Research Article

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# Adoption of Digital Pen and Paper Technology (DPP) in Biomedical Technology

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## ABSTRACT

In recent years, Health Information Management Systems are integrated in Information and Communication Technologies (ICT) in order to ensure that the effectiveness and efficiency of Health Units (H.Us) are improved. The use of major Medical Equipment (M/E) in Hospital Units is necessary for achieving the best possible treatment. Digital Pen and Paper technology (DPP) is a useful ICT tool that aims to enhance the electronic registration and management of Medical Equipment of Biomedical Technology (BIT) Departments. DPP application can help to upgrade the quality of public health services, reorganize and simplify the internal medical processes and save time and costs during the daily nursing practices. Furthermore, DPP technology also promotes a better assessment and management of public health services with full transparency of financial procedures by using real-time monitoring of Medical Equipment. It can also be used for the improvement of accountability procedures of both Health Professionals & Biomedical Engineers, as well as the design of effective health financial policies.

**KEYWORDS:** Digital pen and paper; DPP technology; Process automation; Data digitization; Medical equipment; Financial management

## INTRODUCTION

Health technology has become a critical component of healthcare, as it enables Health Professionals to provide diagnosis, treatment, monitoring and treatment to patients within an appropriate care environment. Quality management of health technologies helps to ensure that these services are provided in a safe and efficient manner [1]. The first step in managing health technology is to determine what data needs to be managed in order to conduct the inventory of medical equipment or otherwise to create a digital platform for the management of medical equipment on order to ensure better diagnosis and health treatment [2]. The inventory is a working document that is updated at regular intervals in order to inform users and medical professionals about the accuracy of their operating equipment [3]. When used properly, the inventory serves as an important and powerful tool for improving the management of key aspects of health technology [4]. It is important to understand that maintaining an accurate record is not the end of the Medical Equipment Management process [5]. Instead, the inventory serves as data input to many different activities of Healthcare Technology Management Cycle [6,7]; (Figure 1). The digital platform of Medical Equipment (M/E) of Hospital Units (H.Us) requires information that is collected by the suppliers' equipment including the contract details entered at the time of purchase. It also requires data which is collected by the online equipment registration in the respective places that is located especially during Covid-19 pandemic [8-12]. The registration of M/E is carried out by specialized staff of Biomedical Technology (BIT) engineers who are usually members of the Department of Biomedical Technology (DBIT) of a H.U. DBIT in collaboration with the Clinics and the Administration of the H.U. (supply office, file of contracts etc.) records the M/E. Registration requires the assignment of a login code of each part of the equipment, the creation and maintenance of a digital file that contains specific information of each device [13].

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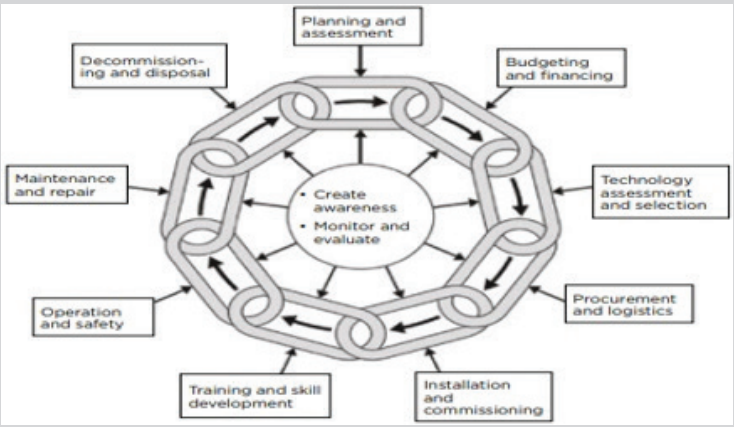


**Figure 1:** Healthcare technology management cycle [1].

Table 1 presents a list of information that follows an ascending order of significance. The entries at the top of the table give the least general information. At the bottom of the table there is more specific data.

The digital platform of M/E should not only be a static record of information but also a dynamic and functional tool of managing and supporting decision making [14-17]. Therefore, it should support the respective services of both the administration and the individual health units.

**Table 1:** List of medical inventory details [1].

| Type of Data | Short Description | Type of Inventory |
|---|---|---|
| Equipment Identification Number | Unique identifier of each part of equipment. | Medical Equipment (M/E) |
| Equipment type | Specifies what the equipment is, using standard nomenclature, such as system (UMDNS) or (GMDN). | All type of equipment not only M/E |
| Short Description of the equipment | Describes the equipment, including its purpose | All type of equipment not only M/E |
| Manufacturer | Identifies the company that produces the equipment, along with the name, address and contact details of the manufacturer. | All type of equipment not only M/E |
| Model | Unique product line identifier (assigned by the manufacturer). | All type of equipment not only M/E |
| Serial Number | Unique equipment ID (assigned by the manufacturer). | All type of equipment not only M/E |
| Location of the equipment inside the H.U. | Includes the room where the device is located or the department number. | All type of equipment not only M/E |
| Operating status | Identifies equipment as "in operation" or "out of order" and the reason in case of non-operation such as calibration, preventive maintenance, repair, waiting for spare parts or destruction. | M/E and test equipment, (simulator) |
| Power Requirements | Clarifies the power required for equipment operation such as 110V, 220V, 380V or three-phase electric power | M/E and test equipment, (simulator) |
| Operation and maintenance requirements | Identifies any special requirements which are needed in the operation or service of the equipment. | M/E |
| Inventory/update date | Date of equipment entry in the inventory and last update. | All type of equipment of a H.U. not only M/E |
| Maintenance service provider | Lists provider details including name, contact and contract details. | M/E and test equipment (simulator) |
| Supplier | Used as a contact point regarding purchase, orders, replacements, warranty and more. | All type of equipment of a H.U. not only M/E |
| Batch Number | Attributed to consumables and reagents manufactured in the same batch. It can help to identify defective items. | Consumables |
| Current software and version numbers | Used for the computer software of M/E. It can be used to detect software related problems | M/E and test equipment (simulator) |
| Ownership | Recognizes the contact point for notifying service delays, e.g., preventive maintenance. | M/E |
| Purchase cost | It serves as an input in the values of capital stock as well as in the draft budget in course of preparation. | All type of equipment of a H.U. not only M/E |
| Purchase date | In case of fixed assets, it's used to calculate depreciation or replacement prices. In case of consumables or spare parts, it can be used to determine utilization rates. | All type of equipment of a H.U. not only M/E |
| Warranty expiration date | Warranty period and expiration date | All type of equipment of a H.U. not only M/E |

| | | |
|---|---|---|
| Date of installation and receipt of tests and results | Serves as a basis of recording the purchase history of M /E and it's used as a reference point when dealing with problems. | M/E and test equipment, (simulator) |
| Safety/risk assessment/classification | Risk assessment is recorded. Data can also be used to determine equipment testing and repair priority. | M/E |
| Preventive Maintenance Schedule Procedures | Describes the frequency of preventive maintenance and maintenance procedures. | M/E and test equipment, (simulator) |
| Calibration Date | Serves as a reference point when troubleshooting equipment and ensuring equipment is within the calibration dates | M/E and test equipment, (simulator) |
| Quantity of orders | When used in control inventory systems, it stimulates the repurchase procedures | All type of equipment not only M/E |

## MATERIAL AND METHODS

In order to develop the digital platform for conducting the inventory of medical equipment, we have used Digital Pen & Paper Technology (DPP technology) that was developed in the Digital Health Applications and Health Economics Analytics Laboratory of University of Peloponnese (DigiTHEA Lab). The DPP application operates on a simple web-based platform and helps users to edit, manage, import, and export any written document in digital form. The application entails user roles (Administrator, Printer, Designer, Viewer, Clerk) and users can operate both a digital pen and a tablet. The digital pen launched by Anoto consists of (Figure 2):

a) A light bulb that emits infrared radiation accompanied by a small-sized image sensor

b) A Bluetooth communication device and a memory storage media

c) A processor and a battery.

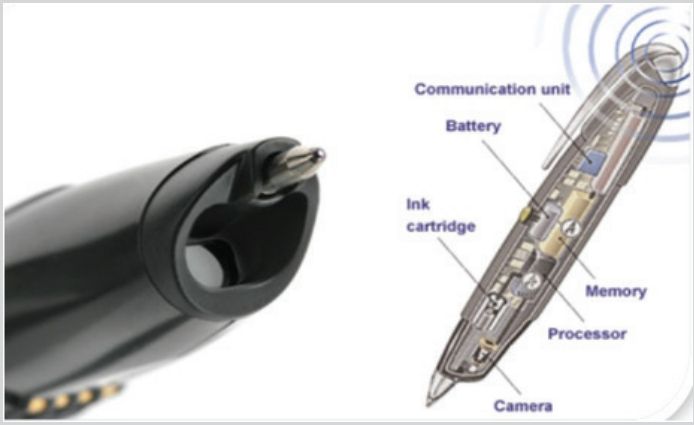


**Figure 2:** Parts of digital pen and paper technology (DPP).

Data that is saved in the memory storage media can wirelessly be transferred by using a Smartphone's Bluetooth device or a usb stick operating on "Pen Pusher" software. Memory unit can store up to 200 A4 pages/forms namely 40 A4 full manuscripts without digital pen connection for sending data and before battery charge [18-21]. The exact location of the pen, the kind of data edited, the editing time (timestamp), the user ID, as well as the kind of paper used can be precisely spotted by each digital image.

By using the so-called "Design Tool" application, the digital field zoning on the standardized form is performed. The existing form can be designed from scratch, depending on the requirements of the service. The next step is registration language setting in all fields. The 2.13 version supports over 30 languages and has access to 9 alphabets. The handwritten imprint takes place in single-line, multi-line, or boxed fields and include date, time, a checkbox, a drawing area and the signature area. The drawing area and the signature area are not edited, and they are saved as an image digital file. The other fields are converted into digital characters, supported by Optical Mark Recognition (OMR) & Optical Character Recognition (OCR) software and they are saved as well. The digital file is downloaded in the "Design Tool" application and it can be exported as .xml, .csv, .pdf, or. textual pdf file. The file receiver can either be the person that uses the digital pen himself or the person who owns Viewer or Clerk rights. It can also be sent as an email message and it can be uploaded on the "Formidable Viewer" application, which enables the final inspection of the form. Finally, data acquisition takes place by the central data acquisition center of the Hospital Unit. The dot pattern consists of small black dots printed in intervals of 0.3mm and can be printed on any type of paper by using various printing techniques, including offset, laser and inkjet printing (Figure 3). The layout of the pattern can be used as a unique identification location code on the paper. Both the pattern and the image sensor located on the tip of the pen, enable Anoto system to record and transmit accurately everything is written in 60 million square kilometers in Anoto pattern [22-24].

Finally, the designed standard form is an A4-sized paper (210 x 297mm) which has been developed by studying the existing documents of BIT departments, the standard documents used by Ministry of Health and Solidarity and the needs of clinical technicians. The medical equipment registration form is based on the Digital Pen and Paper application (DPP) and consists of 22 single-line fields, 1 multi-line field, 1 date field, 12 checkboxes, as well as 1 signature area. In Figure 4, a handwritten document (pdf) is illustrated, and in Figure 5, the conversion of a document into a digital form is performed. The document is filled in by the clinical technicians of Health Care Units.

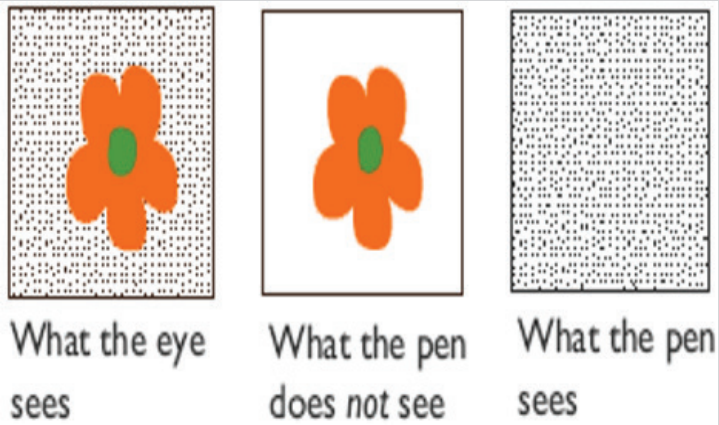


**Figure 3:** Dots pattern of DPP technology.

MEDICAL EQUIPMENT REGISTRATION FORM
USING DIGITAL PEN AND PAPER (DPP)

| | | | |
|---|---|---|---|
| HOSPITAL NAME | GENERAL HOSPITAL OF MOLAOI | CODE | H 123 |
| DEPARTMENT NAME | HEMODIALYSIS UNIT | CODE | B0030 |
| PHYSICAL LOCATION WITHIN HEALTH-CARE FACILITY | HEMODIALYSIS ROOM | CODE | K0040 |
| TYPE OF EQUIPMENT | 34395 | | |
| MANUFACTURER | GAMBRO | | |
| PURCHASE SUPPLIER | MEDICAL PRODUCTS | | |
| MODEL | AK 200S | | |
| SERIAL NUMBER | 14905 | | |
| CE MARKED | YES ☑ | NO ☐ | |
| YEAR OF MANUFACTURE | 2006 | | |
| EQUIPMENT CODE | 00276 | OLD CODE | |
| HIGH TECHNOLOGY EQUIPMENT | YES ☐ | CODE BY GREEK AUTHORITY STATISTICS (400) | NO ☑ |
| SOFTWARE VERSION | 9.20 | | |
| INSTALLATION DATE | DAY 28 | MONTH 12 | YEAR 2006 |
| OBTAINING WAY | PURCHASE ☑ | DONATION ☐ | ATTENDANT EQUIPMENT ☐ / CONCESSION OF USE ☐ |
| EQUIPMENT STATUS | IN USE ☑ | UNDER REPAIR ☐ | NOT IN USE ☐ / NOT INSTALLED ☐ |
| TOTAL COST | 13.500 € | | |

REMARKS

DATA OF ENGINEER FROM THE BIOMEDICAL TECHNOLOGY DEPARTMENT

DATE 24-02-17

SURNAME TSOROMOKOS

NAME DIMITRIOS

SIGNATURE

**Figure 4:** Handwritten text (.pdf).

MEDICAL EQUIPMENT REGISTRATION FORM
USING DIGITAL PEN AND PAPER (DPP)

| | | | |
|---|---|---|---|
| HOSPITAL NAME | GENERAL HOSPITAL OF MOLAOI | CODE | H 123 |
| DEPARTMENT NAME | HEMODIALYSIS UNIT | CODE | B0030 |
| PHYSICAL LOCATION WITHIN HEALTH-CARE FACILITY | HEMODIALYSIS ROOM | CODE | K 0010 |
| TYPE OF EQUIPMENT | 34995 | | |
| MANUFACTURER | GAMBRO | | |
| PURCHASE SUPPLIER | MEDICAL PRODUCTS | | |
| MODEL | AK 200S | | |
| SERIAL NUMBER | 14705 | | |
| CE MARKED | YES ☑ | NO ☐ | |
| YEAR OF MANUFACTURE | 2006 | | |
| EQUIPMENT CODE | 00275 | OLD CODE | |
| HIGH TECHNOLOGY EQUIPMENT | YES ☐ | CODE BY GREEK AUTHORITY STATISTICS (ASD) | NO ☑ |
| SOFTWARE VERSION | 9.20 | | |
| INSTALLATION DATE | DAY 28 | MONTH 12 | YEAR 2006 |
| OBTAINING WAY | PURCHASE ☑ | DONATION ☐ | ATTENDANT EQUIPMENT ☐ / CONCESSION OF USE ☐ |
| EQUIPMENT STATUS | IN USE ☑ | UNDER REPAIR ☐ | NOT IN USE ☐ / NOT INSTALLED ☐ |
| TOTAL COST | 13.500 € | | |

REMARKS

DATA OF ENGINEER FROM THE BIOMEDICAL TECHNOLOGY DEPARTMENT

DATE 24-01-17

SURNAME TSOROMOKOS

NAME DIMITRIOS

SIGNATURE

**Figure 5:** Text conversion in digital form (.pdf).

## RESULTS

A successful pilot test was conducted for three months at a Greek H.U. in Peloponnese using DDP technology. The technicians and nursing staff had been asked to use DDP technology in order to perform specific tasks such as:

A. Medical Devices registration

B. Damage and repair report

C. Prevention of quality failures

Some data was acquired by staff interviewing the staff. The members of the DigiTHEA Lab performed an overall assessment report. The summarized results are the following (Figure 6&7):

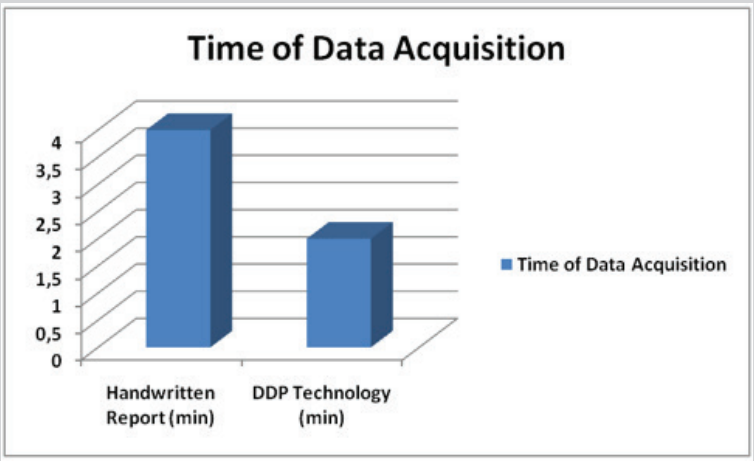


**Figure 6:** Faster data acquisition time by using DPP Technology.

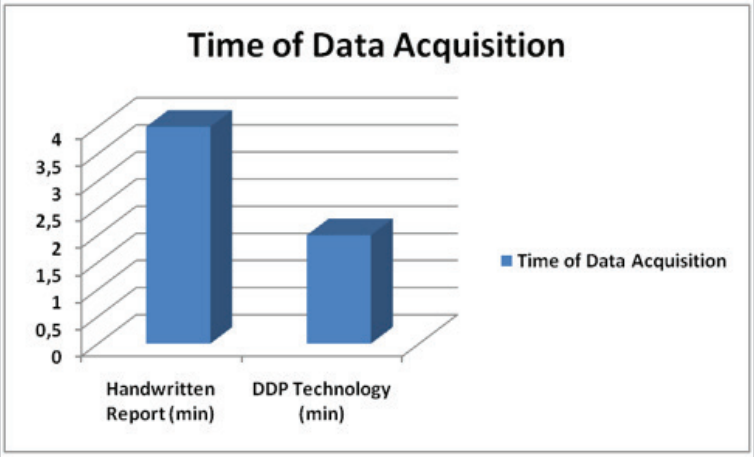


**Figure 7:** Data of DPP Technology compared to handwritten inventory of medical equipment.

a. There was an almost two times faster data acquisition by using DPP technology compared to handwritten forms (2 min compared to 4 minutes of DDP Technology)

b. Nursing staff earned almost their daily duty time to complete the necessary reports

c. More than 85% of the nursing staff reported that DDP technology and the digital platform was absolutely user-friendly (85,8% of DPP Technology compared to 4,2% of handwritten reports)

d. More than 85% of both the technicians and the nursing staff admitted that DPP technology helped them to perform their daily tasks with more confidence and less errors (85,4 % of DPP Technology compared to 4,6% of handwritten reports)

e. The Head of BIT Department confirmed that work efficiency was highly improved because of the quick completion of the forms inside and outside the Department (91% of Head Departments confirmed an improved work efficiency by using DPP Technology)

This pilot research has confirmed that data entry by using this digital pen is a very useful application that reduces the daily workflow. A number of procedures must be followed for the correct equipment handling and special knowledge is needed with regards to the successful system implementation and task coordination.

## DISCUSSION

The proposed digital platform as well as DPP technology can strengthen the electronic registration and management of M/E of the BIT Departments of H.Us. It can also help to improve the quality of healthcare services especially during Covid -19 pandemic. The faster digital procedures of the proposed digital inventory can save medical professionals much time in order to deal with the treatment of Covid19 patients. At the same time, the proposed application can help managers to reorganize the internal processes inside the Intensive Care Units (ICUs).

The utilization of the DDP application in the daily activities of the BIT Department will result in the transition to the direct digitization of the handwritten information. BIT forms will be immediately available in the central information system of the Ministry of Health and Social Solidarity (such as the fault announcement bulletin, M/E registration bulletin and the maintenance bulletin). Data will be routed directly, quickly and securely to authorized users for processing. This technology is ideal for all health procedures based on handwritten forms. The collection of useful statistics for analysis and export of indicators (such as equipment operation time, machine downtime, number of repeated repairs and total maintenance costs) helps significantly in making up the right decisions. Indicators and results can help stakeholders to develop specific policies and programs for saving costs of medical supplies during Covid-19 pandemic. They can also evaluate the effectiveness and have benchmarks on deciding which medical equipment is cost effective during Covid-19 pandemic e.g., respirators.

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