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Chapter 22

Technological Support for Paramedical Asset Management in a Hospital Setting: Opportunities for Efficacy Enhancement and Cost Reduction

By Job Gutteling, Heleen Nelissen and Marijke Vulink

22.1 Introduction

(Para)medical assets, such as syringe pumps, volumetric pumps, mobile 'snapshot' blood pressure/saturation monitors, IV poles, or special needs mattresses, are rarely used continuously. There are always assets 'in reserve', as they may be needed for emergencies, changing patient needs and workflow among nursing staff. However, it is usually less clear how the numbers and availability of the assets actually relate to the total number available and their physical location.

Optimal use and availability of assets can contribute to the efficiency of the medical technology department in several ways. If a smaller number of assets are required, this would lead to reduced investments and also less assets requiring maintenance.

A distinction must be made between types of medical assets: (1) relatively small or low-cost assets are typically present in bulk, e.g., perfusion or volumetric pumps and special needs mattresses, and (2) smaller numbers of more expensive, complex assets like ultrasound carts—for the latter, more specific requirements with regard

to utilization apply, such as immediate availability, which is outside the scope of this project.

The bulk assets are used in many places, with a frequency dependent on variable patient needs and with potentially high peaks. Little is known about 'hoarding' assets and also departmental/ward-specific purchasing (budgets) are not necessarily known to the department of medical technology. A strong driving force is the perception of needs as opposed to actual use. Due to the large numbers of these assets, the ease with which they 'settle' in a departmental/ward storage room strongly supports that a possible efficiency gain here is at least as interesting as with the expensive assets.

Previous studies have shown that nurses can spend up to 10% of their total work time searching for misplaced paramedical assets [1].

European hospitals invest some 100 billion Euro per year in medical technology – a measurable fraction for replacing mobile equipment that has been lent to another department and not returned or which is hidden by staff in their own department to assure they have it available for urgent situations, leading to specific assets utilization as low as 30% [2–5]. In addition, costs other than purchase, such as maintenance and general operational costs, must also be associated with the number of assets available, regardless of their actual usage.

Two separate studies, using different paramedical assets and different wards, were performed in OLVG, to investigate both the flow of these assets and the usage of a centralized storage facility (nursing paramedical assets storage facility). Despite the presence of a nursing assets warehouse with a pool system, and emphatic attention to reducing the ward-level closeting, OLVG was convinced that paramedical equipment could be used more efficiently.

The goals of these studies were to assess the ability of RTLS to provide knowledge and insights from the hospital point of view into nursing workflows by the implementation of an area-wide track and trace system. Secondary goals focus on the ability to implement and support the RTLS infrastructure in a vibrant environment and use Big Data technology for analysis.

The hypothesis in the OLVG is that RTLS can show that the number of bulk paramedical devices can be significantly reduced by device tracking.

22.2 Methods and Materials

Two studies were done successively. For simplicity, they will be described as Study 1 (pumps) and Study 2 OB-GYN ward.

The local Ethics Committee designated that project did not fall under the Medical Research Involving Human Subjects Act (non-WMO) and qualified it as

a quality assessment and improvement study without clinical consequences, and therefore waived the need for informed consent. Data collected through RTLS focus on location data of assets only, and no patient data were involved. All data are securely stored on a local server at the hospital. As no patient data are involved, ethical approval was waived. The study was approved by the hospital's research board. A data-sharing agreement with Philips Research was in place to jointly work with the data.

22.2.1 Materials and Methods—Study 1: Pumps

Study 1 involved installing and use of RTLS in the central assets facility and in the halls of nine clinical wards within OLVG. The study tracked all 183 pumps resourced from the nursing warehouse and clinically used on nine nursing wards with active RFID tags (company CenTrack). These pumps, volumetric (n = 107), syringe (n = 57), and enteral feeding (n = 19), were monitored for 5 weeks by a dozen transmitting/receiving stations (circa one per department). No other pumps of these types were used in these departments during that time.

The stations were able to trace the position of the pumps via triangulation. A pump was defined as 'in use' when it was more than a few meters from the storage space, wherever the station was located. For the purpose of the study, it had previously been agreed with the departments that assets that are not in active use would be returned to the storage facility. In addition, every day nursing warehouse employees actively searched for assets that were not in use but had remained on the ward.

Steps in this project included:

- RTLS localization of pumps
- Active return to storage policy, supported by staff
- Analysis of pump logs to validate actual usage duration

22.2.2 Materials and Methods—Study 2: OB-GYN

Study 2 assessed the process of finding and managing mobile paramedical assets within OLVG. It sought to validate that improved productivity could be achieved by decreasing time spent looking for assets and that the hospital organization could utilize mobile assets more cost-effectively by identifying utilization patterns and by limiting surplus assets. This is by implementing an RTLS system.

Steps in this project included:

- Placement of software showing the actual location of mobile assets on the computers on wheels (COW)

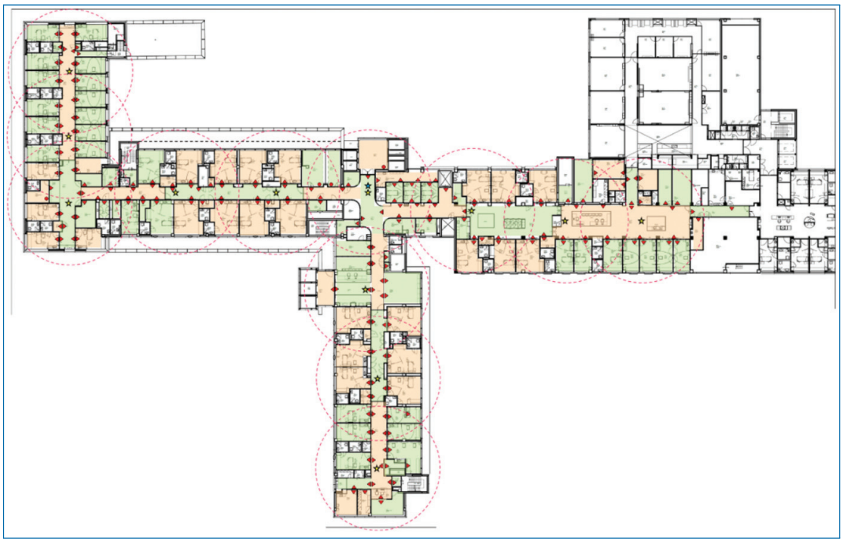

Figure 22.1. Star, device, and zone layout design at OLVG East (OB-GYN).

- Inventory of actual search time by nurses and their satisfaction using RTLS and questionnaires
- Labeling and following the distribution (usage) of mobile assets

A before–after study design was chosen. Initially, data collection was conducted through surveys and an active search time measurement for assets using RTLS. RTLS infrastructure was deployed in the OB-GYN department at location OLVG East (Figure 22.1). This department was chosen because it has a large floor area, it is a closed environment, its assets mostly do not leave the department, and it has a large number of assets and many private patient rooms with closed doors. At the department, the majority of mobile assets received a tag connecting to the RTLS. Three wards were covered by RTLS with room-level accuracy.

We employed a real-time Big Data analytics solution that received streaming data from an RTLS to track mobile assets. The RTLS technology includes InfraRed (IR), Wi-Fi, and Radio Frequency (RF)-enabled tags that are placed on any assets which needed to be tracked. An application on a COW was available for staff, especially nurses, to accurately see the real-time location of mobile assets. Daily and monthly data analytic reports were created on the location of mobile assets to be able to make real-time decisions. In Q3, 2019, a prototype of the application was introduced and the staff was trained using presentations. The project team was available by phone or e-mail for questions.

One year later (Q3, 2020), the prototype was replaced by production software. Staff was retrained at a higher frequency than with the prototype. Additionally,

Table 22.1. List of assets at the OB-GYN department by base location.

		Types of devices/assets	
		Storage room (mobile)	**Patient room (semi fixed)**
Potential for reduction in number of assets	Yes	Category 1 (n = 12)	Category 2 (n = 5)
		Incubator (Type A)	CTG-device
		Incubator (Type B)	Ultrasound
		Breast pump	Delivery bed
		Volumetric pump	Blood pressure device
		CTG (wireless)	Blood pressure device (manual)
		Blood pressure device (automatic)	
		Blood pressure device (mobile)	
		Bladder scan	
		Phototherapy lamp	
		Vacuum pump	
		Heat lamp	

project staff was regularly present at the department for support related to the solution, as well as through e-mail and phone.

To evaluate our objectives, room-level location data of target mobile assets (Table 22.1: assets suitable for tracking) was continuously collected through the RTLS using IR. These data were exported and analyzed to estimate assets utilization on a daily basis. We focused on the 12 asset types that had the potential for reduction based on the number of assets in the department and their main storage location (Table 22.1, Category 1).

Time investment by staff: To monitor time invested in searching for assets, staff badges were distributed and connected to the RTLS network. Staff working at the department were instructed to wear the badge and to press the button when they started searching for an asset and again when they found what they were looking for. Two periods of data collection were conducted with these RTLS badges. Feedback on the results was provided on a daily basis. In addition, surveys were used to evaluate the time invested and subjective staff satisfaction with efficacy (Figure 22.2).

Utilization of assets was estimated using the asset's location information by defining that assets were in use when they were in a patient room. For this assessment, we looked at the number of assets currently available in the department and the number of assets simultaneously in use. Note this was a selection of the paramedical assets available with the OB-GYN department.

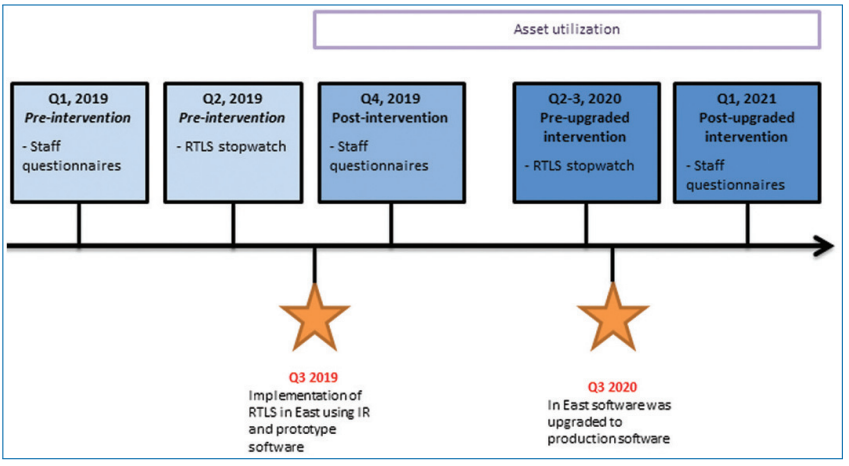

Figure 22.2. Timeline RTLS (RTLS data on COW).

Real-time location on COW: To facilitate staff in finding assets, we placed prototype software (pre-intervention) on the COW. Prior to this, surveys were conducted and search time was measured through RTLS badges. The software enabled staff to see the location of the assets in real-time. After the intervention was implemented, a second round of surveys was conducted (post-intervention).

Device usage: To calculate the usage of, e.g., a pump, the following calculation strategy was used: a department that uses an infusion pump for 8 hours during one a day and then puts it back in the storage room for 16 hours generates a usage rate of 33% for this pump.

22.3 Results

The concept of tracking mobile assets in terms of paramedical devices was readily accepted and recognized as logical by OLVG. Cooperation was without resistance. Technically, the RTLS systems worked well, compliance with badge wearing was acceptable, and staff were interested in the concept and feedback.

22.3.1 Study 1

22.3.1.1 RTLS localization of pumps

Table 22.2 shows that the utilization of the pumps is not optimal. The volumetric infusion pump is best utilized at an average of 65%. This is significantly higher than the syringe and enteral feeding pump, although clinically one would expect that therapy would continue on a 24/7 basis.

Table 22.2. Utilization rate of pumps during the measurement period.

Pump type	Week 1	Week 2	Week 3	Week 4	Week 5	Average
Volumetric infusion pump	65%	65%	62%	66%	67%	65%
Syringe pump	39%	37%	37%	33%	40%	37%
Enteral feeding pump	25%	23%	27%	29%	26%	26%

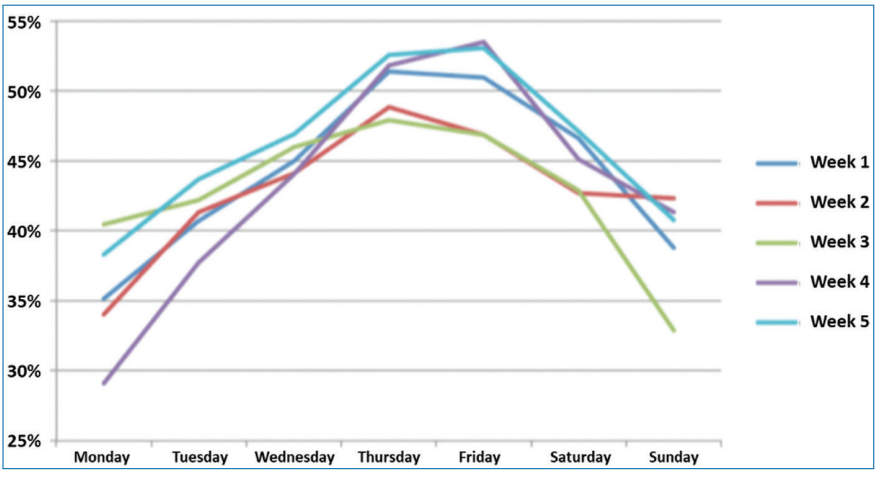

Figure 22.3. Variability of usage during one week for volumetric infusion pumps.

A striking aspect of the results is the variability during the week: utilization is low on Monday, rising during the week, and then falling again at the weekend (Figure 22.3). A possible explanation for this is that more patients are admitted during the week and they are then allowed to go home at the weekend, after which the influx will start again from Monday.

22.3.1.2 Active return to storage policy, supported by staff

In addition, a day/night pattern was sought, but this turned out to be almost a constant, probably because most therapy continues during the nightly hours. It should be noted that no active searches were done during the night for unused pumps, which might have caused an overestimation of the usage rate. Despite the careful methodology, a certain uncertainty remained about the utilization of the equipment being traced from the RTLS data. A pump present in a patient's room is not necessarily in active use and proactive removal and return to the storage facility only took place during office hours.

The three types of pumps are not used equally in the different departments (see Table 22.3).

Table 22.3. Use per type of pump per department.

	Volumetric infusion pump			Syringe pump			Enteral feeding pump		
Department	Avg.	Lowest	Highest	Avg.	Lowest	Highest	Avg.	Lowest	Highest
Nursing ward 1	3,9	2,1	6,1	6,4	2,3	9,7	0,4	0,0	1,0
Nursing ward 2	5,8	2,2	11,6	4,6	2,7	9,4	0,9	0,0	2,0
Nursing ward 3	7,7	3,7	12,2	4,2	1,9	6,3	1,9	0,3	3,7
Nursing ward 4	2,8	1,1	5,0	1,3	0,0	2,8	1,0	0,0	4,0
Nursing ward 5	11,1	6,9	17,3	3,8	2,0	5,2	2,0	0,0	3,7
Nursing ward 6	19,2	12,8	23,7	2,5	1,5	4,2	1,1	0,0	2,6
Nursing ward 7	1,4	0,0	3,5	5,9	2,2	8,6	2,5	0,0	4,5
Nursing ward 8	7,7	5,2	11,0	4,0	1,3	7,5	1,2	0,0	3,0
Nursing ward 9	5,7	2,6	9,4	1,0	0,0	2,9	0,7	0,0	1,9
Nursing	9,5	5,5	11,6	7,2	4,0	10,0	3,4	1,3	4,6

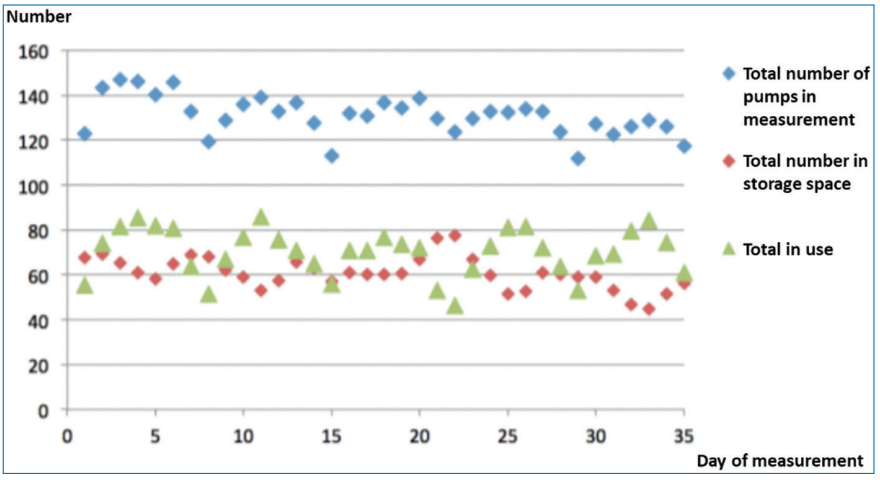

Figure 22.4. Actual pumps in circulation and use per day of measurement.

Figure 22.4 shows that the actually required (total) amount of pumps varies much less than would be suspected on the basis of the department-related lowest and highest values (from Table 22.3). There are between 46 and 86 pumps in use every day and between 45 and 78 pumps in a storage room. Based on these figures, it should be possible to take such a quantity of pumps out of circulation that the number in storage areas is minimal. However, this requires a system that allows departments to quickly obtain a pump if needed, to avoid unnecessary search times.

22.3.1.3 Analysis of pump logs to validate actual usage duration

The log files for a period of 2 weeks during the study of a random sample of 47 pumps were accessed and downloaded. The log files have a capacity for more than 24 days, depending on usage (each log has a fixed number of lines). From these log files, it can be calculated when and how much time a pump has actually been used.

On average, this usage appears to be 37% of the total time in the downloaded period. This varied greatly per pump from 6% to 74%. This suggests that the RTLS estimate of 65% overall utilization for these pumps is high. However, note that the study was designed to investigate the parallel usage of pumps, as this could be an independent limiting factor in the potential for reduction.

Study 1 suggests that there is an overabundance of pumps available and that centralized storage is a strong strategy. Discipline to avoid localized hoarding and returning the pump whenever it is not in use requires more support.

22.3.2 Study 2 in the OB-GYN Setting

22.3.2.1 Placement of Find-it software showing the actual location of mobile assets on the COW

Through surveys and communications, we were informed that utilization of the find-it software was limited. A significant departmental organization and structural change just before the introduction of the asset management system software in the COW may have been distracted from its use. Searching for mobile devices was suggested to be less of an issue following these changes. Before the change, the obstetric department and the neonatology department shared three wings, and assets were used on all wings. After the change, one ward was no longer used by the department and the obstetric and the neonatology care received their own wards. As a result, the assets were less susceptible to sharing and moving around. Moreover, assets were given a designated storage location per ward.

Because of this low utilization and a planned upgrade of the software, it was decided to conduct a second assessment on search time with the RTLS badges before the software upgrade. This also enabled data quality improvement. After the upgraded intervention, a third round of surveys was conducted (post-upgraded intervention). Figure 22.5 shows a print-screen of the layout of the upgraded intervention.

22.3.2.2 Asset tracking

An animation video on how the RTLS solution was implemented at OLVG can be found on the BigMedilytics website [6].

In the post-upgrade, monitoring of a period of 6 months estimated efficiency in Category 1 asset utilization as low averaging around 41% overall (i.e., the breast

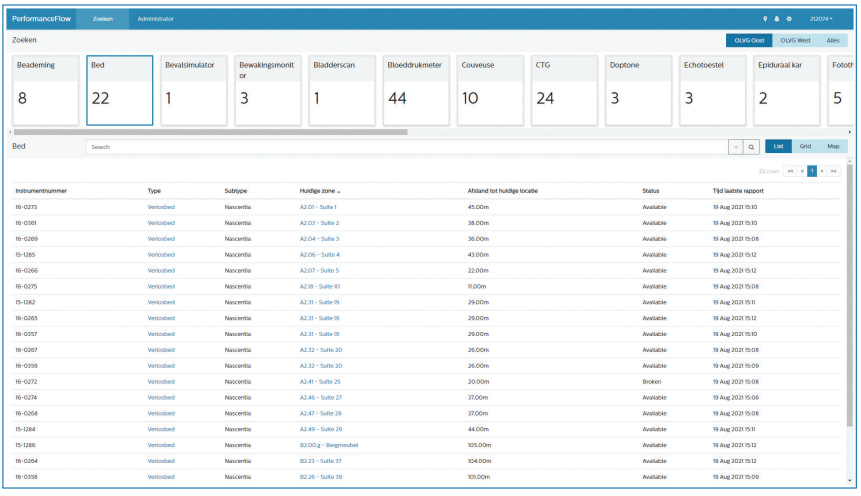

Figure 22.5. Print-screen of the upgraded solution (PerformanceFlow).

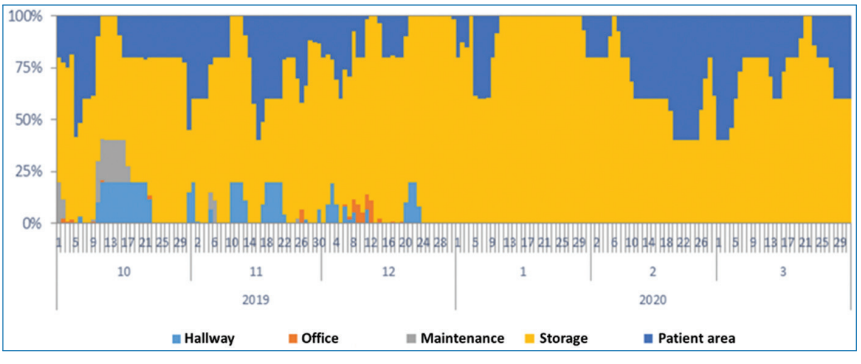

Figure 22.6. Average daily location information for incubator type B.

pump). We observed that, for 5 of the 12 asset types, all these assets could be in use simultaneously.

Figure 22.6 shows the location data of one asset type (incubator type B). The graph can be generated for any asset type, single asset or combination of assets. It distinguishes five locations: hallway, office, maintenance, storage, and patient room, and shows the percentage of time these assets were in each of the locations.

Table 22.4 shows the results of four asset types as an example. We choose to show these assets as an example as they are in a storage room when they are not in use and the initial investment is expensive. Based on this example, a potential saving of €82.500 was identified. When looking at all 12 asset types, potential cost savings could be as high as €93.000, a full 30% of the total asset value in this department.

In addition to the 12 Category 1 asset types, there are five additional Category 2 asset types that have the potential to reduce in number. These assets, for example,

Table 22.4. Asset utilization for four asset types over a period of 6 months.

			Average time in patient room	Maximum assets in patient rooms at the same time			
	# of assets	Costs per asses	%	*n*	(%)	Potential reduction	
Incubator (Type A)	4	€25.000	2%	2	50%	2	€50.000
Incubator (Type B)	5	€17.500	22%	4	80%	1	€17.500
Breast pump	20	€1.500	41%	14	70%	6	€9.000
Volumetric pump	7	€2.000	8%	4	57%	3	€6.000
					Total	**12**	**€82.500**

Table 22.5. Self-reported search times through surveys.

	Pre-intervention	Post-intervention	Post-upgraded intervention
# Searches per shift per nurse	0,6	0,5	0,5
Duration per search per nurse	3,6 minutes	4,7 minutes	4,3 minutes
Total search time per shift for shift staff	11,9 minutes	14,5 minutes	13,5 minutes

a CTG and echo device, are generally fully prepared and ready for use in patient rooms for acute situations, even if they are not in use. Only RTLS location data to estimate asset utilization are therefore not possible. Potential remediation could be to cross-reference whether a patient was in the acute care room and/or to access data logging files with the specific assets.

22.3.2.3 Inventory of actual search time by nurses and their satisfaction using RTLS and questionnaires

Using questionnaires, the average self-reported search time for the breast pump, CTG device, incubator, infusion pump, phototherapy device, and resuscitation table remained unchanged during the study (Table 22.5). Forty pre-intervention surveys were completed. Sixteen and 27 post-intervention and post-upgraded intervention surveys were completed, respectively.

Separately, two search time experiments were conducted using RTLS, one before the intervention and one after the (prototype) intervention. During the

Table 22.6. Queries used in the staff satisfaction experiments. Their responses were free text.

1	I am satisfied in how the use of mobile devices is organized in the department
2	I always find a mobile device immediately when I need it
3	To do my job well there are always enough mobile devices in the department
4	I can perform my work better when I would spend less time looking for mobile devices
5	At the end of my shift, I often feel flustered because I couldn't easily find mobile devices
6	I get enough information to quickly find mobile device
7	I get enough information to know if a device is available or still in use
8	The information I get about the location of mobile devices is reliable
9	They way we handle mobile devices in the department can be imporoved

first experiment, 146 searches were registered, with an average of 13.7 minutes per search. This compared to 24 searches in the second experiment, with an average search time of 4.9 minutes per search.

22.3.2.4 Increase staff satisfaction in using mobile assets

Surveys on staff satisfaction were conducted at the same time as the search time surveys. Table 22.6 shows the questions that were used to calculate an average staff satisfaction score on a scale from 1 to 10. Questions were completed on a 5-point Likert scale. The results show that staff satisfaction in handling mobile assets slightly increased during the study from 4.9 (N = 59) pre-intervention, to 6.1 (N = 17) post-intervention and 6.3 (N = 29) post-upgraded intervention.

22.3.2.5 Labeling and following the distribution (usage) of mobile assets

The main metric of interest when assessing assets is the utilization of all assets of a particular type across time (utilization score). Utilization information allows a hospital to determine whether they are under- or overstocked on a particular asset type. The utilization score can be calculated by measuring the total time a class of assets is in storage over a particular timeframe. A utilization metric was calculated per each individual asset and averaged over the entire group to form the final metric for that asset class.

In Figure 22.7, an example of (daily) utilization can be seen in the (upper)purple line. Due to the nature of RTLS data, the graph contains more data for context. The red line shows the number of assets available to calculate the metric.

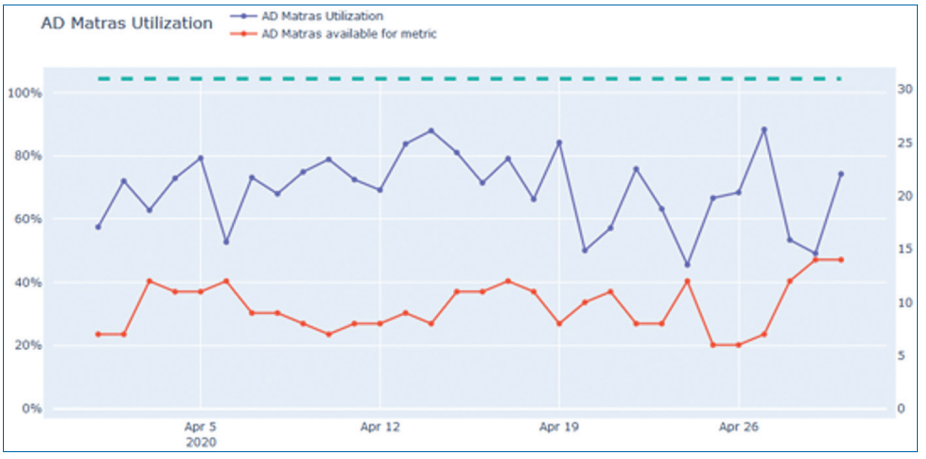

Figure 22.7. Utilization of anti-decubitus mattresses (purple line), assets available for the calculation of the metric (red line), and the maximum supply (blue dotted line). The low number available for calculation may indicate low reliability in the calculation.

It often happens that there are not enough data to reliably report a utilization metric for a particular asset. A common reason for this is so-called 'occlusion' (i.e., due to the covering of the IR sensor: the RTLS system knows the asset is within the system but cannot accurately define its localization. This is due to the different types of signals used). As utilization is reported as a percentage, it is crucial that the number of assets that this percentage is applied to is also known.

22.3.2.6 Time spent in room metric

While utilization gives information regarding the usage of (a class of) devices, it may also be useful to know the total time an asset spent in different types of rooms. This offers a lower level of granularity to the movement patterns of assets.

Additionally, this view is a nice alternative to room-based utilization when the assets rarely change rooms. For example, some ultrasound devices are always in specific (acute care) patient rooms. Therefore, using location to determine utilization is ineffective. However, it may still be useful to view the distribution of assets across rooms to spot anomalies. In Figure 22.8, each bar represents one unit of time (i.e., hour) and is split into multiple room types. Each asset is assigned by the majority of time spent in one room in each unit of time. The final result is that the bar then shows the distribution of assets (of the same type) across room types.

Similarly to the previous graph, there is a line to show the assets available for the analysis. In this case, this same information is also represented by the 'Missing time' category of the bar.

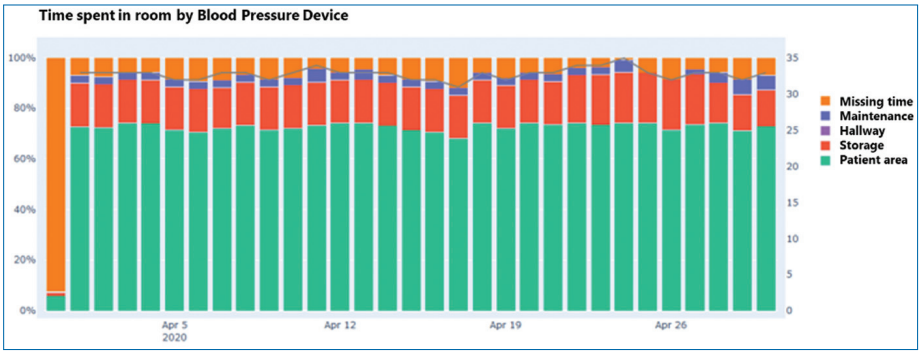

Figure 22.8. The time spent in different room types of blood pressure cuffs.

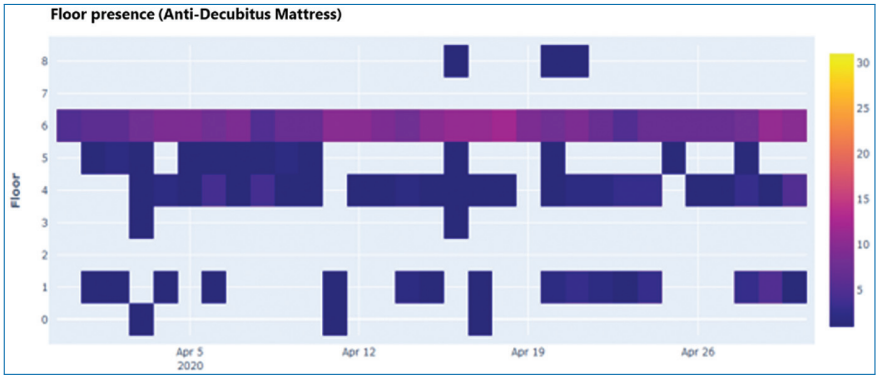

Figure 22.9. The number of mattresses staying predominantly on each floor. The bar on the right shows color coding for the duration.

22.3.2.7 Floor presence

Another potentially useful insight regarding assets is floor distribution. Often, asset types are shared across multiple departments and these departments may be on different floors. This graph allows visualization of how this spread across floors may evolve over time. As in Figure 22.9, the floor per asset is determined by the majority of the time spent somewhere by each asset. For example, if an asset spent more than 50% (on a per hour granularity that means over 30 minutes) of its time on the third floor, then it would be assigned to the third floor on the graph below.

22.3.2.8 Floor transition graph

To further attempt to understand the movement of assets across floors, it may be useful to understand not only where they most often are but also which floors they transition to most often. This is visualized using a network graph from RTLS data. For example, by integrating the 'floor presence' graph from Figure 22.10, we can

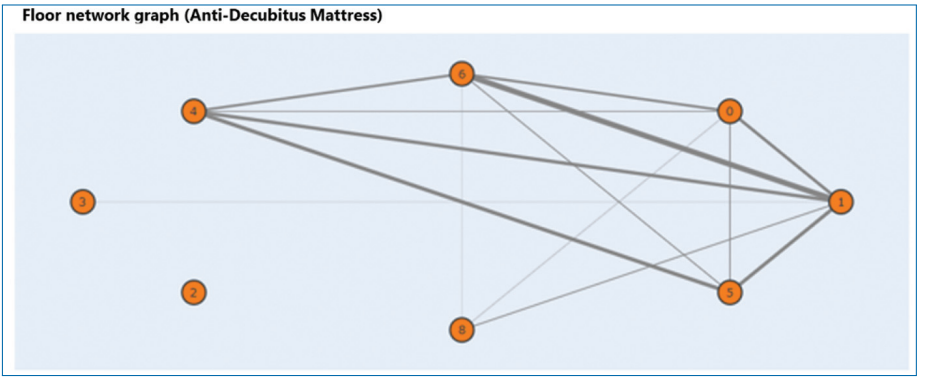

Figure 22.10. The floor transition graph for anti-decubitus mattresses.

see that most of the assets on the first floor come from the sixth floor. This may be an inefficiency in the process that could be worth pointing out to clinical staff.

22.4 Discussion

22.4.1 Study 1: Asset Management

The RTLS system worked well but should have had a higher granularity, to reduce or alleviate search for the assets to return them to the storage area. In addition, while RTLS shows location, it does not show usage in our study design. Pushing a button on the RTLS asset tag when the use is actually started and twice when the use is stopped could alleviate this concern but was not designed for our study. Overall acceptance of the concepts, the need, and the use of the RTLS system was high.

Knowing that the resources are not used fully efficiently is one thing, but attaching consequences to it is a separate challenge entirely. For example, an average of one and a half feed pumps were used full time per department, but in a department itself, that number can still vary from an average of less than one pump to four pumps per day. For syringe pumps the spread is between 1.0 and 7.2 per department and for volumetric pumps even between 1.4 and 19.2. This means that, even if there are 'too many' pumps in total, a department with only one pump cannot easily return it.

Another problem with interpreting the data in this way is that the lowest and highest values per department are measured independently of time. For example, sometime in the measurement period, departments 1 and 2 had the busiest periods with 6.1 and 11.6 volumetric pumps in use, respectively. However, this probably was not on the same day. Figure 22.4 shows that the various departments partly

complement each other in terms of equipment utilization. One aspect that needs to be addressed is the 'occlusion' (the blockage of a tag signal) as this makes data analysis difficult, requires one-by-one analysis, and limits a big data approach.

22.4.2 Nursing Warehouse

The results also support the potential return on investment for the careful development of centralized nursing warehouse(s) in helping to reduce the number of assets required. In a model where each department would have a fixed number of its own, it is logical to expect that the highest values from Figure 22.2 would be needed at least. After all, these are the actual pumps required, as evidenced by a measurement period of 5 weeks (longer measurement would probably have yielded an even higher number). Summing up all the high values across the departments yields an enormous number of 209 pumps, while Figure 22.3 shows that the actual maximum is 147, a difference of 62 pumps or 30%. The one-time investment of correct location(s), support staff are likely to offer return on investment and increased satisfaction plus reduced search times for staff.

This does not alter the fact that even with a nursing warehouse, there is still more cost reduction achievable by monitoring and optimizing the use of pumps. Probably, this is certainly the case at the OLVG; this requires a new working method in which pumps are ordered and returned instead of maintaining small storage spaces locally. A system based on active RTLS tags with which users can see where a pump can be obtained will have great added value.

22.4.3 Study 2: OB-GYN

The RTLS study in the OB-GYN and neonatology setting is seen as successful, despite organizational changes that impacted ground area and staff team needs and wants. The study was welcomed and generally accepted by staff in answering questions and wearing the RTLS badges.

The RTLS data provided us with new insights into asset utilization which can help with future investments in mobile assets. Through the data, we identified a potential overall cost reduction of €93.000, which is 30% of the total value of the asset types studied. This may be a conservative estimate as utilization may be optimized, for example, by scheduling and better insights into actual use in addition to location. Yearly maintenance costs – averaging 6–10% of the asset value – would also decrease.

From the evaluation of staff search time and satisfaction, we learned that change management is important when rolling out an asset-tracking application. We observed low engagement and usage of the system by department staff for software

on the COW as opposed to the willingness to participate. Moreover, a change management system can continuously monitor the process to directly intervene when adaptations are needed. During our study, we experienced that the departmental organization and structure changed before the introduction of the asset management system. This may be a factor in the low engagement with the COW system as the search area became smaller (and walking around is also a social-contact moment).

During the first round of the active search time experiment with RTLS, we learned that close monitoring of the data is needed to develop and maintain accurate results. During the analysis, we found a large number of unsuccessful searches, e.g., very short (<30 seconds) and very long (>30 minutes). During the second round, we improved our data collection by continuously monitoring the data through the RTLS. Our data quality became more realistic, but the number of searches also decreased. As the utilization of the intervention was low, we do not assume that the reduction in searches was impacted by the intervention. We observed a slight increase in staff satisfaction with handling mobile assets during the study.

22.4.4 Overall Limitations

Because the range of the transmitting/receiving stations was limited, a small part of each of the participating departments was out of range. As a result, the total number of (visible) devices in the results is lower than the actual total number of devices with a tag. Correction was attempted by taking a random sample in which devices seemingly not being counted were manually traced. Some 50% of these assets turned out to be in use.

Importantly, a tag cannot detect whether a device is on or off. In this way, a small overestimation of the utilization rate may arise, when some equipment is wrongly earmarked as in use for a time. However, this is not a problem for this pilot, as it was expected that there would still be sufficient profit to be made.

22.5 Conclusion

The first study with asset tracking with its goals of developing and implementing RTLS and using this system makes the process of finding and managing mobile medical equipment (assets) within a hospital more efficient. Productivity was to be improved by ensuring that staff invested less time looking for equipment and that a hospital utilizes its mobile assets in a more cost-effective fashion, e.g., by reducing unnecessary equipment, distributing, and/or scheduling usage. This will be accomplished by using an Asset Finding application that receives real-time data

from an RTLS system to track mobile assets. In this case, electronic asset tags are placed on the assets that need to be tracked.

The study was able to demonstrate that RTLS can be used as a valuable tool in optimizing asset management, making visible staff work in finding assets, and in search for improvements. After establishing search times and utilization levels for the initial situation (baseline), as an intervention, a dedicated Asset Finder Tool was introduced.

In the second study, technical implementation for the different goals was successful. RTLS hardware and software were installed at the OB-GYN department, and assets could be tracked successfully up to room-level accuracy. Data collected through RTLS were centrally stored and could be exported to create (monitoring) reports. Acceptance was middling.

Hospitals are dynamic environments, and when introducing an intervention, this needs to be taken into account. Adoption of the tool on the Computer On Wheels (COW) by staff was more challenging due to changing conditions at the department. Also, participation in the research was lower than expected.

Moreover, the data collection period was long, especially data collection with RTLS staff badges. We did find that staff forgot to wear the badges and to take them with them when searching. The study confirms the usability of RTLS and demonstrates the need to carefully think out the system, its locations, and ways to avoid 'occlusion' and missing data. The potential benefits in investment and maintenance costs were clearly relevant.

The medical technology department is ideally situated to be a driving force and stakeholder in these processes, as they have an overview, distance to the user group, and strong process and safety insights.

22.6 Main Learnings

Our main learnings are as follows:

- RTLS-type systems are a potentially valuable tool to gain insights into asset management, leading to cost reduction in investments and maintenance costs. The medical technology department should be recognized as a major stakeholder in this process.
- Continuous data collection to evaluate the solution and training and awareness for the solutions are needed are essential factors in the success of an RTLS solution.
- Change management needs to be in place to realize potential advantages and savings.

- RTLS infrastructure can be expanded from Wi-Fi to a more accurate (IR) system based on the needs. A thorough analysis of the needs of the institution/department (e.g., bed, room, or floor level accuracy) should be done to decide which technology should be used: Wi-Fi, IR, and/or RF.
- A platform (IoT/data-integration platform) should be in place that integrates multiple data sources and combines this with RTLS data to get in-depth utilization figures but can also be used for other applications.
- Including data from Wi-Fi areas makes it possible to assess asset utilization enterprise-wide.

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