A Novel Emergency Operating Room Online Scheduling Software: Making the Operating Room More Efficient and Cost effective

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Can an Emergency Surgery Scheduling Software Improves Residents' Time Management and Quality of life?

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ABSTRACT

Operating room efficiency is invaluable for all medical systems across the globe but is especially important for public systems such as the one in Canada where resources are limited with many patients requiring care. A new online scheduling software ORNET.CA was created and installed in a level one trauma centre, the Montreal General Hospital (MGH), in Montreal, Canada. All nursing staff were then trained for its use. Physicians were also sent an email with instructions of its use (Appendix A,B). The pilot for the software was launched in October 2015. The results demonstrate that ORnet can improve OR efficiency by up to 10% by improving communication which represent an average cost saving of $267,325.99 annually in Quebec for a single hospital centre. We demonstrate that ORnet improves communication between hospital staff and physicians, reduces workflow interruption, and improves the quality of the working environment. In addition to saving money, the results showed that a simple scheduling software accessible to all health care staff allows for improvement in quality of life, and a leads to a decrease in stress and anxiety levels amongst residents. This in turn could potentially equate to a reduction in attrition rates among surgical residents. We also demonstrate that the software improves OR efficiency, potentially reducing personnel cost by approximately 10% annually.

RÉSUMÉ

L'efficacité des blocs opératoires est indispensable à tous les systèmes de santé à travers le monde, mais surtout au sein de systèmes publics comme au Canada, où les ressources sont limitées et les patients de plus en plus nombreux. Un nouveau logiciel de planification en ligne, ORNET.CA, a été développé et installé dans un centre de traumatologie de niveau 1 à l'Hôpital Général de Montréal (HGM). Tout le personnel infirmier a reçu une formation sur le fonctionnement du système. Les directives d'utilisation ont aussi été envoyées aux médecins par courriel (Annexe A, B). Le projet pilote a été lancé en octobre 2015. Les résultats ont démontré qu'ORnet améliore la communication, ce qui permet d'augmenter l'efficacité des blocs opératoires de 10%. Cela représente une économie moyenne annuelle de 267,325.99 $ pour un seul centre hospitalier au Québec. Nous avons démontré qu'ORnet améliore la communication entre le personnel hospitalier et les médecins, diminue les interruptions au déroulement des opérations, et améliore la qualité du milieu de travail. Autre que des économies d'argent, les résultats ont permis d'observer qu'un simple logiciel de planification accessible à tout le personnel soignant aide à augmenter la qualité de vie des résidents, et contribue à diminuer leurs niveaux de stress et d'anxiété. Par conséquent, cela pourrait potentiellement atténuer le taux d'attrition parmi les résidents en chirurgie. Nous avons également démontré que le logiciel améliore le taux d'efficacité du bloc opératoire en réduisant les coûts liés au personnel d'environ 10% par an.

ACKNOWLEDGEMENTS

A special thanks and acknowledgement is owed to Amir Al-Shourbaji who was involved in the programming and implementation of the ORnet software. Amir played an important role in coding and parts of data acquisition for the web based survey sent to residents, physicians and nurses.

CONTRIBUTION TO ORIGINAL KNOWLEDGE

The elements of this thesis are considered original scholarship and distinct contributions to knowledge. The software was created and implemented by the authors and all data collection is new and contribute to understand how operating efficiency can be improved while improving health workers quality of life.

CONTRIBUTION OF AUTHORS

Dr. James Lee Is the main author. He came up with the creation of the solution and implementation of the software. He is also the main author who was involved in the write-up, analysis, data acquisition and completion of the thesis. Therefore, he was involved in drafting the work and played an important role in all intellectual content.

Dr. Ahmed Aoude contributed to the thesis by revising the thesis. He also was involved in the implementation of the software, data acquisition and analysis. He also helped James Lee finalize user guides and train nursing staff on software use.

Dr. Lucie Lessard was involved as senior author supervising the thesis write up and played an important role in manuscript revision and preparation.

INTRODUCTION

Operating room (OR) efficiency is invaluable for all medical systems across the globe but is especially important for public systems such as the one in Canada where resources are limited with many patients requiring care. Delays affect all hospital staff involved in the system but also affect patient care; peri-operative delays have been linked to adverse events and outcomes for patients [1-4]. Wong et al. [5] introduced the following seven error classifications that cause operating delays: technical, nursing, delays, communication, contamination, anesthesia and other. Addressing any one or more of these classes of error will lead to improved operating room efficiency and allow for better patient care.

The first step in finding solutions and improving operating room efficiency is to identify when delays occur and subsequently identifying the underlying cause. Wong et al. [5] states that hospital medical records can be used to monitor prevalence of operating room delays. In this thesis, we present an online scheduling solution; being launched in a university health care centre, we hypothesized that it could minimize delays and interruptions in the OR by improving communication between physicians and OR personel. Improving the efficiency in the OR can be directly translated into cost savings, particularly important in a public health care system.

We then considered if this online scheduling software could do more than just save money. Being able to visualize the dynamic OR schedule in real time could help residents and hospital staff better predict their on-call schedules and better manage their time. Studies have shown that residents have more work burden, longer work hours, more physical work and high rates of stress [6-10]. The higher stress situation that surgical residents go through partly explains higher burnout rates among surgical residents [7].

Multiple studies have looked at the reasons for this, and in one study, future lifestyle, sleep deprivation, and work hours were the main reasons that residents decided to

quit residency [8]. The higher attrition rates in surgical residents also affects work quality, personal and family problems and in turn affects patient care [9]. Solutions to attempt to decrease attrition rates in surgical programs have included allowing for post call days, decreasing maximum number of work hours, and providing many support methods for residents throughout their residency. However, some studies report negative outcomes even after the implementation of these methods [11, 12]; very little literature exists on methods to improve time management for residents.

Being a surgical resident in Canada differs from the United States because of the lack of OR resources in a public system. In Canada, emergency non-elective cases are more likely to take place during evening and weekends since operating room resources are limited; non-elective surgery is typically limited to one operating room in Canada and performed only once elective cases during the day have all been completed. All surgical specialities are then left to fight to get their emergency non-elective cases done during these hours, ultimately not knowing if they will have to come in during the evenings, night or weekend to get the cases done.

In this thesis we present how a novel software implemented and used in a level one trauma centre improved communication and allowed residents to better predict the emergency room operating room schedule and in turn help improve time management and quality of life. This novel software, ORnet, is currently still in use at the Montreal General Hospital (MGH) due its popularity amongst its users.

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Introduction

Operating room efficiency is invaluable for all medical systems across the globe but is especially important for public systems such as the one in Canada were resources are limited with long wait lists and many patients requiring care. Delays affect all hospital staff involved in the system but also affect patients; peri-operative delays have been linked to adverse events and outcomes for patients [1-4]. Wong et al. [5] introduced the following seven error classifications that cause operating delays: technical, nursing, delays, communication, contamination, anesthesia and other. Addressing any one or more of these classes of error will lead to improved operating room efficiencies and allow for better patient care.

The first step in finding solutions and improving operating room efficiency is to identify when delays occur and then identifying the underlying cause. Wong et al. [5] states that hospital medical records can be used to monitor prevalence of operating room delays. In this paper, we present an online solution to improve operating room efficiency and improve hospital staff's quality of life. This online application is used in a university health care center in Canada and is hypothesized to improve delays in the operating room by improving communication between hospital staff involved in the operating room.

Methods

A new online scheduling software ORNET.CA was created and installed in a Level 1 Trauma Center, the Montreal General Hospital (MGH), in Montreal, Canada. All nursing staff were then trained for its use. Physicians were also sent an email with instructions of its use (Appendix A,B). The pilot project for the software was launched

in October 2015. The software depicts the OR schedule on weeknights or evenings (non-elective operating room time). The nursing team would input the list of cases for the day for the non-elective operating room (OR) in a real time basis with standards established by the Hospital using it. Physicians who were on-call would log in to the web-based real-time scheduling software and view when their case would start and if the start time has been advanced or delayed due to other more urgent cases. In a situation where an OR is delayed due to an emergency, the physicians on-call would be notified immediately via e-mail or text notification or via the web-based scheduling software directly. The schedule, flow of cases and equipment needed were accessible to all healthcare givers to ensure adequate communication through all parties involved. Information about cases, start time, equipment needed was visible to the healthcare givers in real time.

Data acquired from the software from January 2016 to May 2017 was analyzed and is presented in this paper. October 2015 to January 2016 was used as a trial period of the online scheduling software for hospital staff to become familiar with its use. All non-elective (or emergency) case data from the MGH completed from July 2009 to June 2016 was analyzed to estimated number of cases, hours in operating room and determine higher volume months in terms of emergency cases. This data was then used to estimate cost savings associated with the software.

A survey was also sent to all users to determine quality of life measures and impression of the software by its users (Appendix C,D). Number of logins, cases and survey results were analyzed. Descriptive statistics were used to present these results. A cost analysis was also conducted to determine the cost effectiveness such a software program can have on healthcare centres based on average salaries of health care workers in the province of Quebec. It is important to note that no patient information was present on the scheduling software to ensure patient confidentiality; only procedure, expected surgical time and department was shown on the scheduling software. This allowed for communication of start times, surgical equipment

requirements for each case, and allowed for real-time case flow management without compromising patient privacy.

Results

Survey: Nurse Data

A total of 13 nurses who were familiar with the software for at least one year were asked to complete a multiple choice survey on the use of ORNET.CA. Only one nurse answered that she never used ORNET.CA; the remaining 12 either used the program very often (6-10 times per months) or often (3-5 times per month). The majority of nurses also responded that the software reduced the number of phone calls into the main OR by 25-50% and allowed them to focus on their tasks on-call. Over 70% of nurses responded positively to the statement "ORNET.CA has improved nursing work flow during evenings/weekends by reducing incoming calls" by responding that they strongly agreed or agree. In addition, over 70% of nurses agree or strongly agreed that ORNET.CA has improved their quality of life. The majority of nurses also believe that ORNET.CA has improved communication between nurses and physicians during on-call shifts. One of the main comments by nurses at the end of the survey also stated that ORNET.CA should be accessible to nursing units on the wards as well in order to reduce calls from ward nursing staff trying to get updates on the OR emergency list schedule.

Survey Data: Physicians

An email link to the survey was sent to all of the attending staff and residents in orthopaedic surgery, general surgery, and plastic surgery (58 attending staff and 75 residents). Sixty-eight of the people responded to the survey representing a 51% response rate. 20 of those had not completed the survey in its entirety and thus were excluded from our analysis. A total of 48 physicians from general surgery, plastic surgery or orthopedics completed all questions on the online multiple choice questionnaire. The majority (67%) of physicians responded that they use ORNET.CA

very often or often (more than 6 times/month) during their on-call shifts. The remainder of physicians responded that they sometimes (3-5 times/month) use the software. Given that physician have 3-4 calls on average per months, these results point to a routine use of the software when on-call.

When asked if ORNET.CA helped reduced the number of call made into the OR for updates, the majority (90%) of responders said the number of calls had reduced by more than 25%. The majority of physician responders (64%) also believed the software improves communication between nurses and doctors. In addition, more that 80% of responders said that they strongly agree that ORNET.CA has improved their time management during on-call shifts and allowed them to engage in wellness activities and complete their basic errands. Interestingly, more than half the physicians (55%) believe that ORNET.CA helps improve their quality of life while on-call.

Cost analysis

Emergency (non-elective) case data at the MGH

In order to estimate cost savings with the use of ORNET.CA, data from the MGH between 2009-2017 was analyzed. The number of cases by specialty done over each year and the number of hours in the OR on emergency non-elective basis was determined (Table 1). The data showed that an average of 1642 emergency cases where performed annually at the MGH. This corresponded to an average of 3954 hours of operating room time per year. To estimate turnover time, an average of 30 minutes between cases was used. Thus, it was estimated that an average of 821 hours was used for turnover annually. This represented 21% of the actually OR time used to perform surgery on those cases. In a similar fashion, if we assumed 15 minutes per case of phone interruptions related to communication between nurses and physician with respect to the OR scheduling and time management of physicians, then 410.5 hours could be attributed to communication on an annual basis; this represents

approximately 10% of the annual OR time used to actually perform surgeries during emergencies.

Software Data

The login information from the backend of the online software was reviewed. Number of logins per months, number of physician logins, and number of nurse logins were tabulated from January 2016 until May 2017 (Figure 1-3). On average there were 2450 logins per month for all users combined. Of these, an average of 1750 were physician logins per month. The orthopedic surgery department had the largest proportion of logins followed by general surgery and then plastic surgery; this correlated directly with number of cases completed by each speciality on-call. From this data, it was assumed that for each three logins to the software the physician had the necessary information required about scheduling to avoid the need to phone the OR nurse in-charge, thereby avoiding a workflow interruption and saving the nurse's time improving OR flow and efficiency. A factor of three logins per phone call was chosen since it was assumed that logging in to the software to get an update on the schedule is much simpler and quicker than having to phone the OR nurse; thus the phone calls were assumed to not happen as often as each login. The time saving per three logins, i.e. time interruption/delay for one phone call into the OR, was assumed to be 5 minutes. Therefore, this corresponds to an annual saving of 583 hours of phone calls annually which is similar to the estimate made above based on number of annual cases. Again, this represented more than a 10% time saving of OR time annually.

Estimate of Cost Savings

The average cost of health care providers in Quebec can be estimated to be $676.09 per hour in the operating room. This can be broken down to average surgeon cost of $336.59/hour, anesthesiologist cost of $254.66/hour, and nursing cost of $84.84/hour. This excludes case costs of equipment, cleaning products, drapes and instrument sterilization. With an average of 3954 hours of emergency OR at the MGH per year,

this totals an annual cost of over $2,600,000.00 of personnel cost per year. If ORNET saves 10% of this time by improving communication and therefore improving OR efficiency, this can represent an average cost saving of $267,325.99 annually in Quebec for a single busy Level 1 Trauma Center.

Discussion

In this paper we present the results found after launching a new real-time OR scheduling software at a Level 1 Trauma Center in Montreal, Canada. The purpose of this software was to improve communication between nurses and physician during emergency non-elective surgeries in the OR on weeknights and weekends. At this center in Canada, there is typically only one operating room available for emergencies on a given weekend or evening and another reserved for only life-threatening emergencies. This means that all patients with acute surgical needs have to be scheduled with case priority in mind with many surgical subspecialties requesting for time in the OR simultaneously. The software presented in this paper allows for automated prioritization of cases based on surgical priority classification and surgery booking time. The program also allows all surgeons and nurses access to the on-call OR schedule at their convenience and avoiding to repeatedly phone the OR head nurse for updates on the OR schedule and start time of a corresponding case. Therefore, the software is used as a communication tool and an organizational tool for the operating room which in turn improves efficiency and allows for better time management.

The importance of increasing efficiency and decreasing mistakes in the OR is clearly demonstrated in [13]. Kaye et al. [14] demonstrated that improving OR efficiency directly increased the number of cases being performed, improved patient care, and increased profitability for a tertiary academic establishment. We demonstrated that the scheduling software ORNET.CA helped improve OR efficiency by 10%. This can be extrapolated to allow for 10% more cases to be done annually or an average of 164 more cases annually at our center. This improvement can have major impact on

health care in a public system that is becoming more and more burdened by a growing number of patients to be served while trying to utilize limited resources.

The efficiency of the OR and minimizing workflow interruption have been linked to better patient outcomes in the literature [1-4,15,16]. Guedon et al. [17] states that the lack of reliable predictability of OR length for a given case or lack of method to adapt the OR schedule as the day progresses affects the overall OR efficiency. This becomes more important for emergency non-elective cases where many unpredictable events can occur. Therefore, a real time scheduling software accessible to the entire medical team allows for real-time adaptation to unexpected events but also improves communication between OR personnel throughout the day. This improved communication channel obviates the need for frequent phone calls to inquire about the continuously changing OR schedule and thus limits OR workflow interruptions. Limiting interruptions in turn has been demonstrated to limit medical errors and avoids situations that may compromise patient safety as shown in several studies [15,16].

Operating room efficiency has not only been linked to patient care but reduction in medical errors. With the OR being the most costly department in a hospital [14,17], improving its efficiency and decreasing errors becomes increasingly important. Guedon et al. [17] state that OR efficiency depends on many factors including availability of personnel, unpredictable emergency surgeries, and complexity of cases to name a few. The scheduling software presented in this paper allows personnel to be more prepared for cases by removing some of the unpredictability and interruptions related to an emergency OR and allowing all personnel to see the anticipated sequence of cases that will be performed. In addition, surgeons are better able to predict when they will be needed in the operating room, eliminating delays associated with personnel arrival and phone calls to surgeons. In the study by Nagy et al. [18], a software was used to estimate and identify sources of delay in the OR. They demonstrated that approximately 15% of delays can be associated to staff delays such as waiting for the surgeon to arrive for a case [18]. In addition, they show that

as much as 42% of delays to the OR are related to scheduling related issues. Although scheduling delays do not apply directly to emergency cases, the software presented in this paper has the potential to address close to half of the potential causes for delays in the OR. In another paper [19], the most frequent reason for OR interruption was people entering the OR, phone calls, and pagers. Antonaidis et al. [19] showed that an average of 9.82 interruptions occurred per hour in the OR. Thus, a software like ORNET.CA can be very valuable to the OR if it reduces phone calls and OR interruptions. Our results demonstrate that ORNET.CA does in fact reduce phone calls as shown by the OR nursing staff and physician survey responses; physicians indicate that they call less (by at least 25-50% or more), and nurses indicated that they receive less calls since the software was implemented.

Operating room interruptions not only decrease efficiency but also cause stress to the medical team. In a paper by Aurora et al. [16], OR interruptions were shown to be the most frequent cause of stress to OR personnel. Therefore, reducing the number of interruptions by a software such as ORNET.CA can also have positive effect on reducing stress for the OR staff. This is also depicted in our results which show that the majority of nurses and physicians using ORNET.CA seem to think that the implementation of the software program has had a positive impact on quality of life at work.

We present an estimate of personnel cost and the potential decrease in cost from an OR scheduling software for emergency non-elective cases. In our calculation we estimate an hourly OR rate of approximately $676.09 which includes surgeons, anesthesia, and nursing. This hourly cost varies depending on complexity of surgery being performed, number of surgeons required for the case (ex. A poly trauma, requiring orthopedics, plastics, vascular and general surgery) and so on, however, this hourly figure gives an estimate of costs associated with running an operating room. In addition, this estimate does not include additional costs such as disposables, drapes, instruments, and equipment being used. This figure is also on the lower end of estimates published in the literature. For example, in [13], the average OR cost was

estimated to be 62$/min with a range from 22$/min to 133$/min. This would equate to 3,720$/hour on average or 1,320$/hours at the lowest quoted end. Therefore, our estimate is likely an underestimate yet we are still able to demonstrate significant cost saving (approximately 10%) for the emergency OR directly linked to the use a real-time scheduling software such as ORNET.CA. These savings can then be used to improve quality of care in a Canadian public health care system where resources are limited.

This paper is limited to data acquired by one center for its pilot project. Although it is a tertiary academic center, it is not clear if the same effect would be seen in a smaller center where potentially fewer emergency cases are performed. In addition, the center was mainly paper based prior to the implementation of this software and can have different effects on medical personnel in a center where they have already implemented a paperless system. The estimates used in the cost analysis were averages and therefore can either underestimate or overestimate the actual cost savings of such a software.

We believe that a simple scheduling system can be very valuable in many operating rooms across the world and can help improve OR efficiency, decrease workflow interruption, and allow for a better work environment; this being especially true for a public system such as the Governmental Health Care system in Canada.

Conclusion

In this paper we present a new online scheduling software for the emergency operating room at a tertiary university center. We demonstrate that this software improves communication between hospital staff and physicians, reduces workflow interruption, and improves the quality of the working environment. We also demonstrate that the software improves OR efficiency, potentially reducing personnel cost by approximately 10% annually. We believe that such a real-time online scheduling software should be used to improve operating room workflow in many

centers where a similar software program has not been implemented. Future studies include implementation of the software at smaller centres or community hospitals to determine if similar results would be found.

Additional studies will examine if the implementation of such a scheduling software could have other benefits in addition to monetary. Our next study will be examining the effect of ORnet on improving resident time-management and going as far as looking at if quality of life while on-call is improved which in turn can potentially lead to lower burnout rates and lower surgical resident attrition rates.

Table1: Number of cases and hours of emergency surgery performed by subspecialty per year at the MGH

DEPARTMENT	2009-2010		2010-2011		2011-2012		2012-2013		2013-2014		2014-15		2015-16		2016-2017	
	#	Hrs	#	Hrs	#	Hrs	#	Hrs	#	Hrs	#	Hrs	#	Hrs	#	Hrs
ANESTHESIOLOGY	9	11.2	5	5.2	10	9.8	7	8.3	6	5.5	5	5.9	5	5.1	5	4.1
CARDIOLOGY	5	13.2	0	0	0	0	1	0.6	0	0.0	0	0	2	9.4	0	0
CARDIAC	0	0	0	0	0	0	2	3.5	2	4.4	1	4.3	1	1.7	0	0
OTL	17	41.7	10	21.4	18	40.9	23	49.6	22	49.3	8	10.4	3	4.77	2	3.6
GENERAL SURGERY	464	1119	497	1160	572	1271	564	1334	686	1601	581	1315	615	1430	568	1233
GASTROENTEROLOGY	1	0.9	2	2.1	0	0	0	0	2	1.2	0	0	0	0	2	2.7
MEDICINE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NEUROSURGERY	150	445.7	172	487.5	180	530.9	177	546	172	496.1	165	405.4	179	534.4	184	576.1
GYNECOLOGY	0	0	2	3.1	1	1.6	0	0	0	17.6	0	0	0	0	0	0
OPHTHALMOLOGY	10	24.9	7	19.8	10	19.9	15	22.7	8	17.5	28	47.3	87	146.7	86	134.5
MAXILLO FACIAL	80	197.8	72	204.3	77	182.9	74	201.4	76	178.9	68	143.9	63	147.1	58	123.3
ORTHOPAEDICS	520	1350	500	1247	506	1160.6	565	1402.3	504	1299.7	610	1513	594	1517.7	448	1211
PLASTIC	139	310.8	116	239.8	136	243.7	124	236.3	163	356.3	86	164.7	96	261.2	106	214.7
RADIOLOGY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
THORACIC	112	268.7	94	236.2	106	240.5	99	212.8	84	195.6	70	139.3	98	245.0	126	311.4
UROLOGY	20	27.2	14	29.2	14	21.7	19	26.3	26	38.3	23	30.1	6	10.0	4	4.1
VASCULAR	15	47.8	10	26.9	1	1.5	9	25.1	13	27.4	11	20.7	9	29.5	8	30.6
NEPHROLOGY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RESPIROLOGY	0	0	0	0	0	0	0	0	1	1.1	0	0	3	7.22	2	3.82
TOTAL	**1542**	**3859**	**1501**	**3682.9**	**1631**	**3724.9**	**1679**	**4069.3**	**1765**	**4290.5**	**1656**	**3800.6**	**1761**	**4350.3**	**1599**	**3853.7**

Figure 1. Total number of logins per month at the MGH from January 2016 and May 2017

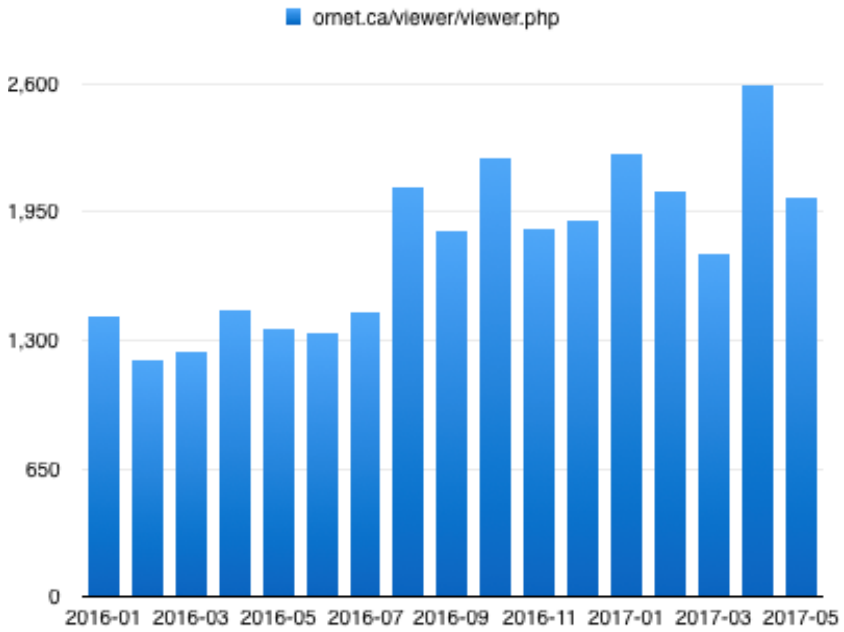


Figure 2. Number of logins by Orthopedic Surgery at the MGH between January 2016 and May 2017

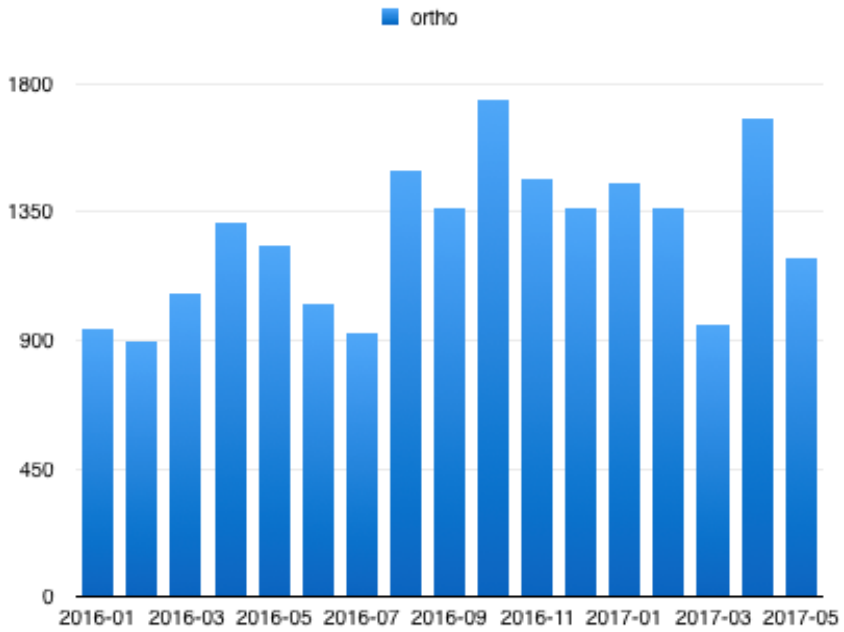


Figure 3. Number of logins by General Surgery at the MGH between January 2016 and May 2017

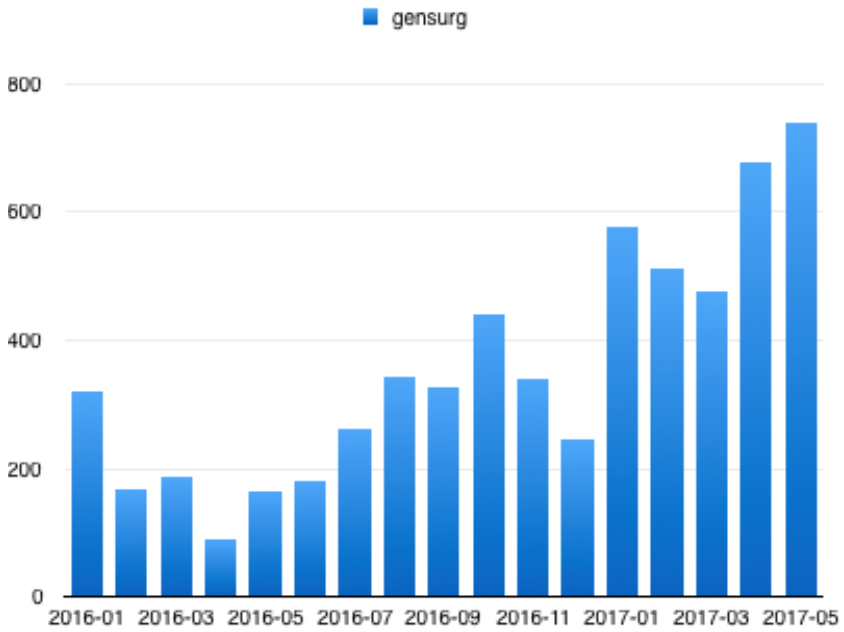
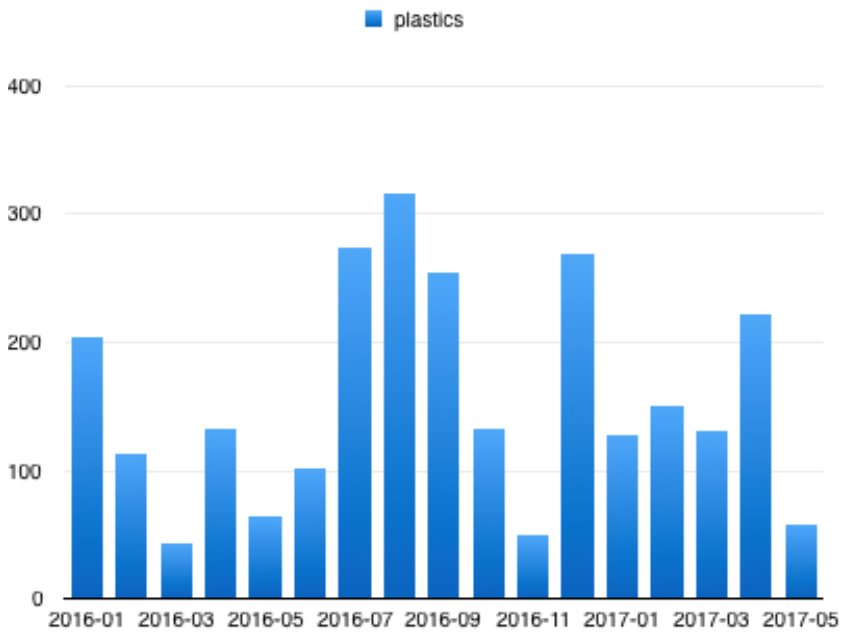


Figure 4. Number of logins by Plastic Surgery at the MGH between January 2016 and May 2017



Can an Emergency Surgery Scheduling Software Improve Residents' Time Management and Quality of life?

J. Lee, A. Aoude, L. Lessard

Introduction

The regular day to day activities for residents in surgical specialities is very demanding. This is seen in studies examining all operating room staff and shows that residents have more work burden, longer work hours, more physical work and high levels of stress [6-10]. In one study, the majority of surgical residents noted that they have work-related stress that is moderate to severe [9]. These residents also reported to be drowsy during the day time and that the stress affected their overall well-being [9].

The higher stress situation that surgical residents go through partly explains higher burnout rates among surgical residents [7]. Multiple studies have looked at the reasons for this, and in one study, future lifestyle, sleep deprivation, and work hours were the main reasons residents decided to quit residency [8]. The higher attrition rates in surgical residents also affects work quality, personal and family problems and in turn affects patient care [9]. Solutions to attempt to decrease attrition rates in surgical programs have included allowing for post call days, decreasing maximum number of work hours, and providing many support methods for residents throughout their residency. However, some studies report negative outcomes even after the implementation of these methods [11, 12]. In addition, little or no literature exists on methods to improve time management for residents, particularly during on-call duties.

Being a surgical resident in Canada differs from the United States because of less operating room (OR) resources in a Governmental Health Care system. In Canada, emergency non-elective cases are more likely take place during evening and weekends since operating room resources are limited; non-elective surgery is typically

limited to one operating room in Canada and performed only once elective cases during the day have all been completed. Therefore, all surgical specialities are struggling to get their emergency non-elective cases done while only one OR room is running. Rarely would two services be operating at the same time in two different rooms unless a life or death situation exists. Hence, cases being done later in the evening or night become more common.

In this paper, we present a novel software implemented and used in a level one trauma center intended to improve communication and allow resident to better predict the emergency room operating room schedule and in turn help improve time management and quality of life.

Methods

A new online scheduling software ORNET.CA (Montreal, Canada) was created and installed in a level one trauma center (Montreal General Hospital (MGH)) in Montreal, Canada. All nursing staff were then trained for its use. Physicians were also sent an email with instructions on its use. The software was launched in October 2015. The software depicts the operating room (OR) schedule on weeknights or evenings (emergency non-elective OR time). The OR nursing staff would input the list of emergency non-elective cases for the day in a real-time based on priority classification levels established by the health care center using it. On-call physicians would then log in to the web based real-time scheduling software and view when their case would start and if the start time has been advanced or delayed due to other emergency cases being completed or booked. In a situation where an OR is delayed due to emergency the physicians on-call would be notified immediately via e-mail/text message notification or via the web-based scheduling software directly. Information about scheduled cases, start times, and equipment needed was visible to the health care professionals in real time.

A short survey was sent to all users to determine quality of life measures and effects of the software on its users. This survey consisted of 20-items and was designed in English (Appendix D) for surgical physicians working at the MGH. The survey inquired about the usability of the software, and its effects on time management and quality of life. A request to participate in this online survey was sent to all the surgical residents and attending surgery staff at the MGH electronically, including a link to anonymously complete the questionnaire. Descriptive statistics using Microsoft Excel 2019 were used to analyze the survey results. Responses were analyzed and grouped based on answer likelihood.

No patient information was present on the scheduling software to ensure patient confidentiality. Only procedure, expected surgical time, and surgical department was shown on the scheduling software. This allowed for communication of start times, surgical equipment requirements for each case, and allowed for real-time case flow management without compromising patient privacy.

Results

A total of 68 respondents answered the survey, representing a 51% response rate. However, 20 responses were not completed and were excluded from our analysis. A total of 30 surgical residents and 18 surgical staff fully completed the survey and their results analyzed. Although the majority of residents used ORNET.CA, 50% of attending staff that completed the survey never used ORNET.CA. Of those attending that did use the software 11 % used it rarely (1-2 times per month) while the remaining 39% used it often (6-10 times per month) or very often (>10 times per month). In contrast, 93% of residents used the software regularly to determine when a case was scheduled to start. In addition, 83% of residents believed ORNET.CA helped improve communication and reduced the number of phone calls to the OR by at least 25-50% in comparison to prior to the software being implemented. Half the Attending physicians also responded similarly.

Time management

When asked if ORNET.CA helped improve time management, 80% of residents (Figure 1.) and 44% of attending physicians agreed or strongly agreed. In addition, 68% of residents (Figure 2.) and 39% of attending physicians agreed that ORNET.CA helped plan their evenings and weekends while on-call to engage in wellness activities, complete errands, and plan their study time more efficiently.

Quality of Life

When asked if ORNET.CA helps reduce anxiety and stress while on-call, 47% of residents agreed or strongly agreed (Figure 3.), whereas only 22% of attending staff agreed or strongly agreed. In addition, 60% of residents (Figure 4.) and 50% of attending staff believed that ORNET.CA improved their quality of life.

Communication and Usefulness

The majority of residents (67%) and 39% of attending physicians believed that the software improves communication between nurses and physicians in the OR. Additionally, 56% of attending physicians and 73% of residents believed that ORNET.CA is useful and should be continued to be used for emergency OR scheduling. Although recently adopted and launched as a pilot project at the MGH, the majority of users find ORNET.CA useful, improving communication and quality of life for those using it.

Discussion

This paper presents a new real-time scheduling software with visual depiction of cases on the emergency list used in a Level 1 Trauma Center in Canada and investigates its ability in improving communication between operating room staff and its ability to improve physician and resident quality of life. This simple solution allowed for

physicians and residents to better predict their on-call duties and in turn help them to have rest when possible or engage in wellness activities. This was shown in our results from an on-line survey sent to physicians and residents 1 year after its launch.

Surgical resident well-being and attrition rates have become an important topic for discussion over the past few years [6-12,20]. With high surgical resident attrition rates in the United States and Canada, research has focused on reasons for the high drop-off rates. The literature consistently showed that long working hours [8], future career lifestyle [8, 20] and sleep deprivation [8] to be common reasons for residents to not complete their residency training. With attrition rates as high as 17% [20], work load and environment have been questioned. Some studies also demonstrate that females are more likely to drop-out compared to their male colleagues [8]; females found to be even twice as likely to drop out in certain studies [20]. Therefore, resident well-being has become important for all surgical programs. In this paper, we present data that shows that a simple scheduling software allowed residents to better plan their time while on-call which contributed to improved quality of life. Our results also found that the software program was able to decrease stress levels and anxiety which have been linked to resident burn out [9].

Solutions to improve surgical residents' attrition has been investigated in the United states [11,12]. Some studies have shown that strategies such as work hour restriction and post-call days have decreased residents time in the hospital but has consequently negatively affected patient care and resident education [12]. Many studies demonstrate that resident stress is high [10] and is related to work hours [8] but limited studies have investigated the effect of stress related to unpredictable work hours and inability to schedule activities while on-call. Here we present a novel method for physicians, residents and other hospital personnel to better predict their on-call shifts. This new software allows for residents to verify in real-time when their case will be expected to start, and verify as frequently as they would like to in the matter of seconds rather than spending minutes to call the OR charge nurse. Therefore, they are able to better predict if they have time to have dinner, get some

sleep, plan a basic life task such a grocery shopping, or scheduling study time. We believe that taking away some of the unpredictability helps reduce their stress and improve quality of life as shown in the survey results.

Although the software used here was implemented for use by all OR personnel, the survey demonstrates that its effect in decreasing anxiety/stress levels, and improving quality of life was more impactful for residents compared to attending staff. This is consistent with the literature that shows the likelihood of burnout due to stress is higher in residents than other OR personnel, including nurses [6]. This can be related to the fact that other operating room staff have fixed shift schedules while residents have more variability in their work hours and highly unpredictable on-call shifts. In addition, in most circumstances, residents are more frequently on-call than attending physicians. Hence, the use of the software presented here allows for better predictability and allows for stress reduction amongst residents as shown in the survey results.

One limitation of this study is that the results are from the experience in one center in Canada. Other centers can have different perspective of the use of the software especially in the United States were more resources are available and emergency non-elective OR time is not scarce. In addition, the survey results are for a small number of surgical residents at the MGH which can differ from other centers. Future studies will look at the use of the software in more centers, including community centers, and determine if differences exist.

Conclusion

Here we present data from a survey after the use of a novel emergency operating room schedule implemented in a level trauma center in Canada. The results show that a simple visual scheduling software allows surgical residents and attending physicians to better predict their on-call shifts. The results also show that a simple scheduling software accessible to all allows for improvement in quality of life and a decrease in

stress and anxiety levels amongst residents. This in turn could potentially equate to a reduction in attrition rates among surgical residents.

Figure 5. Resident Survey Results- ORnet is useful to help manage your time during your on-call shifts

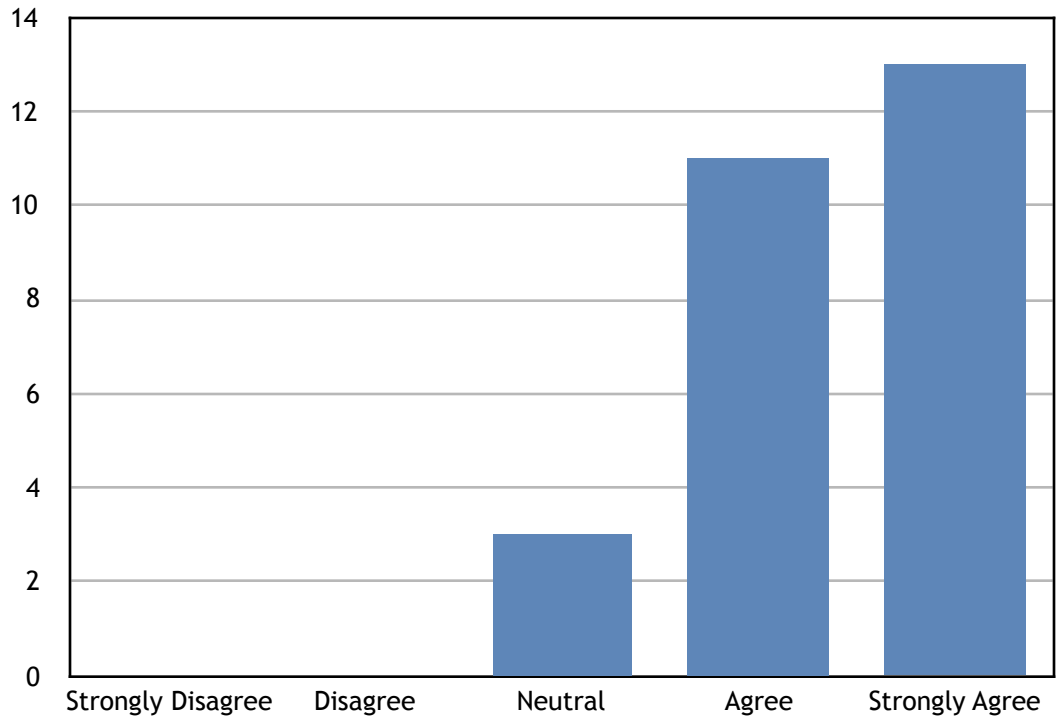


Figure 6. Resident Survey Results- ORnet has helped plan your evenings/weekend on-call to engage in wellness activities or errands

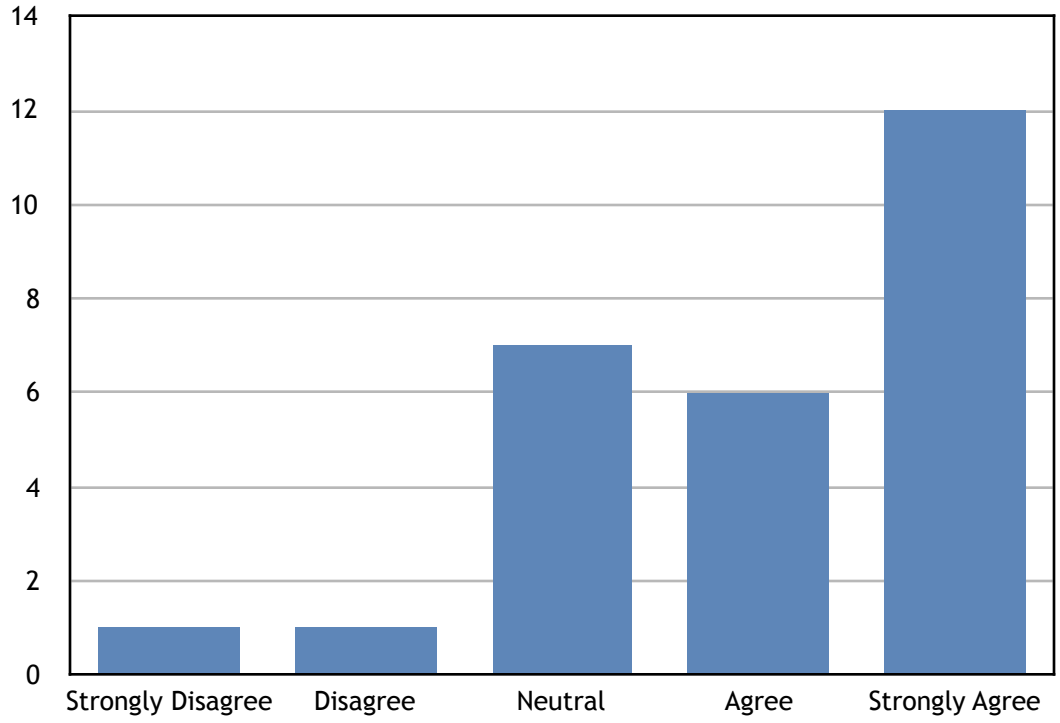


Figure 7. Resident Survey Results- ORnet has helped reduced stress/anxiety during on-call shifts

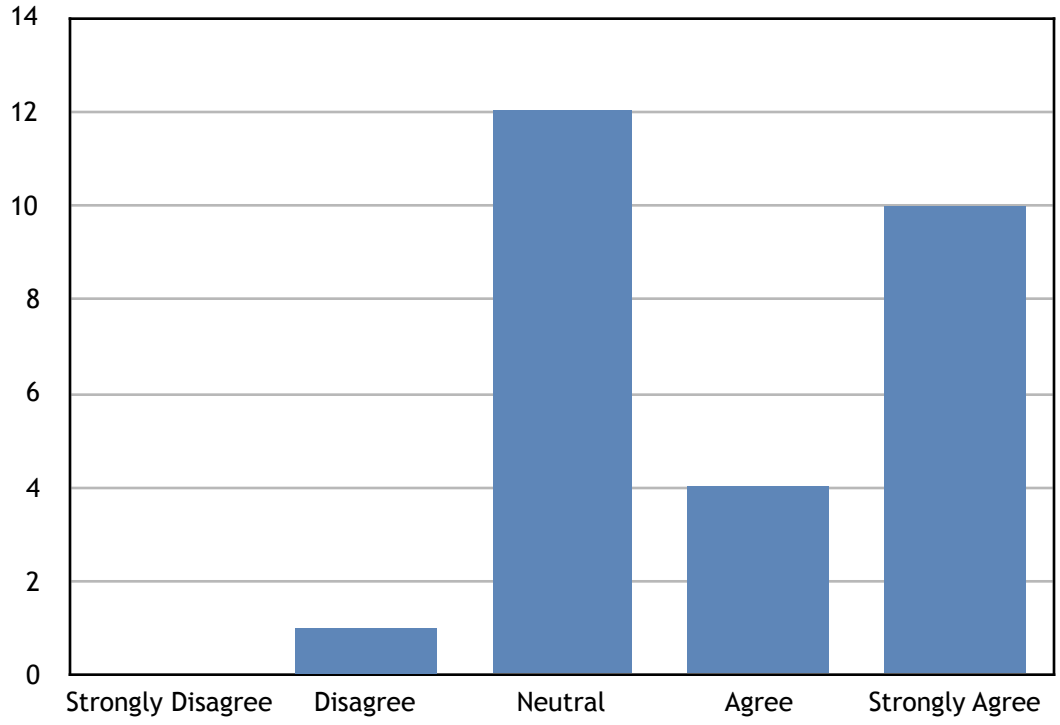
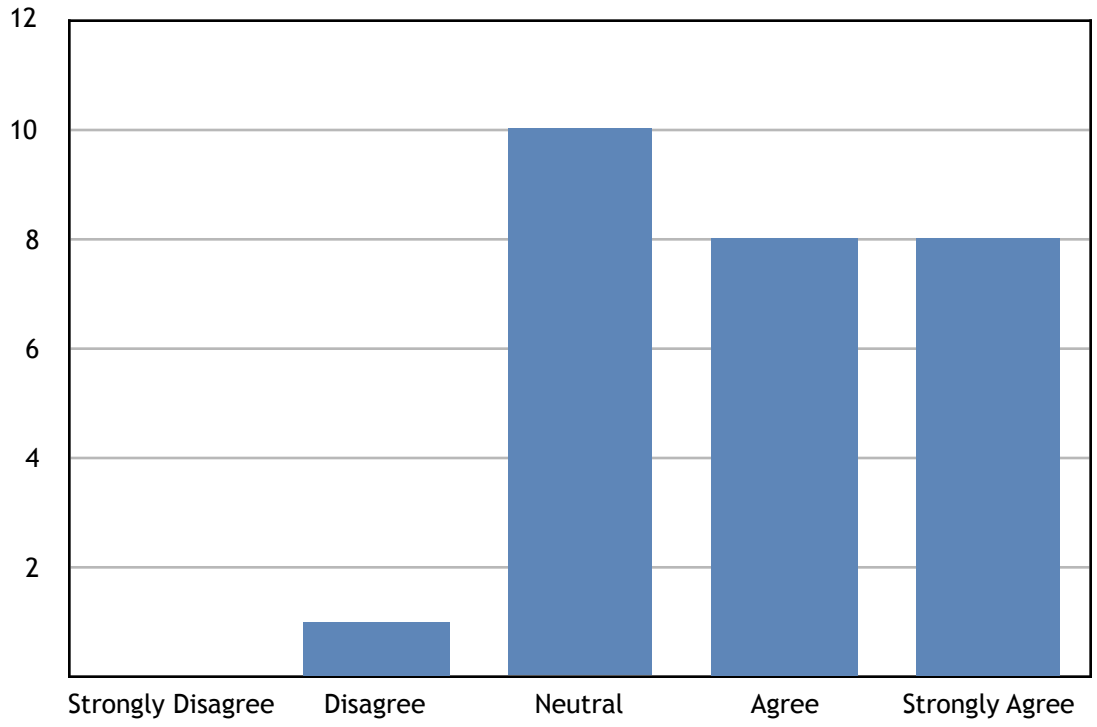


Figure 8. Resident Survey Results- ORnet has helped improve quality of life



CONCLUSION

In this thesis we present a new online scheduling software for the emergency operating room at a tertiary academic centre. We demonstrate that this software improves communication between hospital staff and physicians, reduces workflow interruption, and improves the quality of the working environment. We also demonstrate that the software improves OR efficiency, potentially reducing personnel cost by approximately 10% annually. We believe that such a real-time online scheduling software should be used to improve operating room workflow in many centres where a similar software program has not be implemented.

We also present data from a survey after the use of a novel emergency operating room schedule implemented in a level trauma centre in Canada. The results show that a simple visual scheduling software allows surgical residents and attending physicians to better predict their on-call shifts. The results also show that a simple scheduling software accessible to all allows for improvement in quality of life and a decrease in stress and anxiety levels amongst residents. This in turn could potentially equate to a reduction in attrition rates among surgical residents.

Data acquired form this software is presented in the articles included in the thesis and show clear benefit on a personal and financial basis for Canadian health care centres. The software is simple does not compromise patient information or privacy and allow all health workers real-time feedback on emergency OR schedules. This in turn allowed for better time management for on-call staff and decreased OR interruptions which improved the overall OR efficiency. This software is still in use at the MGH and possible expansion to other Canadian health care centres is currently being pursued.

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Appendix A- ORnet User Guide for Administrators

User Guide for ornet.ca©

Administrator instructions

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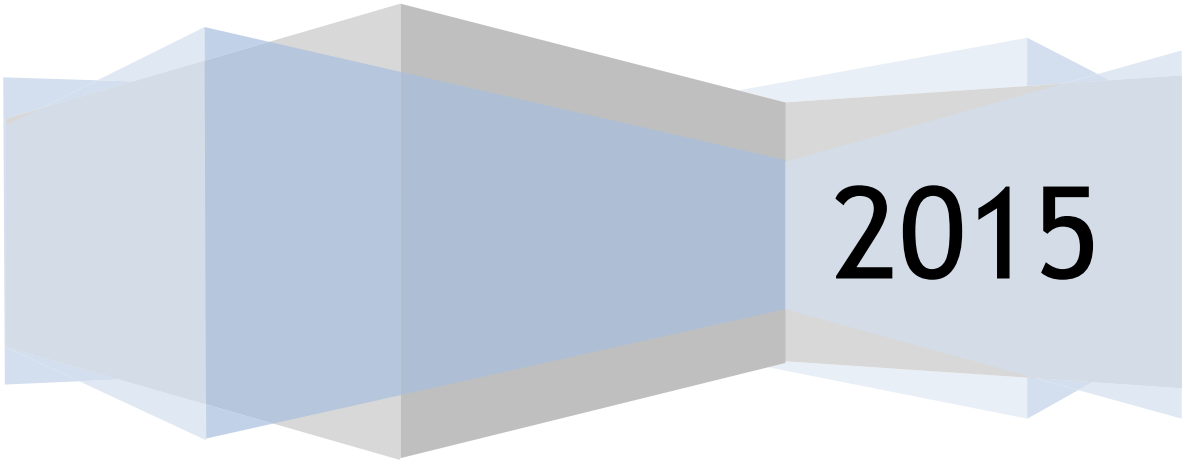


User Guide for Administrators of ornet.ca

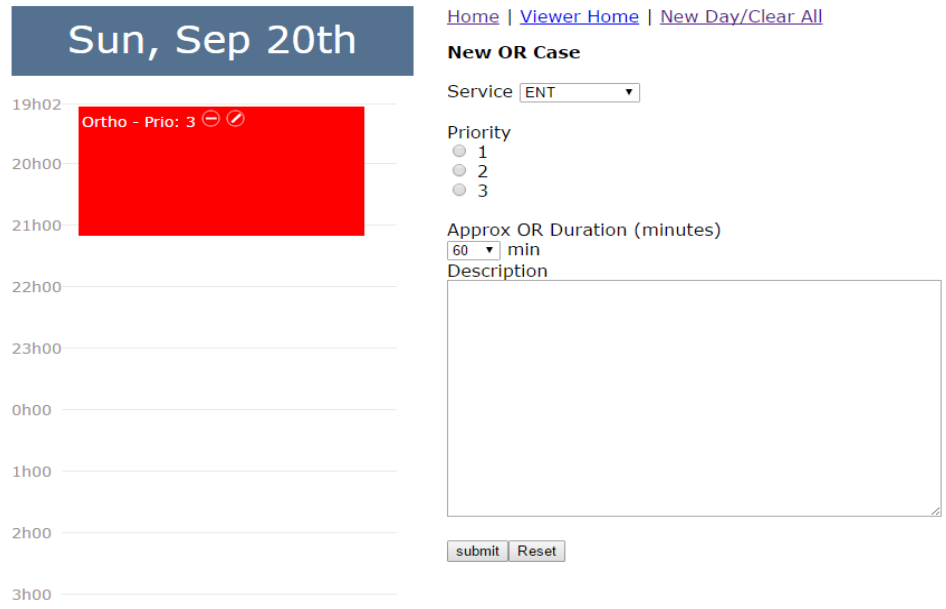
This document provides a step by step guide on how to use the emergency OR list on ornet.ca

Step 1: Go to www.ornet.ca **on any web browser**

Step 2: A login page will open; select <admin> as shown below

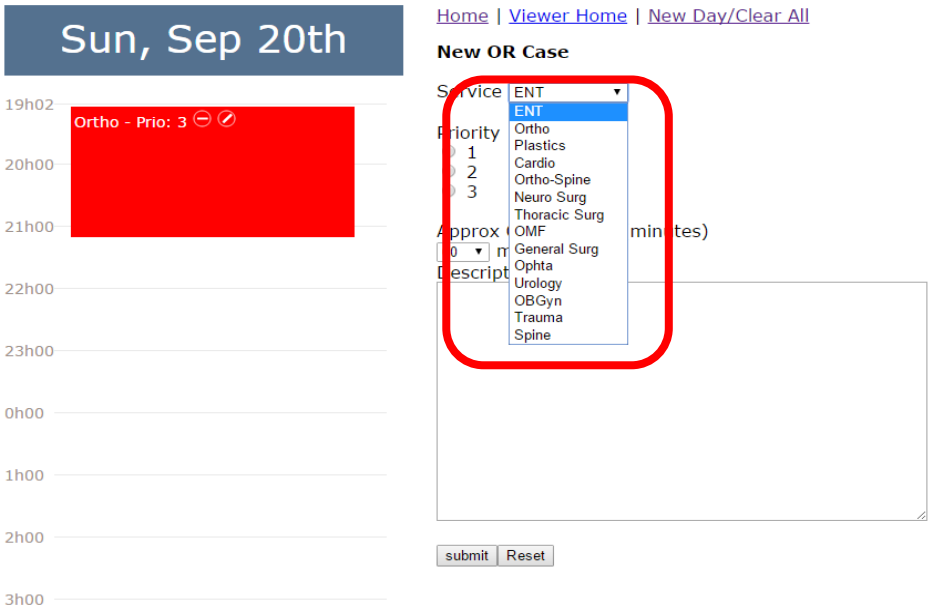
Step 3: Login using ***username*** and ***password*** provided during your training

Once logged in you will arrive at the main page; below is an example on how to add a priority 3 orthopedic surgery case and how to start the case (red indicates that a case has started).

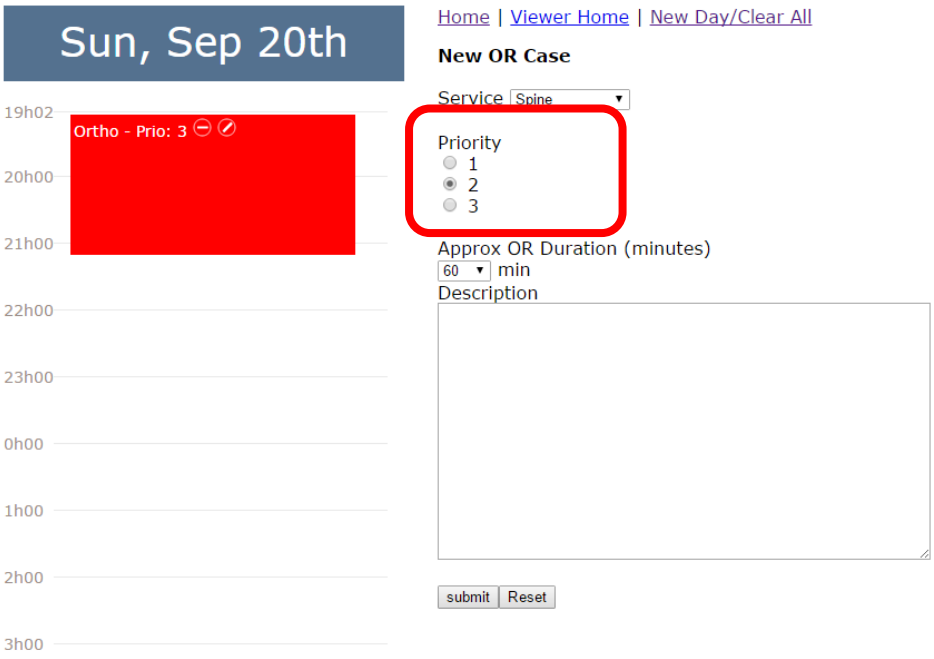


To add a case:

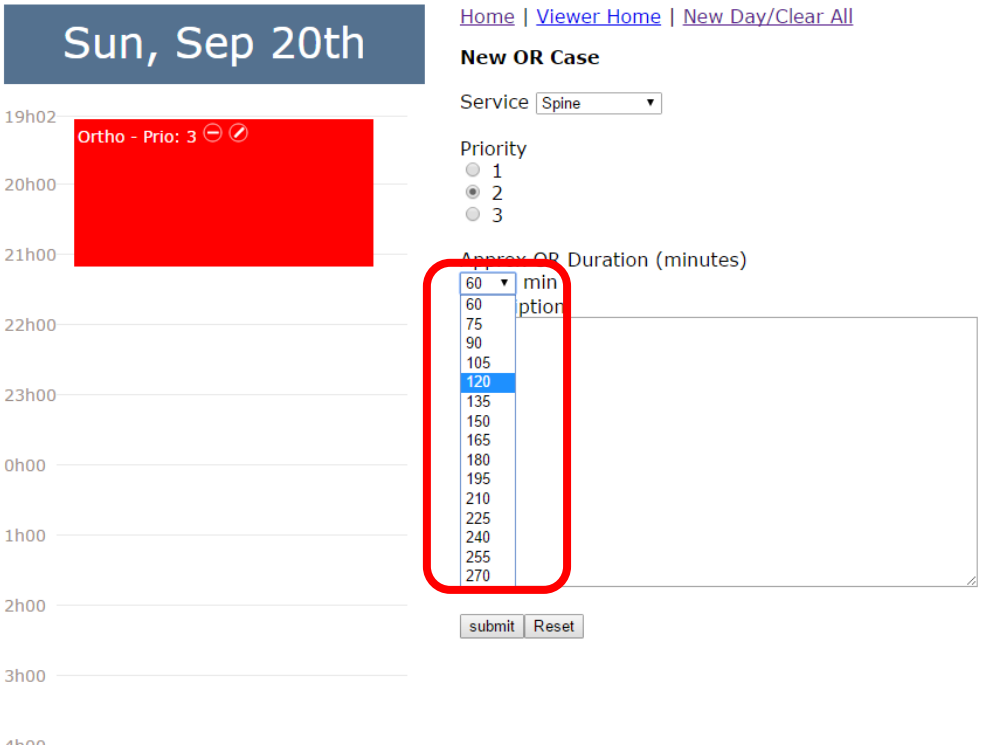
Step 1: Select the appropriate surgical speciality from the service drop down menu as shown in the image below



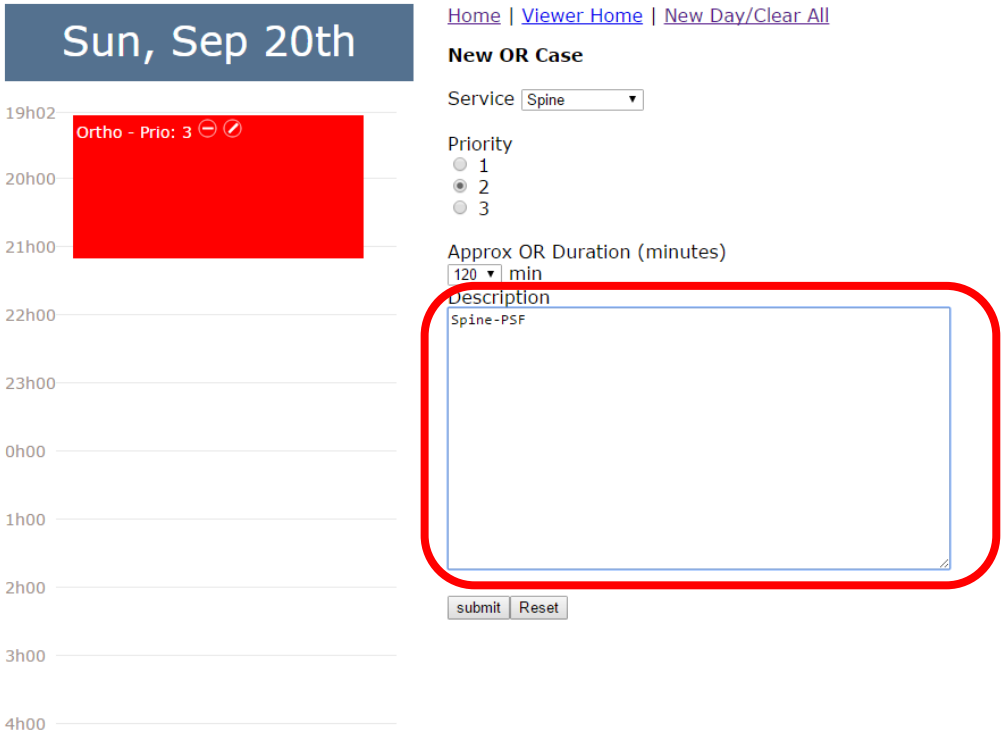
Step 2: Select the priority level by selecting the appropriate number. The example below shows that a priority 2 is selected (note: if priority is left unselected, the priority will be labelled priority 0)



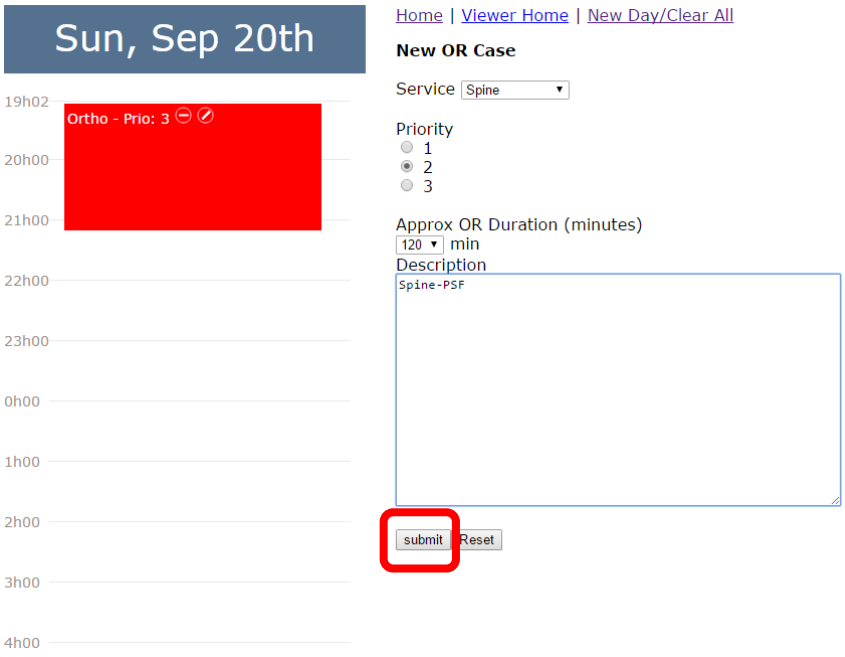
Step 3: Select the estimated length of surgery form drop down menu in minutes; the example below shows a 120 minutes case



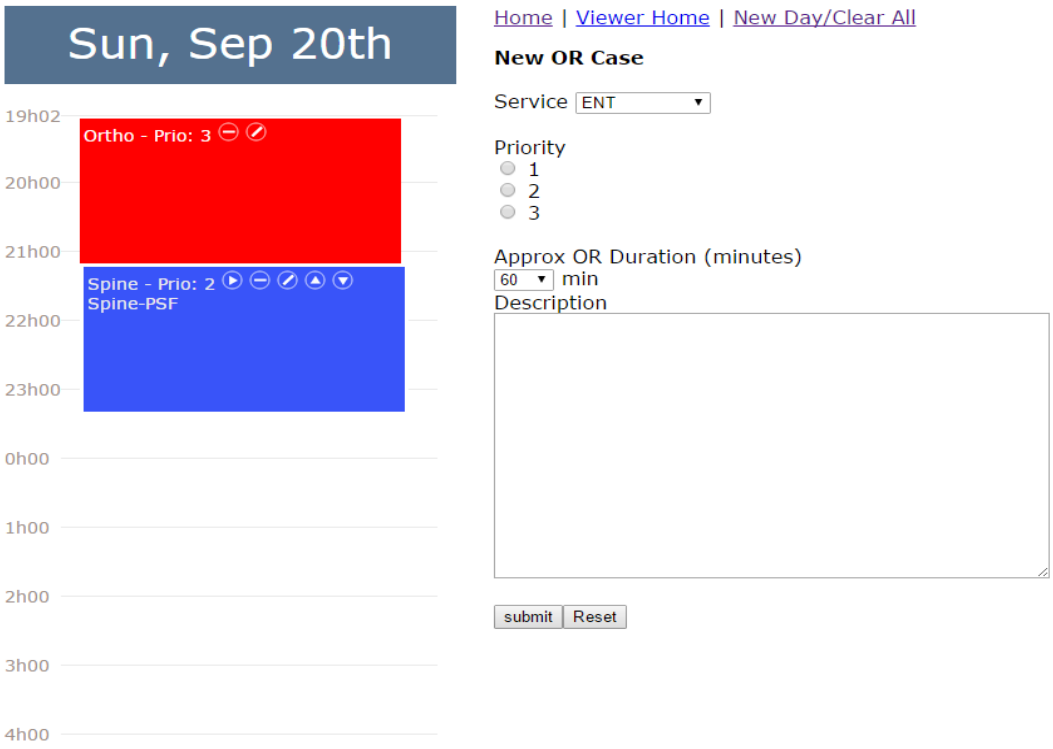
Step 4: A brief description of the procedure can be added to the text box when booking the case. The example show a spine case with the comment “Spine-PSF” added. This will be visible to all users; please do not add any patient identifying information.



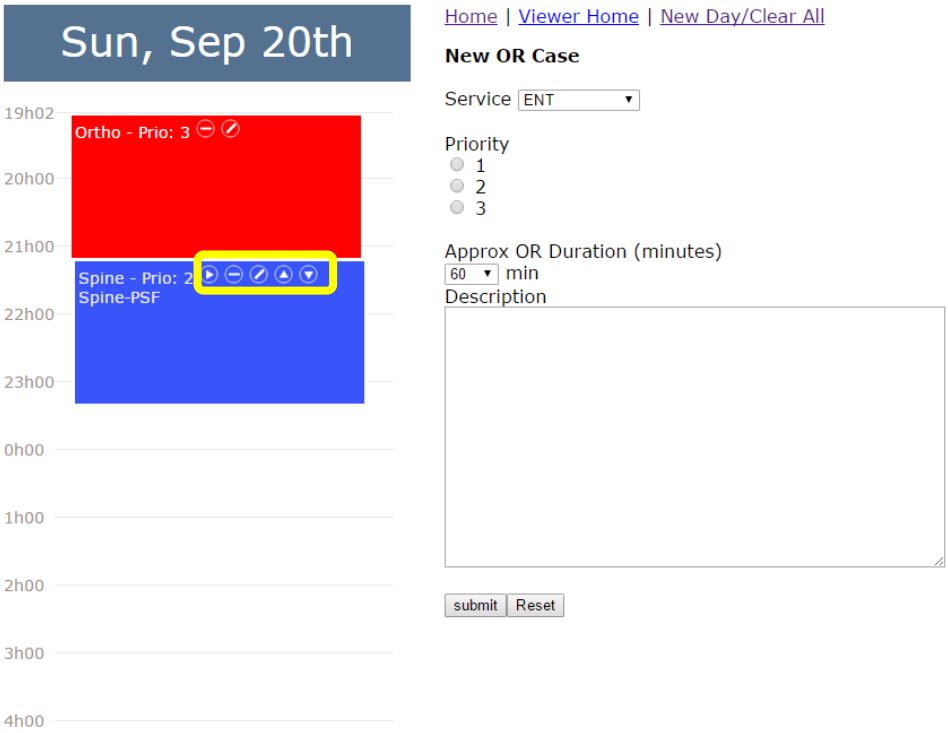
Step 5: Once completed, press the submit button to add case to list. To clear all fields press the <Reset> button.



Once submitted, the case will be added to the OR list as shown(note: blue indicated that the case has not started):



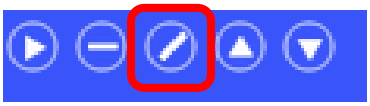
To **start, remove, edit or move a case** that has not yet started (blue), use the icons shown in the figure below in the yellow square:



Click the <play> button to **start** a case (note: the case will change to red indicating that the case has started)

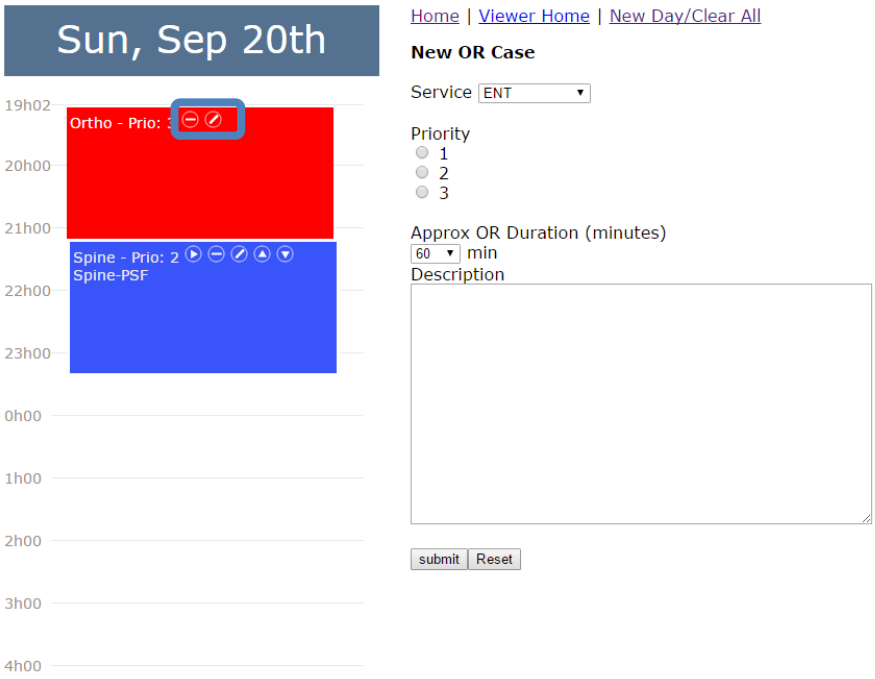
Click <minus> button to **delete** a case

To **edit** a case press the <backslash> button. Edit the information on the right hand side of the screen; once complete, press the <submit> button



To **move** a case up or down use the <up> or <down> arrow respectively (this will the corresponding case up on the list by one position)

To **end or edit** a case that is in progress (red) click the icons shown in the figure below in the blue outline square



To **delete** a started case press the <minus> button; the case will be removed from the list

To **edit** a started case press the <backslash> button; Edit the information on the right hand side of the screen; once completed, press the <submit> button

To **clear** the entire page, press the <**New Day/Clear All**> link on the top of the page; the whole list will be deleted

Appendix B- ORnet User Guide for Physicians/Residents

www.ornet.ca

User Guide ornet.ca ©

For Physicians

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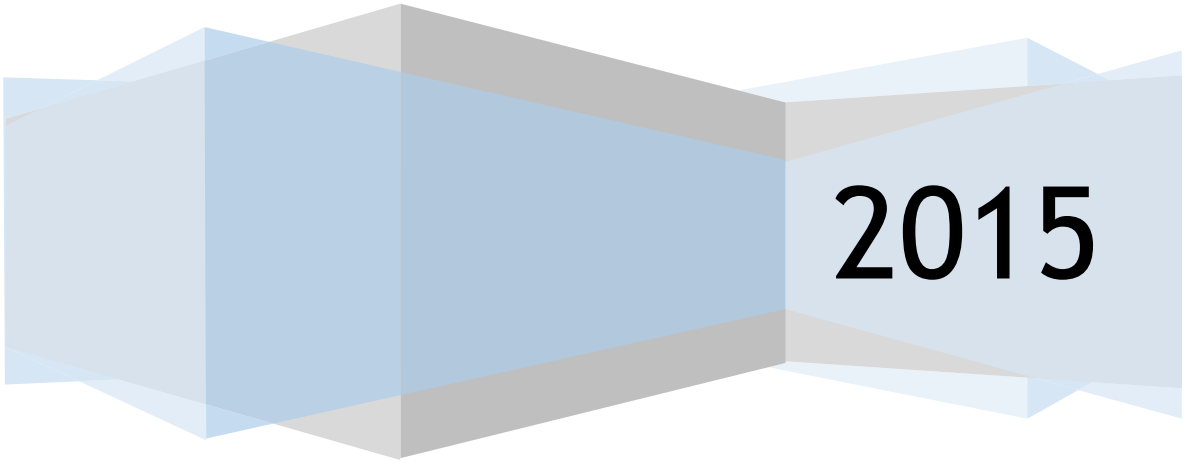


User Guide for Physicians/Residents of ornet.ca

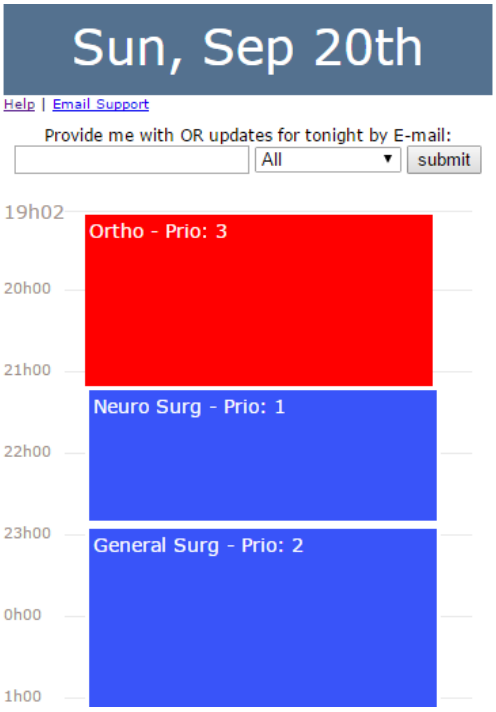
This user guide shows users how to use the ornet.ca website to check and get updates regarding the emergency OR list.

Step 1: Go to www.ornet.ca **on any web browser**

Step 2: A login page will open; select <User Login> as shown below

Step 3: Login using ***username*** and ***password*** provided by your program or speciality

Next you will be brought to the virtual emergency OR list where you can check status of list and all cases book for the night you are on call. An Example is shown below. Red cases indicate a case that has been started, blue are cases pending. The speciality, length and priority are displayed.



In order to get real time updates via email of changes to the list you have the option to input your email and speciality. The website will update you on any changes on the site and the emergency OR list if a case of your speciality is on the board. Note that all emails will have to be inputted on a daily basis in order to avoid overflow of email especially when you are not on call. That is, all email will be erased from the website at 7:30 am each day. The image below shows an example of a user inputting their email for plastics (their speciality). Once submit is press the email will be registered.

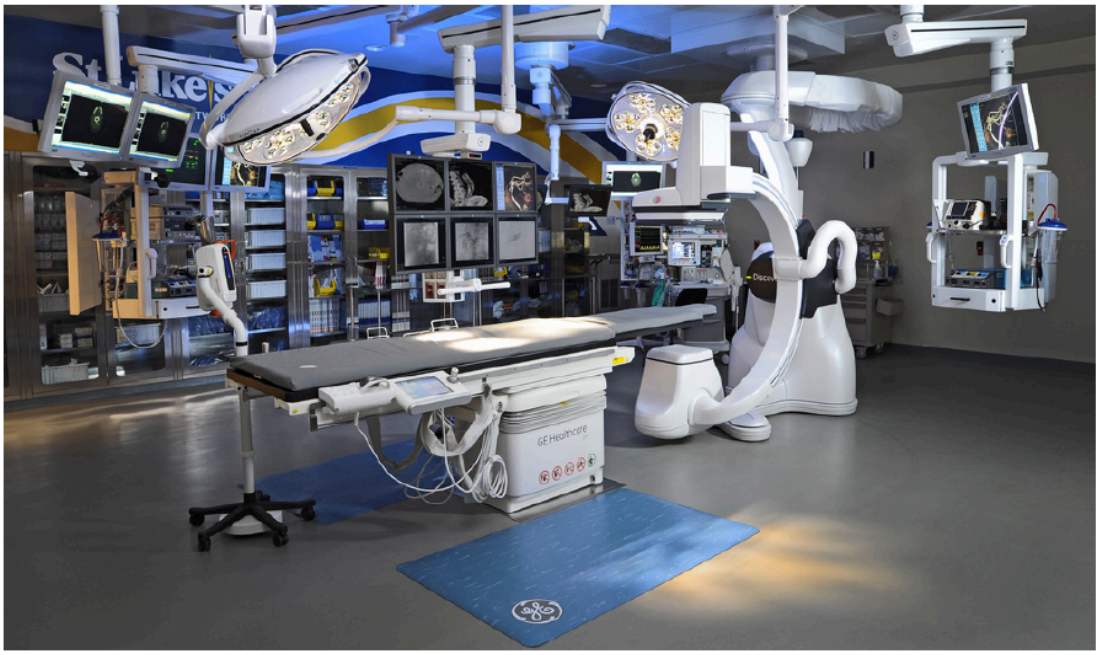
Note that a button to unsubscribe to email will also be present to remove your email if you no longer want to receive email updates.

You can access this from any browser on a computer or smart phone.

Appendix C. Survey for OR Nurses

ORNET Survey for NURSES

Thank you for taking the time to complete the survey!



I am at times the charge nurse during evening/weekends responsible for answering the phone?

- ○ YES
- ○ NO

How often do you work evening/weekend shifts?

- ○ - Never
- ○ - Rarely: 1-2 times per month
- ○ - Sometimes: 3-5 times per month
- ○ - Often: 6-10 times per month
- ○ - Very often: >10 times per month

How often do you access ORnet.ca?

- ○ - Never
- ○ - Rarely: 1-2 times per month
- ○ - Sometimes: 3-5 times per month
- ○ - Often: 6-10 times per month
- ○ - Very often: >10 times per month

ORnet has reduced the number of incoming phone calls during evening/weekend shifts.

- ○ by less than 25%
- ○ by 25-50%
- ○ by 50-75%
- ○ more than 75%

ORnet has improved nursing work flow during evenings/weekends by eliminating incoming calls?

- ○ YES
- ○ NO

ORnet has facilitated communication between nurses and residents/physicians?

- ○ YES
- ○ NO

ORnet has improved Operating Room efficiency and workflow during evening and weekend shifts?

- ○ YES
- ○ NO

ORnet is useful to help plan or prepare for your evening and weekend shifts?

- ○ - 1) Strongly Disagree
- ○ - 2) Disagree
- ○ - 3) Neutral
- ○ - 4) Agree
- ○ - 5) Strongly Agree

ORnet has helped improvement my stress/anxiety before and during my evening and weekend shifts?

- 1) Strongly Disagree
- 2) Disagree
- 3) Neutral
- 4) Agree
- 5) Strongly Agree

ORnet has helped improve your quality of life?

- 1) Strongly Disagree
- 2) Disagree
- 3) Neutral
- 4) Agree
- 5) Strongly Agree

ORnet is easy to use?

- 1) Strongly Disagree
- 2) Disagree
- 3) Neutral
- 4) Agree
- 5) Strongly Agree

I would be disapointed if the ORnet service was cancelled.

- 1) Strongly Disagree
- 2) Disagree
- 3) Neutral
- 4) Agree
- 5) Strongly Agree

Would it be helpful to book cases directly via ORnet (eliminatng the paper system)?

- 1) Strongly Disagree
- 2) Disagree
- 3) Neutral
- 4) Agree
- 5) Strongly Agree

Sugestions & Comments:

Your answer

SUBMIT

Appendix D. Survey for Physicians/Residents

ORNET Survey for RESIDENTS/PHYSICIANS

Thank you for taking the time to complete the survey!

Please select the surgical service you are affiliated with

- ○ - Orthopaedic Surgery
- ○ - Plastic Surgery
- ○ - General Surgery/Trauma
- ○ - ENT
- ○ - OMF
- ○ - Ophthalmology
- ○ - Neurosurgery
- ○ - Vascular Surgery
- ○ - Thoracic Surgery

Please indicate your level of training

- ○ - Junior Resident
- ○ - Senior Resident
- ○ - Fellow
- ○ - Attending Staff

How often do you access ORnet.ca?

- ○ - Never
- ○ - Rarely: 1-2 times per month
- ○ - Sometimes: 3-5 times per month
- ○ - Often: 6-10 times per month
- ○ - Very often: >10 times per month

Has ORnet.ca reduced the number of calls you have to make to the OR nurses during your on-call shifts?

- ○ by less than 25%
- ○ by 25-50%
- ○ by 50-75%
- ○ by more than 75%

Does ORnet provide you with adequate information about cases on your on-call shifts?

- ○ YES
- ○ NO

ORnet is useful to help manage your time during your on-call shifts?

- 1) Strongly Disagree
- 2) Disagree
- 3) Neutral
- 4) Agree
- 5) Strongly Agree

ORnet has helped plan your evenings/weekend on-call to engage in wellness activities or errands?

- 1) Strongly Disagree
- 2) Disagree
- 3) Neutral
- 4) Agree
- 5) Strongly Agree

ORnet has helped reduced stress/anxiety during on-call shifts?

- 1) Strongly Disagree
- 2) Disagree
- 3) Neutral
- 4) Agree
- 5) Strongly Agree

ORnet has helped improve your quality of life?

- 1) Strongly Disagree
- 2) Disagree
- 3) Neutral
- 4) Agree
- 5) Strongly Agree

ORnet is easy to use

- 1) Strongly Disagree
- 2) Disagree
- 3) Neutral
- 4) Agree
- 5) Strongly Agree

I would be disapointed if the ORnet service was cancelled.

- 1) Strongly Disagree
- 2) Disagree
- 3) Neutral
- 4) Agree
- 5) Strongly Agree

Would it be helpful to book cases directly via ORnet (eliminatng the paper system)?

- 1) Strongly Disagree
- 2) Disagree
- 3) Neutral
- 4) Agree
- 5) Strongly Agree

Sugestions & Comments:

Your answer

SUBMIT

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