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(54) SYSTEM AND USER INTERFACE FOR PROCESSING MEDICAL INFORMATION INCLUDING IMAGES FOR HEALTH CARE DELIVERY SUPPORT

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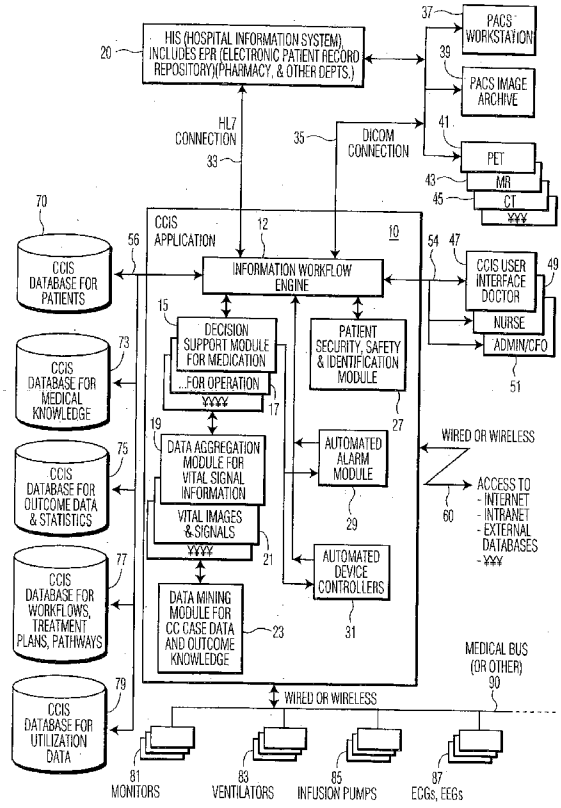
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(57) **ABSTRACT**

A medical information system processes information from multiple sources suitable for access by healthcare personnel for use in clinical (e.g., critical) care delivery. The system includes a communication interface for receiving information from patient monitoring devices and for bidirectionally communicating with a hospital information database containing patient records. The system also includes a data processor using the communication interface for acquiring patient record information from the hospital information database and for acquiring information from patient monitoring devices. The data processor updates the acquired patient record information based on the acquired information from the patient monitoring devices and communicates updated patient record information to the hospital information database. A display processor initiates display of the updated patient record information to a user. The data processor may also include a data analysis unit for analyzing stored patient parameters by correlating stored parameters, patient record information, corresponding medical outcomes and medication database information to identify alternative medication options and improve decision processing. The data processor combines acquired medical parameter information and an acquired patient medical image to provide a composite image for display and storage.



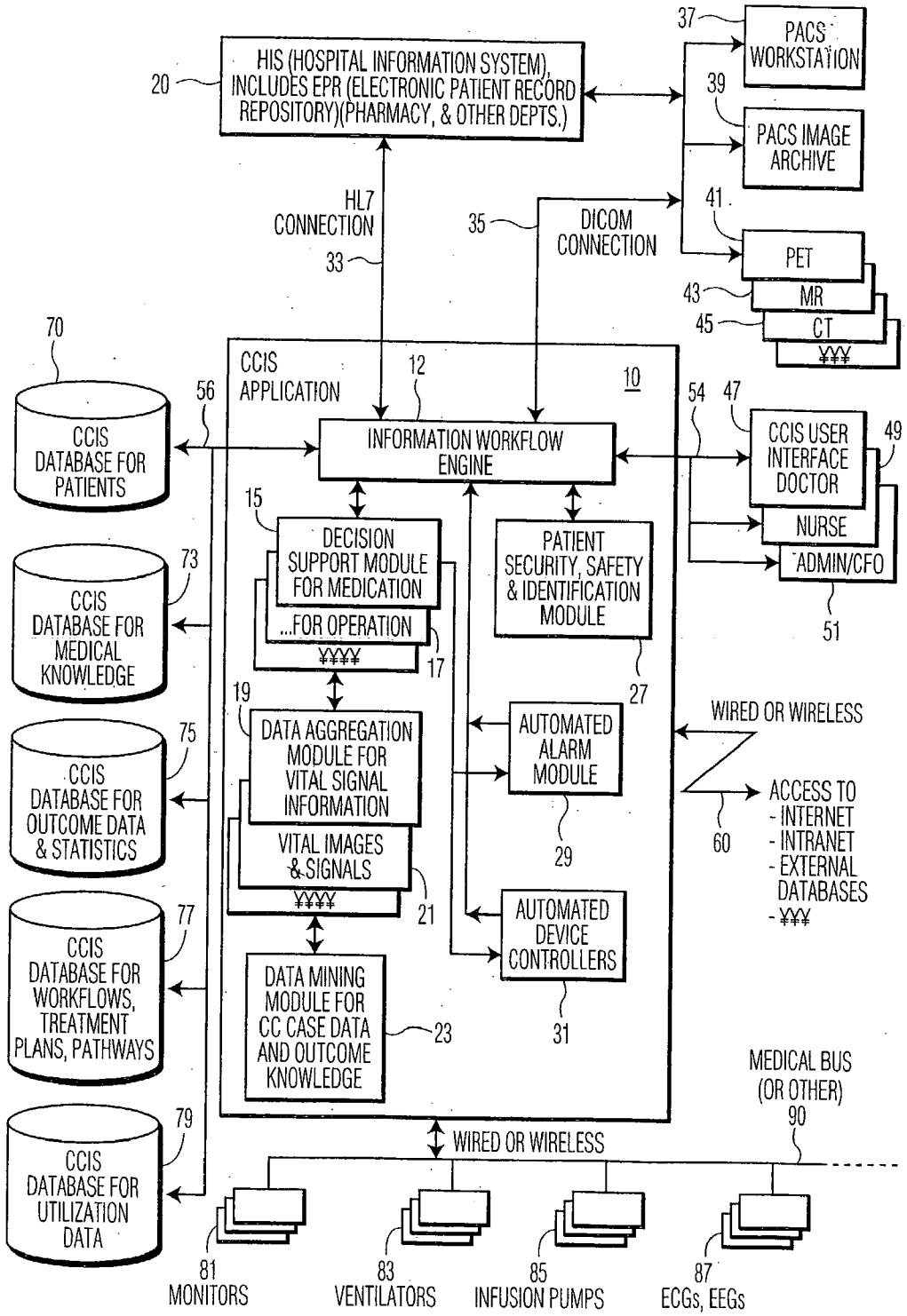

HIS (HOSPITAL INFORMATION SYSTEM), INCLUDES EPR (ELECTRONIC PATIENT RECORD REPOSITORY)(PHARMACY, & OTHER DEPTS.)
20
PACS WORKSTATION
37
PACS IMAGE ARCHIVE
39
HL7 CONNECTION
33
DICOM CONNECTION
35
41
PET
MR
43
CT
45
¥¥¥
70
CCIS APPLICATION
12
10
56
CCIS DATABASE FOR PATIENTS
INFORMATION WORKFLOW ENGINE
54
47
CCIS USER INTERFACE DOCTOR
49
NURSE
ADMIN/CFO
51
15
DECISION SUPPORT MODULE FOR MEDICATION
...FOR OPERATION
¥¥¥¥
17
PATIENT SECURITY, SAFETY & IDENTIFICATION MODULE
27
73
CCIS DATABASE FOR MEDICAL KNOWLEDGE
19
DATA AGGREGATION MODULE FOR VITAL SIGNAL INFORMATION
VITAL IMAGES & SIGNALS
¥¥¥¥
21
AUTOMATED ALARM MODULE
29
WIRED OR WIRELESS
75
CCIS DATABASE FOR OUTCOME DATA & STATISTICS
ACCESS TO
- INTERNET
- INTRANET
- EXTERNAL DATABASES
- ¥¥¥
60
77
CCIS DATABASE FOR WORKFLOWS, TREATMENT PLANS, PATHWAYS
AUTOMATED DEVICE CONTROLLERS
31
DATA MINING MODULE FOR CC CASE DATA AND OUTCOME KNOWLEDGE
23
MEDICAL BUS (OR OTHER)
90
79
CCIS DATABASE FOR UTILIZATION DATA
WIRED OR WIRELESS
81
MONITORS
83
VENTILATORS
85
INFUSION PUMPS
87
ECGs, EEGs

FIG. 1

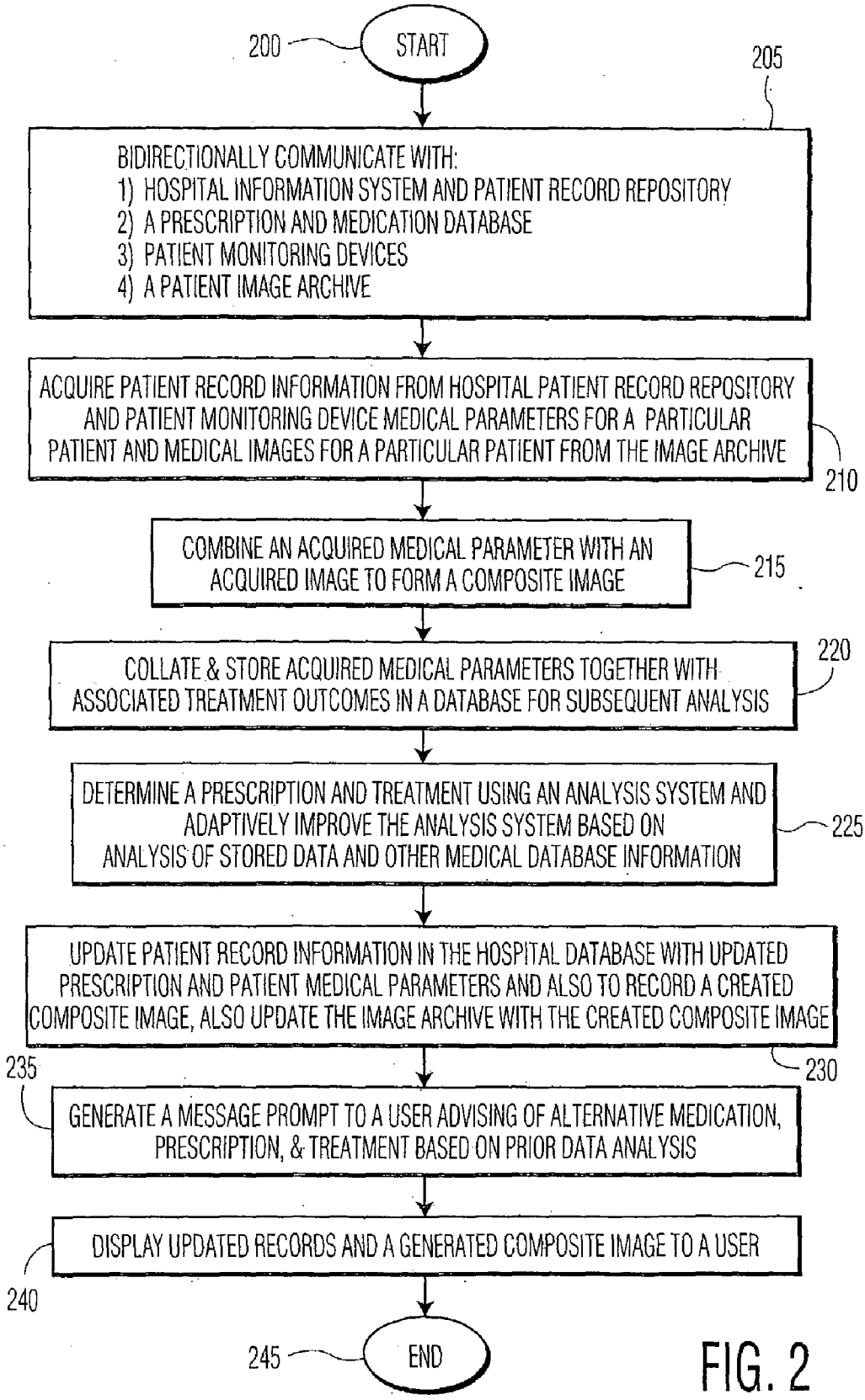

200
START
205
BIDIRECTIONALLY COMMUNICATE WITH:
1) HOSPITAL INFORMATION SYSTEM AND PATIENT RECORD REPOSITORY
2) A PRESCRIPTION AND MEDICATION DATABASE
3) PATIENT MONITORING DEVICES
4) A PATIENT IMAGE ARCHIVE
ACQUIRE PATIENT RECORD INFORMATION FROM HOSPITAL PATIENT RECORD REPOSITORY AND PATIENT MONITORING DEVICE MEDICAL PARAMETERS FOR A PARTICULAR PATIENT AND MEDICAL IMAGES FOR A PARTICULAR PATIENT FROM THE IMAGE ARCHIVE
210
COMBINE AN ACQUIRED MEDICAL PARAMETER WITH AN ACQUIRED IMAGE TO FORM A COMPOSITE IMAGE
215
COLLATE & STORE ACQUIRED MEDICAL PARAMETERS TOGETHER WITH ASSOCIATED TREATMENT OUTCOMES IN A DATABASE FOR SUBSEQUENT ANALYSIS
220
DETERMINE A PRESCRIPTION AND TREATMENT USING AN ANALYSIS SYSTEM AND ADAPTIVELY IMPROVE THE ANALYSIS SYSTEM BASED ON ANALYSIS OF STORED DATA AND OTHER MEDICAL DATABASE INFORMATION
225
UPDATE PATIENT RECORD INFORMATION IN THE HOSPITAL DATABASE WITH UPDATED PRESCRIPTION AND PATIENT MEDICAL PARAMETERS AND ALSO TO RECORD A CREATED COMPOSITE IMAGE, ALSO UPDATE THE IMAGE ARCHIVE WITH THE CREATED COMPOSITE IMAGE
230
235
GENERATE A MESSAGE PROMPT TO A USER ADVISING OF ALTERNATIVE MEDICATION, PRESCRIPTION, & TREATMENT BASED ON PRIOR DATA ANALYSIS
DISPLAY UPDATED RECORDS AND A GENERATED COMPOSITE IMAGE TO A USER
240
245
END

FIG. 2

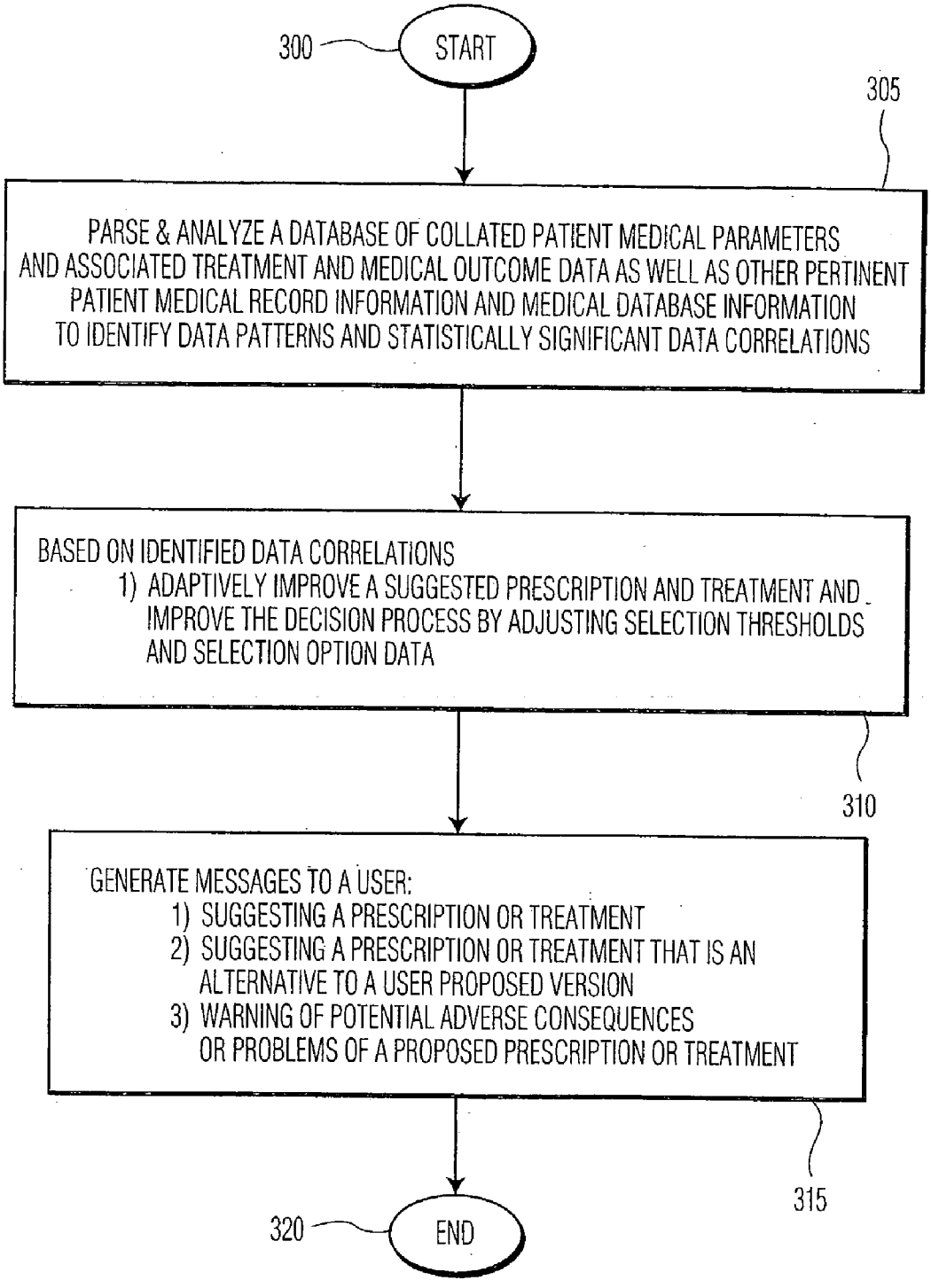

300
START
305
PARSE & ANALYZE A DATABASE OF COLLATED PATIENT MEDICAL PARAMETERS AND ASSOCIATED TREATMENT AND MEDICAL OUTCOME DATA AS WELL AS OTHER PERTINENT PATIENT MEDICAL RECORD INFORMATION AND MEDICAL DATABASE INFORMATION TO IDENTIFY DATA PATTERNS AND STATISTICALLY SIGNIFICANT DATA CORRELATIONS
BASED ON IDENTIFIED DATA CORRELATIONS
1) ADAPTIVELY IMPROVE A SUGGESTED PRESCRIPTION AND TREATMENT AND IMPROVE THE DECISION PROCESS BY ADJUSTING SELECTION THRESHOLDS AND SELECTION OPTION DATA
310
GENERATE MESSAGES TO A USER:
1) SUGGESTING A PRESCRIPTION OR TREATMENT
2) SUGGESTING A PRESCRIPTION OR TREATMENT THAT IS AN ALTERNATIVE TO A USER PROPOSED VERSION
3) WARNING OF POTENTIAL ADVERSE CONSEQUENCES OR PROBLEMS OF A PROPOSED PRESCRIPTION OR TREATMENT
315
320
END

FIG. 3

SYSTEM AND USER INTERFACE FOR PROCESSING MEDICAL INFORMATION INCLUDING IMAGES FOR HEALTH CARE DELIVERY SUPPORT

[0001] This is a non-provisional application of provisional application serial No. 60/263,790 by S. Bocionek et al. filed Jan. 24, 2001.

FIELD OF THE INVENTION

[0002] This invention concerns a comprehensive information system and architecture for use in clinical care delivery and optimization.

BACKGROUND OF THE INVENTION

[0003] Critical care delivered in ICUs (Intensive Care Unit), ERs (Emergency Room), ORs (Operating Rooms), for example, and some other specialized clinical settings, is an area of medicine where improvements have significant life or death impact. As a minimum such improvements ameliorate the critical condition of patients treated there. Specialized personnel (doctors, nurses), equipment (monitors, infusion devices, ventilators, vital sign detectors, etc.), highly efficient drugs and special-purpose disposable devices (e.g. catheters) contribute to the success of critical care delivery. An important component in this setting is the information processed. Specifically, information elements of importance include the available data on the patients history and daily improvement, vital signs indicating patient status and stability, medication plans, but also medical knowledge in general and broad personnel experience (i.e. knowledge gained from a large number of cases) by doctors and nurses.

[0004] Each of the above critical care contributors are periodically examined and hopefully improved. However, such improvement tends to occur in a haphazard and piecemeal manner. For example, new ventilators with sophisticated gas valve controls refine the dosage of anesthesia applied with gas to improve patient care. Also smart alarms generate alarm indications from combined vital signs thereby helping to avoid unnecessary calls of the nurses, and better focus attention on critical situations that are real.

[0005] Despite such limited optimization of the components in critical care and other clinical settings, further improvement is possible by combining smart devices, integrated information processing, and aggregated knowledge derived form large case databanks.

[0006] A system according to invention principles delivers such improvement and addresses associated problems.

SUMMARY OF INVENTION

[0007] A system holistically improves critical care delivery by providing a technical combination of medical information processing devices providing flexible parallel access to static and dynamic patient data as well as medical information relevant for a particular application. A medical information system processes information from multiple sources suitable for access by healthcare personnel for use in clinical (e.g., critical) care delivery. The system includes a communication interface for receiving information from patient monitoring devices and for bidirectionally communicating with a hospital information database containing patient records. The system also includes a data processor using the communication interface for acquiring patient record information from the hospital information database and for acquiring information from patient monitoring devices. The data processor updates the acquired patient record information based on the acquired information from the patient monitoring devices and communicates updated patient record information to the hospital information database. A display processor initiates display of the updated patient record information to a user.

[0008] In a feature of the invention, the system includes a data analysis unit for analyzing stored patient parameters by correlating stored parameters, patient record information, corresponding medical outcomes and medication database information to identify alternative medication options and improve decision processing.

[0009] In another feature of the invention, the data processor combines acquired medical parameter information and an acquired patient medical image to provide a composite image for display and storage.

BRIEF DESCRIPTION OF THE DRAWING

[0010] **FIG. 1** shows a system for providing medical information and health care delivery support, according to invention principles.

[0011] **FIG. 2** shows a flowchart of a process for providing and storing medical information including prescription and treatment recommendations for clinical care delivery support, according to invention principles.

[0012] **FIG. 3** shows a flowchart of a process for analyzing stored patient parameters, patient record information, medication information and corresponding medical outcomes for deriving treatment improvements and adaptive system improvements, according to invention principles.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0013] **FIG. 1** shows a system for providing medical information and health care delivery support. The system advantageously provides a combination of medical and IT devices, and flexible parallel access to static and dynamic patient data, as well as medical information relevant for a particular case. The system advantageously improves clinical care delivery in critical care or other setting in a holistic manner. Currently available systems provide limited capability and fail to provide the comprehensive features of the disclosed system. Currently available systems supply limited combinations of information or devices, e.g. for aggregation of vital signs (ECG, blood pressure, O_2 content) by means of fuzzy logic. Other CCIS systems (critical care information systems) maintain patient data (static, and some vital signals), but exclude other accessible information. These systems also integrate critical care devices using particular dedicated medical bus connections and protocols. Further, although known systems provide access to medical knowledge databases (medical "book knowledge" as well as large case/outcome databases), through the Internet or via database browsers, this access is not integrated into the critical care information flow.

[0014] A medical information system according to invention principles processes data of wider variety from a broader range of sources than hitherto achieved. The system

processes substantially all available data and information relevant to a critical care need. The location of the information is largely immaterial since the system architecture accesses data from a comprehensive array of networks and devices (including local and remote databases and Internet locations etc.). The medical information system advantageously acquires patient record information from a hospital information database, medical parameter information from patient monitoring devices and patient images from an archive. The system updates the acquired patient record information in view of acquired information from the patient monitoring devices as well as to record generated prescription or treatment information. Updated patient record information is communicated to the hospital information database. System data analysis and decision units advantageously analyze stored patient parameters by correlating stored parameters, patient record information, corresponding medical outcomes and medication database information to suggest treatments and prescriptions and to identify alternative medication options and adaptively improve decision processing. The system also advantageously combines acquired medical parameter information and an acquired patient medical image to provide a composite image for display and storage in an archive. The disclosed system is particularly useful in complex critical care environments including stroke units, interventional angiography rooms, neuro surgery ORs, and transplantation centers, etc. In these environments, the disclosed system yields improved care, reduced patient risk and improved clinical care delivery quality and efficiency by the provision of access to a wide variety of information sources combined with fast information processing guided by intelligent decision making.

[**0015**] The medical information system of **FIG. 1** comprises a critical care information system (CCIS) application **10** communicating with devices via local area networks (LANs) or wide area networks (WANs) as well as communicating via the Internet and other telecommunication (including wireless or landline) networks. The CCIS is Internet Protocol (IP) compatible but may also employ other protocols such as, for example, X.25, frame relay, IBM SNA etc. and may use any type of network architecture that provides communication connectivity among the networked devices. CCIS application **10** resides in a CCIS server however, in other embodiments CCIS application **10** may reside at any remote or local level of network hierarchy since the different levels of the network are interconnected. Alternatively, CCIS application **10** may be executed as a local application within a PC or within a dedicated CCIS device, for example.

[**0016**] CCIS application **10** of **FIG. 1** includes information workflow engine **12** for determining medical process task sequences, decision support modules **15** and **17** for medication and operations related decision making respectively and data aggregation processors **19** and **21** for aggregating medical parameters (including vital signs) and images. CCIS application **10** also includes a data mining module **23**, a patient security and identification module **27**, an alarm module **29** and device controllers **31**. CCIS application **10** bidirectionally communicates with Hospital Information System (HIS) **20** patient record repository and other hospital departments typically via an HL7 (Health Level Seven) protocol interface **33** (other interface protocol connections are also possible). Thereby CCIS application **10** accesses and updates patient records retained in the hospital EPR (Electronic Patient Record) repository. CCIS application **10** also accesses data from other HIS **20** departmental systems including a patient management and accounting system, a Radiology Information System (RIS), a Laboratory Information System (LIS), and a hospital Pharmacy. CCIS application **10** accesses and processes the information available from HIS **20** using decision modules **15** and **17**, data aggregation modules **19** and **21** and data mining module **23**. The processed information is collated and stored in local databases **70-79**. Thereby, patient record data and history from the HIS **20** repositories is accessed, processed and displayed on monitor **81** via interface **90**. In addition, patient record updates are advantageously communicated to HIS **20** repositories in a synchronous fashion.

[**0017**] The modules and functions of CCIS application **10** are advantageously able to access and update patient record information in HIS **20** using a Master Patient Index (MPI) stored within HIS **20**. The access process is governed by security and identification unit **27** which ensures that a patient is correctly identified by resolving patient record anomalies including patient name errors, name duplications and patient record and name mismatches. For this purpose unit **27** supports multiple Patient Identification Scheme (PIDS) standards including those of HL7 and CORBAmed (a derivative standard of the Common Object Request Broker Architecture by a task force of the Object Management Group). Unit **27** typically identifies a patient based on patient name, birthdate and sex as primary identifiers and may also employ social security number and patient address. Unit **27** creates a unique number based on these parameters and uses this unique number for internal patient identification. In accessing other systems, unit **27** maps the unique number to corresponding patient identifiers used by these other systems. Unit **27** employs known security protocols including the SSL (secure socket layer) protocol and RSA public key encryption in managing access to patient records and the Master Patient Index. Other security protocols may also be used for this purpose

[**0018**] CCIS application **10** accesses medical image data from PACS (Picture Archiving and Communication System) compatible archive **39** and workstation **37** or directly from diagnostic units such as PET (Positron Emission Tomography) unit **41**, MR (Magnetic Resonance) unit **43** or CT (Computed Tomography) unit **45**. Image data is accessed by CCIS application **10** via interface **35** using DICOM (Digital Imaging and Communications in Medicine) standard (published approx. 1990). CCIS application **10** also accesses medical parameters from patient monitoring devices including ventilators **83**, infusion pumps **85**, electro-cardiograph (ECG) and electro-encephalograph (EEG) units **87**, blood oxygen detectors, pulse detectors and anesthesia units (not shown) and other devices via bus interface **90**. Interface **90** is typically a known medical industry standard Medical Interface Bus (MIB) used for locally interconnecting medical devices in a patient's room, for example, for both display and control to administer care and monitor a particular patient. Alternatively, bus **90** may be a different type of wired or wireless bus, such as an Ethernet-compatible LAN.

[**0019**] CCIS application **10** advantageously accesses both patient image data and patient medical parameters and combines the medical parameters and image data to form a composite image for display and storage in archive **39**.

Therefore, CCIS application **10** is able to combine a vital sign from the critical care setting, such as an ECG or EGG signal from unit **87**, with a patient brain image (e.g., identifying a dead area detected by a PET unit after a stroke) or a patient heart image (e.g., identifying damage after a myocardial infarct) to form a composite image. The aggregation of such a vital sign and functional image is performed by data aggregation units **19** and **21** in conjunction with decision units **15** and **17**.

[**0020**] Consequently, a patient image from a PACS compatible archive or from a diagnostic unit such as a PET, MR, Ultrasound, or other unit may be advantageously displayed, evaluated and manipulated on a critical care patient monitor **81** directly in a patient critical care bedside location.

[**0021**] CCIS application **10** incorporates Information workflow engine **12** for the definition and generation of detailed task sequences and associated control operations supporting tasks or processes used in clinical care delivery. Workflow engine **12** does this in response to task commands, requests and inputs received from either HIS **20**, from healthcare personnel via direct user interfaces **47-51**, from monitors and patient monitoring devices **81-87**, or from external users via interface **60**. Specifically, in response to task commands, workflow engine **12** generates and maintains detailed task lists (worklists) and controls decision processors **15** and **17**, data aggregation processors **19** and **21** and data search and mining processor **23** in generating and implementing workflow task sequences. In responding to task commands, CCIS application **10** in conjunction with workflow engine **12** may generate individual, intermittent or periodic messages for communication to other units. This may include deriving and combining vital sign parameters using units **19** and **21** and communicating the derived signals to automated alarm unit **29**, for example. Further, workflow task sequences generated by workflow engine **12** are stored in database **77** and are advantageously dynamically updated to incorporate improvements identified by analyzing treatment and associated medical outcome results for either an individual patient or for multiple patients. The data analysis involves searching patient records in multiple patient medication and treatment databases for statistically significant data correlations and patterns identifying treatment features leading to verifiable improvement. Such multiple patient medication and treatment databases may comprise local databases (e.g., database **75**) or a remote database accessible via interface **60** involving an Internet or other network protocol.

[**0022**] CCIS application **10** also advantageously acquires, tracks and stores a variety of resource utilization data for both goods and services in database **79** for inspection by healthcare personnel including doctors, nurses and administrators via respective interfaces **47**, **49** and **51**. Interfaces **47-51** together with CCIS application **10** permit a user to search, query, collate and display desired resource utilization data in a user selectable format. The resource utilization data monitors time and services provided by personnel including doctors and nurses for specific treatment purposes. Similarly, the resource utilization data also monitors use of goods including drugs, disposable medical goods, infusion liquids, equipment accessories and other items. CCIS application **10** further analyzes the stored data to identify typical or normal cost guideline thresholds and treatment cases exceeding normal cost thresholds. CCIS application **10** thereby identifies cost reduction and containment opportunities and assists in investment and planning and other financial control activities.

[**0023**] Decision support modules **15** and **17** of CCIS application **10** are used for supporting, diagnosis and associated medication and prescription selection using local or remote databases of medical information and known standard medical data access codes. In particular, decision functions **15** and **17** generate prompts, medication selection guidance and warnings through alert and guidance display elements displayed via user interfaces **47** and **49**. A generated warning may indicate a patient drug-allergy or a potential drug to drug interaction that may lead to an "adverse event" for the patient, for example. Further, decision functions **15** and **17** respond to specific medication and medical condition questions submitted by a user via query display elements presented via interfaces **47** and **49**. A doctor may submit a query via interface **47** to determine what medication is best in a current situation, for example.

[**0024**] Decision functions **15** and **17** also access patient vital signs and corresponding vital images for improved decision processing. A particular improvement is derived from superimposing color-coded ECG or EEG signals, for example, on an associated anatomical structure image (e.g., a PET image, or functional MR image). This superimposition aids the identification of conditions supporting a diagnosis or medication prescription by indicating the conjunction of a corresponding anomaly occurring in both an image and a vital sign trace. The identification of image anomalies is supported by an image interpretation algorithm employing known techniques including automatic edge detection, semi-automatic area segmentation and analysis and image comparison with standard images obtained from an archive or library, for example. Alternatively, the identification of image anomalies may be performed manually by a doctor. In this case, image anomaly identification data and interpreted characteristic information may be entered by the doctor via interface **47** for use by decision modules **15** and **17**.

[**0025**] Decision functions **15** and **17** employ data aggregation functions **19** and **21** as well as data searching and mining function **23** for processing data from various sources. These sources include patient monitoring and associated equipment sources (**81**, **83**, **85** and **87**), various databases (**70**, **73**, **75** and **79**), general patient information from sources like the HIS **20**, image stores (**37**, **39**), image generating devices (**41**, **43** and **45**) and external data and knowledge sources accessed via interface **60** using the Internet or other access mechanisms. Data aggregation functions **19** and **21** identify data patterns, statistical correlations and data anomalies suggestive of potential treatment improvements. Aggregation functions **19** and **21** further test identified improvements against known medical knowledge and available patient record and parameter databases for verification. Resulting conclusions comprise improved decision rules and thresholds, treatment plans, workflow triggers and other medical conclusions. Data aggregation units **19** and **21** also monitor the performance of the aggregation function internal operation including the algorithms used in deriving the conclusions and adaptively improve the aggregation function operation by tailoring the algorithms based on the monitored performance. This feedback mechanism yields dynamic improvement of aggregation functions **19** and **21** and thereby yields dynamic improvement in treatment workflow task sequences and associated control operations.

[**0026**] Data mining function **23** searches the available information sources for relevant data for processing by aggregation functions **19** and **21**. The relevant data is processed by aggregation functions **19** and **21** in identifying

data correlations and patterns from combinations of parameters indicating statistically significant conclusions, as previously discussed. Data mining function **23** advantageously employs known standard medical condition code sets and associated category or class code sets and medical terminology in searching available information sources. For this purpose data mining function **23** associates corresponding codes and terminology of different code and terminology sets by a map. The map is used in associating and acquiring desired information elements from different information sources employing different information code and category classifications.

[**0027**] Decision support functions **15** and **17**, in conjunction with data aggregation functions **19** and **21** and data mining function **23**, determine new or improved treatment solutions or processes (including workflow task and control sequences). The improved workflow task sequences, treatment solutions and processes are substituted for the existing workflow task sequences, treatment solutions and processes stored in database **77**. Further, derived knowledge and data are stored in databases **73**, **75**, and **79** and communicated via interface **60** to remote databases. Decision support functions **15** and **17** in conjunction with aggregation functions **19** and **21** and alarm function **29** also provide intelligent automated alarm control in the critical care setting. Alarm function **29** generates an alarm based on individual, composite or weighted composite vital signs from units **81**-**87** via bus **90** and additional information from decision support functions **15** and **17**. Decision support functions **15** and **17** derive conclusions based on available medical data and patient vital signs and parameters and optimize alarm function **29** settings and thresholds.

[**0028**] Further, device controller **31** in conjunction with decision functions **15** and **17** intelligently control devices including ventilator **83** and infusion pump **85**. Decision support functions **15** and **17** determine optimal drug dosage to be applied by infusion pump **85** based on the available vital signs and available medical data and knowledge using a closed feedback loop tracking and control mechanism.

[**0029**] **FIG. 2** shows a flowchart of a process employed by CCIS application **10** for providing and storing medical information including prescription and treatment recommendations for clinical care delivery support. In step **205** following the start at step **200**, CCIS application **10** (**FIG. 1**) establishes bidirectional communication with HIS **20** via bus **33** and also establishes communication with patient monitoring devices **81**-**87** via bus **90**. CCIS application **10** also establishes communication with image archive **39** via bus **35** and treatment medication and prescription databases **73**-**79** via bus **56** and external databases via interface **60**. In step **210**, CCIS application **10** acquires medical parameters for a particular patient from devices **81**-**87**, a patient record for the patient from a record repository in HIS **20** and a medical image for the patient from archive **39**. The acquired medical parameters may include some or all of electro-cardiograph (ECG) data, electro-encephalograph (EEG) data, ventilation data, blood oxygen data, blood pressure data, infusion pump data and pulse data.

[**0030**] In step **215**, CCIS application **10** combines a selected medical parameter and the image data to form a composite image for display and storage in archive **39**. The selected medical parameter and image that are combined concern a common anatomical organ, feature or function. For instance, a color PET image of a brain may be combined with an EEG signal to verify information about dead tissue areas. Also a CT vessel image may be combined with a blood pressure signal for use in estimating the risk of a thrombosis or a vessel rupture (since a CT image shows plaque, i.e. narrowed vessel, an increased blood pressure would tend to indicate a narrowed vessel). CCIS application **10**, in step **220**, collates and stores the acquired medical parameters together with any associated treatment outcome data in local or remote databases for subsequent analysis.

[**0031**] In step **225**, CCIS application **10** applies an internal analysis system in determining a prescription and proposed treatment for the patient based on analysis of the stored data including the composite image. CCIS application **10** also adaptively updates and improves the analysis system based on stored data including treatment outcome data. In step **230**, CCIS application **10** updates the patient record to reflect the determined prescription and proposed treatment and also to indicate the creation and storage of the composite image and acquired patient monitor information. The updated patient record information is stored in the local patient record repository of database **70** and is subsequently communicated to the HIS **20** patient record repository for synchronized storage. The updated patient record information is communicated to the HIS **20** patient record repository in response to the detection of a patient record alteration in local database **70**. Alternatively, the updated patient record information is communicated to the HIS **20** patient record repository in response to other conditions such as, upon user command, upon predetermined intermittent intervals, upon termination of execution of CCIS application **10**, or interruption of communication by CCIS **10** with HIS **20**, for example.

[**0032**] The patient record contents of local patient record repository **70** and the remote patient record contents of the HIS **20** patient record repository may be matched by known mechanisms such as by a messaging mechanism, for example. Using such a mechanism, one of the databases (e.g. HIS **20** repository) receives an update message from the other database (e.g., database **70**) and locates a record for update based on predetermined common data field information, (e.g., a common patient name or identifier). The located record field is updated using received message content. In another embodiment, CCIS application **10** and HIS **20** may share a common database, for example, and either CCIS application **10** or HIS **20** make updates to records stored in the database. Thereby, database **70** replicates the patient record repository in HIS **20**.

[**0033**] A message prompt is generated by CCIS application **10** in step **235** for display to a user on monitor **81** or interface displays **47** and **49**. The message prompt is generated based on the analysis performed in step **225** and comprises, a warning of a potential problem of a proposed prescription, a suggested alternative prescription, medication or treatment, or advice to a user to check a patient condition affecting a proposed prescription. CCIS application **10** in step **240** initiates display of updated patient record information or a composite image to a user via monitor **81** or displays **47** and **49**. The process of **FIG. 2** terminates in step **245**.

[**0034**] **FIG. 3** shows a flowchart of a process for analyzing stored patient parameters, patient record information, medication information and corresponding medical outcomes for deriving treatment improvements and adaptive system improvements. In step **305** following the start at step **300**, CCIS application **10** parses and analyzes medical information from multiple sources to identify data patterns

and statistically significant data correlations in order to identify potential treatment improvements and internal system and algorithm improvements. The multiple medical information sources examined comprise collated patient medical record information, patient medical parameters and associated treatment outcome data as well as pertinent medical information available in local databases **70-79 (FIG. 1)** and external databases available via interface **60**.

[**0035**] CCIS application **10** in step **310** adaptively improves a prescription and treatment suggestion and decision process by adjusting selection thresholds and selection option data to tailor the prescription process to select the treatments shown to have produced the most favorable outcomes in the analyzed cases. Specifically, this involves refining one or more threshold values that determines the level at which one or more particular medical input parameters (e.g. monitored patient data) suggest the use of one treatment in preference to a different alternative treatment. Similarly, the set of treatment and prescription options available for selection in this manner is reviewed and potentially updated to include those treatments and medications shown to have produced the most favorable outcomes in the analyzed cases and to remove inferior, redundant or harmful treatment and medication options. Either individual or multiple threshold values may be involved and adaptively adjusted in diagnosing treatment for a particular condition. A medical condition may be indicated by the combination of temperature exceeding 39 Celsius and blood pressure or blood oxygen level being below a particular level, for example. Further, threshold values may have a range of values that are associated with corresponding physical conditions such as physical posture, physical activity or other medical conditions and either the range of threshold values or particular threshold values (corresponding to particular conditions) within the range may be adaptively adjusted.

[**0036**] In step **315**, CCIS application **10** initiates generation of a message based on the analysis of step **305** for display to a user on monitor **81** or interface displays **47** and **49 (FIG. 1)**. The message prompt comprises, a suggested prescription or treatment, a suggested alternative prescription or treatment to a user proposed version, or a warning of potential adverse consequences or problems of a proposed treatment or medication.

[**0037**] The architectures and processes presented in FIGS. **1-3** are not exclusive. Other architectures and processes may also be derived in accordance with the principles of the invention to accomplish the same objectives. Further, the inventive principles may be advantageously employed in any clinical health care delivery system for accelerating and accurately guiding decision making based on data accessed from a wide variety of information sources.

What is claimed is:

1. A medical information system for processing information from a plurality of sources suitable for access by healthcare personnel for use in critical clinical care delivery, comprising:

a communication interface for receiving information from patient monitoring devices and for bidirectionally communicating with a hospital information database containing patient records;

a data processor using said communication interface for,

acquiring patient record information from said hospital information database and acquiring information from patient monitoring devices,

updating said acquired patient record information based on said acquired information from said patient monitoring devices, and

communicating updated patient record information to said hospital information database; and

a display processor for initiating display of said updated patient record information to a user.

2. A system according to claim 1, wherein

said hospital information database is a shared database accessible by multiple users and remote from said medical information system.

3. A system according to claim 1, wherein

said step of updating said acquired patient record information comprises updating patient record information in a database replicating said hospital information database and

said step of communicating said updated patient record information to said hospital information database comprises communicating changed data to said hospital information database to support substantially matching of hospital information database content with said replicated database content upon a predetermined condition.

4. A system according to claim 3, wherein

said predetermined condition comprises at least one of, (a) periodically, (b) upon detection of a record update and (c) upon user command.

5. A medical information system for processing information from a plurality of sources suitable for access by healthcare personnel for use in clinical care delivery, comprising:

a communication interface for receiving medical parameter information from patient monitoring devices for a specific patient and for receiving medical images from an archive of patient medical images;

a data processor using said communication interface for,

acquiring patient record information from said hospital information database and a medical image for said specific patient from said archive, and

combining said medical parameter information and said patient medical image for display as a composite image,

a display processor for initiating display of said composite image to a user.

6. A system according to claim 5, wherein

said medical parameter information includes at least one of (a) electro-cardiograph (ECG) or electro-encephalograph (EEG) data, (b) ventilation data, (c) blood oxygen or pressure data, (d) infusion pump data and (e) pulse data.

7. A system according to claim 5, wherein

said step of combining said medical parameter information and said patient medical image comprises combining a medical parameter and image associated with

at least one of, (a) a common anatomical structure and (b) a common anatomical function.

8. A system according to claim 7, wherein

said step of combining said medical parameter information and said patient medical image comprises overlaying said medical image with said medical parameter.

9. A system according to claim 5, including the step of,

updating said archive to include said composite image.

10. A system according to claim 5, including the step of,

acquiring patient record information from a hospital information database using said communication interface, and wherein

said data processor uses said communication interface for,

updating patient record information to record existence of said composite image, and

communicating said updated patient record information to said hospital information database for update.

11. A medical information system for processing information from a plurality of sources suitable for access by healthcare personnel for use in clinical care delivery, comprising:

a communication interface for receiving medical parameters from patient monitoring devices and for bidirectionally communicating with a hospital information database containing patient records;

a data processor using said communication interface for acquiring patient record information for a particular patient from said hospital information database and for collating and storing received medical parameters for said particular patient from monitoring devices;

a decision processor supporting determination of a prescription for a patient medical condition using a medication information database and said collated patient parameters; and

an update processor for initiating updating of said patient record information to record a determined prescription.

12. A system according to claim 11, wherein

said decision processor uses said patient record and said medication information database in at least one of, (a) generating a warning of a potential problem of a proposed prescription, (b) suggesting a potential prescription, and (c) generating a display message to prompt a user to check a patient condition affecting a proposed prescription.

13. A system according to claim 11, wherein

said decision processor suggests a prescription based on at least one of, (a) a received patient parameter exceeding a predetermined threshold value and (b) a received patient parameter being outside a value range determined by upper and lower threshold values.

14. A system according to claim 13, wherein

said predetermined threshold value is selected from a plurality of predetermined threshold values based on information derived from said acquired particular patient record information.

15. A system according to claim 13, wherein said medical information system includes

a data analyzer for intermittently parsing and analyzing stored collated medical parameters from a plurality of patients to identify an improved threshold value based on previous treatment outcomes and to adaptively update said threshold value to said improved threshold value.

16. A medical information system for processing information from a plurality of sources suitable for access by healthcare personnel for use in clinical care delivery, comprising:

a communication interface for receiving information from a medication information database and for bidirectionally communicating with a hospital information database containing patient records;

a data processor using said communication interface for acquiring patient record information for a particular patient from said hospital information database;

a decision processor supporting determination of a prescription for a patient medical condition based on said acquired particular patient record information and information from said medication information database; and

an update processor for initiating updating of said patient record information to record a determined prescription.

17. A system according to claim 16, wherein

said decision processor uses said patient record and said medication information database in at least one of, (a) generating a warning of a potential problem of a proposed prescription, (b) suggesting a potential prescription, and (c) generating a display message to prompt a user to check a patient condition affecting a proposed prescription.

18. A system according to claim 16, wherein said clinical care delivery comprises,

health care delivered in at least one of, (a) an emergency room, (b) an intensive care unit, (c) an operating room and (d) another clinical care delivery setting.

19. A medical information system for processing information from a plurality of sources suitable for access by healthcare personnel for use in clinical care delivery, comprising:

a communication interface for receiving medical parameters from patient monitoring devices and for bidirectionally communicating with a hospital information database containing patient records;

a data processor using said communication interface for acquiring patient record information from said hospital information database and for collating and storing received patient medical parameters from monitoring devices;

a data analysis unit for analyzing stored patient parameters by correlating stored parameters and corresponding medical outcomes to identify alternative medication options; and

a message generator for generating a message to suggest to a user an alternative medication option in response to an identified alternative medication option.

20. A system according to claim 19, wherein

said data analysis unit analyzes stored patient parameters by searching for patterns in stored patient parameters and corresponding medical outcomes to identify statistically significant data correlation.

21. A system according to claim 19, wherein

said data analysis unit analyzes stored patient parameters and related information in a medical information database by searching for patterns in stored patient parameters and corresponding medical outcomes to identify statistically significant data correlation.

22. A system according to claim 19, including

a decision processor for identifying alternative medication options using a patient record and a medication information database.

23. A system according to claim 22, wherein

said decision processor uses a patient record and a medication information database in at least one of, (a) generating a warning of a potential problem of a proposed prescription, (b) suggesting a potential prescription, and (c) generating a display message to prompt a user to check a patient condition affecting a proposed prescription.

24. A method for use by a medical information system for processing information from a plurality of sources suitable for access by healthcare personnel for use in critical clinical care delivery, comprising the steps of:

receiving information from patient monitoring devices;

bidirectionally communicating with a hospital information database containing patient records;

acquiring patient record information from said hospital information database and acquiring information from patient monitoring devices;

updating said acquired patient record information based on said acquired information from said patient monitoring devices;

communicating updated patient record information to said hospital information database; and

initiating display of said updated patient record information to a user.

25. A method for use by a medical information system for processing information from a plurality of sources suitable for access by healthcare personnel for use in clinical care delivery, comprising the steps of:

receiving medical parameter information from patient monitoring devices for a specific patient and receiving medical images from an archive of patient medical images;

acquiring patient record information from said hospital information database and a medical image for said specific patient from said archive, and

combining said medical parameter information and said patient medical image for display as a composite image,

initiating display of said composite image to a user.

26. A method for use by a medical information system for processing information from a plurality of sources suitable for access by healthcare personnel for use in clinical care delivery, comprising the steps of:

receiving medical parameters from patient monitoring devices;

bidirectionally communicating with a hospital information database containing patient records;

acquiring patient record information for a particular patient from said hospital information database;

collating and storing received medical parameters for said particular patient from monitoring devices;

determining a prescription for a patient medical condition using a medication information database and said collated patient parameters; and

initiating updating of said patient record information to record a determined prescription.

27. A method for use by a medical information system for processing information from a plurality of sources suitable for access by healthcare personnel for use in clinical care delivery, comprising the steps of:

receiving information from a medication information database;

bidirectionally communicating with a hospital information database containing patient records to acquire patient record information for a particular patient;

determining a prescription for a patient medical condition based on said acquired particular patient record information and information from said medication information database; and

initiating updating of said patient record information to record a determined prescription.

28. A method for use by a medical information system for processing information from a plurality of sources suitable for access by healthcare personnel for use in clinical care delivery, comprising the steps of:

receiving medical parameters from patient monitoring devices;

bidirectionally communicating with a hospital information database containing patient records;

acquiring patient record information from said hospital information database;

collating and storing received patient medical parameters from monitoring devices;

analyzing stored patient parameters by correlating stored parameters and corresponding medical outcomes to identify alternative medication options; and

generating a message to suggest an alternative medication option to a user in response to an identified alternative medication option.

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