In a health care method for providing medical care in a rural community, a patient in the rural community is contacted by a community health worker (14) disposed in the rural community. Medical data of the contacted patient are acquired in the rural community using a medical device (30, 32) possessed by the community health worker in the rural community. The acquired medical data are wirelessly communicated to a central station (10) comprising a computer using a mobile device (46) possessed by the community health worker in the rural community, and stored at a patient data storage (34) of the central station. The stored medical data are thereafter wirelessly transmitted to a medical facility (12, 22) for use in a consultation with the medical facility regarding the contacted patient that is initiated by the community health worker.

**FIG. 1**
SYSTEM AND METHOD FOR IMPROVING CLINICAL OUTCOME IN PRIMARY CARE

FIELD

The following relates generally to the medical arts, maternal and neonatal care arts, medical communication arts, and related arts.

BACKGROUND

Rural areas such as certain regions of sub-Saharan Africa exhibit high mortality and morbidity rates for pregnant women and infants during pregnancy and childbirth. Various efforts have been made to leverage technology to improve maternal and neonatal care in rural settings. One such effort is the Mobile Obstetrical Monitoring ("MoM") project, which provides on-site medical screening for pregnant women. See http://Vmwnewscenter.philipsx on/main/standard/news/press/2014/20140311-irtobiie-obstetrical-monitoring-project.wpd#.VFIIKufiif9HLI (last accessed Nov. 7, 2014). The MoM project provides a cellular telephone application ("app") for supporting midwives in the field. Imaging the World ("ITW") provides portable ultrasound machines in rural areas via which a trained machine operator can acquire a volume scan (which does not require advanced anatomical knowledge) and transmit it in compressed form to a remote physician for an ultrasound reading, risk assessment and a medical referral if appropriate based on the ultrasound results. See http://imagiri.theworld.org/ (last accessed Nov. 7, 2014).

The World Health Organization (WHO), United Nations Population Fund (UNFPA), and United Nations Children's Fund (UNICEF) have developed a monitoring emergency obstetric care handbook. For the purposes of assessing and monitoring the level of care that a facility is actually providing, it is helpful to use a short list of clearly defined "signals functions". These are key medical interventions that are used to treat the direct obstetric complications that cause the vast majority of maternal deaths around the globe. The list of signal functions does not include every service that ought to be provided to women with complicated pregnancies or to pregnant women and their newborns in general; rather, the signal functions are indicators of the level of care being provided. Furthermore, some critical services are subsumed within these signal functions. For example, if caesarean sections are performed in a facility, this implies that anesthesia is being provided. The signal functions are used to classify facilities on the basis of whether various signal functions have been performed in the past 3 months. More generally, it is helpful to use a more inclusive list
of functions and supplies when assessing need for emergency obstetric care (EmOC) in order to plan programs. The list of signal functions has recently been updated with the addition of the new signal function: "perform neonatal resuscitation" at basic and comprehensive levels. In addition, the name of the another signal function has recently been changed from "administer parenteral oxytocics" to "administer uterotonic drugs". The list of signal functions in Table 1 includes some parentheticals listing a few examples of drugs or equipment that could be used when performing the various signal functions; however, the drugs and procedures mentioned in the parentheticals are illustrative and not exhaustive. In one facility assessment paradigm, a basic emergency obstetric care facility is one in which all signal functions 1-7 are performed. A comprehensive emergency obstetric care facility is one in which all signal functions 1-9 are performed.

Table 1 - List of Signal Functions

<table>
<thead>
<tr>
<th>Basic services</th>
<th>Comprehensive services</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Administer parenteral1 antibiotics</td>
<td>Perform signal functions 1–7, plus:</td>
</tr>
<tr>
<td>(2) Administer uterotonic drugs2 (i.e. parenteral oxytocin)</td>
<td>(8) Perform surgery (e.g. caesarean section)</td>
</tr>
<tr>
<td>(3) Administer parenteral anticonvulsants for preeclampsia and eclampsia (i.e. magnesium sulfate).</td>
<td>(9) Perform blood transfusion</td>
</tr>
<tr>
<td>(4) Manually remove the placenta</td>
<td></td>
</tr>
<tr>
<td>(5) Remove retained products (e.g. manual vacuum extraction, dilation and curettage)</td>
<td></td>
</tr>
<tr>
<td>(6) Perform assisted vaginal delivery (e.g. vacuum extraction, forceps delivery)</td>
<td></td>
</tr>
<tr>
<td>(7) Perform basic neonatal resuscitation (e.g. with bag and mask)</td>
<td></td>
</tr>
</tbody>
</table>

Such approaches have improved maternal survival rates and reduced infant mortality rates in regions where they have been applied. However, these approaches have certain limitations. The combination of portable ultrasound machines and machine operators with typically limited medical training leads to limited diagnostic capability. The remote physician may be unwilling (or even legally barred from) making diagnostic decisions based on compressed images acquired by a relatively unskilled ultrasound machine operator. Accordingly, the physician is limited to making medical referrals or suggesting medical follow-up - the pregnant woman then seeks care at the regional hospital leading to further overburdening of the hospital and longer patient waiting periods. More generally, while
programs such as ITW can provide early detection of possible pregnancy complications, they are generally unable to effectively remediate emergency situations.

The following discloses a new and improved systems and methods that address the above referenced issues, and others.

SUMMARY

In one disclosed aspect, an electronic system is disclosed in support of a health care system for providing medical care in a rural region. The electronic system comprises: a patient data storage; at least one wireless communication server; and a central station comprising an electronic data processing device configured to wirelessly communicate via the at least one wireless communication server to receive, via the wireless communication server, a wireless electronic message containing patient data from a medical device and to transmit, via the wireless communication server, a wireless electronic message containing patient data, the central station further configured to extract patient data from a wireless electronic message containing patient data received from a medical device and store the extracted patient data in the patient data storage and to formulate the wireless electronic message containing patient data that is transmitted via the wireless communication server.

In another disclosed aspect, a method is disclosed to support providing medical care in a rural region. The method comprises: at a remote site, acquiring patient data using a medical device; communicating the acquired patient data from a mobile device at the remote site to a central station as an incoming wireless electronic message containing the acquired patient data that is wirelessly sent from the mobile device to the central station; at the central station, extracting the acquired patient data from the incoming wireless electronic message and storing the extracted acquired patient data in a patient data storage of the central station; at the central station, formulating an outgoing wireless electronic message containing patient data retrieved from the patient data storage; communicating the outgoing wireless electronic message from the central station to a medical facility remote from the central station; and at the medical facility, extracting the patient data retrieved from the patient data storage from the outgoing wireless electronic message received at the medical facility.

In another disclosed aspect, a method is disclosed to support providing medical care in a rural community. The method comprises: contacting a patient in the rural community by a community health worker disposed in the rural community; acquiring medical data of the contacted patient in the rural community using a medical device possessed by the community health worker in the rural community; wirelessly
communicating the acquired medical data to a central station comprising a computer using a mobile device possessed by the community health worker in the rural community; storing the acquired medical data wirelessly communicated to the central station at a patient data storage of the central station; and wirelessly transmitting the acquired medical data stored at the patient data storage of the central station to a medical facility.

**BRIEF DESCRIPTION OF THE DRAWINGS**

The invention may take form in various components and arrangements of components, and in various steps and arrangements of steps. The drawings are only for purposes of illustrating the preferred embodiments and are not to be construed as limiting the invention.

FIGURE 1 diagrammatically illustrates an electronic system for supporting a health care system that provides maternal and neonatal care to a rural region.

FIGURE 2 diagrammatically illustrates a method for supporting providing medical care in a rural community that is suitably performed using the system of FIGURE 1.

**DETAILED DESCRIPTION**

A recent clinical trial has been conducted at Tygerberg Hospital (a tertiary hospital located in Parow, Cape Town, South Africa). At this hospital, maternal mortality and morbidity was increasing due to the Obstetric Critical Care Unit (OCCU) being overburdened with a 95% occupation rate and an increased admission rate of severe critically ill and ventilated patients. A source of this increase was expansion of the Tygerberg Hospital service area to include the Kayalitsha region, which has more than 10,000 deliveries per year. As a consequence, referrals increased by 2000 patients from which 1500 were deliveries. A bottleneck arose due to lack of an emergency obstetrical unit for high risk pre- and post-natal cases, non-viable pregnancies and abruption UID. A dedicated "step down unit" was built to tackle this challenge. However, problems remained, including: lack of monitoring for at-risk step down patients with arterial lines, central venous pressure's (CVP's) and epidurals; lack of ECG monitoring; unavailability of Continuous Positive Airway Pressure (CPAP); and limited training for nurses and midwives.

Approaches disclosed herein are designed to strengthen care coordination and risk stratification for pregnant women across the different levels of healthcare delivery (primary, secondary and tertiary level). To bring quality care into rural communities, approaches disclosed herein take into account knowledge of where and how expectant
mothers are treated in the different levels of the health delivery system and for which set of symptoms. For example: How do hospitals organize patient data collection and patient data-management? Who does the interpretation of the patient data and who decides on the treatment, on what basis? The disclosed approaches recognize that many of expectant mothers and neonates are dying during transport, and this is addressed by considering risk stratification mechanisms and resulting referral pathways.

The disclosed approaches comprise synergistic combinations of devices (patient monitoring, fetal monitoring, ultrasound ventilation devices, and so forth), software (an electronic health, or "e-health", system), training and continuous education. These can be organized in accord with a maintenance contract and coaching (quality control & quality assurance) to ensure the sustainability of the overall healthcare service delivery solution.

Advantages achieved by the disclosed approaches include: improved follow-up of mother and child pre- and post-natal; early recognition and effective management of critically ill obstetric patients (via treatment and/or referral); increased capacity to manage high risk pregnancies and complications in OCCU; earlier discharge achieved as critically ill patients receive effective and timely initial treatment; reduced admission to the EmOC unit as only those patients who are in need for advanced monitoring are admitted to EmOC; reduced mortality and morbidity rates for pregnant women and infants during pregnancy and childbirth; and improved collection, management and interpretation of patient data.

In the Tygerberg Hospital trial, existing step-down unit infra-structure was improved by installation of patient monitoring, (with transport capabilities and clinical decision support tools) and fetal monitoring in the EmOC unit, and installation of a central station in the OCCU. Medical staff was trained on the use of these devices, and a continuous education program was developed to tackle staff turn-over and to ensure sustainability. Over the one year trial period, critically ill mothers and women with at-risk pregnancies were prospectively evaluated and stratified according to which patients needed emergency critical care in the EmOC. Critically ill pregnant women and mothers were transferred directly to the OCCU, while those in less critical condition were treated or observed for a certain period of time in the EmOC. Patient turnover and admission rates in the maternity department were compared before and after the 12 month trial period. Based on the collected data, an "Emergency Obstetric Care unit- blueprint" was developed, that can be replicated across South Africa and in other African countries and healthcare service delivery systems.
Some conclusions of the Tygerberg Hospital trial are as follows. With the implementation of a well-equipped EmOC, staffed with well-trained medical personal in the former step-down unit, the trial was able to improve the workflow in the maternity department of Tygerberg Hospital as indicated by the following metrics: 25% increase in Obstetrical Critical Care Unit acceptance, (from 402 to 519 mothers); 400 mothers were directly admitted from the labor ward; decreased bed occupancy from 95% to 70% in the OCCU; 814 mothers were admitted in the EmOC, coming from OCCU, labor ward and referral hospital ICU’s; the early emergency and risk prevention capacity of the department was increased (early detection → early treatment); and, during the last 18 months, there were no maternal deaths in the EmOC and the mortality rate in OCCU did not increase.

The approaches disclosed herein address more fundamental reasons, recognized herein, as to why certain rural areas exhibit high mortality and morbidity rates for pregnant women and infants during pregnancy and childbirth. One source of these problems is limited options for delivery. Due to transportation issues and other factors many women deliver at home, which reduces the maternal survival rate and increases the infant mortality rate. As an alternative, the pregnant woman may travel to a hospital expecting to obtain better medical care; however, rural regional hospitals are often overburdened, and long waiting times can again lead to reduced maternal survival and increased infant mortality. The decision to seek hospitalization is sometimes driven by a worsening condition of the pregnant woman, and a late decision to seek hospitalization can lead to high maternal and infant mortality during transport, especially in rural areas that may lack ambulance services.

By attempting delivery at home, or traveling at some risk to an overburdened regional hospital, pregnant women do not utilize a local primary care facility (PCF) that could potentially provide life-saving care.

A way to increase trust in (and hence utilization of) the primary care facility is to improve the care at the primary care facility, by adding additional healthcare equipment in order to increase the range of pathologies that can be diagnosed at the facility. However, such improvements are of limited value if staff are unable to effectively utilize these tools. Additionally, effective mechanisms are needed to provide efficient referral from the primary care facility to higher care levels (such as the regional hospital) when needed, but without "over-referring" patients to the hospital so as to further overburden the hospital.

This issue is addressed in embodiments disclosed herein by providing a central station that links various parts of the health system and facilitates collaboration with higher care levels. The disclosed approaches combine information technology (IT) with improved
primary care facility capabilities (i.e., "more pathologies, more equipment") to provide a synergetic effect. The information technology solution becomes especially valuable when the related medical equipment becomes more advanced; at the same time, adding more advanced medical equipment is difficult without the IT solution, as training of the health worker would otherwise be a barrier, so that the information technology enables effective insertion of advanced medical equipment at the primary care facility level.

With reference to FIGURE 1, in one illustrative embodiment an electronic system is described, which supports a health care system that provides medical care in a rural region. A central information technology (IT) system or station 10 provides connections between health workers of the health care system. The health care system includes at least one primary care facility (PCF) 12 and at least one community health worker 14, and more preferably a number of health care workers providing the capability to visit women during their pregnancies in their homes or in common meeting places (e.g. town market places, community centers, or so forth). The central IT system 10 stores in a central location data generated by the community health worker 14 and by the primary care facility 12. To this end, a data link 16 is provided between each PCF 12 and the central station 10, and a data link 18 is provided between each health care worker 14 and the central station 10. The central IT system 10 makes central data available to all levels of the care system. Accordingly, in some embodiments a further data link 20 is provided between the central station 10 and a regional hospital 22 (or other care facility that has more resources, i.e. is at a "higher level", than the PCFs 12). The central IT system 10 is configured to receive input derived with at least one of a patient monitoring device 30 and an ultrasound device 32. Patient data such as patient name and characteristics (gender, age, weight, height, etcetera), patient vital signs acquired by the patient monitoring device 30, ultrasound images or data acquired by the ultrasound device 32, text-descriptive observations provided by the community health worker 14, and so forth, are received from the primary care facility 12 and/or the community health worker 14 and are suitably stored at the central station 10 in a data storage 34. Since patient data may be received in different formats, may be compressed, or otherwise exhibits diversity, a data converter 36 is provided which includes algorithms for converting received patient data to a common format used for storing the patient data in the data storage 34, and for converting patient data from that common format to a data communication transmission channel-specific format for transmission to a particular recipient 12, 14, 22.

Each primary care facility 12 is equipped to perform patient diagnosis, triage, and to perform treatment or stabilization for transport. Each community health worker 14 is
likewise equipped to perform patient diagnosis, triage, and to perform treatment or stabilization for transport (albeit possibly at a "lower level", e.g. with less equipment available, as compared with the PCF 12). As used herein, the term "treatment" encompasses both preventative care and treatment in emergency situations.

With continuing reference to FIGURE 1, in the illustrative embodiment the primary care facility 12 is suitably equipped to perform diagnosis, triage, and treatment or stabilization for transport by being provided with equipment such as a patient monitor device 30, for example an illustrative electrocardiograph (ECG) machine 30, a respiratory monitor, an Sp02 sensor, or so forth. Additionally or alternatively, the PCF 12 is equipped with an ultrasound device 32, such as a fetal Doppler device, a fetal monitor, an ultrasound imaging device, or so forth. Additionally or alternatively, the PCF 12 may be equipped with chemical diagnostics, for example to analyze blood (e.g. for glucose), urine or sputum. Additionally or alternatively, the PCF 12 may be equipped with ventilation equipment (for example CPAP / BIPAP devices and nebulizer).

Likewise, in the illustrative embodiment the community health worker 14 is suitably equipped to perform diagnosis, triage, and treatment or stabilization for transport by being provided with equipment such as a patient monitor device 30, for example an illustrative ECG machine 30, a respiratory monitor, an Sp02 sensor, or so forth. Additionally or alternatively, the community health worker 14 is equipped with an ultrasound device 32, such as a fetal Doppler device, a fetal monitor, an ultrasound imaging device, or so forth. Additionally or alternatively, the community health worker 14 may be equipped with chemical diagnostics, for example to analyze blood (e.g. for glucose), urine or sputum.

The central IT system 10 is configured to receive data derived with the patient monitoring device 30 of the PCF 12 or the community health worker 14. This data transfer may be an automatic data connection between the patient monitoring device 30 and the central IT system 10, or the data transfer may be performed indirectly via manual input by a community health worker 14. Likewise, the central IT system 10 is configured to receive data derived with the ultrasound device 32 of the PCF 12 or the community health worker 14.

The PCF 12, and optionally also the community health worker 14 operating in the field, is preferably equipped to handle emergency situations. To this end, the central station 10 preferably has a continuous data connection with the health care worker 14. This can for example be achieved using mobile phone technology, such as Short Messaging Service (SMS)-based, Multimedia Messaging Service (MMS)-based, 3G based, 4G based, or WiFi based. The SMS protocol, commonly referred to as "text messaging", is limited to text
messages. For sending images or other non-textual data, the MMS protocol is suitably
employed. Both SMS and MMS are relatively slow transmission protocols with relatively
low bandwidth, but advantageously do not require substantial IT infrastructure and are more
likely to be available in rural areas with limited data connectivity. Where available, 3G, 4G,
or WiFi provide high transmission speeds and bandwidth and hence are preferable to SMS or
MMS. Due to the typically patchy data communication infrastructure in rural areas, in some
embodiments the central station 10 preferably provides both an SMS/MMS server 40
(providing SMS service and preferably also providing MMS service) and a 3G/4G/WiFi
server 42 (providing 3G connectivity, or 4G connectivity, or WiFi connectivity, or some
combination of 3G, 4G, and/or WiFi). The community health worker 14 suitably transmits
data to the central station 10 using an illustrative cellular telephone 46 or other mobile
electronic device (e.g. tablet computer) with suitable wireless data connectivity (e.g., one or
more of SMS, MMS, 3G, 4G, wifi, et cetera). The data connectivity transmitter and/or
receiver are optionally additionally or alternatively incorporated into the portable medical
device(s) 30, 32 with which the community health worker 14 is equipped.

Communication between the mobile device 46 (and/or transceiver of the
medical device 30, 32) and the corresponding server 40, 42 of the central station 10 is
suitably mediated by an application program ("app") executing on the mobile device 46 (or
on the microprocessor or microcontroller of the medical device 30, 32). The patient data is
received by the app running on the mobile device 46 in one or more ways, such as via direct
entry by the health worker 14 using a physical or screen-based keyboard; or reading the
patient data from the medical device 30, 32 via a wired connection (e.g. USB) or short-range
wireless connection (e.g. Bluetooth). The latter approaches assume that the medical device
30, 32 includes an electronic microprocessor or microcontroller programmed to connect with
the mobile device 46 to perform such data communication - this is often the case since
medical devices are commonly digital devices in which patient data are acquired in digital
format via suitable analog-to-digital conversion circuitry or the like. The app performs any
appropriate data conversion, data compression, and formatting as an SMS/MMS/3G/4G/wifi
message in order to implement the wireless data transmission. Alternatively, some of this
data conversion/compression processing may be performed at the medical device 30, 32 that
acquired the patient data, again assuming the medical device has a suitably programmed
microprocessor or microcontroller. At the central station 10, the patient data are extracted
from the received message, decompressed if necessary, and converted to the common data
format (for the particular data type, e.g. images are stored at the central station in a common
image format, text in a common text format, et cetera) by the data converter 36 for storage in the patient data storage 34.

In similar fashion, patient data may be transmitted from the central station 10 to the mobile device 46 carried by the community health worker 14. In this case, patient data requested by the community health worker 14 via a cellphone text message or other mechanism are retrieved from the data storage 34, formatted as a wireless (SMS, MMS, 3G, 4G, WiFi, et cetera) message in a format (optionally compressed) that can be processed by the mobile device 46 carried by the health worker 14, and transmitted to the mobile device 46. At the mobile device 46, the app running on the mobile device 46 processes the message to extract the patient data and displays the extracted patient data on a display of the mobile device 46.

Data exchange between the primary care facility 12 and the central station 10, and between the hospital 22 and the central station 10, operates similarly, except that in some embodiments the mobile device is replaced by a desktop computer or other less portable electronic device (not shown) having the requisite wireless connectivity. This can be done since the PCF 12 and hospital 22 do not have the mobility of the deployed community health care worker 14, and hence a desktop computer or other device may be preferable as it trades limited or eliminated mobility for features such as a larger display, faster wireless communication hardware, a larger battery or other energy source, et cetera. On the other hand, since the central station 10 includes the server(s) 40, 42 capable of communicating patient data via mobile devices, this approach can be used if the PCF 12 does not have more advanced IT infrastructure, or if such IT infrastructure is temporarily unavailable due to a power outage or equipment failure, or if the PCF 12 has a large staff such that it is more convenient for individual health workers at the PCF 12 to communicate via their cellphones.

The use of a mobile device 46 with limited capability, possibly in conjunction with a less advanced communication infrastructure such as SMS and/or MMS, advantageously enables the deployed community health worker 14 to maintain both communication and patient data connectivity with higher levels of the health care system, such as with the PCF 12 and/or the hospital 22, under various conditions that may be encountered in rural environments with limited wireless connectivity. This is enabled by providing the central station 10 with the appropriate wireless communication server or servers 40, 42 and a data converter 36 configured to formulate patient data as messages of appropriate format and size for transmission to the mobile device 46, or conversely to receive and extract patient data from such limited-bandwidth messages received from the mobile
device 46. Similar advantages are attained for the primary care facility 12, especially if this facility is located in an area with limited wireless connectivity.

In spite of the foregoing, in some instances the community health worker 14, and possibly the PCF 12 itself, may not have any wireless electronic connectivity. This can occur, for example, if the community health worker 14 operates in an area with no wireless coverage at all, or if the PCF 12 loses wireless connectivity due to a power outage, natural disaster, or the like. To address such situations, in some embodiments a printer 50 is connected to the central station 10. The printer 50 allows patient data stored in the patient data storage 34 of the central station 10 to be printed on paper, in case the data needs to be transported (e.g. by a human courier) to a location that has no data connection to the central station 10. In an alternative approach, the data can be downloaded to a portable data storage device (e.g. a USB flash drive, optical disk, or so forth, for example via a USB port 52 of the central station 10) for transportation to another location (again, e.g. by a human courier). In this alternative embodiment, the data is preferably downloaded to the portable data storage device in a device-agnostic format, such as in the Portable Document Format (pdf) format. Advantageously, many cellphones, tablet computers, and other mobile devices include a micro-USB port or other physical storage medium connector via which such data can be loaded into the mobile device 46 for viewing by the community health worker 14.

In some embodiments, data can be sent to a mobile phone number using a cellular telephone technology such as SMS, MMS, or an app-based solution such as WhatsApp Messenger (available from WhatsApp Inc., Mountain View, CA, USA). In such embodiments, the central station 10 is configured by the data converter 36 to format the data in a package that can be sent to a mobile phone. For example, in the case of SMS, the format is suitably text-based, while in the case of WhatsApp an image or pdf file is suitably transmitted.

In general, it will be appreciated that the central station 10 comprises a computer, network server, or other electronic data processing device having suitable wireless server hardware 40, 42 wirelessly connected with a nearby cellular station or tower (not shown) which may be provided by a wireless service provider or may be installed specifically to service the central station 10. The patient data storage 34 may be variously embodied, for example as a hard disk or RAID disk array (for improved redundancy), a cloud storage service (physically embodied by networked computers located remote from the central station 10), or so forth. The data converter 36 is suitably implemented as software executing on a computer of the central station 10. The illustrative USB port 52 or other physical
medium connection port may, for example, be provided as a USB port of the computer of the central station 10.

With reference to FIGURE 2, a method suitably performed using the system of FIGURE 1 to support providing medical care in a rural community is illustrated. In an operation S1, a community health worker 14 approaches a patient in the community (for example, via a home, or by meeting the patient in the town market, or so forth). The community health worker 14 is typically a volunteer or low-paid worker, and typically does not have significant conventional medical training (e.g. from a medical school, nursing school, or the like). However, the community health worker 14 is typically a local person, and hence may know the patient personally (or know some mutual friend(s)) so that the approach operation S1 is thereby facilitated. If the patient already has a patient record in the patient data storage 34, then the community health worker 14 uses the app on the mobile device 46 to access this record. If the patient is a new patient who is not yet in the system, then the community health worker 14 may create a patient record for the patient in the patient data storage 34. In this latter case, the patient is identified based on available information, which in some rural areas may be fairly limited (e.g. patient name and telephone number, in some cases). To assist in subsequent identification, it is contemplated to acquire biometric information in the form of a fingerprint (e.g. read using an optional fingerprint reader of the mobile device 46), a portrait photograph, or the like - if such biometric identifier information is acquired it may be suitably stored in the patient data storage 34 along with other patient identification information such as name and phone number.

In an operation S2, the community health worker 14 performs at least one of diagnosis, triage, treatment, and/or stabilization for transport of the patient contacted in operation S1, and stores the related data in the central station 10. The community health worker 14 preferably receives training for these tasks, for example in a distributed manner in which system deployment specialists travel the region served by the system of FIGURE 1 and train community health workers 14 in their respective local towns. This relatively limited medical training is accommodated (or compensated for) by the IT-based support system as described with reference to FIGURE 1.

In an operation S3, if a problem occurs during the operation S2 (such as the patient showing an unstable condition or abnormal vital sign reading(s)), the community health worker 14 suitably communicates "on demand" via the central station 10 with a "higher level" care provider (e.g., with a medical worker at the primary care facility 12, or with a physician at the hospital 22) to receive feedback. This communication may take
various forms. Because the doctor-to-patient ratio in many rural areas is low, the communication may log a call-back request at the central station 10 that notifies a doctor or other medical professional of the request. Optionally, such call-back requests may be prioritized, for example based on a priority designation assigned by the community health worker 14 who submits the request, and/or based on the type of request. If the priority is high enough it may trigger an urgent request to the physician asking for immediate response.

Advantageously, the higher-level care provider can access the patient data stored at the central station 10 to assist the community health worker 14 in assessing the patient's condition. This data may include vital signs measured by the community health worker 14 using the patient monitor device 30, and/or may include ultrasound data acquired using the ultrasound device 32. In an operation S4, if the community health worker 14 refers the patient to the primary care facility 12, the patient data acquired by the community health worker 14 is made available at the primary care facility 12 through the central station 10, and the primary care facility 12 suitably performs at least one of diagnosis, triage, treatment, stabilization for transport, and stores the related data in the central station 10.

In an operation S5, if a problem occurs at the primary care facility 12 (such as the patient showing an unstable condition or abnormal vital sign reading(s)), the primary care facility 12 communicates "on demand" with via the central station 10 with a "higher level" care provider (e.g., with a physician at the hospital 22) to receive feedback. Because the hospital 22 may be backlogged, the communication may log a call-back request at the central station 10, optionally prioritized, that notifies a doctor or other medical professional at the hospital 22 of the request.

Advantageously, the doctor at the hospital 22 can access the patient data stored at the central station 10 to assist in assessing the patient's condition. This data may include vital signs measured by the community health worker 14 and/or the primary care facility 12 using the patient monitor device 30 and/or the ultrasound device 32. In an operation S6, if the primary care facility 12 decides to refer the patient to the hospital 22, the patient data stored at the central station 10 is made available to the physician or other care worker(s) at the hospital 22. Again, this data may include vital signs measured by the community health worker 14 and/or the primary care facility 12 using the patient monitor device 30 and/or the ultrasound device 32.

The illustrative embodiments are directed to providing maternal and neonatal care, which is an urgent need in rural areas of Africa and other continents. More generally, however, the disclosed electronic support for health care systems, and methods using same,
can be used for providing medical care generally to rural communities, or for providing medical care of a specific type other than maternal/neonatal care to such communities. For example, the disclosed approaches would be suitable for rapid deployment of medical care in the event of a regional epidemic or a natural disaster. Advantageously, deployment entails constructing only limited infrastructure, e.g. constructing the central station (which could be constructed as a mobile truck-based facility that is driven to the rural location and powered by on-board diesel generators, batteries, or the like) and deploying medical workers equipped with mobile devices with the appropriate app pre-loaded and further equipped with portable medical devices appropriate for diagnosing and treating patients. The term "community" health worker is used herein as local community members are typically effective at engaging pregnant women in remote rural locations; however, more generally the deployed health workers may be non-local, e.g. during a spreading epidemic volunteer health workers may be brought in from abroad. Similarly, the "primary" care facility may more generally be local medical care facilities, e.g. tent-based mobile medical units that are set up in various parts of a rural region in response to a spreading regional epidemic.

The invention has been described with reference to the preferred embodiments. Modifications and alterations may occur to others upon reading and understanding the preceding detailed description. It is intended that the invention be construed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.
CLAIMS:

1. An electronic system in support of a health care system for providing medical care in a rural region, the electronic system comprising:
   a patient data storage (34);
   at least one wireless communication server (40, 42); and
   a central station (10) comprising an electronic data processing device configured to wirelessly communicate via the at least one wireless communication server (40, 42) to receive, via the wireless communication server, a wireless electronic message containing patient data from a medical device (30, 32) and to transmit, via the wireless communication server, a wireless electronic message containing patient data, the central station (10) further configured to extract patient data from the wireless electronic message containing patient data received from the medical device and store the extracted patient data in the patient data storage (34) and to formulate the wireless electronic message containing patient data that is transmitted via the wireless communication server.

2. The electronic system of claim 1 further comprising:
   said medical device (30, 32) disposed remotely from the central station (10) and in wireless communication with the central station via the at least one wireless communication server (40, 42) to communicate patient data acquired by the medical device to the central station as a wireless electronic message containing the acquired patient data.

3. The electronic system of claim 2 further comprising:
   a mobile device (46) in wired or short-range wireless communication with the medical device (30, 32) to transfer the acquired patient data from the medical device to the mobile device, wherein the mobile device (46) is in wireless communication with the central station (10) via the at least one wireless communication server (40, 42) to communicate the acquired patient data from the mobile device to the central station as a wireless electronic message containing the acquired patient data.
4. The electronic system of claim 3 wherein the mobile device (46) is a cellular telephone (cellphone) or tablet computer.

5. The electronic system of any one of claims 1-4 wherein the at least one wireless communication server (40) is configured to communicate via one or both of Short Messaging Service (SMS) and Multimedia Messaging Service (MMS).

6. The electronic system of claim 5 wherein the central station (10) is configured (36) to extract patient data from the wireless electronic message containing patient data by extracting the patient data from an SMS or MMS message, and is configured to formulate the wireless electronic message containing patient data that is transmitted via the wireless communication server by formatting the patient data into an SMS or MMS message.

7. The electronic system of any one of claims 1-6 wherein the at least one wireless communication server (40, 42) is further configured to communicate via at least one of 3G, 4G, and WiFi.

8. The electronic system of any one of claims 2-7 wherein the medical device (30, 32) comprises a patient monitoring device (30).

9. The electronic system of claim 8 wherein the patient monitoring device (30) comprises an electrocardiograph (ECG) machine.

10. The electronic system of any one of claims 2-9 wherein the medical device (30, 32) comprises an ultrasound device (32).

11. The electronic system of any one of claims 1-10 wherein the at least one wireless communication server (40, 42) is configured to provide continuous wireless communication.

12. The electronic system of any one of claims 1-11 further including at least one of:

   a printer (50) configured to print patient data stored in the patient data storage (34); and
a port (52), wherein the central station (10) is configured to retrieve patient data from the patient data storage (34) and transfer the retrieved patient data to a portable data storage device via the port.

13. The electronic system of claim 12 wherein the central station (10) further includes:

- a data converter (36) configured to convert the wireless electronic message containing patient data received from the medical device (30, 32) to a common format used for storing the patient data in the data storage (34), and configured to convert patient data from the common format to a format for output to the printer (50) or portable data storage device (52).

14. A method to support providing medical care in a rural region, the method comprising:

- at a remote site, acquiring patient data using a medical device (30, 32);
- communicating the acquired patient data from a mobile device (46) at the remote site to a central station (10) as an incoming wireless electronic message containing the acquired patient data that is wirelessly sent from the mobile device to the central station;
- at the central station, extracting the acquired patient data from the incoming wireless electronic message and storing the extracted acquired patient data in a patient data storage (34) of the central station;
- at the central station, formulating an outgoing wireless electronic message containing patient data retrieved from the patient data storage;
- communicating the outgoing wireless electronic message from the central station to a medical facility (12, 22) remote from the central station; and
- at the medical facility, extracting the patient data retrieved from the patient data storage from the outgoing wireless electronic message received at the medical facility.

15. The method of claim 14 wherein the mobile device (46) comprises a cellular telephone (cellphone) or tablet computer.

16. The method of any one of claims 14-15 wherein the medical device (30, 32) is a patient monitoring device (30) or an ultrasound device (32).
17. The method of any one of claims 14-16 further comprising:
transferring the acquired patient data from the medical device (30, 32) to the
mobile device (46) via a wired connection or a short-range wireless connection.

18. The method of any one of claims 14-17 wherein the incoming wireless
electronic message is wirelessly sent from the mobile device (46) at the remote site to the
central station (10) using Short Messaging Service (SMS) or Multimedia Messaging Service
(MMS).

19. A method to support providing medical care in a rural community, the
method comprising:
contacting a patient in the rural community by a community health worker
(14) disposed in the rural community;
acquiring medical data of the contacted patient in the rural community using a
medical device (30, 32) possessed by the community health worker in the rural community;
wirelessly communicating the acquired medical data to a central station (10)
comprising a computer using a mobile device (46) possessed by the community health
worker in the rural community;
storing the acquired medical data wirelessly communicated to the central
station (10) at a patient data storage (34) of the central station; and
wirelessly transmitting the acquired medical data stored at the patient data
storage (34) of the central station to a medical facility (12, 22).

20. The method of claim 19 wherein the wirelessly communicating comprises:
transferring the acquired patient data from the medical device (30, 32) to the
mobile device (46) via a wired connection or a short-range wireless connection; and
wirelessly communicating the acquired medical data transferred to the mobile
device (46) from the mobile device to the central station (10).

21. The method of claim 20 wherein the wirelessly communicating comprises:
wirelessly communicating the acquired medical data transferred to the mobile
device (46) from the mobile device to the central station (10) using Short Messaging Service
(SMS) or Multimedia Messaging Service (MMS).
22. The method of any one of claims 19-21 further comprising:

performing a consultation regarding the contacted patient, initiated by the

community health worker (14), with a medical person disposed at the medical facility (12, 22), wherein the wireless transmitting is performed during the consultation to provide the acquired medical data of the contacted patient to the medical person disposed at the medical facility (12, 22).

23. The method of claim 22 wherein the contacted patient is a pregnant woman and the consultation pertains to a pregnancy complication.
Community health worker contacts a patient  

Community health worker performs diagnosis, triage, treatment, and/or stabilization for transport, and stores the related data in the central station  

Community health worker communicates with higher-level care provider via the central station to obtain feedback on the patient  

Primary care facility receives patient data acquired by the community health worker via the central station, performs diagnosis, triage, treatment, and/or stabilization for transport, and stores the related data in the central station  

Primary care facility communicates with higher-level care provider via the central station to obtain feedback on the patient  

Patient referred to the hospital, with patient data being made available to the hospital via the central station  

FIG. 2
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

INV. G06F19/00

ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

G06F G06Q A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal , WPI Data, BIOSIS, EMBASE, INSPEC

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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<td>wo 97/28736 AI (NOKIA MOBILE PHONES LTD [FI] ; HEINONEN PEKKA [FI] ; 0KKONEN HARRI [FI]) 14 August 1997 (1997-08-14) the whole document</td>
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**X** Further documents are listed in the continuation of Box C. **X** See patent family annex.

* Special categories of cited documents:

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  *E* earlier application or patent but published on or after the international filing date
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  **"S** document member of the same patent family

**Date of the actual completion of the international search**

11 March 2016

**Date of mailing of the international search report**

17/03/2016

Name and mailing address of the ISA

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