



# Intelligent Medical Devices in Hospitals— An Overview

A HIMSS Analytics Whitepaper

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# Executive Summary

Intelligent medical devices,<sup>1</sup> are emerging as a critical component of the electronic medical record (EMR) environments. This trend will continue as U.S. hospitals advance beyond Stage 3 of the EMR Adoption Model<sup>SM</sup> (see Figure 1). The ability to automatically capture and manage patient data from these devices as part of the EMR becomes a function of improving both patient safety and clinical outcomes. As this scenario evolves, we believe that many hospitals will begin to position the biomedical operations as part of the information services operation due to the need to create, maintain, and update the interfaces that will be required to both capture data for the EMR and to also manage the devices for clinical decision support functions that reside in the EMR environment. This study suggests that the majority of the interfacing support for these devices is already being done by the hospital's information systems (IS) department.

From a financial standpoint, intelligent medical device capital costs outpace operating costs by an average factor of 2.6 to 1, and by a median factor of 3 to 1. This depicts a capital intensive environment fed by the need to replace and upgrade equipment to keep up with the latest technological advancements that can improve patient care.

Purchasing plans were identified by more than 50 percent of the study participants even in our current challenging economic environment. The majority of these purchasing plans are tied to replacement purchases.

The American Recovery and Reinvestment Act (ARRA) will provide the funding catalyst for hospitals to advance their EMR capabilities. As this occurs, hospitals will begin to spend more time on creating the strategies for effectively interfacing the intelligent medical devices that will improve patient safety, clinical outcomes, and support more advanced clinical studies and reporting.



- Intelligent medical device – networked diagnostic equipment that provides data streams of diagnostic readings that can be interfaced
- Interactive medical devices – diagnostic equipment that can have operating parameters updated via a networked computer connection (changes to functions of the device can be changed via a computer versus through the device itself)

## EMR Adoption Model<sup>SM</sup> Trends 2007-2008

Stage	Cumulative Capabilities	2007 Final	2008 Final
Stage 7	Medical record fully electronic; HCO able to contribute CCD as byproduct of EMR; Data warehousing in use	0.0%	0.3%
Stage 6	Physician documentation (structured templates), full CDSS (variance & compliance), full R-PACS	0.3%	0.5%
Stage 5	Closed loop medication administration	1.9%	2.5%
Stage 4	CPOE, CDSS (clinical protocols)	2.2%	2.5%
Stage 3	Clinical documentation (flow sheets), CDSS (error checking), PACS available outside Radiology	25.1%	35.7%
Stage 2	Clinical Data Repository, Controlled Medical Vocabulary, Clinical Decision Support System, may have Document Imaging	37.2%	31.4%
Stage 1	Ancillaries – Lab, Rad, Pharmacy - All Installed	14.0%	11.5%
Stage 0	All Three Ancillaries Not Installed	19.3%	15.6%

Data from HIMSS Analytics™ Database

N = 5073/5166 ©HIMSS Analytics

## Study Methodology

This study was constructed from the responses of 51 U.S. hospitals that completed a survey of key intelligent medical device products for the financial and management aspects of supporting and extending these solutions in their healthcare environments. This study used a web based survey supported by telephone follow-up and support. We evaluated the data using standard statistical methods to determine the leading indicators that provide directional insight into this market.

# Financial Overview

In this study, we wanted to evaluate the operating, capital, interface maintenance, and staffing metrics to provide insights for hospitals in managing their intelligent medical device environments. What we found is that capital expenses are an average of two to three times higher than operating expenses (see Table F1), and that the ratio of clinical engineers to biomedical technicians is 1 to 4 (see Table F2). This environment is highly capital intensive as hospitals continue to purchase, replace and upgrade intelligent medical devices to ensure they have the latest technology to improve patient safety and clinical outcomes. Capital budgets are an area we will continue to monitor as the capital markets recover from the current recession. We also believe that interface maintenance expenses will rise as more and more hospitals begin to interface intelligent medical devices to their EMR environments. We believe growth will occur in the operating rooms (ORs), emergency department (ED), and intensive care (ICU) environments as hospitals advance their EMR environments with ARRA funding.

Descriptive Statistics	Capital Budget	Operating Budget	Interface Maintenance Expense
Average	\$5,821,368	\$2,266,696	\$115,759
Median	\$4,300,00	\$1,412,000	\$9,924
Valid Responses Only	29	38	20

Table F1

Descriptive Statistics	Number of Engineers Supporting Biomed	Number of Technicians Supporting Biomed
Average	2.0	8.2
Median	1.0	4.0
Valid Responses Only	40	43

Table F2

# Intelligent Medical Device Plan Summary

Even with a recession impacting capital markets for hospitals over the last 12 – 18 months, 58 percent of study respondents stated that they were either planning to replace, upgrade, or buy intelligent medical devices for the first time (see Table PS1). This suggests the importance of these devices for delivering effective patient care.

Any Medical Device Purchase Plans (for either replacement, upgrade, or first time)	Count	Percentage
Yes	29	58.86%
No	22	43.14%
<b>Total Respondents</b>	<b>51</b>	<b>100.00%</b>

Table PS1

Among the hospitals reporting they plan to purchase new medical devices, more than half are replacing their medical devices; only eight percent are buying these devices for the first time (see Table PS2).

Any Medical Device Purchase Plans	Count	Percentage
Replacement	29	58.86%
Upgrade	15	29.14%
First Time	4	7.84%

Table PS2

An evaluation of the top intelligent medical devices planned for replacement, upgrade or first time purchase suggests that physiologic monitors and infusion pumps have the highest number of mentions (see Table PL3). One quarter of respondents also suggested that they will purchase vital sign monitors, diagnostic ultrasound devices, radiologic/fluoroscopic systems, or anesthesia units.

Medical Devices Purchase Plans	Yes	No (includes no response, no plans)	N	Percent
Physiologic Monitors	19	32	51	37.25%
Infusion Pumps	19	32	51	37.25%
Vital Sign Monitors	13	38	51	25.49%
Ultrasounds, Diagnostic	13	38	51	25.49%
Radiologic/Fluoroscopic Systems	13	38	51	25.49%
Anesthesia Units	13	38	51	25.49%
Ventilators	11	40	51	21.57%
Infant Incubators	10	41	51	19.61%
Mammography Systems	8	43	51	15.69%
Intelligent Medical Device Hubs	8	43	51	15.69%
Defibrillators	7	44	51	13.73%
Electrocardiographs	7	44	51	13.73%
Blood Gas Analyzers	7	44	51	13.73%
Blood Glucose Monitors	7	44	51	13.73%
Monitors, Fetal	7	44	51	13.73%
Intra-aortic Balloon Pumps	7	44	51	13.73%
Dialysis Units	6	45	51	11.76%
Cardiac Output Monitors	4	47	51	7.84%
Extracorporeal Therapy Systems	4	47	51	7.84%

Table PS3

A more detailed analysis of the purchasing plans suggests that infusion pumps and physiologic monitors are the two leading replacement markets (see Table PS4). Other top devices being replaced are diagnostic ultrasound, vital sign monitors, and radiographic/fluoroscopic systems. Respondents were most likely to identify physiologic monitors and radiographic/fluoroscopic systems as devices they are planning to upgrade. Initial buying is very limited relative to the responses from this study group, but shows some activity around intelligent medical device hubs, vital signs monitors and anesthesia units.

More detailed data on purchasing plans is found in Appendix A.

Medical Devices Purchase Plans	Number of Respondents with Plans of Purchasing		
	Replacement	Upgrade	First Time
Physiologic Monitors	16	7	1
Defibrillators	7	0	0
Vital Sign Monitors	11	1	2
Electrocardiographs	6	2	0
Infusion Pumps	17	3	0
Ventilators	10	2	0
Cardiac Output Monitors	3	1	0
Infant Incubators	10	0	0
Blood Gas Analyzers	7	2	0
Blood Glucose Monitors	7	1	0
Extracorporeal Therapy Systems	4	0	0
Ultrasounds, Diagnostic	12	3	0
Monitors, Fetal	7	0	0
Radiologic/Fluoroscopic Systems	11	5	0
Mammography Systems	8	0	0
Intra-aortic Balloon Pumps	7	1	0
Anesthesia Units	10	1	2
Dialysis Units	6	0	0
Intelligent Medical Device Hubs	2	3	3

Table PS4

Key:

Highest Response

2nd Highest Response

3rd Highest Response

\*An organization may include more than one status for one medical device.

# Medical Device Support

General medical/surgical nursing units have the highest numbers of devices to support, followed by the laboratory and radiology (see Table DS1).

Medical Devices Supported by Area	Average	Median	Count
General Biomedical	7,721	6,000	42
Imaging/Radiology	177	49	42
Laboratory	471	150	42
Total Quantity of Medical Devices Supported by Clinical Engineering	9,510	7,650	43

Table DS1

While the support of general biomedical devices are as likely to be supported by either the clinical engineering or IS department (despite the fact that the governance of the two departments is different in the vast majority of hospitals), the majority of imaging and laboratory devices are supported by the IS department (see Table DS2).

Supporting Department	General Biomed		Imaging*		Laboratory	
	Yes (%)	Valid N	Yes (%)	Valid N	Yes (%)	Valid N
Clinical Engineering	63.41%	41	32.50%	40	18.42%	38
IS Department	67.50%	40	85.00%	40	90.00%	40

Table DS2

\*Radiology and Cardiology

It appears that the IS department is becoming the key support department for interfaced intelligent medical devices. This is a natural extension as IS departments build and support a cadre of interfaces to improve the collection and use of data within the hospital.

# Deployment of Intelligent Medical Devices

The deployment profile of intelligent medical devices from this study is shown in Table D1. This table represents the number of respondents who indicated that they have a specific type of medical device currently deployed at their organization.

Medical Devices Currently Deployed	Yes (Count)	Yes (Percent)
Physiologic Monitors	45	88.24%
Ultrasounds, Diagnostic	45	88.24%
Defibrillators	44	86.27%
Electrocardiographs	44	86.27%
Infusion Pumps	44	86.27%
Monitors, Fetal	44	86.27%
Ventilators	43	84.31%
Infant Incubators	43	84.31%
Blood Gas Analyzers	43	84.31%
Radiologic/Fluoroscopic Systems	43	84.31%
Anesthesia Units	43	84.31%
Vital Sign Monitors	42	82.35%
Cardiac Output Monitors	41	80.39%
Blood Glucose Monitors	39	76.47%
Mammography Systems	38	74.51%
Intra-aortic Balloon Pumps	35	68.63%
Dialysis Units	32	62.75%
Intelligent Medical Device Hubs	25	49.02%
Extracorporeal Therapy Systems	22	43.14%

Table D1 N=51

The number of devices deployed as ranked by median is shown in Table D2. Infusion pumps and physiologic monitors far outnumber other devices in hospital deployment.

Medical Devices Currently Deployed	Average	Median	Count
Infusion Pumps	542.0	332.0	36
Physiologic Monitors	356.4	169.0	37
Vital Sign Monitors	145.7	87.0	36
Defibrillators	87.7	50.0	35
Blood Glucose Monitors	57.3	47.0	24
Ventilators	47.2	28.0	36
Monitors, Fetal	32.9	21.0	34
Cardiac Output Monitors	51.7	17.0	29
Anesthesia Units	28.9	17.0	35
Electrocardiographs	27.9	17.0	37
Infant Incubators	35.5	12.0	34
Radiologic/Fluoroscopic Systems	23.1	12.0	32
Ultrasounds, Diagnostic	28.0	10.0	33
Dialysis Units	12.5	8.5	22
Extracorporeal Therapy Systems	36.2	5.0	13
Intelligent Medical Device Hubs	23.6	5.0	16
Blood Gas Analyzers	10.4	4.5	32
Intra-aortic Balloon Pumps	5.8	4.0	27
Mammography Systems	4.7	3.0	29

Table D2

# Intelligent Medical Device Interfaces

Evaluating the number of intelligent medical devices interfaced to the EMR by median metrics shows that infusion pumps, and physiologic monitors are the leading devices that are being interfaced by hospitals. While infant incubators is identified in second place in this table, only one respondent reports having an EMR interface, which is not a reliable sample size (see Table D11).

Number of Medical Devices Interfaced with EMR	Average	Median	Count
Infusion Pumps	324.4	241.0	7
Infant Incubators	79.0	79.0	1
Physiologic Monitors	158.5	68.5	20
Blood glucose Monitors	79.4	55.0	8
Cardiac output Monitors	48.7	35.5	6
Anesthesia Units	31.0	32.5	4
Vital Sign Monitors	25.5	25.5	2
Dialysis Units	23.0	23.0	2
Ventilators	35.0	22.0	8
Monitors, Fetal	26.9	20.0	19
Intelligent Medical Device Hubs	32.9	15.0	10
Electrocardiographs	22.9	12.0	19
Intra-aortic Balloon Pumps	11.5	9.0	4
Radiologic/Fluoroscopic Systems	18.4	8.0	23
Ultrasounds, Diagnostic	17.7	6.0	23
Defibrillators	3.0	3.0	1
Blood Gas Analyzers	7.9	2.0	18
Mammography Systems	4.3	2.0	15

Table D11

Evaluating the median planned interfaces from intelligent medical devices to the EMR shows that infusion pumps, and cardiac output monitors are leading devices for interfacing over the next one to two years (see Table D12).

Number of Planned Medical Devices Interfaced with EMR In 1-2 Years	Average	Median	Count
Infusion Pumps	728.8	364.0	11
Cardiac Output Monitors	84.7	107.0	3
Physiologic Monitors	238.7	80.0	15
Ventilators	89.1	78.0	7
Vital Sign Monitors	86.7	30.0	3
Intra-aortic Balloon Pumps	28.0	28.0	1
Dialysis Units	23.0	23.0	1
Anesthesia Units	24.0	22.0	3
Monitors, Fetal	16.4	18.0	5
Intelligent Medical Device Hubs	65.8	15.0	4
Electrocardiographs	9.3	9.0	3
Radiologic/Fluoroscopic Systems	8.5	8.5	2
Ultrasounds, Diagnostic	8.3	8.0	4
Mammography Systems	1.0	1.0	2

Table D12

Performing an analysis of the median number of medical devices planned for interfacing with the EMR over the next two to four years indicates that infusion pumps, defibrillators, and physiologic monitors will be the most planned interfaced devices over the next two to four years (see Table D13).

Number of Planned Medical Devices Interfaced with EMR In 1-2 Years	Average	Median	Count
Infusion Pumps	616.7	550.0	3
Defibrillators	226.0	226.0	2
Physiologic Monitors	207.3	100.0	11
Vital Sign Monitors	288.3	87.5	6
Cardiac Output Monitors	126.0	75.0	3
Anesthesia Units	49.5	37.0	4
Blood Glucose Monitors	15.0	15.0	1
Radiologic/Fluoroscopic Systems	11.0	11.0	2
Ultrasounds, Diagnostic	10.0	10.0	1
Ventilators	8.0	9.0	3
Electrocardiographs	5.0	5.0	2
Monitors, Fetal	5.0	5.0	1
Intelligent Medical Device Hubs	32.3	5.0	3
Blood Gas Analyzers	2.0	2.0	1
Mammography Systems	2.0	2.0	1
Intra-aortic Balloon Pumps	2.0	2.0	1

Table D13

An evaluation of the types of interfaces used for connecting the medical devices to the EMR (see Table D14) shows that fetal monitors, physiologic monitors, and electrocardiographs are interfaced most often with one way interfaces (data flowing from the device to the EMR), while intelligent medical device hubs, radiologic/fluoroscopic systems, and diagnostic ultrasounds tend to be connected to the EMR via bi-directional interfaces (the EMR can communicate with the medical device for managing the data streams the devices are sending to the EMR).

Tell Us About the Interface Used to Connect to the Electronic Medical Record (EMR)–Percent Interface Type	Bi-Directional	One Way Interface	Not Interfaced	Valid N
Anesthesia Units	0.00%	16.13%	83.87%	31
Blood Gas Analyzers	19.35%	45.16%	35.48%	31
Blood Glucose Monitors	11.11%	29.63%	59.26%	27
Cardiac Output Monitors	3.45%	13.79%	82.76%	29
Defibrillators	0.00%	0.00%	100.00%	31
Dialysis Units	0.00%	8.33%	91.67%	24
Electrocardiographs	28.13%	50.00%	21.88%	32
Extracorporeal Therapy Systems	0.00%	0.00%	100.00%	14
Infant Incubators	0.00%	0.00%	100.00%	31
Infusion Pumps	16.13%	3.23%	80.65%	31
Intelligent Medical Device Hubs	47.37%	42.11%	10.53%	19
Intra-aortic Balloon Pumps	0.00%	7.69%	92.31%	26
Mammography Systems	33.33%	29.63%	37.04%	27
Monitors, Fetal	18.75%	53.13%	28.13%	32
Physiologic Monitors	13.89%	50.00%	36.11%	36
Radiologic/Fluoroscopic Systems	37.50%	40.63%	21.88%	32
Ultrasounds, Diagnostic	37.50%	37.50%	25.00%	32
Ventilators	3.13%	28.13%	68.75%	32
Vital Sign Monitors	0.00%	3.23%	96.77%	31

Table D14

Key:

Highest Response

2nd Highest Response

When evaluating the networks used to connect the devices to the EMRs for interfacing data, defibrillators, intra-aortic balloon pumps, and anesthesia are only connected via local area networks (LANs). This is probably due to the reliability provided by LANs as opposed to wireless LANs (WLANs). (see Table D15). A high number of laboratory, radiology, and ventilators are also connected via LANs. The devices that demonstrate the highest numbers of connections with a variety of LANs and WLANs are cardiac output monitors and dialysis units. The devices that are connected most often via WLANs are infusion pumps and vital sign monitors.

Tell Us About the Network Used to Connect the Device to the EMR - Percent Connection Type	Wired and Wireless LAN Connection	Wired LAN Connection	Wireless (b,g,n) LAN Connection	Valid N
Anesthesia Units	0.00%	100.00%	0.00%	6
Blood Gas Analyzers	16.67%	83.33%	0.00%	18
Blood Glucose Monitors	20.00%	80.00%	0.00%	10
Cardiac Output Monitors	33.33%	66.67%	0.00%	6
Defibrillators	0.00%	100.00%	0.00%	1
Dialysis Units	33.33%	33.33%	33.33%	3
Electrocardiographs	16.00%	60.00%	24.00%	25
Infant Incubators	0.00%	100.00%	0.00%	1
Infusion Pumps	14.29%	14.29%	71.43%	7
Intelligent Medical Device Hubs	29.41%	64.71%	5.88%	17
Intra-aortic Balloon Pumps	0.00%	100.00%	0.00%	2
Mammography Systems	11.76%	88.24%	0.00%	17
Monitors, Fetal	19.05%	80.95%	0.00%	21
Physiologic Monitors	20.83%	79.17%	0.00%	24
Radiologic/Fluoroscopic Systems	25.00%	75.00%	0.00%	24
Ultrasounds, Diagnostic	17.39%	82.61%	0.00%	23
Ventilators	10.00%	90.00%	0.00%	10
Vital Sign Monitors	0.00%	50.00%	50.00%	2

Table DI5

Key:

Highest Rating

2nd Highest Rating

The medical device interfaces that have the highest support from the clinical engineering department are physiologic monitors, and intelligent medical device hubs (see Table DI6).

Interface Supported by Clinical Engineering	Yes	No	Valid N
Physiologic Monitors	58.62%	41.38%	29
Intelligent Medical Device Hubs	41.18%	58.82%	17
Ventilators	30.00%	70.00%	20
Monitors, Fetal	25.93%	74.07%	27
Electrocardiographs	25.00%	75.00%	32
Infusion Pumps	25.00%	75.00%	16
Ultrasounds, Diagnostic	24.14%	75.86%	29
Radiologic/Fluoroscopic Systems	22.22%	77.78%	27
Cardiac Output Monitors	21.43%	78.57%	14
Anesthesia Units	21.43%	78.57%	14
Mammography Systems	17.39%	82.61%	23
Blood Gas Analyzers	12.00%	88.00%	25
Dialysis Units	10.00%	90.00%	10
Vital Sign Monitors	7.69%	92.31%	13
Intra-aortic Balloon Pumps	7.69%	92.31%	13
Defibrillators	6.67%	93.33%	15
Blood Glucose Monitors	5.26%	94.74%	19
Infant Incubators	0.00%	100.00%	11
Extracorporeal Therapy Systems	0.00%	100.00%	5

Table D16

Table D17 shows where the interfaced medical devices are located within the hospital.

Patient Care Areas where the Interfaced Medical Devices Deployed? (count)	Med-Surg	ED	ICU/SCU	Card.	Rad.	Cath-Lab	OR	RT	L&D	Lab	Other
Physiologic Monitors	9	16	24	11	6	11	14	1	10	0	2
Defibrillators	11	10	10	10	9	8	8	2	9	1	4
Vital Sign Monitors	12	11	8	8	8	4	6	3	5	1	2
Electrocardiographs	16	20	19	23	2	7	5	3	5	0	3
Infusion Pumps	17	15	15	12	11	12	13	1	10	1	3
Ventilators	3	9	17	1	0	2	5	10	0	0	1
Cardiac Output Monitors	1	8	15	3	0	6	8	1	0	0	2
Infant Incubators	0	2	2	0	0	0	1	0	8	1	2
Blood Gas Analyzers	1	5	5	1	0	1	3	11	2	10	3
Blood Glucose Monitors	13	12	11	6	3	5	8	2	7	7	2
Extracorporeal Therapy Systems	1	1	2	0	0	0	3	0	0	0	0
Ultrasounds, Diagnostic	2	8	6	13	18	5	8	0	6	0	2
Monitors, Fetal	0	1	1	0	0	0	1	0	26	0	1
Radiologic/Fluoroscopic Systems	1	8	4	3	24	12	10	0	1	0	1
Mammography Systems	0	0	0	0	19	0	1	0	0	0	1
Intra-aortic Balloon Pumps	0	2	7	3	0	8	3	0	0	0	0
Anesthesia Units	1	0	0	0	2	4	13	0	3	0	1
Dialysis Units	1	1	2	0	0	0	0	0	0	0	6
Intelligent Medical Device Hubs	4	8	12	4	3	3	4	1	5	0	2

Table D17

Key:

Highest Response

2nd Highest Response

**Key:** Med/Surg – Medical Surgical; ED – Emergency Department; ICU/SCU – intensive care unit/special care unit; Card. – Cardiology; Rad. – Radiology/Fluoroscopic Systems; Cath-Lab – Catheter Laboratory; OR – Operating Room/Surgery; RT – Respiratory Therapy; L&D – Labor and Delivery; Lab – Clinical Laboratory; Other – Other departments identified by study respondents

The most significant factor for interfacing medical devices with the EMR was to create automatic charting of patient data (see Table D18). The two other highest factors identified were to improve clinical decision support alarms, and to enable remote support of the medical devices (this would require a bi-directional interface).

Reasons for Interfacing Medical Devices	Count	Percentage
Automatic Charting of Data to the EMR	36	70.59%
Clinical Decision Support/Alarms	18	35.29%
To Enable Remote Support of Medical Devices	12	23.53%
Capturing Data for Research Purposes	4	7.84%
Closed Loop System Needs	4	7.84%

Table D18 N=51

Note: respondents could choose more than one answer.

# Intelligent Medical Device Vendor Summary

A ranking of the intelligent medical device vendors by market share in this study (the sample size is not statistically significant) are shown in Tables V1 – V19.

In Table V1, GE Healthcare has a slight lead over Philips Healthcare in this study, but both of these vendors have a significant lead over other vendors mentioned for physiologic monitor products.

Physiologic Monitors	Count	Percentage
GE Healthcare Technologies	24	53.33%
Philips Healthcare	22	48.89%
Datascope Patient Monitoring	6	13.33%
Welch Allyn Inc	4	8.89%
Draeger Medical Inc	3	6.67%
Nihon Kohden America Inc	3	6.67%
Datex-Ohmeda Inc	2	4.44%
Spacelabs Healthcare Inc	2	4.44%
Bionetics Ltd	1	2.22%
Ivy Biomedical Systems Inc	1	2.22%
Pace Tech Inc	1	2.22%

Table V1 N=45 (More than one vendor may be mentioned from each respondent)

Physio-Control, Inc. demonstrated a significant lead over other defibrillator vendors in this study in Table V2.

Defibrillators	Count	Percentage
Physio-Control Inc	28	63.64%
Philips Healthcare	14	31.82%
ZOLL Medical Corp	9	20.45%
P J Hilton & Assoc	1	2.27%

Table V2 N=44 (More than one vendor may be mentioned from each respondent)

GE Healthcare is the leading vendor of vital sign monitors in this study by more than 50 percent over other named vendors in Table V3.

Vital Sign Monitors	Count	Percentage
GE Healthcare Technologies	25	59.52%
Welch Allyn Inc	12	28.57%
Philips Healthcare	9	21.43%
Datascope Patient Monitoring	4	9.52%
Cardinal Health	2	4.76%
Invivo Corp	1	2.38%
IVAC	1	2.38%
Masimo	1	2.38%

Table V3 N=42 (More than one vendor may be mentioned from each respondent)

In Table V4, GE Healthcare also has a significant lead in electrocardiograph devices compared to other named vendors in this study.

Electrocardiographs	Count	Percentage
GE Healthcare Technologies	26	59.09%
Philips Healthcare	7	15.91%
Cardiac Science Corp	3	6.82%
Burdick	1	2.27%
Edwards Lifesciences Corp	1	2.27%
Midmark	1	2.27%
Mortara Instrument Inc	1	2.27%
Quinton	1	2.27%
Spacelabs Healthcare Inc	1	2.27%
Welch Allyn Inc	1	2.27%

Table V4 N=44 (More than one vendor may be mentioned from each respondent)

Cardinal Health had the most mentions for infusion pump vendors in this study in Table V5.

Infusion Pumps	Count	Percentage
Cardinal Health Inc	14	31.82%
Hospira Inc	8	18.18%
Baxter Healthcare Corp	6	13.64%
Sigma International LLC	6	13.64%
B Braun Medical Inc	4	9.09%
Smiths Medical MD Inc	3	6.82%
Abbott Lifecare	1	2.27%
Bard Infus OR	1	2.27%

Table V5 N=44 (More than one vendor may be mentioned from each respondent)

In Table V6, Maquet, Inc, Draeger Medical, Inc., and Puritan Bennett are the leading vendors of ventilator devices to respondents of this study.

Ventilators	Count	Percentage
Maquet Inc	13	30.23%
Draeger Medical Inc	12	27.91%
Puritan Bennett	11	25.58%
Bird Products Corp	4	9.30%
Philips Healthcare	4	9.30%
Mallinckrodt	3	6.98%
Bear Medical Systems Inc	2	4.65%
Newport Medical Instruments Inc	2	4.65%
BioMed Devices	1	2.33%
eVent Medical Ltd (US)	1	2.33%
Hamilton Medical Inc	1	2.33%
IT 1200	1	2.33%
Sensomedica	1	2.33%
Siemens	1	2.33%
Smiths	1	2.33%
VersaMed Medical Systems Inc	1	2.33%
Viasys	1	2.33%

Table V6 N=43 (More than one vendor may be mentioned from each respondent)

Edwards Lifesciences Corporation, Philips Healthcare, and GE Healthcare were the leading suppliers of cardiac output monitors in this study in Table V7.

Cardiac Output Monitors	Count	Percentage
Edwards Lifesciences Corp	9	21.95%
Philips Healthcare	7	17.07%
GE Healthcare Technologies	6	14.63%
Spacelabs Healthcare Inc	2	4.88%
BioZ ICG Systems	1	2.44%
Hospira	1	2.44%
Nihon Kohden	1	2.44%
Witt	1	2.44%

Table V7 N=41 (More than one vendor may be mentioned from each respondent)

In Table V8, Hill-Rom Co. Inc., and GE Healthcare are the leading vendors of infant incubators in this study.

Infant Incubators	Count	Percentage
Hill-Rom Co Inc	14	32.56%
GE Healthcare Technologies	11	25.58%
Draeger Medical Inc	8	18.60%
Datex-Ohmeda Inc	7	16.28%
Ohmeda Medical	3	6.98%
International Biomedical Inc	1	2.33%
NeoForce	1	2.33%

Table V8 N=43 (More than one vendor may be mentioned from each respondent)

Radiometer America Inc. has a significant lead over other blood gas analyzers in this study in Table V9.

Blood Gas Analyzers	Count	Percentage
Radiometer America Inc	12	27.91%
Abbott Point of Care	3	6.98%
Instrumentation Laboratory Co	3	6.98%
Nova Biomedical Corp	3	6.98%
Bayer	2	4.65%
GMI, Inc.	2	4.65%
Roche Diagnostics	2	4.65%
Siemens	2	4.65%
IL	1	2.33%

Table V9 N=43 (More than one vendor may be mentioned from each respondent)

In Table V10, Roche Diagnostics, Abbot, and Johnson & Johnson are the most mentioned vendors by respondents in this study for blood glucose monitors.

Blood Glucose Monitors	Count	Percentage
Roche Diagnostics	6	15.38%
Abbott	4	10.26%
Johnson & Johnson	4	10.26%
Fisher Healthcare	2	5.13%
Boehringer Ingleheim	1	2.56%
Clinitech	1	2.56%
HemoCue Inc	1	2.56%
Sure Step	1	2.56%

Table V10 N=39 (More than one vendor may be mentioned from each respondent)

There were not enough mentions for vendors of extracorporeal therapy systems to provide any insights as to leading vendors in Table V11.

Extracorporeal Therapy Systems	Count	Percentage
Sorin Group USA Inc	3	13.64%
Medtronic Perfusion Systems	2	9.09%
Terumo Cardiovascular Systems Corp	2	9.09%
Circon	1	4.55%
Maquet-Dynamed Inc	1	4.55%
Medispec	1	4.55%

Table V11 N=22 (More than one vendor may be mentioned from each respondent)

Philips Healthcare, Siemens, and GE Healthcare are the leading vendors in this study for ultrasound medical device products in Table V12.

Ultrasounds	Count	Percentage
Philips Healthcare North America	25	55.56%
Siemens	16	35.56%
GE Healthcare USA	15	33.33%
B-K Medical Systems Inc	3	6.67%
SonoSite	2	4.44%
ZONARE Medical Systems Inc	2	4.44%
Aloka Co Ltd (USA)	1	2.22%
Sonoscan Inc	1	2.22%

Table V12 N=45 (More than one vendor may be mentioned from each respondent)

In Table V13, Corometrics, Philips Healthcare, and GE Healthcare are the leading vendors mentioned by respondents of this study for fetal monitors.

Fetal Monitors	Count	Percentage
Corometrics	16	36.36%
Philips Healthcare	15	34.09%
GE Healthcare USA	12	27.27%
Hewlett Packard	1	2.27%

Table V13 N=44 (More than one vendor may be mentioned from each respondent)

GE Healthcare, Siemens, and Philips Healthcare were the leading vendor mentions in this study for radiologic/fluoroscopic systems. Refer to Table V14.

Radiologic/Fluoroscopic Systems	Count	Percentage
GE Healthcare USA	22	51.16%
Siemens	14	32.56%
Philips Healthcare North America	11	25.58%
Shimadzu	3	6.98%
Toshiba	3	6.98%
Carestream Health Inc	1	2.33%
Del Medical	1	2.33%
HP	1	2.33%
Ziehm Vison	1	2.33%

Table V14 N=43 (More than one vendor may be mentioned from each respondent)

In Table V15, Hologic Inc., and GE Healthcare are the leading vendors in this study for mammography systems.

Mammography Systems	Count	Percentage
Hologic Inc	12	31.58%
GE Healthcare USA	9	23.68%
Siemens	6	15.79%
FujiFilm Medical Systems USA Inc	1	2.63%

Table V15 N=43 (More than one vendor may be mentioned from each respondent)

Datascope Corporation is the clear leader for intra-aortic balloon pumps for hospitals who participated in this study in Table V16.

Intra-Aortic Balloon Pumps	Count	Percentage
Datascope Corp	23	65.71%
Arrow Medical Products Ltd	2	5.71%
Teleflex Medical	1	2.86%

Table V16 N=35 (More than one vendor may be mentioned from each respondent)

In Table V17, Datex-Ohmeda Inc. and Draeger Medical Inc., are the leading vendors for anesthesia units in this study.

Anesthesia Units	Count	Percentage
Datex-Ohmeda Inc	30	69.77%
Draeger Medical Inc	22	51.16%
GE Healthcare USA	2	4.65%
Spacelabs Healthcare Inc	1	2.33%

Table V17 N=43 (More than one vendor may be mentioned from each respondent)

Fresenius Medical Care is the leading vendor for mentions of respondents for dialysis units in Table V18.

Dialysis Units	Count	Percentage
Fresenius Medical Care North America	13	40.63%
Baxter Healthcare Corp	5	15.63%
Gambro	4	12.50%
B Braun Medical Inc	1	3.13%
GE Healthcare USA	1	3.13%

Table V18 N=32 (More than one vendor may be mentioned from each respondent)

In Table V19, Philips Healthcare, GE Healthcare, Cerner, and McKesson were the leading mentions for vendors supplying intelligent medical device hubs.

Intelligent Medical Device Hubs	Count	Percentage
Philips Healthcare/Vuelink	5	20.00%
GE Healthcare	4	16.00%
Cerner	3	12.00%
McKesson	3	12.00%
BayTech	1	4.00%
Capsule	1	4.00%
Epic	1	4.00%
LiveData	1	4.00%
MedSphere	1	4.00%

Table V19 N=25 (More than one vendor may be mentioned from each respondent)

# Conclusion

The intelligent medical device market is still emerging and will become a significant factor for hospitals creating EMR strategies, which given ARRA, is, or will be, all of them. We expect the capital and operating budgets will increase, especially after hospitals have achieved the desired EMR data collection and management levels to receive ARRA funding. We also believe that operations for supporting and maintaining the interfaces for intelligent medical devices to the EMR will fall under the purview of the hospital's (IS) department. What is less clear at this time is whether the biomedical operations will be placed under the IS department for management. We believe that it should be, ala the movement of responsibility for telecommunications to the CIO when telecommunications and information technologies merged in the last 15 years.

As the requirements for interfacing intelligent medical devices becomes more acute, we believe that wireless networks will become more important for the design of effective medical device utilization. At some point in time, the intelligent medical devices will become just another application extension of the EMR.

# Appendix

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## Replacement Data for Intelligent Medical Devices

Replacement Plans	Count		Percentage		Valid N
	Plans	No Plans to Replace	Plans	No Plans to Replace	
Infusion Pumps	17	13	56.67%	43.33%	30
Physiologic Monitors	16	14	53.33%	46.67%	30
Ultrasounds, Diagnostic	12	19	38.71%	61.29%	31
Radiologic/Fluoroscopic Systems	11	18	37.93%	62.07%	29
Anesthesia Units	10	20	33.33%	66.67%	30
Infant Incubators	10	19	34.48%	65.52%	29
Ventilators	10	19	34.48%	65.52%	29
Vital Sign Monitors	10	17	35.71%	60.71%	28
Mammography Systems	8	16	33.33%	66.67%	24
Blood Gas Analyzers	7	23	23.33%	76.67%	30
Blood Glucose Monitors	7	20	25.93%	74.07%	27
Defibrillators	7	22	24.14%	75.86%	29
Intra-aortic Balloon Pumps	7	17	29.17%	70.83%	24
Monitors, Fetal	7	23	23.33%	76.67%	30
Dialysis Units	6	14	30.00%	70.00%	20
Electrocardiographs	6	24	20.00%	80.00%	30
Extracorporeal Therapy Systems	4	9	30.77%	69.23%	13
Cardiac Output Monitors	3	24	11.11%	88.89%	27
Intelligent Medical Device Hubs	2	14	12.50%	87.50%	16

## Upgrade Plans for Intelligent Medical Devices

Upgrade Plans	Count		Percentage		Valid N
	Plans	No Plans to Upgrade	Plans	No Plans to Upgrade	
Cardiac Output Monitors	13	0	100.00%	0.00%	13
Physiologic Monitors	7	10	41.18%	58.82%	17
Radiologic/Fluoroscopic Systems	5	7	41.67%	58.33%	12
Infusion Pumps	3	10	23.08%	76.92%	13
Ultrasounds, Diagnostic	3	11	21.43%	78.57%	14
Intelligent Medical Device Hubs	3	5	37.50%	62.50%	8
Electrocardiographs	2	12	14.29%	85.71%	14
Ventilators	2	10	16.67%	83.33%	12
Blood Gas Analyzers	2	12	14.29%	85.71%	14
Vital Sign Monitors	1	12	7.69%	92.31%	13
Blood Glucose Monitors	1	11	8.33%	91.67%	12
Intra-aortic Balloon Pumps	1	9	10.00%	90.00%	10
Anesthesia Units	1	11	8.33%	91.67%	12
Defibrillators	0	13	0.00%	100.00%	13
Infant Incubators	0	12	0.00%	100.00%	12
Extracorporeal Therapy Systems	0	6	0.00%	100.00%	6
Monitors, Fetal	0	14	0.00%	100.00%	14
Mammography Systems	0	10	0.00%	100.00%	10
Dialysis Units	0	10	0.00%	100.00%	10

## First Time Purchase Plans for Intelligent Medical Devices

First Time Purchase Plans	Count		Percentage		Valid N
	Plans	No Plans to Purchase	Plans	No Plans to Purchase	
Intelligent Medical Device Hubs	3	11	21.43%	78.57%	14
Vital Sign Monitors	2	0	100.00%	0.00%	2
Anesthesia Units	2	0	100.00%	0.00%	2
Physiologic Monitors	1	0	100.00%	0.00%	1
Defibrillators	0	2	0.00%	100.00%	2
Electrocardiographs	0	2	0.00%	100.00%	2
Infusion Pumps	0	2	0.00%	100.00%	2
Ventilators	0	2	0.00%	100.00%	2
Cardiac Output Monitors	0	3	0.00%	100.00%	3
Infant Incubators	0	2	0.00%	100.00%	2
Blood Gas Analyzers	0	2	0.00%	100.00%	2
Blood Glucose Monitors	0	3	0.00%	100.00%	3
Extracorporeal Therapy Systems	0	15	0.00%	100.00%	15
Ultrasounds, Diagnostic	0	1	0.00%	100.00%	1
Monitors, Fetal	0	1	0.00%	100.00%	1
Radiologic/Fluoroscopic Systems	0	2	0.00%	100.00%	2
Mammography Systems	0	6	0.00%	100.00%	6
Intra-aortic Balloon Pumps	0	7	0.00%	100.00%	7
Dialysis Units	2	8	0.00%	100.00%	8