



US 20110313789A1

(19) **United States**(12) **Patent Application Publication**
Kamen et al.(10) **Pub. No.: US 2011/0313789 A1**(43) **Pub. Date: Dec. 22, 2011**(54) **ELECTRONIC PATIENT MONITORING
SYSTEM**(52) **U.S. Cl. 705/3**(75) **Inventors:** **Dean Kamen**, Bedford, NH (US);
Marc J. Gorayeb, Hampton, NH
(US); **David Blumberg, JR.**,
Manchester, NH (US)(57) **ABSTRACT**

An electronic patient monitoring system comprising a monitoring client module configured to receive real time data from monitoring devices connected to a patient, and historical information pertaining to the patient's physical characteristics, past medical history, current medications, drug allergies, among other information; the monitoring client capable of processing this information to determine whether a treatment ordered by a health care provider is appropriate under the circumstances. The monitoring client module may communicate with a communications module having a user interface, through which orders, such as medication orders, may be entered and transmitted to the monitoring client module. The monitoring client module, in turn, may transmit warnings or recommendations to the communications module for review by the provider. The original order may be confirmed by the provider, or a modified order may be entered in the communications module, which may then be transmitted to the monitoring client module for further processing of the order.

(73) **Assignee:** **DEKA Products Limited
Partnership**, Manchester, NH (US)(21) **Appl. No.: 13/011,543**(22) **Filed: Jan. 21, 2011****Related U.S. Application Data**(60) Provisional application No. 61/297,544, filed on Jan.
22, 2010.**Publication Classification**(51) **Int. Cl.**
G06Q 50/00 (2006.01)

2:51 PM

☒ Arterburn, A Room 308

WARNING:

Medication Database

Nitroglycerin and Zanaflex

(1 of 2) Clinically Significant Adverse
table: hypotension, liver injury and seda-
tion...

(2 of 2) Additive hypotensive effect:
Zanaflex (tizanidine) 4mg, four times a day

RECOMMENDATION

Decrease rate 50% from 5 mcg/minute to:

Change to 2.5 mcg/minute PDR

Manually adjust dose

Add note

32

33

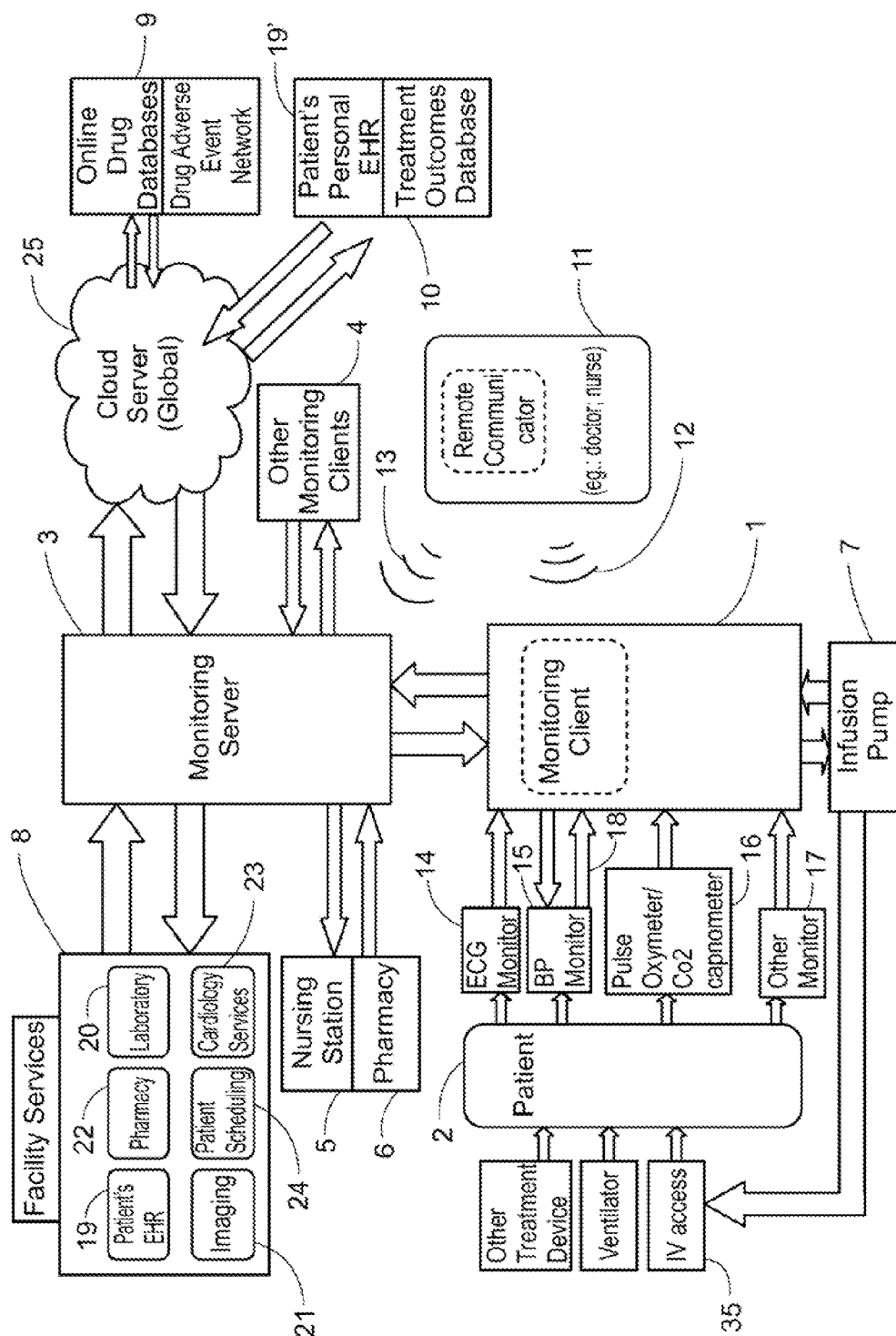


FIG. 1

11

2:51 PM	
☒ Patient List	General Hospital
	Adams, M 72/M Account: A0015077 Pneumonia
	 Arterburn, A 60/F Account: A0001875 Acute Coronary Syndrome
	Holcomb, V 45/F Account: H00858183 Acute Renal Failure
	Ignatoski, M 36/M Account: I00058533 Diverticulitis
	★ Jones, A

26

27

FIG. 2

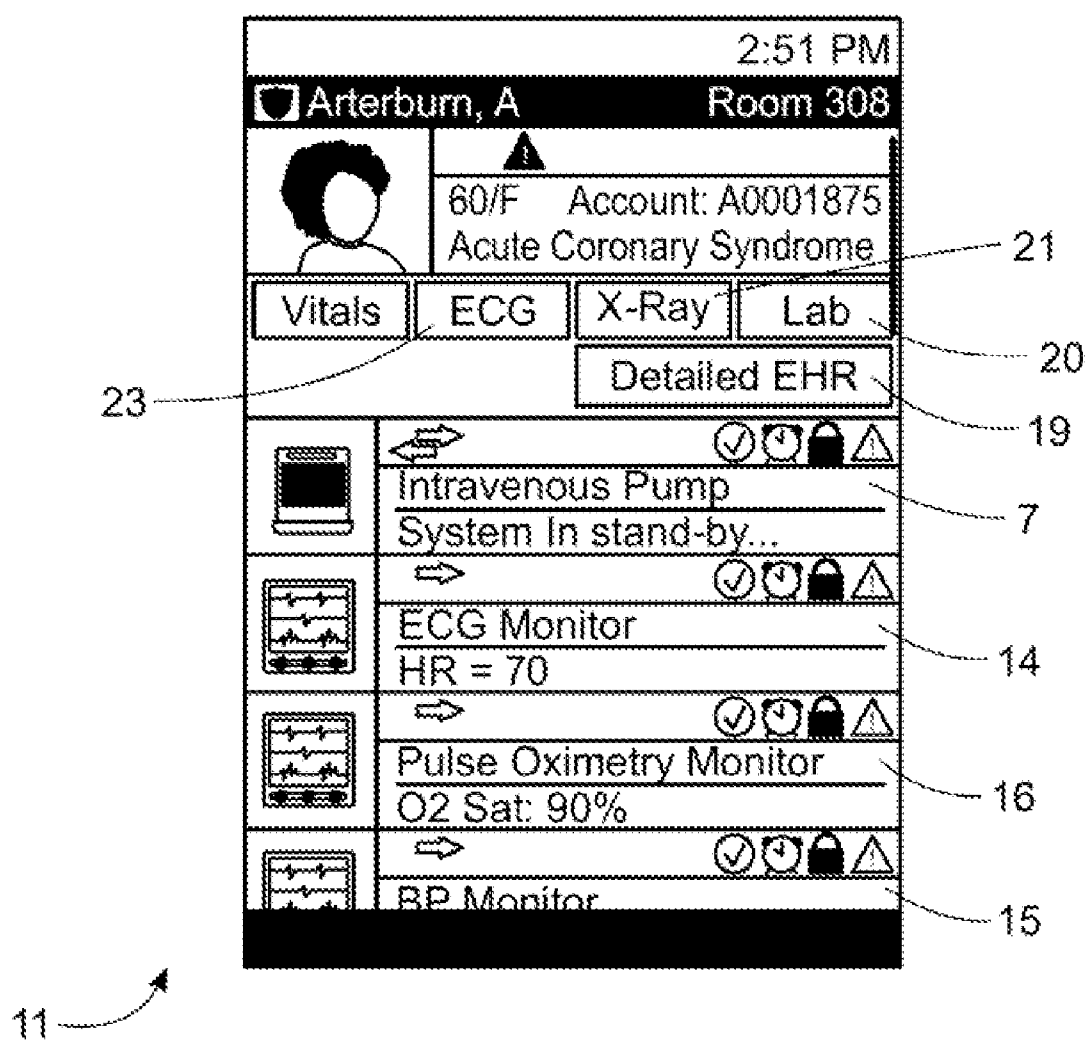
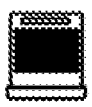


FIG. 3

2:51 PM

☒ Arterburn, A Room 308

  60/F Account: A0001875
Acute Coronary Syndrome

     
Intravenous Pump
System In stand-by...

Nitroglycerin: IV **PDR**

Usual range: 5-10 mcg/minute

5-10 mcg/minute dose

NS type 100 cc/hr fluid rate

Submit Prescription

11

FIG. 4

2:51 PM

☒ Arterburn, A Room 308

WARNING:

Medication Database

Nitroglycerin and Zanaflex
(1 of 2) Clinically Significant Adverse
table: hypotension, liver injury and seda-
tion...

32

(2 of 2) Additive hypotensive effect:
Zanaflex (tizanidine) 4mg, four times a day

RECOMMENDATION

Decrease rate 50% from 5 mcg/minute to:

33

Change to 2.5 mcg/minute

PDR

Manually adjust dose

Add note

FIG. 5

2:51 PM

☒ Arterburn, A Room 308

 60/F Account: A0001875
Acute Coronary Syndrome

     
Intravenous Pump
System In stand-by...

Nitroglycerin: IV **PDR**

Usual range: 5-10 mcg/minute

dose

type fluid rate

Corrective Actions

CAR-040539 Jan. 22, 2012 14:51
Nitroglycerin and Zanaflex

11

33

34

FIG. 6

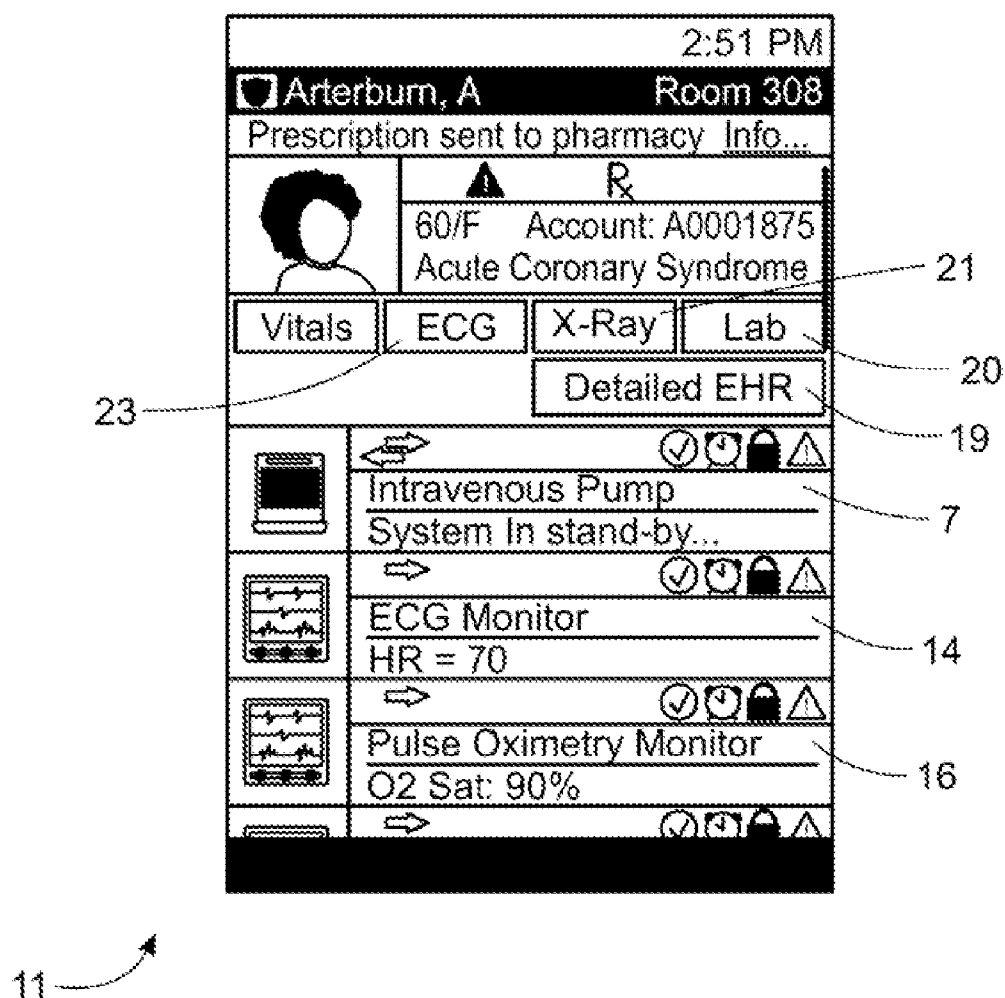


FIG. 7

ELECTRONIC PATIENT MONITORING SYSTEM

BACKGROUND

[0001] The present invention relates to systems and methods to provide electronic intermediation among medical devices delivering treatments to patients, medical devices monitoring parameters associated with those patients, and health care providers who order, process or initiate those treatments. An object of the invention is to reduce the incidence of medical treatment errors, and to improve the efficiency of tracking a patient's course of treatment.

[0002] Despite the existence of systems incorporating electronic medical records ("EMR"), and computerized provider order entry ("CPOE"), the process of ordering and delivering medical treatments still has the potential to cause critical information to be miscommunicated, to allow treatment decisions to be made without ready access to complete information, and to delay implementation of treatment orders due to unnecessarily redundant and inefficient procedures. An approach to dealing with this problem is illustrated herein by using medication ordering as an example. It should be noted, however, that the invention as described herein can be applied to other treatment or diagnostic decisions involving the care of a patient.

[0003] Medication errors may be responsible for over 300 deaths and may injure over one million people each year in the United States. Hospitals under financial stress may experience an increased incidence of medication errors. Medications associated with the most dangerous errors include insulin, narcotics, heparin and chemotherapy. Sources of error include administering the wrong drug, the wrong concentration of drug, at the wrong rate, or via the wrong route (medications can be administered orally, intravenously, intramuscularly, subcutaneously, rectally, topically to the skin, eye or ear, intrathecally, intraperitoneally or even intravesically). Even with proper orders and proper labeling, medications still can be administered improperly because of illegible handwriting, miscommunication of orders, and mispronunciation of drugs having similar names. The trend toward the use of electronic medical records (EMR), and bar coding systems for medications has been shown to reduce the incidence of medication errors. EMR systems, for example, can facilitate computerized provider order entry (CPOE), and flag orders for drugs that do not match a patient's characteristics such as diagnosis, allergies, weight or age. However, these systems have not been widely adopted, and their implementation can result in significant delays and inefficiencies in ordering, preparing and administering medications.

[0004] It has been estimated that medication infusion devices are involved in up to one third of all medication errors that result in significant harm. The wrong drug may be hung, incorrect parameters (e.g. drug concentration or rate of infusion) may be entered, or existing infusion parameters may be improperly changed. Of infusion pump-related deaths, nearly half may be due to user error, and most of these may be due to errors in programming the infusion device.

[0005] An effective Monitoring system should monitor and intercede at any phase of the medication ordering and administration process to help minimize any of a number of adverse events that could result from the treatment. The medication treatment process conceptually can be separated into three phases: a prescription phase, a medication preparation phase, and an administration phase. Errors can occur when a pre-

scription is written or entered, when a drug is retrieved for use or mixed in solution, or when it is administered to the patient. It would be particularly desirable for a monitoring system to not significantly impair the efficiency with which medications are ordered, prepared or administered, and preferably to actually reduce the time required to perform those activities by collecting, organizing and presenting relevant real-time information to the user.

SUMMARY

[0006] In an exemplary embodiment involving the ordering and administration of medications, the Electronic Patient Monitoring system may comprise a first data-gathering module (e.g., a Monitoring Client) and a second order-input module (e.g. a fixed or portable communications device) having a user interface for transmitting an order or receiving patient-related information. The first module may be configured to receive and store measured parameters pertaining to a patient's current condition, such as blood pressure, heart rate, heart rhythm, temperature, oxygenation, respiratory rate, or ventilation, for example. The first module may also be configured to receive information about pre-existing parameters related to the patient from a first database (e.g. an EHR database containing information about the patient), including drug allergies or sensitivities, other currently administered drugs, age, weight, height, kidney or liver function, for example. The first module may also be configured to obtain medication information about the ordered medication and/or pre-existing drugs from a second database (e.g. a drug information database), such as known drug interactions, effects of the medication or pre-existing drugs on blood pressure, pulse, heart rhythm, or respirations, for example. The first module can be configured to compare the patient's currently measured parameters and received pre-existing parameters with known normal ranges, and create a table of patient parameters found to be outside the normal ranges. The first module may then compare the table of patient parameters with a table of corresponding parameters obtained from the drug information database. If a match is found to exist between the table of patient parameters and the table of corresponding parameters, the first module may then retrieve one or more pre-entered and stored messages for transmission to the second (order input) module. These messages may include, for example, warnings to a user of the second module that are appropriate for the particular medication ordered, the patient's pre-existing drugs, and the patient's current and pre-existing medical condition. Optionally, further repetitions of warnings may be avoided once a warning has been received by the second module, and the warning has been acknowledged by the user of the second module through an input signal from the user interface.

[0007] In other embodiments, the Electronic Patient Monitoring system may provide the user with editable default values derived from standard dosing and administration guidelines obtained from the drug information database, and can alert the user to modifications that may be indicated based on the patient's current and pre-existing medical condition, allergies or other existing drugs. The Monitoring system preferably minimizes the amount of typed input required of a user.

[0008] In other embodiments, the first module or other modules of the Electronic Patient Monitoring system may also be used to identify ordered medications to be delivered to the patient's bedside (through the use of, for example, bar codes and readers or RFID tags and scanners), and verify that

the appropriate medication and dosage are being prepared and delivered to the patient. In an embodiment, the first module may also interact either in a hard-wired or wireless fashion with a device that administers treatment, such as a solution/medication infusion pump. In the case of an infusion pump, the first module or another connected module may provide the pump with infusion settings such as flow rate or infusion pressure, and receive from it various state parameters such as, for example, the presence of air in the infusion line, the amount of solution remaining in an IV bag to which it is connected, or the pressure of fluid in the infusion line. If the parameters are found to be abnormal, the first module may be configured to respond by signaling the pump to halt infusion, alter the rate of infusion, and/or alert a health care provider or others of the abnormality, either directly through an alarm incorporated in the first module, or by transmission of an alarm to the second module. In a further embodiment, the first module may also be configured to communicate with various medical devices used to monitor a patient's condition, such as, for example, blood pressure monitors, ECG monitors, pulse oximetry monitors, temperature monitors, and the like. In some cases, the first module can be programmed to emit an alert to the patient or other persons if the monitored parameters fall outside a pre-determined range. In some embodiments, the first module can transmit a signal to a monitoring device to conduct an unscheduled measurement by the device. The first module may communicate with various health care providers at various locations, and in an embodiment may be able to notify the patient to whom it is assigned of an abnormality, and recommend corrective action through, for example an audible alert or recorded message.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 is a schematic representation of an exemplary Electronic Patient Monitoring system, showing paths of communication among system components.

[0010] FIG. 2 is an illustration of a display screen on a health care provider's portable communications device, showing a list of patients whose information the provider can access.

[0011] FIG. 3 is an illustration of a display screen on a health care provider's portable communications device, showing devices associated with a particular patient, with current data from the devices and one-touch access to some of the patient's medical information.

[0012] FIG. 4 is an illustration of a display screen on a health care provider's portable communications device, showing data entry fields for a prescription for a medication for use with an intravenous infusion pump.

[0013] FIG. 5 is an illustration of a display screen on a health care provider's portable communications device, showing a risk profile associated with an ordered medication, and a suggested course of action, as generated by the Monitoring.

[0014] FIG. 6 is an illustration of a display screen on a health care provider's portable communications device, showing a medication prescription ready for submission by the ordering provider.

[0015] FIG. 7 is an illustration of a display screen on a health care provider's portable communications device,

showing how the Monitoring system can display confirmation to the ordering provider that the prescription has been transmitted to the pharmacist.

DETAILED DESCRIPTION

[0016] As shown in FIG. 1, components of the Electronic Patient Monitoring System may include one or more Monitoring Clients 1,4, each of which may be assigned and in physical proximity to an individual patient 2, and a more remote Monitoring Server 3 for the uploading of information from a number of Monitoring Clients 1,4, and for downloading information and instructions from various sources to the Monitoring Clients 1,4. When in the patient's room, a health care provider can interact directly with a Monitoring Client 1 to obtain information about the patient 2 or to enter orders pertaining to the patient 2. Alternatively, providers at remote locations (e.g., doctor's office, nursing station 5, hospital pharmacy 6) may interact with an individual Monitoring Client 1 through a communications link with the Monitoring Server 3, or directly via a hospital local area network having each Monitoring Client 1,4 as a node.

[0017] In an embodiment, each Monitoring Client 1 is assigned to a specific patient 2, and can be a desk-based, portable or hand-held controller with display and user input capability. Preferably, it is portable and allows for efficient data viewing and data entry, such as a notebook PC, netbook PC, tablet PC, or even a 'smart-phone,' with or without touch screen capability. The designation of a particular Monitoring Client 1 to a particular patient 2 may be made using any of a number of methods, including (but not limited to) a unique patient identifier using a bar coded or RFID tag-embedded wrist band, for example. The Monitoring Client 1 may include one or more microprocessors to send and receive information relevant to the patient's care or condition. In some embodiments, the Monitoring Client 1 may be physically associated with a medical infusion pump 7 either permanently or detachably. This can be accomplished by a docking interface between the two devices. The Monitoring Client 1 can communicate with the pump 7 in a number of ways, including, for example, through electrical contacts in the docking interface, by means of an electrical connector, or wirelessly by means of transceivers on each device. The Monitoring Client 1 can also communicate with other databases in the facility 8, with databases external to the facility 9,10, and with health care providers via portable communications devices 11 (including, for example, physicians, nurses, and pharmacists). This can be accomplished by a wired connection to a facility server through a connector in the patient's room (such as, for example, a Category 5 local area network connector), or wirelessly 12. In one embodiment, access to intra and extra facility databases is mediated 13 through the Monitoring Server 3, which can then centralize the software and application programming interfaces required to communicate with databases having disparate organization, formatting and communications protocols. Thus, in an embodiment, any software updates may be largely limited to the Monitoring Server 3, reducing the maintenance requirements on the individual Monitoring Clients 1,4. Optionally, a Monitoring Client 1 can communicate with medical treatment devices such as infusion pumps 7 to receive information about the progress of treatment, and to provide operational instructions to the treatment device. In another embodiment, the Monitoring Client 1 may also communicate with medical diagnostic or monitoring devices (such as, for

example, an electrocardiographic (ECG) monitor **14**, a blood pressure (BP) monitor **15**, a pulse oximeter or CO₂ capnometer **16**, or other devices such as temperature monitors, etc.) to receive readout information from the devices, and potentially to instruct **18** the devices to take a reading when desired by a provider or by algorithm.

[0018] In an embodiment, the Monitoring Client **1** has the ability to communicate and interact directly with a health care provider using a hand-held or portable communications device **11**. This may be conveniently accomplished wirelessly **12**, so that communications can be maintained regardless of the patient's location in the facility, or the provider's location either within or outside the facility. In one aspect, information specific to the patient **2** can be stored locally in the Monitoring Client **1**, so that the patient's health care provider can access the information directly without having to access the Monitoring Server **3**. By incorporating appropriate safety and security clearances, changes to the settings or flow parameters of a connected infusion pump **7** or monitoring device **14-17** can be accomplished directly between a provider's communications device **11** and the Monitoring Client **1**, with selected changes being also communicated to Monitoring Server **3**, and thence to other appropriate locations, such as the Nursing Station **5**, and/or Pharmacy **6**. Furthermore, any new order pertaining to the patient **2** may be entered in the ordering provider's communications device **11** and transmitted to the Monitoring Client **1**, which in turn can then notify the care giver (e.g. RN) via the care giver's own portable communications device **11**. Preferably, any information acquired and stored in the Monitoring Client **1** is periodically uploaded to the Monitoring Server **3** and stored in a patient-specific database. Thus, if a patient's Monitoring Client **1** needs to be taken out of service, a new device can be assigned to the patient **2** and quickly re-populated with the patient's current information from the Monitoring Server **3**. Orders, medications, progress notes, monitoring and treatment data from the patient's attached devices may also be uploaded from the Monitoring Client **1** to the patient's EHR **19**, **19'** for permanent storage.

[0019] The Monitoring Server **3** may comprise a computer that can communicate with and provide some elements of control for a number of Monitoring Clients **4** in the facility. It may provide a Monitoring Clients **1**, **4** with data extracted from a number of databases both within **8** and outside **9** of the facility. In an embodiment, the Monitoring Server **3** can interrogate the facility's EHR system **19** for targeted information pertaining to a patient **2**, and then populate that patient's Monitoring Client **1** with a pre-defined set of information (such as, for example, the patient's age, height, weight, categories of diagnoses, current medications and medication categories, medication allergies and sensitivities, etc.). The Monitoring Server **3** may establish a link to EHR **19**, Laboratory **20**, Radiology **21**, Pharmacy **22** and other systems (such as, e.g., Cardiology **23** or Scheduling database **24**) in the facility when, for example, a Monitoring Client **1** has been assigned to a patient **2**. With a unique patient identifier, the Monitoring Server **3** can obtain electronic access (permission) to receive and send patient-specific data from and to these systems. A pre-determined (but selectable) subset of the data may be downloadable into the Monitoring Client **1** memory. The information thus acquired can then serve as a key database against which new orders can be analyzed. Orders entered into a Monitoring Client **1** can be checked for compatibility with the patient-specific information obtained

by the Monitoring Server **3**. Optionally, for safety redundancy, orders entered remotely from a portable communications device **11** can be intercepted by the Monitoring Server **3** and similarly can be checked. The Monitoring Server **3** may also obtain information from medication databases residing in the facility's pharmacy **22** or externally **9** to determine whether a new patient order may generate an incompatibility with a patient's existing medications, for example. In an embodiment, the Monitoring Server **3** may be programmed to access publicly available internet sites **25** to determine whether new information pertaining to the patient's ordered medication should be downloaded and transmitted **13** in an alert to the patient's health care provider(s). The Monitoring Server **3** may also route information between remote portable communications devices **11** and a patient's Monitoring Client **1**.

[0020] In an embodiment, the patient's physician, nurse or pharmacist may have access to the patient's Monitoring Client **1** to relay or receive new orders (such as medication orders, for example) pertaining to the patient **2**. The Monitoring Client **1** or Server **3** may then log the new order and relay the request to the pharmacist **6**, and the patient's nurse via the nurse's portable communications device **11** and/or via a fixed terminal at the nursing station **5**. A 'smart phone' having a customized communications application with Monitoring Client **1** (such as, e.g., a Google Nexus One phone or Apple i-phone, among others) may serve as a convenient portable communications device **11** for providers who are not at a fixed location (such as at an office or remote nursing station). A tablet PC, netbook, or laptop computer may also serve as a convenient portable communications device **11** for both portable and fixed locations. A PC may act as a convenient communication device **11** for fixed or desktop locations. If a provider is located in the patient's room, he or she may enter or receive information pertaining to the patient **2** using a direct input through a keyboard or touch screen on the Monitoring Client **1**.

Example of Monitoring-Assisted Order Entry

[0021] The functionality of the Patient Monitoring system can be illustrated by an example in which an ordering provider enters a new medication prescription for a patient. In this scenario, the physician may view his list of admitted patients on his hand-held device after entering the appropriate security pass code. In this example, the physician's patients can be listed as shown in FIG. **2**, with limited and user-selectable information **26** on each patient, such as, for example, age, diagnosis, and medical record number. Alert symbols **27** may be transmitted by the Monitoring Client **1** to the physician's device **11** if, for example, orders for the patient **2** are incomplete, the nurse has flagged the patient for attention, or if the Monitoring Client **1** has received input from a database or a patient monitoring device **14-17** that has exceeded a pre-determined threshold for physician notification.

[0022] After the physician selects a patient for further review, a display such as that shown in FIG. **3** may be transmitted to the physician's device **11**. The physician can view user-selectable data originating from monitors **14-17** to which the patient is connected, and the physician may have one-touch access to a number of databases **19-21**, **23** containing patient-specific information. In an embodiment, the Monitoring Client **1** may be connected or docked to an infusion pump **7** available for use with the patient **2**. In a scenario

illustrated in FIG. 3, the physician can press on the icon representing the infusion pump 7 to order an intravenous medication for the patient 2.

[0023] FIG. 4 shows one of a number of possible prescription ordering screens with which a physician can remotely order a medication. In the example illustrated, the physician enters the drug IV Nitroglycerin 28, which may be entered by typing or via a drop-down screen populated by the hospital pharmacy's formulary 22, accessed by the Monitoring Client 1 via the Monitoring Server 3. The 'PDR' button 29 may represent the physician's one-touch access to an in-hospital 22 or proprietary drug database 9 for detailed drug information. The physician can order the dose of medication, either directly or by accepting a default standard starting dose 30 provided by the Monitoring Client 1 via the Monitoring Server 3. The physician may also specify the maximum fluid infusion rate 31 for the infusion pump 7, in order to assist the pharmacist in preparing the proper concentration of the drug in a bag for infusion.

[0024] FIG. 5 shows an example of how the Patient Monitoring system can detect a risk of an adverse reaction after the physician has entered the prescription. The Monitoring Client 1 can compare the new medication 28 to the patient's existing medications and drug allergy list downloaded from the EHR 19. The Monitoring Server 3 preferably will have populated the appropriate patient-specific data into the Monitoring Client 1, and the Client 1 will be programmed to look up this information after the new medication order has been entered. The Monitoring Client 1 may be programmed to request a listing of significant adverse reactions and drug interactions associated with each of the patient's medications and the new medication 28 from the Monitoring Server 3. The Server 3, in turn can access a pharmacy database 22 or external database 9 for this information. If a potential drug interaction or adverse reaction common to an existing medication and the new medication 28 are detected, the Monitoring Client 1 may issue a warning 32 and transmit it to the ordering physician, as shown in FIG. 5. If the potential adverse reaction is due to an effect common to both the new medication and an existing medication, the Monitoring Client 1 may categorize this as a potentially additive adverse effect and issue a recommendation 33 to reduce the initial drug dose, for example, by 50%.

[0025] As shown in FIG. 6, the ordering physician has the option either to accept the recommendation 33 or edit the recommended dose to another value. In any event, the Monitoring Client 1 may generate and log a report 34 of the warning 32 and any corrective action 33, if any, taken by the physician, with the option for the physician to further edit the report before logging and entry into the patient's EHR 19.

[0026] Once the medication dosing is finally determined, the Monitoring Client 1 can forward the order to the communication devices of both the hospital pharmacist 6 and the patient's nurse 5. A report of the accomplishment of this task may then be transmitted back to the ordering physician 11, as shown in FIG. 7. The pharmacist can use the information provided by the ordering physician to mix an appropriate concentration of the medication in a solution bag. Both the medication vial and the solution bag may have identification tags, such as, e.g., bar code identifiers, that can be read into the pharmacist's communications device 6, and which can be verified as correct by the Monitoring Client 1 (using the pharmacy database 22 as accessed by the Monitoring Server 3). The pharmacist may then generate a unique identification label, such as a bar code label, to be permanently affixed to the

medication bag, the code now being linked uniquely to the patient 2 for whom the medication 28 has been prepared. The identifying code on the label may be transmitted to the Monitoring Client 1 for later reconciliation when the nurse is about to administer the medication 28.

[0027] After the prepared medication 28 arrives to the patient's floor, the nurse can then prepare to administer it to the patient 2. In this exemplary scenario, the Monitoring Client 1 may include an input device such as a bar code reader, which the nurse can use to verify that the identifying code on the medication bag matches the identity of the patient 2 for whom it has been prescribed. If the identification matches the information entered into the Monitoring Client 1 by the pharmacist, the nurse may be cleared by the device 1 to hang the medication bag and initiate the infusion via the infusion pump 7. In an embodiment, the Monitoring Client 1 displays to the nurse the prescription, including the dose, the maximum fluid rate for the patient, the concentration of the drug in the bag, and the infusion rate for the pump (which can optionally be calculated by a processor in the Monitoring Client 1). With this information, the nurse has the ability to manually calculate and verify that the infusion rate set by the Monitoring Client 1 for the pump 7 is correct.

Network Connectivity Among System Components and Devices

[0028] A Monitoring Client device 1 can receive, process, and transmit information about a specific patient 2 to which it has been assigned or designated. The Monitoring Client 1 can most conveniently be attachable or dockable to an infusion pump 7, bed, or other device to which the patient 2 may be connected. The Monitoring Client 1 can be a hand-held device about the size of a wireless phone or tablet-style netbook, for example. Conveniently, it may have a touch-screen interface for use by the patient's provider. It may also be capable of providing output to a larger stationary display screen in the patient's room or at a nursing station 5 or other convenient location, either through a wired or wireless connection. Each Monitoring Client 1 may communicate with a central Monitoring Server 3, through which it can access patient data from the facility's EHR database 19, Laboratory database 20, Radiology database 21, Pharmacy database 22, or other databases in various other facility departments. In some cases, the Monitoring Client 1 can upload information it receives from patient monitoring systems 15-17 or from provider inputs to the patient's EHR 19 via the Monitoring Server 3. Monitoring Clients 1,4 may also receive information from databases outside of the facility through a Monitoring Server 3 having an internet connection 25. Various external databases 9 may thus be accessible, including various drug information databases and alert networks dealing with adverse medication-related events. The Monitoring Server 3 could be arranged, for example, to manage various levels of external database information helpful in keeping the Monitoring Client 1 contents as up-to-date as possible. This can be accomplished, for example, by comparing safety and drug information related to the patient as it becomes available, and prioritizing for updates/downloads on a data transfer schedule. The Monitoring Clients 1,4 may also communicate either directly or through the Monitoring Server 3 with portable communications devices 11 used by health care providers such as nurses, physicians and pharmacists. In some cases, these devices can have wired connections to the Monitoring Server 3 (if used, for example, in fixed locations such as

hospital pharmacies or nursing stations). In other cases, a portable communications device **11** may communicate with the Monitoring Server **3** through VPN-based internet connections using a computer and a wired or wireless (such as, e.g., Bluetooth or WiFi 802.11) connection **13** with the device **11**. Alternatively, a hand-held device **11** (such as a wireless smart-phone or tablet netbook) may communicate directly **12** with the facility's Monitoring Client **1** via a cellular telephone network.

[0029] The communications link between the Monitoring Clients **1,4** and the Monitoring Server **3** may exist via a Category-5 wired network if widely available in the facility, or via wireless transmission using one of a number of standards, linking all the patient-specific Monitoring Clients **1,4** with the central Monitoring Server **3**. The server **3** may then serve as a relay for communications with other facility servers **8**, with web-based servers **25**, and with inside and outside portable communications devices **11** carried by medical care providers. A wireless network provides the additional functionality of being able to communicate with the Monitoring Server **3** no matter where in the facility the patient **2** may be.

[0030] One method of blanketing an entire facility with wireless coverage involves having the facility obtain a license for a private cell-phone network. It may obtain or lease one or more micro-cellular frequencies to provide for a local communications network throughout the facility. This arrangement can preserve communications when patients and their Monitoring Clients **1,4** are moved from one location to another within the facility, maintaining communications with a Monitoring Server **3**, various in-hospital and out-of-hospital databases **8,25**, and users at fixed stations **5,6** or with mobile smart-phone, laptop or tablet-type devices **11** either inside or outside the hospital. An advantage of this type of system is the level of security provided by a licensed cellular communications infrastructure. In addition, an active wireless system can monitor the intensity of use in an area and direct additional channel frequencies to that area as needed. However, the bandwidth capacity of the network may not allow for efficient transmission of large data files, such as those containing radiology images, for example.

[0031] Alternatively or additionally, a hospital may implement an interne or intranet based communications system, in which an 802.11 WiFi-type protocol is used for wireless communications between individual Monitoring Clients **1,4** and the main Monitoring Server **3**. To ensure adequate signal reception throughout the facility, a broadband antenna may be mounted on the roof of the building to collect cell phone signals from local wireless phone companies. A fiber-optic or cable network may then distribute the signals throughout the facility. Alternatively, the Monitoring Server **3** may use the private cell-phone network mentioned above. Although this system may not be as secure as a micro-cell system, it may be capable of providing the data throughput to accommodate large files, such as, for example, radiology images stored in the Radiology database **21**. Home or office-based users may be able to connect to the hospital server through VPN access using wired or fiber-optic cable, or a DSL phone line. Data encryption may be used to provide needed patient data security. In some applications it may be advantageous to implement an asymmetric bandwidth communications network in order to optimize infrastructure capabilities. An example of this would be using licensed cellular frequencies in the "upstream" direction from the Monitoring Client **1** to the Monitoring Server **3** and the unlicensed 802.11 WiFi frequen-

cies in the "downstream" direction from the Monitoring Server **3** to the Monitoring Client **1**. In this example the upstream bandwidth and data rate requirements are relatively small compared to the downstream requirements. In low priority upstream transmissions the Monitoring Client **1** may allow data to be sent over a more distributed and cost-efficient network, such as, for example, a ZigBee network.

[0032] Communications between various monitoring devices and the Monitoring Client **1** may be achieved in a cost effective manner using, for example, a ZigBee wireless mesh network. Exemplary monitoring devices include ECG monitors **14**, blood pressure monitors **15**, pulse oximeters/capnometers **16**, thermometers, and weight scales, among others. A common characteristic of most of these devices is that they provide periodic readouts of a single or small number of parameters. An intra-hospital device communications system such as the wireless mesh network provides for low-power digital radio connectivity among devices, and may employ a widely available, license-free 2.4 GHz frequency band. High-level communications protocols may be employed to ensure data fidelity and security. It is highly scalable, allowing hundreds or thousands of devices to be used on a single self-forming, self-healing mesh network. Devices connected to the network may communicate with one another and serve as repeaters to transfer data efficiently. The advantages of this system are its relatively low cost, scalability and mobility for the patient being monitored. The wireless range for devices linked to the wireless mesh network can approach 70 meters from each node of the system inside a facility. A similar network may be used in providing a wireless link within the facility between portable communications devices **11** carried by health care providers and their assigned patients through the patients' Monitoring Clients **1,4**.

[0033] In many cases, the information being transmitted to the Monitoring client **1** may include a single parameter value (such as, for example, blood pressure) and a time stamp. The Monitoring Client **1** can be programmed to determine whether the value is outside a predetermined range, record the value in the patient's EHR **19**, and notify the appropriate care-giver via their communications device **11**. Furthermore, the network may enable bidirectional communications, and may allow the Monitoring Client **1** to query **15** the monitoring device, instructing it **18** to take an unscheduled reading. This can be useful, for example, when an abnormal reading is received, and its authenticity needs to be verified. The Monitoring Client **1** may be programmed to request a repeat reading to verify the abnormal reading. In a further refinement, the Monitoring Client **1** may be programmed to interrupt or adjust the infusion pump **7** flow rate, depending on the value of the reading received from a monitoring device **14-17**. For example, if the BP monitor **15** indicates a blood pressure below a pre-determined acceptable range, the Monitoring Client **1** may be programmed to instruct the infusion pump **7** to stop the infusion, and it can transmit an urgent notification **12** to the health care provider(s)' communications devices **11**. In another embodiment, if the infusion pump **7** is capable of measuring the volume of fluid being delivered to the patient **2**, a processor in the Monitoring Client **1** may track the cumulative volume delivered and estimate the amount of fluid remaining in the medication bag. (Alternatively, a processor in the Monitoring Client **1** or infusion pump **7** may calculate the volume delivered from the infusion rate and elapsed time of infusion). Once the estimated residual volume reaches a pre-determined amount, the Monitoring Client **1** may signal

the infusion pump **7** to reduce its flow rate to keep the patient's IV access **35** from running dry. It may also send a notification to the nurse's communications device **11**, recommending replenishment of the medication or solution.

1. An electronic patient monitoring system comprising:
 - a first module configured to receive and store information pertaining to a patient, said information including data related to a first parameter of the patient measured by a device connected to the patient, and data related to a second parameter of the patient received from a first database containing information about the patient; and
 - a second module configured to receive a medication order from a user via a user interface associated with the second module, said second module being further configured to transmit said treatment order to the first module, wherein

said first module is further configured to:

- a) obtain medication information about said medication or other drugs from a second database, the medication information including data providing limitations under which such medication is generally administered;
- b) determine whether the medication order must be confirmed by the second module based on the medication information, the value of the first parameter and the value of the second parameter, and
- c) transmit a pre-established message from the first module to the second module for display on the user interface,

said message confirming or warning about the acceptability of said medication order.

2. The electronic patient monitoring system of claim **1**, wherein the medication information includes drug interactions information, drug allergies information, blood pressure effects information, heart rate effects information, heart rhythm effects information, or respiration effects information, and wherein the first parameter or the second parameter include data about the patient's currently administered drugs, known drug allergies, current blood pressure, current pulse rate, current heart rhythm, current respiratory rate or current ventilation.

3. The electronic patient monitoring system of claim **2**, wherein the pre-established message includes a warning about the potential effects of the ordered medication, said warning including measured data about the first parameter, received data about the second parameter, or medication information obtained by the first module.

4. The electronic patient monitoring system of claim **3**, wherein the first module is configured to generate a signal that the medication order or a modified medication order is to be processed after the pre-established message has been transmitted and upon receipt of a confirmation signal from the second module, the confirmation signal being triggered by an input signal from the user interface.

* * * * *