link, and

wherein the epidemiological link includes at least one of an ‘airborne’ link, an ‘animal reservoir’ link, an ‘environmental reservoir’ link, a ‘food and drinking water’ link, an ‘insect bite’ link, an ‘animal-to-person contact’ link, a ‘contaminated object’ link, a ‘droplet spread’ link, or a ‘person-to-person contact’ link.