Research Square

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Point-of-Care Biomedical Engineering Equipment Management System

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Abstract

Background

Medical devices and equipment play an important role in the modern medical service. It is necessary to integrate the relevant information in order to effectively manage all the equipment into a biomedical engineering equipment management system (BEEMS).

Aims: To report our experience and satisfactory from the users of a BEEMS.

Method

We combine a central core module with intra-net and a mobile device application with internet to become a real-time BEEMS. With the combination of these two modules, the point-of-care software system become real-time and mobile for all users in the hospital. We conduct a survey about satisfactory from the users after more than one-year implementation of this system.

Results

After the application more than one year, only 7% users show unsatisfactory about the BEEMS. We also find this real-time and point-of-care BEEMS has high satisfactory and is especial helpful for the management staff in hospital.

Conclusion

A real-time BEEMS has high satisfactory and is helpful for the staff in hospital.

Relevance to clinical practice

A real-time biomedical engineering equipment management system is helpful to effectively manage all the equipment in hospital.

Background

Medical devices and equipment play an important role in the medical service. Those are important in the disease prevention, diagnosis, monitoring and treatment, as well as patient rehabilitation. However, due to their variety and huge volume, it is necessary to integrate the relevant information in order to effectively manage all the medical instruments and equipment.[1, 2]

Therefore, the "` Biomedical Engineering Equipment Management System (BEEMS)" and "Medical Instrument Mobile Device Application (APP)" are established and become a point-of care mobile system in our hospital since 2018 to 2019. The system builds a complete medical equipment database, including the maintenance schedule and records, annual repaired cost, contracts, abnormality monitoring,

automatic output management reporting, etc., and connecting with various systems to share information in the hospital (Figure 1).

By using this powerful software and applications, the hospital staff can conduct online repair application, equipment operation instruction and consultation, maintenance recording, simple trouble shooting solving, which could be performed on a mobile device by the internet. The system database is also connected to other data system of the hospital, such as Tableau system, which can generate various management reports including the engineer performance, repair effectiveness monitoring, etc.[3, 4]

The aims of this report are to introduce the policy brief of this novel mobile device integrated point-of-care BEEMS and report the satisfaction from clinical staff for this system.

Material And Methods

The roadmap of our BEEMS is basically based on previous reported studies[1, 3, 4, 5, 6] and summarized in **Figure 1**. The system architecture is consisting of a central core module with intra-net and a mobile device application with the internet. With the combination of these two modules, the point-of-care software system become real-time and mobile for all users. The first step in establishment of this system is to update the equipment inventory database. We classified our equipment into multiple categories and update the basic information within the database. The device information is based on a property number and include the picture of medical device, the operation power current, the maintenance interval, contract duration, operating system and information security risk assessment, basic usage guideline and fast trouble shooting solving guideline. With the property number, we can connect the database with other system in the hospital through intranet (**Figure1**). Such as our property management system, equipment repairing system, Tableau system and budget management system.

Preventive maintenance (PM): We classified our PM into 1st degree and 2nd degree. First degree PM is inspected and is recorded by the user monthly, 2nd degree PM is carried out by biomedical engineers under a scheduled program. Our 2nd PM program scheduling is based the suggestion from WHO medical maintenance program.[4] In brief, a risk-based biomedical equipment management number based on four domain (EM number #: Equipment function, physical risk associated with clinical application, maintenance requirements and incident history) is created. The inspection interval is determined by the EM number and automate scheduled by the BEEMS. If any out of order condition occurs, a notice message will be send to the management staff and responsible engineer.

Corrective maintenance (CM) and Repair: any failed device is reported by the users with the equipment repair reporting system to the BEEMS system, and a message will be send to the engineer. After transfer the message to the responsible engineer, who will restore function of the failed device and allow it to be put back into the service. If the failure equipment cannot be repaired, the engineers will mark the condition in the BEEMS and the message will be send to the users and budget management system. The

clinical staff can prepare a renew planning in the future if necessary. Any warning information from product manufacture will be also recorded through the same pathway.

Medical Instrument Mobile Device Application (APP)

The most difficult part for this system is to recognize each equipment through the mobile devices application (APP). We attach a small QR code to most equipment; through the code, and the camera of mobile device, the APP can obtain the equipment identification property number and exchange information with the **BEEMS.** However, some equipment can't be pasted a QR code sticker, such as the endoscopes, which need to be cleaned with disinfection liquid and sterilization in high temperature condition. Therefore, we attach water proof color coding SURG-I-BAND (Scanlan International, Inc. Minnesota, USA) on the instrument and developed a simple artificial intelligence system to read the color bandage and connect with the equipment identification property number (**Figure 2**). Finally, all of our medical equipment can be recognized through the APP with real-time mobile device.

Tableau system

Tableau system is our analytics platform; with the database connection, we can real-time trace the condition of each equipment and performance of staff.

System Satisfaction Survey

In order to clarify the satisfaction of our system, after the application more than one year, we conduct a questionnaire survey. We invite the system users in our hospital and use Google spread sheet with 5 point Likert scale anonymous questionnaire to survey the satisfaction of our BEEMS. The study is conducted according to the criteria set by the declaration of Helsinki and it is waived from written informed consent due to the anonymous design, but we still explain the design of this questionnaire survey to the system users. After the approval of the responders, they can fill out the survey. This study is approved by Research Ethics Review Committee, Far Eastern Memorial Hospital (IRB-109141-E). We classify the responder into management staff or not.

Statistical analysis

Category variables are expressed as the number and percentage and the difference is tested with Chi-square test with fisher exact correction.

Results

From Jan to March 2021, total 289 users join our survey and answer the questionnaire anonymously. The characteristics of responders is summarized in Table 1. Most of the responders (88.6%, 256/289) are from nursing department, most the education level for the responder is bachelor as 72% (207/289), the years of hospital servicing ranges from less than 3 years (29.1%) to more than 16 years (19.7%). And 13.5% in our responders is the management staff (MS).

The satisfactory about our BEEMS from the 289 responders is shown in Table 2. Only 7% show unsatisfactory about the BEEMS. Most of the responders show that the system is convenient (52%) or very convenient (16%). And they reveal convenient (52%) or very convenient (13%) in data query, convenient (50%) or very convenient (13%) in solving trouble shooting. There are 57% and 26% responders show helpful and very helpful for them in management of the medical equipment.

We further analysis the satisfactory according to MS or not (Table 3). Responder with manager level show a higher satisfactory than not a MS about interface design, data query, problem solving, no paper storage, grasping equipment condition and general satisfactory about the system (All p-value <0.05 by Chi-square test with fisher exact correction).

Discussion

A useful bio-information management system can keep the medical equipment reliable, safe and available to be used when necessary, besides it can minimize the cost of equipment and increase efficiency.[6, 7] We find that the responders of the users show high satisfactory for our BEEMS, especially for the management staff. Only 7% users show unsatisfactory about the BEEMS.

There Are Some Features About Our Beems:

1. In modern hospital, the number of medical equipment are numerous that organizing the information need a computer system.[4] I our system, we use a risk-based prioritization suggested by WHO, with the automated scheduling preventive maintenance and calibration programs, the engineers can arrange their PM schedule according to the system and the MS can inspect and monitor the results.
2. Some hospital use stickers on the equipment to demonstrate basic information, such as operation guide, operation power need or fast trouble shooting guide. Medical device-associated healthcare-acquired infections pose a threat to patient safety.[8] With the internet APP system in our system, the user can not only complete real-time surveillance of the condition of any device and the but also get information and condition query, including the power need, operation system information risk check-up without any tags or labels attached to the equipment. This may decrease infection rate in the hospital.
3. During the COVID19 pandemic, the ventilator may become insufficient[9]; our system provides spare ventilators data and increase the efficiency of ventilators. Because the fail or spare equipment is marked in system, therefore the system can also provide the location of spare equipment when necessary. For ventilators, each patient is recorded in our BEEMS, which makes it more convenient for equipment allocation in our hospital. This system also provides the real-time data to national health care system, such data also help the government in decision making during the pandemic.
4. The BEEMS also can share information with other systems and decrease the printed paper consumption. By connecting with property management system, equipment repairing system and the mobile device, there is no need to printed files between departments; therefore, we can dramatically

decrease the printed papers need. According to our estimation, we can decrease 50,000 printed papers annually after the use of this system.

A good BEEMS is helpful for the users in equipment monitoring, technology assessment and resource allocation and shows high satisfactory. By connecting to the tableau system, the performance of all staff could also be inspected real-time. We can trace the completion rate of equipment acceptance, prevention maintenance, repair and eliminate.

At the same time, the system can also provide reference for the management decision through the complete instrument resume and data integration. Furthermore, the system also simplifies the operation process, alleviates the medical personnel workload and enhances the management efficiency. The database can be used to control the instrument information and manage the relevant risk on a real-time basis, further ensuring the patient safety and service quality. We find the managers level show higher satisfactory in MS, which may reflect the system provide real-time information for MS and is helpful in resource allocation and decision making.

However, our system still has some limitations, there are still some users do not satisfactory for this system. This may be due to the internet signal become unstable in some corner in the hospital, and the system provide a lot of information and may need time to familiar with it. We believe, such a point-of-care and real-time information system is very helpful in the hospital management and medical resource allocation. In the future, it is expected that we can input and connect more data in BEEMS to continuously improve this innovative system and enhance the management efficiency.

Conclusion

A real-time point-of-care BEEMS has high satisfactory and is helpful for the staff in hospital.

Declarations

1. Ethics approval and consent to participate

This survey is approved by Far Eastern Memorial hospital ethical review board (IRB-109141-E). It is waived from informed consent due to the anonymous design.

Full name of ethics committee approve this study: Research Ethics Review Committee, Far Eastern Memorial Hospital

Reason for IRB waived the written informed consent: The study is conducted according to the criteria set by the declaration of Helsinki and it is waived from written informed consent due to anonymous from the responders, but we still explain the design of this questionnaire survey to the users. After the approval of the responders, they can fill out the survey.

2. Consent for publication

All the authors give our consent for the publication of identifiable details.

3. Availability of data and materials

The authors confirm that the data supporting the findings of this study are available within the article

4. Competing interests

The authors have no competing interests to declare.

5. Funding

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6. Author contributions

HC Wu and LJ Liao conducted the survey and analyzed data. DY Chen is responsible for develop the AI integrated endoscopy identification system. All authors wrote the manuscript and gave approval for submission.

7. Acknowledgements

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9. Informed consent: The figure 2 and video represent the first author who takes a picture of the endoscopy. The first author has signed informed consent for the publication.

10. The requirement of informed consent was waived by ***[Name of ethics committee:*** Research Ethics Review Committee, Far Eastern Memorial Hospital (registry number: IRB-109141-E); ***the reason that waived the consent is due to the study design is anonymous from the responders with the intension of no***

disturbance and influence on their response. Therefore,Ethics Review Committee waived the written informed consent.

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Tables

Table 1. Characteristics of responders (n=289)

Characteristics	Number	%
Service department		
Nursing	256	88.6
Medicine	19	6.6
administrative	13	4.5
Others	1	0.4
Education		
Master	30	10.4
Bachelor	207	71.6
College	49	17.0
High school	3	1.0
Years of Hospital Service		
Less than 3 years	84	29.1
4-6 years	72	24.9
7-9 years	31	10.7
10-12 years	27	9.3
13-15 years	18	6.2
More than 16 years	57	19.7
Management staff (MS)		
Yes	39	13.5
Not	250	86.5

Table 2. Results of the satisfaction survey (Responders n=289)

	1. Very inconvenient	2. Inconvenient	3. Fair	4. Convenient	5. Very convenient
1.How do you feel about the BEEMS?	1 (0.35)	7(2.42)	84(29.07)	150(51.90)	47(16.26)
2. Data query in the BEEMS	0(0)	11(3.81)	88(30.45)	151(52.25)	39(13.49)
3. Solve trouble shooting in BEEMS	2(0.69)	17(5.88)	87(30.10)	145(50.17)	38(13.15)
	1. Very not helpful	2. Not Helpful	3.Fair	4.Helpfl	5. Very helpful
2. Management the medical equipment with BEEMS	0(0)	4(1.38)	45(15.57)	166(57.44)	74(25.61)
	1.Very unsatisfactory	2.Unsatisfactory	3.Fair	4. Satisfactory	5. Very satisfactory
3.Satisfactory about BEEMS	0(0)	7(2.42)	67(23.18)	165(57.09)	50(17.30)

BEEMS (Biomedical Engineering Equipment Management System)

Table 3. The satisfactory from users classify according to management staff (MS) or not.

1. Is the interface design of the system easy to operate? (p=0.0491)	1. Very inconvenient	2. Inconvenient	3. Fair	4. Convenient	5. Very convenient
Management staff (MS)	0(0)	0(0)	11(28.21)	15(38.46)	13(33.33)
Not MS	1(0.40)	7(2.80)	73(29.20)	135(54)	34(13.60)
2. Is the data in the medical instrument system easy to query? (p= 0.0073)					
MS	0(0)	1(2.56)	8(20.51)	18(46.15)	12(30.77)
Not MS	0(0)	10(4)	80(32)	133(53)	27(10.8)
3. When I encounter a system usage problem, is it easy to find someone to help solve it? (p=0.0120)					
MS	0(0)	1(2.56)	9(23.08)	18(46.15)	11(28.21)
Not MS	2(0.8)	16(6.4)	78(31.2)	127(50.8)	17(10.8)
4. I agree with the management model of replacing paper storage with electronic records? (p= 0.0048)					
MS	0(0)	1(2.56)	1(2.56)	11(28.21)	26(66.67)
Not MS	1(0.4)	2(0.8)	23(9.2)	120(48)	104(41.6)
5. After the establishment of the system in our hospital, is it helpful for you to grasp the condition of the instruments ? (p=0.0009)					
MS	0(0)	1(2.56)	1(2.56)	19(48.72)	18(46.15)
Not MS	0(0)	3(1.2)	44(17.6)	147(58.8)	56(22.4)
6. Overall, how about your satisfaction with the use of the system? (p=0.0069)					
MS	0(0)	0(0)	3(15.38)	20(51.28)	13(33.33)
Not MS	0(0)	7(2.8)	61(24.4)	145(58)	37(14.8)

Figures

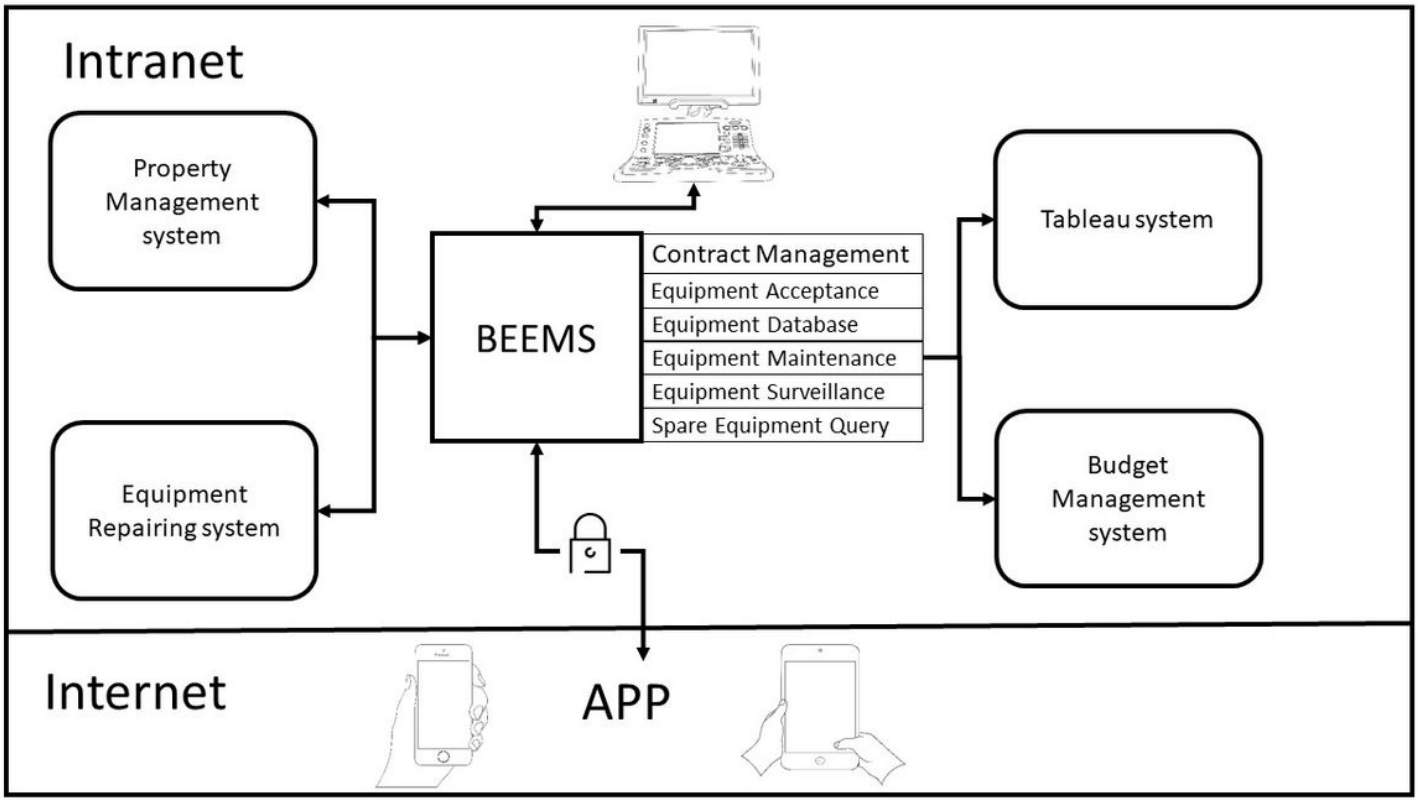

Figure 1

Roadmap of our biomedical engineering equipment management system (BEEMS). The system architecture is consisting of a central core module with intra-net and a mobile device application with internet. With the combination of these two modules, the point-of-care software system become real-time and mobile for any user. Mobile Device Application (APP)

Figure 2

All the staff in hospital can use the APP with mobile device to identify the equipment, including rigid endoscopy and then check the information of the device. (Attached video clip is in the supplemental material)

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- 20210701supplementalmaterial.mov