A Comparison Study—Oral Patient-Controlled Analgesia Versus Traditional Delivery of Pain Medication Following Orthopaedic Procedures

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BACKGROUND: Orthopedic surgical patients have reported significantly lower numeric pain scores using a Wi-Fi oral patient-controlled analgesia (PCA) device compared to patients receiving oral as-needed (PRN) medication by manual administration. More than 90% of nurses using the oral PCA device have agreed that the device saved them time. The manual administration of PRN pain medication is frequently delayed and consumes a significant amount of nursing time. Delays in PRN pain medication delivery have been classed as missed nursing care, called an error of omission.
PURPOSE: The purpose of this timing study was to examine if the use of the oral PCA device would reduce the nursing time to accomplish the delivery of PRN oral pain medication compared to the manual administration by nursing staff.
METHODS: Each total task for the manual and device administration of a single PRN delivery of an oral pain medication was divided into subtasks. Personal data assistant (PDA) devices were programmed to enable the collection of timing data for each subtask for both methods.
RESULTS: The manual administration time was 12.7 minutes per single dose beginning with the patient medication request and ending with pain reassessment. The oral PCA device steps to program the device, deliver one of eight doses of medication, and discharge the patient from the device required 2.06 minutes of nursing time. Reloading an additional eight-dose tray required 40 seconds of nursing time per dose of medication administered.
CONCLUSION: The oral PCA saved 84% of the nursing time to administer each dose of PRN medication manually. These data provide evidence that the oral PCA device would reduce the nursing time to deliver a single dose of PRN oral pain medication.

Background

Multimodal postoperative pain management includes as-needed (PRN) oral pain medication combined with other scheduled oral pain medications for patients who can take oral medication (Chou et al., 2016). This approach reduces pain by combining medications targeting pain control along different pharmacological pathways. The manual administration of PRN oral pain medication in surgical units can consume a significant amount of nursing work time. A study designed to obtain the nursing time for the manual administration of a single dose of oral PRN pain medication – including the time for reassessment of pain in an orthopaedic postoperative unit – found that it took 10.9 minutes per dose (Pizzi et al., 2014).

Another option for the delivery of oral PRN pain medication is via a Wi-Fi oral patient-controlled analgesia (PCA) device. Patient-reported pain control using this device has previously been compared with the manual administration of PRN oral pain medication after total knee arthroplasty and total hip arthroplasty (Lambert & Cata, 2014; Pizzi et al., 2020). Patients using the oral PCA device compared with manual medication administration reported significantly less pain with each dose of pain medication as reflected in lower pain scores using the Numerical Rating Scale (NRS) from 0 to 10, with 0 being no pain and 10 representing the worst possible pain (Williamson & Hoggart, 2005). More than 90% of nurses surveyed in a recent study using the device after total hip arthroplasty indicated

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This research has been partially funded by Avancen MOD Corporation by providing the study protocol as prepared by N. Sharon Conley, MD, PhD, outside statistical expertise, and the PDA (Personal Data Assistant) programmed devices for the timing study collection data. Dr. Conley did not participate in any data collection or statistical analysis. The oral PCA devices and related disposable supplies for the device use were the property of Flagler Hospital.

The article was primarily written by Dr. Conley with input from L. Collins and D. Cata. L. Collins and D. Cata have no conflict of interest to report and received no remuneration from Avancen MOD Corporation or the hospital for their involvement in the study.

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DOI: 10.1097/NOR.0000000000000697

that the oral PCA device saved their time (Pizzi et al., 2020). However, no timing studies have compared the actual nursing time required for the manual administration of PRN oral pain medication with the delivery of medications using the oral PCA device in the same postoperative unit.

Two nursing time and workflow problems exist with the manual delivery of PRN pain medication by the nursing staff. A patient request for medication is an unscheduled interruption in the nursing workflow that frequently leads to delays in the delivery process and a potential for errors (Kalisch & Aebersold, 2010). The second is the time required to administer PRN medication. PRN medication administration can consume a significant amount of nursing time, particularly in units where many patients require PRN oral pain medication.

Nursing time can be conceptualized to exist in three forms—physical, psychological, and sociological (Jones, 2010; Jones & Yoder, 2015). Physical time is time measured by the clock. Psychological time reflects, for example, on what the patient observes as adequate time spent on their needs and expectations, whereas nursing may experience a psychological time pressure with too many tasks to complete during a period of time. Sociological time may reflect the patient's perception of care time including delayed or missed care; for nurses, it may be experienced as time during the expected performance of tasks and workflow within a society of other nurses in their patient care unit. Multiple competing demands for nursing time during each shift have resulted in the concept of rationed or missed and delayed nursing care.

Kalisch (2015) developed a model citing episodes of missed nursing care as errors of omission that can impact the quality and outcomes of patient care. The missed nursing care model has been defined as any aspect of essential patient care omitted or delayed in part or whole. A tool to measure elements of missed nursing care and the reasons given for missed care was reported by Kalisch and Williams (2009). Two groups of hospital staff nurses were surveyed in Midwestern hospitals. Group 1 included 459 nurses from three hospitals with a total bed count of 1,178 beds. Nurses in Group 1 were from inpatient units including maternity, intensive care, intermediate care, cardiac, surgical, renal, oncology, and rehabilitation. Group 2 represented a total of 639 nurses from a single 913-bed medical center from 18 different patient care units. Surveys asked for the percentage of specific missed care tasks in their unit by all the staff. The percentage of time the staff was unable to respond to PRN medication requests within 15 minutes was 80% in Group 1 and 54% in Group 2. A separate questionnaire asked nurses to identify reasons for missed care. The three reasons most commonly identified were inadequate labor resources, inadequate material resources when needed, and poor communication and teamwork between staff members. A review of multiple publications with nurse surveys on missed nursing care has indicated that low or inadequate nurse staffing was a significant contributor to missed nursing care (Griffiths et al., 2018).

Unfinished nursing care, missed care, or rationed care is a predictor of decreased patient care quality, increased patient adverse events and mortality, and decreased nursing occupational satisfaction in the United States and many other countries (Ball et al., 2018; Jones et al., 2015; Kalisch & Xie, 2014).

When 729 hospitalized patients were surveyed regarding their experience with missed nursing care, one of the four key contributors from patients' perspectives was related to the time to respond to patient requests for a variety of care needs (Kalisch et al., 2014). A recent PRN medication nursing timing study in an inpatient surgical unit identified the multiple steps required by nursing to respond to a request for PRN medication. Among those patients receiving PRN administration of opioids for pain, 18% of the deliveries were delayed beyond 15 minutes by a complex variety of circumstances (Hwang et al., 2018).

Inpatient surveys using the American Pain Society Patient Outcome Questionnaire Revised, (APS-POQ-R) (Gordon et al., 2010), were completed in a tertiary academic medical center to identify barriers to adequate acute pain management. The most significant barrier for adequate pain management reported by 60% of the patients was the significant delay time for the delivery of pain medication (Lin et al., 2015).

The study here was devised to compare the nursing time for a single manual administration of PRN oral pain medication compared with the nursing time required for the delivery of a single dose of PRN pain medication from a Wi-Fi oral PCA device. A quantitative determination of the nursing time differences, if significant, could provide more nursing time to reduce the amount of missed nursing care while improving pain management.

Purpose

The purpose of this study was to examine whether the use of the Wi-Fi oral PCA technology would reduce the amount of nursing time required to accomplish the delivery of PRN oral pain medication. This would further validate the previous nursing survey reporting that the use of the oral PCA device saved time.

Methods

Research Design

This was a descriptive comparative timing study that compared the nursing time to accomplish the manual administration of a single dose of oral PRN pain medication with the nursing time to prepare and program the oral PCA device to accomplish a single delivery of an oral PRN pain medication for self-administration by the patient. The pain reassessment step following medication administration was included to gauge the improvement in pain control after medication administration. The study site was an inpatient orthopaedic surgical unit.

Study Protocol

The study protocol was reviewed and approved by the hospital institutional review board. Patient and nursing consents were not required for the study execution. The Wi-Fi oral PCA devices and device-related disposables were the

property of the hospital. The device protocol and personal data assistant (PDA) devices were provided by the study sponsor, Avancen MOD Corporation. Statistical analysis was conducted by a consultant of the study sponsor.

The inpatient orthopaedic surgery unit is a 30-bed unit that also includes non-orthopaedic surgical patients. The unit is designed with two linear hallways of patient rooms, with a nursing station at each end of the hallways. An automated dispensing unit (ADU) for medication is located near each nursing station.

Patient selection for the use of the oral PCA device was per the hospital policy and procedure and clinician order. Patient selection required that all patients be alert and oriented with no evidence of dementia. Each patient was required to agree to cooperate with a brief education module administered by their nurse to understand the device concept, be able to understand and demonstrate the device use, and agree to their device use responsibilities. Patients with a history of drug abuse or deemed unable to be responsible for device use were excluded. Patients with swallowing disorders or any physical disability that would prevent easy self-administration of medication were excluded. Medication administration from the device by any family member or visitor was strictly forbidden and would result in the removal of the device. No specific number of patients was specified for the timing studies because task timing was measured with any available patients present for the timing studies during the data collection days.

The PDA devices were programmed using the WorkStudy+4 Program from Quetech Ltd (Waterloo, Ontario, Canada). A touch screen was created on the PDA handheld devices, with subtasks of either the manual delivery process or the device delivery process shown in a set of labeled colored boxes on the PDA screen.

To start a timing step, the appropriate subtask box was touched to begin the stopwatch in the device. When the task was completed, a stop icon was touched. Devices were collected at the end of each shift to obtain the recorded timing data for the steps that were timed. Once the data were collected and entered into a database at the end of each day, the data were cleared in the devices in preparation for the collection of timing data the following day.

The time for each medication administration process from start to finish was divided into specific tasks that could be timed during a nursing shift. The rationale for this approach was the realization that nurses do not always finish each complete procedure without interruption. Accordingly, all tasks of each delivery process were divided into discrete steps that could be individually time measured. No attempt was made to time each step sequentially, but the nursing staff was encouraged to time any tasks that could easily be timed.

Table 1 lists the tasks timed for the manual delivery and the device delivery. The summation of times for the nursing tasks for each method was used to derive the total time to deliver a single dose of medication for both the manual and device delivery methods. For the manual delivery Tasks 3 and 4, the time measurement included travel to the patient room and the completion of the described task inside the patient room. The Return Next Task (RNT) measured the time from leaving the patient room to arriving at either the nearby nursing station or the next task within the unit. The RNT times were measured in both the manual and device delivery steps and combined for a total mean time as shown in Table 1.

The device delivery tasks as shown in Table 1 were measured for the first cycle of eight delivered doses of medication from the eight-dose tray loaded into the device during the Program New Patient task. Tasks 1–5 for the device delivery steps were performed once regardless of the number of doses ultimately self-administered by the patient from the device. The delivery of eight doses of medication from the first loaded tray into the device was considered as one cycle of medication delivery. This total nursing time was divided by eight to calculate the nursing time required for the delivery of a single dose of medication. The reassess pain step with the device was accomplished by the patient responding to an audible command from the device to enter a pain score on the device by pushing the matching numeric pain score button 1 hour after the self-administered oral dose of medication. The reassess pain step after each self-administered dose did not require any nursing time. For the device delivery Tasks 4 and 5, the addition of an RNT time was necessary to complete those timed steps.

Table 1. Nursing Tasks for Manual and Wi-Fi Oral PCA Pain Medication Delivery

Manual Delivery Tasks per Single Dose Delivered	Device Delivery Tasks for One Cycle of Eight Doses	Device Medication Administration Steps
1. Patient Medication Request	1. Verify Device Order	Task 3. Get Medication Tray From ADU
2. Get Medication From ADU	2. Get Device & Supplies	Task 7. Replace Device Tray With Eight Doses
3. Administer Patient Medication	3. Get Medication Tray From ADU	Task 6. Return to Next Task
4. Reassess Pain	4. Program New Patient	
5. Return to Next Task	5. Discharge From Device Use	
	6. Return to Next Task	

Note. ADU = Automated Dispensing Unit for medication on the patient unit; PCA = patient-controlled analgesia.
Return to Next Task time was added to a task measuring the travel time to the patient room and completion of the task inside the patient room with a stop icon pressed on the PDA upon completion of the task. Once a task was completed in the patient room, a RNT time was measured for both the Manual and Device Delivery steps with the data pooled and used for those tasks requiring either a return to the nurse station or a next task.

To replace a device tray in an already programmed device for an additional eight doses of medication, only two tasks were needed, that is, the time to get a new loaded device medication tray from the ADU and the time to enter the software program to open the device, remove the empty medication tray, and then load a new tray plus the time for RNT. No new programming steps were needed. The time for these tasks was added together to calculate the nursing time to provide additional doses of medication beyond the first cycle of medication delivery. The total time divided by eight or the number of doses self-administered prior to discharge from the device would be the nursing time to provide a single dose of medication after the first cycle of medication delivery.

As task timing data were collected, some data were outside the expected range for any task. A cutoff time for any recorded task less than 10 seconds or greater than 660 seconds was used to avoid including data outside these ranges, assuming a possible timing error either by an interruption of data collection or by a delay in touching the stop icon for that task. The minimum number of timed observations for each task within acceptable ranges was set at 15 observations. After sufficient data were collected for each step of the manual process, the process was repeated with the nursing staff using the oral PCA devices to collect timing data for those specific tasks related to the device use.

Manual Medication Administration Steps

The oral dose of a PRN oral pain medication was provided and administered manually by the nursing staff, with the dose determined by the numeric pain score from 0 to 10 and authorized, upon patient request, after a minimum of 4 hours since the last dose.

The manual medication administration process was divided into five tasks that could be timed as a baseline for comparison with the device process. The tasks for the manual administration were divided as follows:

Task 1—Patient Medication Request: The timer was begun when the nurse was notified of a patient request for PRN pain medication. If necessary, the nurse checked the medical record to be sure the appropriate time had passed since the last PRN medication was administered. In some cases, the nurse interacted with the patient to determine dose according to patient-reported numeric pain score. Once the medication request was completed, the stop icon was pressed on the PDA to stop the timer.

Task 2—Get Medication From ADU: The timer was begun when the nurse traveled to the ADU containing the oral medication, waited in line if necessary, and then removed the appropriate medication for the patient. Once the medication was obtained, the nurse would exit from the ADU and press the stop icon on the timer.

Task 3—Administer Patient Medication: The nurse began the timer upon initiating travel to the patient room with the medication in hand. Upon arrival, the patient's verbal numeric pain score was confirmed and the medication was provided with the dose specified by the hospital pain protocol. Administration of the medication was recorded at the bedside using the bar code on the unit dose package of the medication to document the medication, the dose, and time of administration into the electronic medical record (EMR). The stop icon on the PDA screen was pressed when this task was complete.

Task 4—Reassess Pain: The nurse traveled to the patient room approximately 1 hour after the previous pain medication administration to obtain a reassessment numeric pain score from the patient to document the effectiveness of the pain medication and to assess for any evidence of sedation and changes in pain locations or other related problems. These collected data were documented in the EMR, followed by pressing the stop icon on the timer. Often, this step would also serve as one of the daily every 4-hour pain assessment surveys the nursing staff would do routinely regardless of the mode of pain medication delivery.

Task 5—Return Next Task: Upon completion of a task in the patient room, the timer was begun when the nurse left the patient room to travel back to the next task or to the closest nurse station in the unit. Upon arrival, the timer was stopped. To discover the total time for a single manual delivery, an RNT time was added to the final time for the manual delivery process following Tasks 3 and 4.

Device Program for Patient Medication Self-Administration

The Wi-Fi oral PCA device has been deployed in this unit for more than 4 years; as such, nursing staff were fully familiar with this technology. The device was always loaded with a prefilled tray of eight tabs of identical doses of oral pain medication obtained from the ADU. The dose of medication in the tray was equivalent to the lowest dose of the same medication made available using the manual administration process. However, the oral PCA device was usually programmed to allow access by the patient for a single tab of medication with a shorter lockout time interval than the manual administration time frame. For example, with the manual administration protocol, for a patient reporting a pain score of 5 or more, 10 mg of oxycodone could be administered manually by the nursing staff. The oral PCA was loaded with eight tabs of 5 mg of oxycodone, with a 2-hour lockout time interval between allowed doses. The logic of the oral PCA device was that the delivery of smaller doses of medication allowed more frequently could achieve a more consistent plasma concentration of pain medication for better pain control.

The usual maximum dose of medication allowed from the oral PCA device within a 4-hour time interval was 10 mg, administered over two 2-hourly doses. This was identical to the 10-mg maximum dose allowed every 4 hours using the manual administration of a single dose of medication corresponding to a high pain score. For pain not controlled with the usual manual or

device programmed dosing regimen, an additional 5-mg bolus dose of medication could be available for physical therapy or a special need to control pain. The total maximum allowed dose of medication within a 4-hour interval for both manual and device delivery was 15 mg of oxycodone.

Although the oral PCA device allowed medication access every 2 hours, there was no requirement for the patient to retrieve the medication after each 2-hour time interval. The patient was alerted by a green light that illuminated on the device once the required lockout interval had elapsed. If the patient did not require the medication at that time, the light would remain illuminated until a dose of medication was requested, removed from the device, and self-administered. Once this process was completed, the device timer would begin again and the green light would not illuminate again until the predesignated lockout time interval had passed. As with all PCA devices, the dose of medication provided with each dispense was not governed by a numeric pain score but by the patient need of medication.

Each patient using a device was given a unique Radiofrequency Identification (RFID) wristband scanned into their device during the device programming steps, allowing that patient medication access only from their device. When a patient desired a dose of medication, provided the lockout interval had passed, they recorded their numeric pain score by pushing the appropriate numbered button on the front of the device and then held their RFID wristband in front of the device. If the device recognized their wristband, the dispenser wheel would turn to expose a single tab of medication that could be removed and promptly self-administered by the patient. Registration of the numeric pain score for each dose of medication was for documentation only because the dose was standard, for example, a 5-mg dose of oxycodone. Each device was secured with a proprietary wrench onto an intravenous pole within easy reach of the patient.

The device programming platform was accessed on the staff computer workstation screens as a visible program icon that could be accessed using a unique password for each nursing staff member. The device data were downloaded in real time into the facility's EMR, capturing patients' times of medication administration, numeric pain scores, and reassessment pain scores obtained 1 hour after each self-administered dose of pain medication. Device data also included the identity of the nurse who programmed the device or accessed any other program module, for example, the program for reloading a device medication tray, providing a bolus dose of medication, and discharging a patient from device use.

Device Medication Administration Steps

The seven nursing tasks to program and provide the Wi-Fi oral PCA device for the patient use were as follows:

Task 1—Verify Device Order: The timer was started when the nurse obtained the electronic computerized provider order entry (CPOE) for their patient, including oral pain medication, dose, and the required lockout time interval in hours between allowed doses. Upon receipt of the order, the timer is stopped. All patients in this study received oxycodone 5 mg available with a 2-hour lockout time interval.

Task 2—Get Device & Supplies: The timer was begun when the nurse traveled to the clean device and supply room and obtained a clean oral PCA device mounted and locked onto an intravenous pole and a disposable new RFID wristband for the patient. Once obtained, the timer was stopped.

Task 3—Get Device Tray From ADU: The timer was begun when the nurse traveled to the ADU and obtained a sealed barcoded device medication tray containing eight identical doses of the requested medication. The timer was stopped once the loaded medication tray was obtained, and the nurse exited the ADU. Medication trays were not patient specific, only medication and dose specific.

Task 4—Program New Patient: The timer was begun when the nurse traveled to the patient room with the oral PCA device locked onto an intravenous pole, a new disposable RFID wristband, and the loaded sealed medication tray. Before initiating the device programming steps for a new patient, the nurse completed the educational module with the patient, which required a return demonstration and acknowledgment of their responsibility either by verbal consent or by a signature on the device agreement contract.

The device programming module was obtained by selecting the appropriate icon on the nurse workstation computer screen and entering the requested password. To access the new patient device program, the nurse selected Connect on the device programming screen and followed the step-by-step wizard software program to complete a new patient order that identified the patient, the medication, the medication dose, and the lockout time interval in hours. As part of the new patient programming steps, the patient's unique RFID wristband was scanned into the device, which provided exclusive patient access to the medication. The RFID wristband was then applied to the patient wrist for the device use. Following completion of the device programming steps, the device top opened and the medication tray was loaded into the device, the seal was removed, and the top was closed and locked. The PDA timer was then stopped prior to the nurse leaving the patient room.

Task 5—Discharge From Device Use: The timer was begun when the nurse initiated travel to the patient room to remove the patient from the device use. The removed patient program module was accessed on the workstation screen. As part of the program to remove a patient from the device, any remaining pill count was documented on the device program, followed by an automatic opening of the device top. Two

nurses then disposed of any remaining medication in the dispenser wheel tray according to hospital policy, removed and discarded the empty tray and the patient RFID wristband, wiped down the device inside and out according to the device cleaning procedure, and returned the device to the clean supply room. The timer was stopped when the device was returned to the clean room.

Task 6—Return Next Task: Each time the nurse left the patient room following the recorded task as in Task 4, or completed the patient discharge steps from the device as in Task 5, the travel time was recorded to either arrive at the next task or back to the nearest nursing station.

Task 7—Replace Device Tray: To replace the device medication tray, the nurse traveled to the ADU to obtain a new medication tray (Task 3). Once the tray was obtained, the timer was begun when the nurse initiated travel to the patient room to replace an empty tray in the device. The device program was accessed on the workstation computer screen and the replace tray program module was selected. As part of the replace tray program, the device top automatically opened, the empty disposable tray was removed and discarded by the nurse, and a new tray was installed into the device dispensing wheel, the tray sealer was removed, and the device was closed and locked. Once the new tray was successfully loaded into the device, the timer was stopped. This step did not require any further programming steps as this was already accomplished when a new patient was programmed into the device as in Task 4.

With any step that included medication exposure (Tasks 4 and 5), a second nurse was required to observe and enter their code on the program screen to indicate that they had witnessed that step. This process was required to ensure safety and prevent medication diversion.

The reassessment of pain to obtain a numeric pain score using the oral PCA device did not require any nursing time. The patient entered this information into the device when asked to do so by an audible message emanating from the PCA one hour after each medication self-administration. Patients were educated to expect this request. The request asked the patient to "Enter your pain score now." Patients would then push the appropriate number button on the front of the device to enter their pain score.

Routine Pain Reassessment

In this unit, regardless of the medication delivery process, the nursing staff continued to round every 4 hours to obtain complete pain assessments according to hospital policy. This step included vital signs, patient-reported numeric pain scores, any evidence for patient sedation, and any changes in pain severity or pain locations. In many cases, the routine round for pain assessment served as the pain reassessment step following manual administration of pain medication because it often approximately coincided within the 1-hour post-manual administration of pain medication and served as the actual pain reassessment step after manual administration of an oral PRN pain medication.

For patients using the oral PCA device, a device pill count was documented by viewing the medication tabs through the clear device top during the 4-hourly nursing staff rounds. The device pill count was not included in the device timing steps. For patients using the oral PCA device, the pain assessment during the 4-hourly nursing rounds served as a more thorough record of the patient's pain status including any evidence of sedation or change in the pain description or pain location.

Data Collection for the Manual and Device Medication Delivery

At the end of each day shift, an assigned unit nurse uploaded all the PDA timing data into a database by recording the date, the time in seconds for each step recorded, and the name of the nurse(s) who collected the data. Seventeen nurses participated in the data collection. Data were collected only during 12-hour day shifts. The manual delivery data were collected and completed prior to the device delivery data collection.

Statistical Analysis

The data were analyzed for the mean, the standard deviation, and the minimum and maximum times recorded for each step. It was acknowledged that due to differences in patient room locations, individual nurse workflow differences, and variations in patient behaviors and interactions, a significant range in timing events would occur. The RNT data for both manual and device steps were pooled for a total of 26 observations.

Results

Recorded times for the manual administration steps are shown in Table 2. The number of collected times (*N*) for each task, the mean minutes for each task, and the minimum and maximum values in minutes are shown. For Task 3, Administer Patient Medication, and Task 4, Reassess Pain—both tasks timing started with the travel to the patient room and the timer was stopped upon completion of the task inside the patient room. Task 5, RNT, was the amount of time it took from completion of either Task 3 or 4 to travel to the next task or nursing station. All return task times were combined to arrive at a final mean time. With both return times after Tasks 3 and 4, it was then necessary to add the mean time for both returns into the database. This resulted in two Returns as noted in Table 1 for the Manual Administration Time. The mean nursing time to accomplish the manual administration of a single dose of PRN pain medication, including the required trip to the patient room for the reassessment pain step approximately 1 hour later, was 12.7 minutes.

Table 3 shows all the measured times for the use of the oral PCA for one cycle of device use with eight doses of

Table 2. Manual Administration Time for a Single Dose of Oral PRN Pain Medication

Recorded Task #	*N*	Mean Minutes (*SD*)	Min Time (Min)	Max Time (Min)
1. Patient Medication Request	27	1.43 (1.65)	0.22	7.21
2. Get Medication From ADU	27	1.86 (2.04)	.035	10.7
3. Administer Patient Medication	29	3.68 (2.47)	0.68	10.3
4. Reassess Pain	18	2.77 (2.26)	0.98	10.8
5. Return to Next Task (1.47 minutes × 2)	26	2.94 (3.96)	0.18	10.0
Total		12.7[a]		

Note. ADU = Automated Dispensing Unit for medication on the patient unit; *N* = number of timed tasks; PRN = as-needed; RNT = Return to Next Task; *SD* = standard deviation of mean minutes. Task 5 RNT time was necessary to add to Tasks 3 and 4; each RNT was 1.47 minutes for a total of 2.94 minutes.
[a]Total nursing minutes per single dose of medication administered.

medication. Once a patient had self-administered all eight doses of medication from the medication tray, considered in these calculations as one full cycle of medication administered, the nurse would ultimately return to discharge the patient from the device use. These two steps, that is, the initial programming steps (Task 4) and the discharge from the device steps (Task 5), occurred only once for each patient. These tasks required two trips to the patient bedside and ended once the task in the patient room was completed. Rather than actually timing RNT after completion of Tasks 4 and 5, an RNT of 1.47 minutes was added to the timing of each of these two tasks, as noted in Table 3.

The summation of the means of all these timing steps as shown in Table 3 resulted in 16.5 minutes of nurse time for the delivery of eight doses of medication from the oral PCA. The nursing time of 16.5 minutes was divided by eight doses of medication to calculate the nursing time for the delivery of a single dose of medication. The result was 2.06 minutes of nursing time required to deliver a single dose of pain medication using the Wi-Fi oral PCA device.

Table 4 notes the time required to replace an empty medication tray inside the device with a new tray of eight doses of medication. Assuming all eight doses were consumed by the patient, the total nursing time for this step was 5.35 minutes to provide eight doses of medication. Dividing this time by eight resulted in 0.66 minutes or 40 seconds of nursing time required per dose delivered. If fewer than eight doses were used, the total time of 5.35 minutes would be divided by the number of tabs dispensed from the device.

Discussion

A nurse timing study has been completed to compare the nursing time needed for the single delivery of an oral PRN pain medication either by manual administration by the nursing staff or using a Wi-Fi oral PCA device in an inpatient orthopaedic surgery unit. The total nursing time for the manual administration including obtaining and documenting the reassessment pain score was recorded at 12.7 minutes (see Table 2). The manual administration time in this study was similar to the manual administration time of 10.9 minutes in another orthopaedic inpatient unit at a different facility (Pizzi et al., 2014).

The total time for the delivery of eight doses of medication from the oral PCA device was 16.5 minutes, which included all the timed necessary steps (Tasks 1–6) for a full cycle of medication from an eight-dose loaded tray inserted into the device during the programming steps for a new patient. The time of 16.5 minutes divided by eight doses resulted in 2.06 minutes of nursing time per dose delivered and self-administered by the patient. The pain reassessment step was completed by the

Table 3. Recorded Tasks for One Cycle of Device Delivery

Recorded Task #	*N*	Mean (*SD*)	Adjust by Eight Tabs	Min Time (Min)	Max Time (Min)
1. Verify Device Order	44	0.31 (0.09)	0.04	0.20	0.60
2. Get Device & Supplies	25	2.30 (1.01)	0.29	0.72	4.15
3. Get Medication Tray From ADU	27	1.53 (0.98)	0.19	0.62	5.00
4. Program New Patient	23	7.23 (2.83)	0.90	1.62	10.6
5. Discharge from Device Use	18	2.15 (2.21)	0.27	0.75	10.4
6. Return to Next Task (1.47 minutes × 2)	26	2.94 (3.96)	0.37	0.18	10.0
Total		16.5	2.06[a]		

Note. ADU = Automated Dispensing Unit for medication on the patient unit; *N* = number of timed tasks; RNT = Return to Next Task; *SD* = standard deviation of mean minutes. Task 6, RNT, was added to Tasks 4 and 5; each RNT was 1.47 minutes for a total of 2.94 minutes.
[a]Total nursing minutes per single dose delivered from the device.

Table 4. Recorded Device Tasks for Additional Medication Tray Cycles of Use

Recorded Task #	*N*	Mean (*SD*)	Adjust by Eight Tabs	Min Time (Min)	Max Time (Min)
3. Get Medication Tray From ADU	27	1.53 (0.98)	0.19	0.62	5.00
7. Replace Device Tray	18	2.35 (0.47)	0.29	1.28	3.57
6. Return to Next Task	26	1.47 (1.98)	0.18	0.18	10.0
Total minutes		5.35	0.66[a]		

Note. *N* = number of timed tasks; *SD* = standard deviation of mean minutes. Tasks 6 RNT time was necessary to add to Task 7, that is, 1.47 minutes.
[a]Nursing minutes per dose delivered or 40 seconds after the initial cycle of the first eight doses of medication with timed tasks as shown in Table 3.

patient 1 hour after medication administration when the patient was automatically prompted by the device to enter a numeric pain score to document their level of pain improvement since the last medication administration. This step did not require any nursing time.

The loading of a new filled medication tray assuming all eight doses would be taken by the patient required only 0.66 minutes or 40 seconds of nursing time as shown in Table 4. If all eight doses are consumed by the patient, the set-up time is distributed over all 8 doses, which yields a more efficient per dosage time.

At 12.7 minutes/dose for the manual delivery and 2.06 minutes/dose for the oral PCA device, the oral PCA device represents significant nurse time savings per dose of medication. To illustrate, a nurse working a 12-hour shift in an orthopaedic inpatient unit with five patients, each requiring a dose of PRN oral medication every 4 hours, would deliver 15 doses of medication. This nurse would have spent more than three hours or 26% of their total 12-hour shift delivering PRN oral medication. In contrast, 15 deliveries by the oral PCA device would take 31 minutes of nursing time if the device lockout time interval is at 4 hours. However, if the device was programmed for more frequent dosing, for example 2 hours instead of 4 hours, the time for 30 doses of medication would be 62 minutes, or only 8.6% of the nursing shift time. Each time a pain medication is dispensed from the oral PCA, more than 10 minutes of nursing time is saved.

Study Limitations

It is acknowledged that each patient encounter was unique, with wide variations in the times needed to achieve each task. Moreover, work flow differs not only between nurses working on a single unit, but certainly between units and between hospitals; as such time saving will likely differ if the study were to be repeated at any other geographic location. An arbitrary cutoff in short and long recorded task times was done to exclude errors in the use of the PDA devices. If a patient's pain was not adequately controlled with the usual regimen of medication, additional medication was available PRN. An extra PRN dose given manually would require additional time whether the patient was receiving their medication manually or from the oral PCA device. This step was not timed, as a bolus dose of medication could not be estimated to occur with a predictable frequency, although it is acknowledged that it may occur for any patient following a surgical procedure.

The reassessment pain score entered by the patient responding to an audible command from the device 1 hour after each self-administered dose of pain medication was added in real time to the EMR database. However, it is acknowledged that in any surgical unit, more complete pain assessments are accomplished at regular intervals during each nursing shift as was the case in this surgical unit. The frequency of these pain reassessments may vary with each facility.

Conclusion

The goal of this study was to measure the nursing time for the delivery of a single dose of PRN oral pain medication if given manually by the nurse compared with the nursing time for the delivery of a single dose of oral PRN pain medication via the Wi-Fi oral PCA device in an orthopaedic postoperative surgical unit. Like the Pizzi study (2020), this study found that use of the Wi-Fi oral PCA device saved nursing time when compared with the manual delivery process. The reduction in nursing time from 12.7 to 2.06 minutes per single dose delivered is 10.7 minutes or an 84% reduction in the time necessary to accomplish the same task in this surgical unit. The nursing time savings are greater once additional doses of medication are used beyond the first eight doses from the device. Research with larger sample sizes in specific surgical units could further support these data with statistical analyses. Because nursing workflow processes and spatial geography of an inpatient unit can vary with each facility, additional studies in different postoperative surgical populations would be of interest.

The intent of the device use is not to remove the nurse from the bedside but to free up nursing expertise to attend to patient care and reduce the incidence of missed nursing care overall. Time scarcity has been called a common occurrence in the nurse work environment, contributing to missed nursing care and impacting patient outcomes (Jones, 2016).

This PCA technology provides oral pain medication that can be self-administered by carefully selected patients while collecting patient recorded pain data at the time of medication administration and at a pain reassessment time. These pain data can be integrated directly into the EMR also contributing to saved nursing time.

Nursing thought leaders are acknowledging that the adoption of new technologies in the future will be necessary to enable nursing to keep up with the fast pace of

increasingly complex patient care while avoiding missed nursing care (Bolton et al., 2008).

References

Ball, J. E., Bruyneel, L., Aiken, L. H., Sermeus, W., Sloane, D. M., Rafferty, A. M., Lindqvist, R., Tishelman, C., Griffiths, P., & RN4Cast Consortium. (2018). Post-operative mortality, missed care and nurse staffing in nine countries: A cross-sectional study. *International Journal of Nursing Studies*, *78*, 10–15. https://doi.org/10.1016/j.ijnurstu.2017.08.004

Bolton, L. B., Gassert, C. A., & Cipriano, P. F. (2008). Smart technology, enduring solutions. Technology solutions can make nursing care safer and more efficient. *Journal of Healthcare Information Management*, *22*(4), 24–30.

Chou, R., Gordon, D. B., de Leon-Casasola, O. A., Rosenberg, J. M., Bickler, S., Brennan, T., Carter, T., Cassidy, C. L., Chittenden, E. H., Degenhardt, E., Griffith, S., Manworren, R., McCarberg, B., Montgomery, R., Murphy, J., Perkal, M. F., Suresh, S., Sluka, K., Strassels, S., Thirlby, R., ... Wu, C. L. (2016). Management of postoperative pain: A clinical practice guideline from the American Pain Society, the American Society of Regional Anesthesia and Pain Medicine, and the American Society of Anesthesiologists' Committee on Regional Anesthesia, Executive Committee, and Administrative Council. *The Journal of Pain*, *17*(2), 131–157. https://doi.org/10.1016/j.jpain.2015.12.008

Gordon, D. B., Polomano, R. C., Pellino, T. A., Turk, D. C., McCracken, L. M., Sherwood, G., Paice, J. A., Wallace, M. S., Strassels, S. A., & Farrar, J. T. (2010). Revised American Pain Society Patient Outcome Questionnaire (APS-POQ-R) for quality improvement of pain management in hospitalized adults: Preliminary psychometric evaluation. *The Journal of Pain*, *11*(11), 1172–1186. https://doi.org/10.1016/j.jpain.2010.02.012

Griffiths, P., Recio-Saucedo, A., Dall'Ora, C., Briggs, J., Maruotti, A., Meredith, P., Smith, G. B., Ball, J., & Missed Care Study Group. (2018). The association between nurse staffing and omissions in nursing care: A systematic review. *Journal of Advanced Nursing*, *74*(7), 1474–1487. https://doi.org/10.1111/jan.13564

Hwang, J., Koo, G. K., De Palm, S. E., Sigafus, K., Farrar, J. T., Clapp, J. T., Lane-Fall, M. B., & Nazarian, S. M. (2018). Inpatient pain medication administration: Understanding the process and its delays. *Journal of Surgical Research*, *232*, 49–55. https://doi.org/10.1016/j.jss.2018.05.080

Jones, T. L. (2010). A holistic framework for nursing time: Implications for theory, practice and research. *Nursing Forum*, *45*(3), 185–196. https://doi.org/10.1111/j.1744-6198.2010.00180.x

Jones, T. L. (2016). What nurses do during time scarcity—and why. *Journal of Nursing Administration*, *46*(9), 449–454. https://doi.org/10.1097/NNA.0000000000000374

Jones, T. L., Hamilton, P., & Murry, N. (2015). Unfinished nursing care, missed care, and implicitly rationed care: State of the science review. *International Journal of Nursing Studies*, *52*(6), 1121–1137. https://doi.org/10.1016/j.ijnurstu.2015.02.012

Jones, T. L., & Yoder, L. H. (2015). Dimensions of nurse work time: Progress in instrumentation. *Nursing & Health Sciences*, *17*(3), 323–330. https://doi.org/10.1111/nhs.12191

Kalisch, B. J. (2015). Part I: The problem. In Errors of omission. How missed nursing care imperils patients (pp. 1–75). American Nurses Association.

Kalisch, B. J., & Aebersold, M. (2010). Interruptions and multitasking in nursing care. *The Joint Commission Journal on Quality and Patient Safety*, *36*(3), 126–132.

Kalisch, B. J., & Williams, R. A. (2009). Development and psychometric testing of a tool to measure missed nursing care. *The Journal of Nursing Administration*, *39*(5), 211–219.

Kalisch, B. J., & Xie, B. (2014). Errors of omission: Missed nursing care. *Western Journal of Nursing Research*, *36*(7), 875–890. https://doi.org/10.1177/0193945914531859

Kalisch, B. J., Xie, B., & Dabney, B. W. (2014). Patient-reported missed nursing care correlated with adverse events. *American Journal of Medial Quality*, *29*(5), 415–422. https://doi.org/10.1177/1062860613501715

Lambert, T. L., & Cata, D. M. (2014). The traditional method of oral as-needed pain medication delivery compared to an oral patient-controlled analgesia device following total knee arthroplasty. *Orthopaedic Nursing*, *33*(4), 217–223. https://doi.org/10.1097/NOR.0000000000000065

Lin, R. J., Reid, M. C., Liu, L. L., Chused, A. E., & Evans, A. T. (2015). The barriers to high-quality inpatient pain management: A qualitative study. *American Journal of Hospital Palliative Care*, *32*(6), 594–599. https://doi.org/10.1177/1049909114530491

Pizzi, L. J., Bates, M., Chelly, J. E., & Goodrich, C. J. (2020). A prospective randomized trial of an oral Patient-Controlled Analgesia (PCA) device versus usual care following total hip arthroplasty. *Orthopaedic Nursing*, *39*(1), 37–46.

Pizzi, L. J., Chelly, J. E., & Marlin, V. (2014). Nursing time study for the administration of a PRN oral analgesic on an orthopedic postoperative unit. *Pain Management Nursing*, *15*(3), 603–608. https://doi.org/10.1016/j.pmn.2013.04.002

Williamson, A., & Hoggart, B. (2005). Pain: A review of three commonly used pain rating scales. *Journal of Clinical Nursing*, *14*(7), 798–804. https://doi.org/10.1111/j.1365-2702.2005.01121.x

