ICT SOLUTION FOR MEDICAL WASTE MANAGEMENT AND TRACKING

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ABSTRACT

Poor management and treatment of medical waste exposes the community at large to infection, potential health hazards, and risks polluting the environment. In spite of all medical waste management regulations and inspections, unsafe disposal of health-care waste exists. This paper proposes an easy to use and affordable solution that utilizes the information and communication technology (ICT) to locate, track, monitor, and manage medical waste. The Radio Frequency Identification (RFID) is used in conjunction with wireless connectivity for indoor tracking. The Global Positioning System (GPS) is integrated with a mobile module for outdoor tracking. The proposed solution gathers information and performs several tasks enabling a system administrator 24/7 to audit the whole process and predicts possible unsafe disposal and to make sure that each category of health-care waste is treated and disposed with the right method.

Keywords: Medical Waste Tracking, Monitoring, Management, ICT, RFID, GPS.

INTRODUCTION

Healthcare-associated medical waste is generated by health care activities includes a broad range of materials during the course of receiving medical care, e.g. used needles and syringes, body parts, diagnostic samples, blood, chemicals, pharmaceuticals, and radioactive materials [1]. Medical advances have brought lifesaving care to patients in need, yet many of those advances come with a risk of infections, bio-hazards, and risks polluting the environment that can be devastating and even deadly. Wherever patient care is provided, adherence to medical waste management guidelines is needed to ensure that all care is safe care [1-5]. This includes traditional hospital settings as well as outpatient surgery centers, long-term care facilities, rehabilitation centers, and community clinics. In spite of recent successes in medical waste...
management, regulation, and standardization that have been very encouraging, unsafe disposal of health-care waste still exists. Therefore, a medical Bio-Hazard Waste monitoring system is needed to assist in enforcing policies and rules, and then evaluated for their effectiveness.

This paper does not aim to introduce new medical waste regulations nor treatment methods. This paper proposes an easy to use and affordable solution that utilizes ICT to locate, track, and manage medical waste enabling a healthcare facility administration to make sure that each category of health-care waste is treated and disposed with the right method, ensures optimal operation, and cuts down on the amount of paper records.

CURRENT METHODOLOGY

The health-care waste producer is responsible for safe packaging and adequate labeling of waste to be transported off-site and for authorization of its destination. Packaging and labeling should comply with national regulations governing the transport of hazardous wastes and with international agreements if wastes are shipped abroad for treatment. Let us take an example of the five-section consignment note, shown in figure 1, from the United Kingdom (U.K.), with its corresponding route as illustrated in figure 2 [5].

Currently, any control strategy for health-care waste should have the following components:

I. A consignment note should accompany the waste from its place of production to the site of final disposal. On completion of the journey, the transporter should complete the part of the consignment note especially reserved for him and return it to the waste producer. A typical consignment note for carriage and disposal of hazardous waste, used in the U.K. and the routing of the consignment note are shown in Figs 1 and 2, respectively [5].

II. The transporting organization should be registered with, or known to, the waste regulation authority.

III. Handling and disposal facilities should hold a permit, issued by a waste regulation authority, allowing the facilities to handle and dispose of health-care waste.
Fig. 1: Example of a consignment note used in the U.K.
There is no mean of audit the whole process except through personnel inspection which is 

Fig. 2: Route of the consignment note used in the U.K.

The consignment note should be designed to take into account the waste control system in operation within the country. If a waste regulation authority is sufficiently well established, it may be possible to pre-notify the agency about the planned system of transport and disposal of the health-care waste and obtain the agency’s approval. Anyone involved in the production, handling, or disposal of health-care waste has a general “duty of care”, i.e. an obligation to ensure that waste handling and associated documentation comply with the national regulations.

After analyzing the manual system, as described above, the following drawbacks exists and are considered to be of high risk to the safety of patients, medical staff, and environment in general:

1. The current manual system highly depends on the awareness of well-trained personnel.

There is no mean of audit the whole process except through personnel inspection which is
very costly to be done on a daily basis. Quality Assessment (QA) of bio-medical waste management should be done from time to time.

2. There is no way to record the time period of each step of the process; e.g. storage times for healthcare waste (i.e. the delay between production and treatment) should not exceed certain time frame based on the type of the medical waste and according to the guidelines of medical waste management procedures.

3. Specific personnel need to be assigned to monitor the bio-medical waste management in the hospital and up to point of disposal which is very costly.

4. Sufficient financial and human resources are needed to maintain the record registers of the medical waste proper management to be compliance with safety requirements and regulation. Some records needs to be maintained for more than three years.

**NEW METHODOLOGY**

Today’s healthcare organizations struggle to control costs and maximize valuable resources while delivering quality care and managing medical waste. Healthcare organizations must track and treat medical waste properly and also ensure patient and staff safety. Existing manual systems requires human resources and a lot of paper work and still can’t prevent unsafe disposal of health-care waste. The proposed solution utilizes leading edge ICT technology to reduce the need for human work while providing an automated control system which is a reliable solution for across-the-board visibility and control throughout all hospital departments, meeting the challenges of patient and staff safety, bio-hazards materials management/treatment and more.

**In-door Tracking**

Of particular interest to medical waste tracking within a healthcare facility, is the use of Radio frequency identification (RFID) for indoors object localization. RFID is an automatic identification method which stores and remotely retrieves data through wireless communication channels between tags, i.e. electromagnetic waves (EMW) transmitters, and readers, i.e. EMW receivers. RFID has gained much ground in commercially based localization systems due to their availability, small footprint, and low cost [6,7]. The used RFID tags are color coded with the same color codes of the medical waste bags and containers. The basic architecture of an RFID system consists of a tag that includes an
antenna and a chip, a reader equipped with antenna and a transceiver, and a workstation to host the Middleware and database.

Our system generic platform is a comprehensive, fully integrated solution for expert healthcare systems via an open, flexible architecture, and Application Programming Interfaces (APIs) for multi-system integration. It includes all RFID software and hardware, such as tags, receivers, exciters and repeaters. Our system can monitor in real-time thousands of tags (items) their presence, location, as well as other parameters, such as movement, tampering, verticality, temperature, humidity and more.

It is designed to track moving items within a healthcare facility, such as a hospital, using RFID technology. The proposed system has hardware and software components. The hardware architecture consists of RFID active/passive tags, RFID tag reader, web-based server and database server. The web server and database server are located in the master station. The tag readers are distributed within the facility. The tags are programmed with item’s profiles and are fixed on each item. Communication between the tag reader and the web server is done via wireless LANs. The software architecture consists of a communication driver that handles all communication functions done at the master station, an API that handles and analyzes the data, a friendly intuitive graphical user interface (GUI) and a database that saves all readings and tracked items information.

**RFID Patient and Radioactive Materials Tracking:**

The use of radiation sources in medical and other applications is widespread throughout the world. Occasionally, the public is exposed to radioactive waste, which originated from radiotherapy treatments that have not been disposed of properly. Serious accidents have been documented in Brazil in 1988 (where four people died and 28 had serious radiation burns), Mexico and Morocco in 1983, Algeria in 1978 and Mexico in 1962. Radioactive waste may be solid, liquids and gases used for analytical procedures, body organ imaging and tumor localization and treatment. Radioactive materials need to be treated with special care; therefore, they are tracked by our system from the moment the radiotherapy department receives them till they became waste and properly disposed. The sheer volume of patients and medical staff in hospitals creates new challenges, and a need for a system that can regulate the human flow in these vast institutions, not only to ensure that each patient receives the right treatment in a timely fashion, but also to monitor the location of staff members in real time,
enabling their work's efficacy and protecting them from potential threats. Our system can be extended to track patients, medical staff, equipments, and any other items as needed. True to the ancient principle of the medical profession to “do no harm”, our system's RFID tracking capabilities are used in the radiotherapy department to track patients, medical staff as well radioactive materials to ensure that the right person gets the right treatment, by fail-safe identification of the patient and their updated status, condition, and planned treatment.

Whilst the success of any healthcare RFID solution depends critically on the freedom to select for each project the most suited hardware, the healthcare software packages are limited to their own hardware;our solution closes this major gap. It includes a powerful parameterization tool, enabling the implementation of RFID tracking project easily without any risky specific developments. Being an end-to-end RFID tracking software solution or system and at the same time open to any RFID hardware, our solution significantly reduces the total cost of RFID medical waste tracking implementations, without compromising on the RFID hardware selection and without taking any risk.

**Out-door Tracking**

As the waste generator, healthcare facility is responsible for the waste until it receives the proof-of destruction or proper treatment. Our solution has Global Positioning System (GPS) tracking capabilities to monitor medical wastes during transportation to their proper disposal location [8]. The GPS part of our solution is an affordable GPS tracking system that provides with cost effective, real-time medical waste location, mapping and reporting very similar to any other GPS solution that tracks vehicles. Our system enables healthcare organizations to better and more efficiently control their medical waste management and to be in a position to better serve the community. To reduce the running cost of our system, the RFIDs and GPS have to be recycled / reused.

**Statistics Module**

By using the proposed solution, each medical waste container is labeled, scanned/detected, located, tracked and documented from “cradle-to-grave”. Therefore, it can be used as a measurement tool to track the amount of medical waste generated in a specific department of a healthcare facility. A statistical data analysis module is part of the solution that enables a system administrator to audit the whole process and predicts possible unsafe disposal in the level of departments of a healthcare facility.
Polices Enforcement

In the medical waste management process using our solution, policies are efficiently enforced, and then evaluated for their effectiveness. Without an evaluation exercise, organizations may find that certain policies are actually impeding people's ability to get work done; often an increase in the number and severity of violations is an indicator that policies need to be adjusted.

DISCUSSION

Lack of awareness about the health hazards related to health-care waste, inadequate training in proper waste management, absence of waste management and disposal systems, insufficient financial and human resources and the low priority given to the topic are the most common problems connected with health-care waste [9, 10]. Many countries either do not have appropriate regulations, or do not enforce them [11 – 13]. An essential issue is the clear attribution of responsibility for the handling and disposal of waste. According to the 'polluter pays' principle, the responsibility lies with the waste producer, usually the health-care provider, or the establishment involved in related activities. To achieve the safe and sustainable management of health-care waste, financial analyses should include all the costs of disposal.

Improvements in health-care waste management rely on building a comprehensive system, addressing responsibilities, resource allocation, handling and disposal. Our solution provides services such as communicating with the RFID tags, RFID reader, GPS, database management, 3rd party integration, user permission and more. This warrants for a robust performing infrastructure. It is highly scalable and evolves with customer's needs. It allows gradual implementation from a small partial project and up to large multi-site installations, in order to avoid the risk implicitly involved in big-bang operations. It is an open system with exhaustive APIs to facilitate its integration with other systems in the organization in order to produce the overall the required processes. It is a new approach to medical waste tracking software which dramatically reduces the level of risk and costs involved in medical waste management projects, by giving an end-to-end solution.

CONCLUSIONS

The management of health-care waste requires increased attention and diligence to minimize the potential for the spread of disease from a medical setting to the general public. To ensure
promotes the best practice that includes the following main benefits:

1. Real-time tracking and location of up to thousands of items to manage medical waste of high volume and intense environments;
2. Effective waste reduction and waste segregation via real-time tracking and location to enforce the medical waste process and policies, e.g. to ensure that medical waste went through segregation step before treatment. Segregation of waste, i.e. sorting into waste categories, leads to reduced quantities of hazardous waste, then lead to reduced efforts and costs in subsequent handling, treatment and safe disposal operations;
3. Healthcare facility-wide monitoring with automatic real-time rule-based alerts, e.g. monitoring tagged high-risk items, such as radioactive medical waste;
4. Ensure that medical waste are located away from populated areas or areas where food is served/stored, thus minimizing exposures and thereby risks;
5. A properly engineered design, ensuring real-time temperature monitoring to regulatory compliance, automate alerts, reports and more;
6. Construction following detailed dimensional plans, thus avoiding flaws that can lead to incomplete destruction of medical waste;
7. Easy way to periodic inspection and record keeping and so forth that increases the awareness and the sense of responsibility to protect the environment. It helps to change the practices of medical waste production to reduce the generated amount of medical waste;
8. Enhanced training and management, possibly promoted by certification and inspection programs for operators, the availability of appropriate manuals relevant waste and hazardous materials, and management oversight;
9. Automated technique to detect operational problems with creation of detailed reports to recognize critical issues that should be addressed in assessment and waste management plans to ensure patients safety as well as that all employees can safely perform their normal duties without undue health risks.

The proposed solution offers a comprehensive medical waste management service with the capability of automatic monitoring; i.e. locating and tracking. The solution provides a web-based interface to access all records 24/7. The solution is configurable to be used to
monitor medical waste of one healthcare facility or of several facilities independent of the geographical location.

The newly developed system generates automatic rule-based alerts when any medical waste items are missing, located in unauthorized areas or in violation of any other rule that requires follow-up action. Our healthcare solution enables better management of medical waste via a single, unified interface, and integrates completely with legacy information technology (IT) systems. Our solution is a scalable system that does not interfere with existing medical equipment and communication systems and Hazard-free for all types of patients, infants and personnel.

REFERENCES