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Accurate Pulse Assessment by Radial Artery Palpation: A Pilot Study

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Honors Research Project

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Abstract

Pulse assessment is an essential component of an individual's health state. Assessment of a pulse by palpation is the most commonly used technique. A patient's pulse rate informs healthcare workers of the status of a variety of body systems, including cardiac, neurologic, and endocrine functions. Despite the widespread and frequent use of pulse assessment, current methods for counting a pulse lack strong supporting evidence. Additionally, published research on accuracy of pulse palpation used only young, healthy participants without arrhythmias or cardiac problems, limiting generalizability to the broader population who contain those variables. The purpose of this study is to determine if the pulse assessment count should begin with "zero" or "one," and to examine the length of time the pulse should be counted for (i.e., 15, 30, or 60 seconds), to ensure accuracy. The researchers found that beginning the pulse count with "zero" and counting for 15 seconds or 30 seconds and multiplying as necessary to achieve beats per minute was the most accurate. The researchers also support Stankute's (2022) finding that counting for a full 60 seconds is *not* the most accurate. These findings can be used to inform healthcare providers of the most accurate and reliable methods to assess pulse rate and serve as a building block for additional studies on pulse counting.

Key words: *radial pulse, pulse assessment, pulse, heart rate, telemetry, vital signs*

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One of the first skills healthcare students are taught is how to take a patient's vital signs. Vital signs include blood pressure, respiratory rate, temperature, oxygen saturation, and pulse rate. Despite these skills being used regularly in most healthcare settings, there is still no standard way to count a radial pulse rate. This lack of standardization can cause an unreliable and incorrect assessment. Further, because these results can influence whether a patient does or does not receive medication or other necessary interventions, an inaccurate pulse rate can lead to a risk of patient safety. In addition to medication administration, pulse rate determines other aspects of clinical judgment, such as when to check a patient's blood pressure and when to notify a provider of abnormal results or a change in a patient's status.

Few studies examining pulse rate assessment have been published since Hargest (1974) who found that the majority of healthcare professionals start the pulse count with "one," despite evidence that starting with "zero" was found to be more accurate. Regarding counting intervals, healthcare professionals will count for 15, 30, or 60 seconds and multiply as needed to find the pulse rate in beats per minute (bpm). However, again there are no clear evidence-based recommendations for when to count by 15, 30, or 60 seconds. In other words, the count time is up to the individual.

Purpose and Research Questions

The purpose of this pilot study is to examine the effects of starting point and counting interval on pulse count accuracy, and to direct future research design and methodology. Of the studies to date, many focus on a young, healthy adult population without any cardiac abnormalities, so findings may not apply to other populations and samples (e.g., hospitalized patients, people with dysrhythmias). In the study, the researchers intentionally collected data

from a hospital population, specifically patients in an outpatient cardiopulmonary rehabilitation program and patients admitted to an inpatient cardiac telemetry unit, to address groups not included in prior research.

Using a 5-lead telemetry monitor as the gold standard comparison to the palpated radial pulse rate, the researchers' primary questions:

- Should a pulse count begin with "zero" or "one"?
- What is the most accurate length of time to count a pulse (15 seconds x4, 30 seconds x 2 or 60 seconds)?

Literature Review

Overview of Heart Rate and Pulse Rate

The heart is a pulsating pump that propels blood intermittently into the arterial system. Contraction of the left ventricle (systolic ejection) produces the pumping action that propels blood from the heart into the peripheral blood vessels in a cyclic pressure wave called the "pulse" (Jarvis, 2020). The palpable pulse is the result of pressure in the arteries increasing as the heart contracts and pushes blood out to the body. The heart rate is the result of electrical signals that originate in the heart's sinoatrial node (the normal "pacemaker") and travel through the conducting system to depolarize the heart and cause it to beat. If the electrical signal comes from an abnormal or aberrant place in the heart (e.g., the ventricles), an abnormal beat or cardiac rhythm can occur. Abnormal beats or rhythms may or may not result in a palpable pressure wave at a peripheral pulse site. In other words, in patients with normal cardiac rhythms, the pulse rate is equivalent to the heart rate (1:1 ratio). However, in certain cardiovascular diseases or abnormal heart beats, the heart may pump but limited blood is sent to the vessels, making that beat not palpable as a pulse, so the ratio is unequal. This poorly perfused beat or a non-perfused beat can

result in a *pulse deficit*, in which the electrical heart rate is greater than the palpable pulse rate. Because vital sign assessment uses pulse rate in place of heart rate when a cardiac monitor is not in place, researchers and clinicians must recognize that cardiovascular abnormalities can lead to a discrepancy between the heart rate (as determined by electrocardiography [ECG] or telemetry) and the palpated pulse rate.

The radial artery is the most common location for pulse palpation because it is easy to locate on the ventrolateral surface of the wrist. Through pulse palpation, health professionals can learn much about a person's health. For example, a fast and weak pulse may indicate conditions such as circulatory shock or cardiac dysrhythmia, and further assessment is necessary (e.g., assess blood pressure, obtain an ECG recording).

To best provide care, health professionals must use an accurate, evidence-based method to count the radial pulse. Hargest (1974) was one of the first researchers to question the accuracy of radial pulse palpation. Hargest found that approximately two-thirds of nurses incorrectly palpated pulses as compared to an ECG monitor, with up to a 15% discrepancy between reported and actual pulse rates. A discrepancy of this magnitude could be problematic for patient health and safety. For example, a nurse may fail to identify a low heart rate (bradycardia) and mistakenly administer a medication contraindicated by a low heart rate.

Pulse Count Starting Number

Hargest (1974) was also an advocate for starting the pulse count with "zero" instead of "one," making a comparison to birthdays: a person is not "one" when they are born. Similarly, when the time interval starts at zero seconds, the examiner should begin the pulse count at "zero", so the entire first cardiac cycle is included within the time interval.

Hwu et al. (2020) found that in current clinical practice, nurses tend to begin counting with “one”. However, Hargest (1974), Jarvis (2020), and Hollerbach & Sneed (1990) all suggest the pulse count should begin with “zero.” Hwu et al. found that beginning the radial pulse count at “one” yielded “more accuracy or less error than counting from zero irrespective of measuring time” (p. 151). Stankute’s (2022) research yielded conflicting results with Hwu et al. (2020). Stankute examined 68 healthy college-aged participants, comparing palpated radial pulse to ECG, and found that using the start point of “zero” was more accurate than “one,” no matter which count time (15, 30, or 60 seconds) was used. These conflicting findings support further research in this area, especially since, as Hwu et al. stated, most nurses in clinical settings begin their count with “one” and not “zero.” Given that Stankute and Hwu et al. both included a homogenous sample of young and relatively healthy adults, additional research in acute care clinical settings is needed to include broader patient populations to increase the generalizability of findings before recommending a widespread change in clinical practice.

Pulse Palpation Interval

Hwu et al. (2020) found that nurses in clinical areas often measure pulse rates for 10-, 15, - or 30-seconds. Hwu et al. used the mean difference between radial pulse rates and the rates shown by the ECG to represent the accuracy of the calculation. After analyzing the data, Hwu et al. came to the conclusion that rates obtained when counting for 15 or 30 seconds can be used to estimate 60-second resting pulse rates without significant error. However, it is important to recognize that if a patient has a known arrhythmia or is tachycardic, the nurse should count their pulse for 60 seconds (Jarvis, 2020).

Hollerbach & Sneed (1990) also questioned and later researched if counting for a full 60 seconds in patients with no cardiovascular abnormalities was necessary in lieu of counting for

10, 15, and 30 seconds. The average measurement error at each measurement in the nurse group was 2.86 bpm (10 seconds), 2.44 bpms (15 seconds), 0.97 bpm (30 seconds), and 0.82 bpm (60 seconds). There was no significant difference between the 30-second and 60-second measurements in either the student nurse or nurse group, supporting the accuracy of the 30-second measurement. It is important to note that Hollerbach & Sneed do not recommend counting for 10 or 15 seconds and multiplying accordingly due to an increasing error as the heart rate becomes faster. On the other hand, Margolius et al. (1991) argue that counting for 15- or 30-seconds is more accurate compared to counting for 60 seconds. Stankute (2022) also found counting for 15- or 30- seconds did not create any noticeable differences, and therefore suggests multiplying by 4 or 2 (respectively) yields an accurate pulse rate.

However, unlike Hwu et al. (2020) and Stankute (2022), Hollerbach & Sneed (1990) do not suggest counting for less than 30-second intervals and state using these time increments is not appropriate to estimate the 60-second resting pulse rates. In other words, more error was evident if the nurse only palpated for 10 or 15 seconds instead of 30 or 60 seconds. Although, it is important to recognize that the error was 2.86 bpm (10 seconds) and 2.44 bpm (15 seconds) and most likely would have not impacted a decision to withhold or give a contraindicated medication (which directly impacts patients' safety). However, calculations such as pulse deficit (i.e., the finding of an ECG heart rate greater than a palpated pulse count) are based on differences of only a few beats per minute.

Research in Acutely Ill Patients

In comparison to other research, Opio et al. (2017) conducted research with acutely ill patients. Opio et al. found that in acutely ill patients, there is a poor correlation between the radial pulse and the ECG heart rate, and that in clinical practice, the radial pulse should *not* be

used to determine the heart rate. Furthermore, Opio et al. noted that tachycardia increases the variance (decreases the accuracy) of radial pulse palpation and is the only independent predictor of a pulse deficit. Opio et al. also argue there was a poor correlation between heart rates recorded in the medical record and electrocardiogram (ECG) heart rates. In addition to human error, the radial pulse may be difficult to feel when the blood or pulse pressure is low, or the heart rate is rapid or irregular. Pulse rates over 100 beats per minute are recorded less accurately than slower rates, and frequent ectopic beats and atrial fibrillation are associated with a pulse deficit, although the bias was only 1 or 2 beats per minute.

Gudmundsdottir et al. (2021) found that when screening for atrial fibrillation, the most common irregular heart rhythm, ECGs were superior to radial pulse palpation. While Opio et al.'s results also strongly suggest that in clinical practice, the radial pulse should not be used to determine the heart rate in acutely ill patients, ECGs are expensive and not always available. Therefore, medical professionals must rely on their palpation skills to determine the patient's heart rate. Healthcare professionals often start with a set of vital signs (including a palpated pulse rate) to determine if a patient (who may or may not be in a heart monitor) is stable or unstable. Therefore, the most accurate method of pulse rate assessment, even in patients with fast or irregular rhythms, requires further investigation.

Methods

Sample and Setting

This research took place at a community hospital, designated as a level 2 trauma center, with 221 beds. Participants were either patients of the outpatient cardio-pulmonary rehabilitation program, or inpatients in a non-critical cardiovascular/telemetry unit. Two hospital staff nurses and an exercise physiologist – designated as part of the research team – determined if a

participant was alert, oriented, and able to describe their past medical history and current medications, and also considered the inclusion criteria. The assigned staff members worked with this group of participants on a regular basis and were therefore familiar with each individual participant's cognitive status.

The inclusion criteria were:

- Participants must be existing patients enrolled in the Cardio-Pulmonary Rehabilitation or patients in the Cardiovascular Care Unit at the hospital.
- Participants must be alert, oriented, and able to describe their past medical history.
- Participants must have a palpable radial pulse.
- Participants must be adults aged 18 or older.
- No forms of gender, race, and ethnicity will be excluded.
- Be able to speak and comprehend English fluently (as a primary or second language)
- Participants must already be on continuous telemetry monitoring.

A staff member approached participants and asked them if they would like to participate in a study about counting the pulse accurately, using the script to conduct this initial introduction (see Pulse Study Introduction Script, Appendix A). No participants chose to not take part in the study, but if they did not want to be involved in the study, there were no consequences, and the nurse or exercise physiologist would have thanked them and moved on. After participants agreed, the primary investigator (PI) and co-investigator introduced themselves and obtained informed consent.

Procedures and Data Collection Methods

Privacy was maintained by assigning participants a number, and the same number was recorded on other printed study materials (Demographic and Health History Questionnaire, Pulse

and Telemetry Data Collection Tool, and printed telemetry recording). Participants completed a Demographic and Health History Questionnaire (see Appendix B), either by reading and filling it in themselves, or by the PI or co-investigator readings and filling in the form based on verbal responses. No electronic medical records were accessed by the research team.

The researchers used continuous 5-lead telemetry monitoring as the gold standard comparison to the radial pulse palpation. The participant was already attached to the 5-lead telemetry as part of their visit, so no new monitoring devices were applied. Before taking the participant's radial pulse, the participant sat in a chair or lay in bed quietly for 5 minutes to decrease any initial anxiety and yield a more accurate pulse assessment (Jarvis, 2020).

Determining the Radial Pulse

After sitting (or lying) quietly for 5 minutes, the co-investigator located and began counting down the radial pulse aloud, from "three" to "zero." The right radial pulse was used unless the right radial pulse was difficult to palpate due to low pulse amplitude or tremors. At "zero," the PI started a one-minute timer and the printed telemetry recording. From "zero", the co-investigator continued counting upward from "zero." If there was an error with the machine or the counting process, the researcher started the counting process again from the beginning. The co-investigator continued counting the pulse aloud for 60 seconds.

Measures

To generate the data for pulse starting at "zero," the PI recorded the verbalized pulse count at 15, 30, and 60 seconds. The pulse count that was recorded at 15 seconds was multiplied by four and used for analysis. Similarly, the number recorded at 30 seconds was multiplied by two and used for analysis. The number recorded at 60 was compared directly to the telemetry. These numbers were also used to determine statistical means in later analysis. After counting for

60 seconds with a successful telemetry recording, the participant completed the session. The participant was then thanked for their time.

To generate data for pulse starting at "one," the researchers added 1 beat to the pulse rate recorded at 15, 30, and 60 seconds. Then, these numbers were multiplied to achieve beats per minute and were used in the analysis. Additionally, these numbers were also used to calculate means. To find the telemetry heart rate, the researchers immediately reviewed the 60-second telemetry recording, and hand counted how many ventricular depolarizations (QRS complexes) occurred in the 15, 30, and 60 second counting intervals. The researchers also interpreted and recorded the cardiac rhythm and recorded any abnormal beats (e.g., ventricular beats). If during counting the researchers noted a QRS complex directly on the 15 or 30 second line, the beat was included in the next time interval (because electrical depolarization precedes mechanical contraction). Any abnormalities on the telemetry recording were reported to the participant's assigned nurse or exercise physiology instructor.

Ventricular beats will always appear on the telemetry, but may or may not be perfused and result in a palpable pulse. Therefore, two different telemetry measures were used. The first telemetry measure that was used excluded ventricular beats and the second telemetry measure that was used included ventricular beats. These numbers were used to calculate the different telemetry means. Ventricular beats appear wider than normal QRS complexes, and therefore the researchers were able to identify which beats were ventricular. Conducting analysis with ventricular beats excluded decreased the discrepancy between the heart and pulse rates (due to a possible pulse deficit). However, by having a telemetry count with ventricular beats included, allowed the researchers to better understand the most accurate way to assess a pulse in a patient with cardiac abnormalities.

In the analysis, the researchers focused on difference scores. Difference scores were calculated by subtracting the telemetry number from the radial pulse count, (pulse - telemetry). A difference score of zero indicates no difference, or a perfect count. A positive difference score indicates an overcount, and a negative difference score demonstrates an undercount. The researchers also chose the significance cut off to be $p > 0.05$.

Reliability and Validity

The Demographic and Health History Form was created by the PI for the study, compiled based on the PI's clinical experience, but had not been tested before it was used. The participants were asked to complete the form to the best of their abilities; these self-reported findings may not be valid. For example, some participants had a printed medication list to refer to, and some tried to report their medications from memory. Similar errors occurred when reporting medical history, such as a patient reporting that "one doctor told me I had a heart attack, but another said I did not."

The same two researchers remained in the same roles (the co-PI counting the pulse and the PI starting the telemetry recording and timer) to increase interrater reliability. The PI had to start two devices simultaneously (stopwatch and telemetry recording), and manually recorded the first pulse stated out loud at 15, 30, and 60 seconds. Each of these methods introduces the possibility of measurement error. Participants were also recruited through connivence sampling, which decreases external validity. Additionally, the majority (96.67%) of the participants identified as "white persons," which reduces the external validity of the data.

It is important to note that the co-investigator was a student nurse with less experience palpating pulses, and therefore there may be some additional concerns for measurement error. The telemetry monitor was calibrated and serviced regularly by the biomedical department,

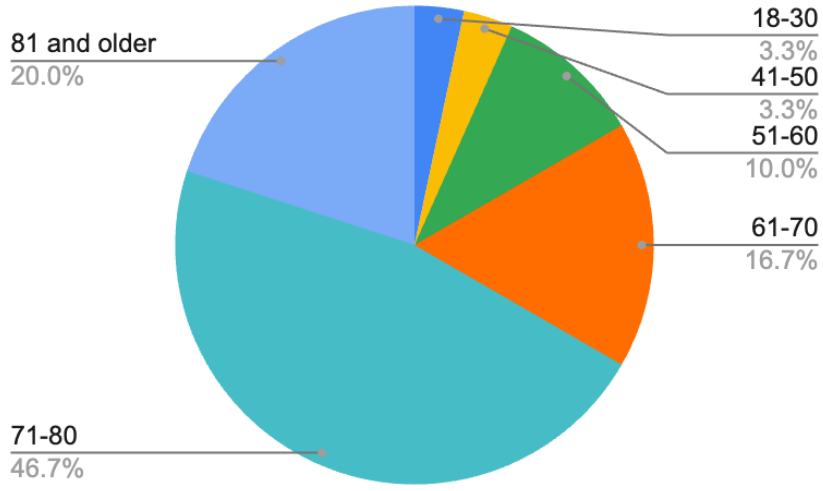
which means it was highly reliable and valid. However, participants in Cardiopulmonary rehabilitation were on a different telemetry system than inpatients (possibly impacting reliability and validity), but the other measurement methodology remained the same.

Results

Sample Characteristics

Figure 1

Age of Participants



There were 30 total participants, 16 men and 14 women. Twenty-one of the participants came from Cardiopulmonary Rehabilitation and 9 from a non-critical, inpatient Cardiovascular Care unit. One (3.33%) participant reported being 18 to 30 and 5 (16.67%) participants reported being 61 to 70 years old (Figure 1). Additionally, 19 (66.67%) participants reported being 71 or older, which means the data may be slightly skewed and not representative of all ages. No participants chose to withdraw from the study.

Most patients (23, 76.67%) were in sinus rhythm (as seen in Table 1); however, 13 of the 23 were in sinus rhythm with abnormal features, such as ventricular beats or heart blocks. Four (16.67%) participants had ventricular beats, and two had premature junctional contractions. One

(3.33%) participant was in atrial fibrillation, and one (3.33%) participant was in ventricular bigeminy. Four participants (13.33%) were in rhythm determined by an implanted pacemaker. Three (10%) of pulses were graded as a 1+/low amplitude, and the remaining 27 (90%) were graded as a 2+/normal by the co-investigator.

Table 1

Cardiac Rhythms of Participants, as Determined by PI

Cardiac rhythm or ECG feature	n (% of 30 participants)
Normal sinus rhythm	23 (76.67%)
Sinus rhythm with no superimposed abnormal beats or heart blocks observed	10 (33.33%)
Sinus rhythm with additional abnormal features (e.g., ventricular beats)	13 (43.33%)
Sinus arrhythmia	3 (10%)
Atrial fibrillation	1 (3.33%)
Ventricular bigeminy	1 (3.33%)
Paced (atrial or ventricular)	4 (13.33%)
Atrioventricular block	2 (6.67%)
Bundle branch block	4 (13.33%)
Premature ventricular contractions	4 (13.33%)
Premature atrial contractions	2 (6.67%)
Unknown [a]	1 (3.33%)

[a] unknown tachycardiac rhythm - RN notified

Table 2 includes the health history by self-report. The average number of comorbidities reported was 6.60, with a standard deviation of 3.14. Eleven (36.67%) participants reported being overweight or obese, significant given the causal link between obesity and cardiac disease. Almost half (13, 43.33%) of the participants reported having coronary artery disease, and many mentioned having multiple stents placed. Eight (26.67%) of the participants had a history of a

heart attack, and eight (26.67%) of the participants reported having a pacemaker or defibrillator. Nineteen participants (63.33%) reported hypertension. The form also gave a "free response" section under each category, labeled as other. One (3.33%) participant reported a congenital heart disease, and another reported hypertrophic cardiomyopathy. Ten patients (33.33%) reported having COPD/emphysema, and 10 participants (33.33%) reported having asthma. See Appendix C for the complete list of health history collected.

Table 2

Participant Health History by Self-Report, Including Positive Findings Only

Category	Specific behavior or diagnosis	n (% of 30 participants)
Lifestyle Factors	Drink alcohol	8 (26.67%)
	Current tobacco use	1 (3.33%)
	Previous tobacco use	6 (20%)
	Marijuana use (smoke)	1 (3.33%)
	Overweight or obesity	11 (36.67%)

Cardiovascular	Coronary artery disease	13 (43.33%)
	History of heart attack	8 (26.67%)
	Congested heart failure	5 (16.67%)
	Heart valve disease	10 (33.33%)
	Atrial fibrillation or flutter	2 (6.67%)
	History of cardiac arrest	2 (6.67%)
	Implanted pacemaker or defibrillator	8 (26.67%)
	Other heart rhythm problems	4 (13.33%)
	Hypertension	19 (63.33%)
	Low blood pressure	3 (10%)
	Carotid artery stenosis	2 (6.67%)
	History of DVT	3 (10%)
	History of pulmonary embolism	1 (3.33%)
	Other	1 (3.33%) hypertrophic cardiomyopathy 1 (3.33%) congenital heart failure

Pulmonary Disorders	Asthma	10 (33.33%)
	COPD/emphysema	6 (20%)
	Home oxygen use	4 (13.33%)
	Sleep apnea	5 (16.67%)
	Interstitial lung disease	2 (6.67%)

Table 3 includes a list of the medications the participants reported taking at the time of the study. A total of 262 medications were reported. The mean number of medications per participant was 8.73 (mode = 6, median = 7.5). These numbers were notable because polypharmacy is defined as taking 5 or more medications (Varghese et al., 2022) which demonstrates the complex health status of participants in the sample.

Antiplatelet medications were the most frequently reported (30 antiplatelet medications were reported from 23 [76.67%] participants, since some participants reported taking more than one antiplatelet). Twenty-six (86.67%) participants reported taking at least one type of dyslipidemia medication. Medications that antagonize the renin-angiotensin-aldosterone system (RAAS), such as ACE inhibitors and angiotensin receptor blockers, were also highly reported (n = 18, 60%). The category of "other" included medications that were reported only once or twice.

The frequency of medications reported that can affect heart rate are of particular importance to a study about heart rate and pulse. Twenty-one participants (70%) reported taking a medication that could increase or decrease their heart rate. A beta blocker is a commonly prescribed medication to lower blood pressure and heart rate, and over half of the participants reported taking one (n = 16, 53.33%). Additionally, beta-agonists, although inhaled, can increase heart rate. Diuretics do not directly influence heart rate, but indirect effects are possible (e.g.,

compensatory tachycardia due to volume depletion). Reflex tachycardia is a possible effect of certain vasodilators, such as nitrates and nonselective alpha-blockers. It is important to recognize that some patients were on multiple medications influencing heart rate or on medications that could have opposing effects (e.g., a decongestant can increase heart rate while a beta blocker would decrease heart rate). Participants' mean heart rates are displayed in Table 4.

Table 3

Participants' Current Scheduled Medications by Self-Report

Drug Class	n (% of 30 participants)
Medications that antagonize RAAS (ACE-i, ARB, aldosterone antagonists)	18 (60%)
Beta blockers[b]	16 (53.33%)
Calcium channel blockers	2 (6.67%)
Dihydropyridine (1)	
Non-dihydropyridine (1)[a]	
Diuretics[b]	14 (46.67%)
Vasodilators	2 (6.67%)
Nitrates[b]	2 (6.67%)
Medications for dyslipidemia	26 (86.67%)
Antiplatelets	23 (76.67%)
Anticoagulants	8 (26.67%)

Inhaled or nebulized beta agonists[a]	11 (36.67%)
Inhaled or nebulized muscarinic antagonists[a]	1 (3.33%)
Inhaled or nebulized steroids	2 (6.67%)
Insulins	4 (13.33%)
Oral diabetic medications	9 (30%)
Levothyroxine	11 (36.67%)
Multivitamin and other supplements	10 (33.33%)
Electrolyte supplements	14 (46.67%)
Medications for anxiety and depression	6 (20%)
Antihistamines	3 (10%)
Denosumab injection (Prolia)	3 (10%)
Analgesics	2 (6.67%)
Leukotriene receptor antagonists	2 (6.67%)
Dofetilide[b]	1 (3.33%)
Lidocaine patch[b]	1 (3.33%)
Vyndamax[a]	1 (3.33%)
Digoxin[b]	1 (3.33%)
Timolol[b]	1 (3.3%)
Latanoprost	1 (3.33%)

Hematopoietic Growth Factors	1 (3.33%)
Janus kinase (JAK) inhibitor	1 (3.33%)
Hydroxychloroquine	1 (3.33%)
Selective 5-HT3 Antagonist	1 (3.33%)
Skeletal muscle relaxants	1 (3.33%)
Nonsteroidal aromatase inhibitor	1 (3.33%)
Protectant	1 (3.33%)
Bile acid sequestrant	1 (3.3%)
Antacid	1 (3.33%)
5-alpha reductase inhibitors	1 (3.33%)
Antibiotics	1 (3.33%)
Anticonvulsant	1 (3.33%)
Osmotic laxative	1 (3.33%)
Xanthine oxidase inhibitor	1 (3.33%)
ARNi	1 (3.33%)
Steroid	1 (3.33%)
Decongestant[a]	1 (3.33%)
Nonselective alpha-1 blockers[b]	1 (3.33%)
Selective alpha-1 blockers	1 (3.33%)

Note. There were 4 unknown medications for the sample. Two "medications for high blood pressure," 1 "eye vitamin," and 1 misspelled medication that researchers were unable to identify.

[a]Medications that can increase the heart rate

[b] Medications that can decrease the heart rate

Table 4

Mean Pulse Rate and Mean Telemetry Rate

Counting method	15 second count x4	30 second count x2	60 second count
	M (*SD*)	*M* (*SD*)	*M* (*SD*)
Pulse rate, count started at 0	75.06 (14.92)	74.33 (13.65)	73.27 (12.46)
Pulse rate, count started at 1	79.07 (14.92)	76.33 (13.65)	74.27 (12.46)
Heart rate by telemetry, ventricular beats included			77.60 (14.50)
Heart rate by telemetry, ventricular beats excluded			75.60 (15.49)

Note. There is an exact 2-second beat difference between the telemetry means

Comparisons of Accuracy with Ventricular Beats Excluded

Zero Count

Two one-way ANOVAs were chosen to compare the accuracy of the counting intervals with a start count of "zero" and "one." First, the researchers ran a one-way within subjects ANOVA to test for a significant difference in accuracy (pulse palpation - telemetry) based on measuring intervals (15, 30, and 60 seconds) when the start number was "zero." Figure 2 illustrates the one-way ANOVA when starting the count with "zero." There was no statistically significant difference in accuracy across measuring intervals, $F(1.16, 33.61) = 3.53$, $p = 0.063$

(see Table 7, Figure 2). There was not a significant difference in accuracy between the counting interval of 15, 30, or 60 seconds. There was a 0.53 bpm to 2.33 bpm underestimate when the count began with "zero."

Researchers conducted dependent *t*-tests to determine if the accuracy for each interval was significant from no error (zero). Three dependent t-tests were run, one for each counting interval beginning with "zero". There was no significant difference when counting with different intervals. Accuracy did not differ from no error (zero) for each interval. See Appendix D for more details.

Table 7

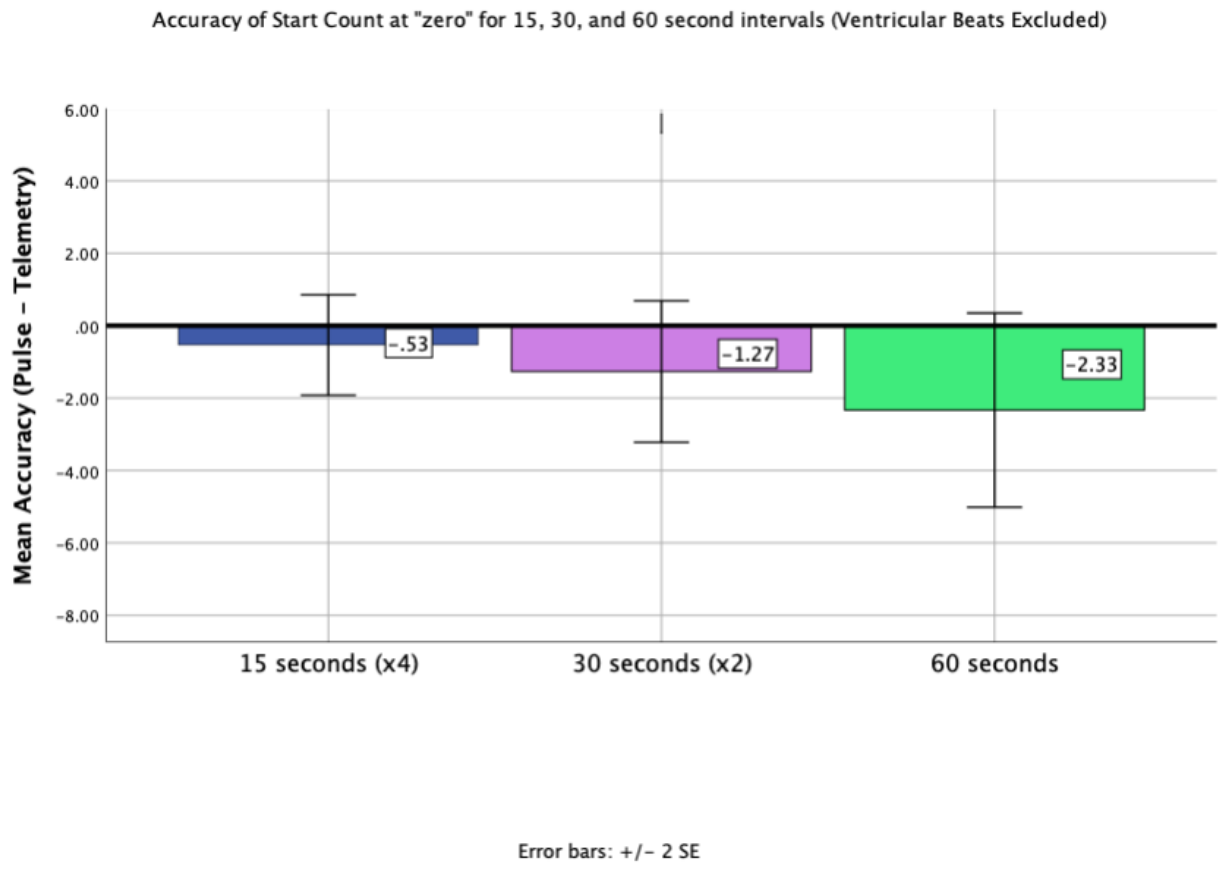
One-way ANOVA, Ventricular Beats Excluded

Counting method	15 seconds x4	30 seconds x2	60 seconds	
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*F*(2,29)
Pulse count started at 0	-0.54 (3.80)	-1.27(5.356)	-2.33(7.341)	3.53
Pulse count started at 1	3.47(3.80)	0.73 (5.356)	-1.33 (7.341)	24.96*

* $p < .001$

Figure 2

One-way ANOVA: Accuracy of Start Count at "Zero" for 15, 30, and 60 Second Intervals, Ventricular Beats Excluded



One Count

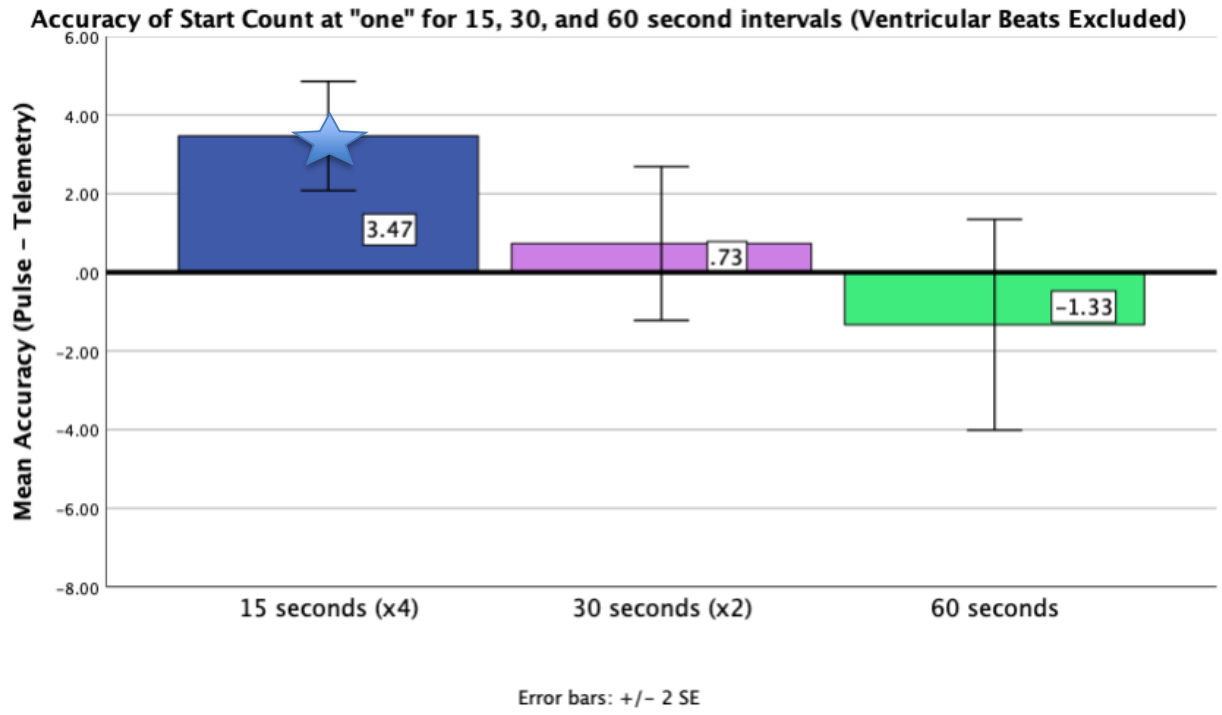
The researchers ran a one-way within subjects ANOVA to test for a significant difference in accuracy (pulse palpation - telemetry) based on measuring intervals (15, 30, and 60 seconds) when the start number was "one." Figure 3 demonstrates the one-way ANOVA when starting the count with "one." When starting the count with "one", there was a significant difference in accuracy across measuring times, $F(1.16, 33.61) = 24.96$, $p < 0.001$ (as seen in Table 7). Follow-up pairwise comparisons with Bonferroni adjustment showed a significant difference between all

3 interval accuracy measures. There was a 3.47 bpm overestimate and 1.33 bpm underestimate when the count begins with “one.”

Researchers again conducted dependent *t*-tests to determine if accuracy for each interval was significant from no error (zero). Three dependent t-tests were run, one for each counting interval beginning with “one.” There was a significant difference when counting for 15-seconds and then multiplying the number by 4, $t(2,29) = 4.99$, $p < 0.001$. When counting for 30 seconds (x2) and 60 seconds, there was no significant difference when counting. See Appendix D for more details.

Figure 3

One-way ANOVA: Accuracy of Start Count at “One” for 15, 30, and 60 Second Intervals, Ventricular Beats Excluded



Note. The blue star indicates significance.

Comparisons of Accuracy with Ventricular Beats Included

As stated earlier, ventricular beats always appear on the telemetry monitor, but may not be palpable. The researchers chose to conduct additional two one-way ANOVAs with ventricular beats included to compare the accuracy of the counting intervals for both a start count of "zero" and "one." Understanding how ventricular beats affect pulse assessment is helpful when trying to determine how to most accurately measure radial pulses in patients with cardiac abnormalities.

Zero Count

The researchers ran a one-way within subjects ANOVA to test for a significant difference in accuracy (pulse palpation - telemetry) based on measuring intervals (15, 30, and 60 seconds) when the start number was "zero," as seen in Table 8 and Figure 4. When starting the count with "zero," there was no statistically significant difference in accuracy across measuring intervals, $F(1.16, 33.61) = 3.53$, $p = -0.063$. In other words, there was not a significant difference in accuracy between the counting interval of 15, 30, or 60 seconds. However, for each interval, there was a 2.53 bpm to 4.33 bpm underestimate, or undercount.

Thus, researchers conducted dependent *t*-tests to determine if the accuracy was significant from no error (zero). Three dependent t-tests were run, one for each counting interval. There was a significant difference when counting for 60 seconds, $t(2,29) = -2.15$, $p < 0.05$. When counting for 15 seconds (x4) and 30 seconds (x2) there was no significant difference in accuracy from no error. See Appendix E for more details.

Table 8

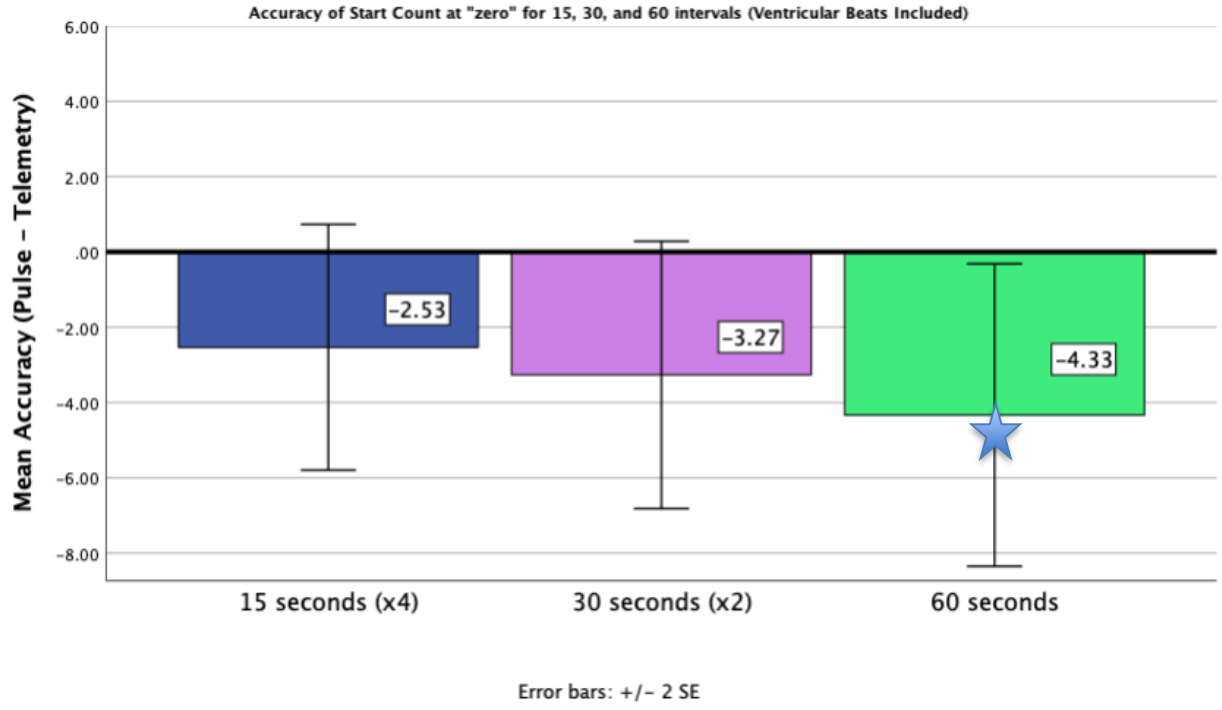
One-way ANOVA, Ventricular Beats Included

Counting method	15 seconds x4	30 seconds x2	60 seconds	
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*F*(2,29)
Pulse count started at 0	-2.53(8.94)	-3.261(9.72)	-4.33(11.0)	3.53
Pulse count started at 1	1.467(8.939)	-1.2607(9.72)	-3.33(11.0)	24.96*

* $p < 0.001$

Figure 4

One-way ANOVA: Accuracy of Start Count at "Zero" for 15, 30, and 60 Second Intervals, Ventricular Beats Included



Note. The blue star indicates significance.

One Count

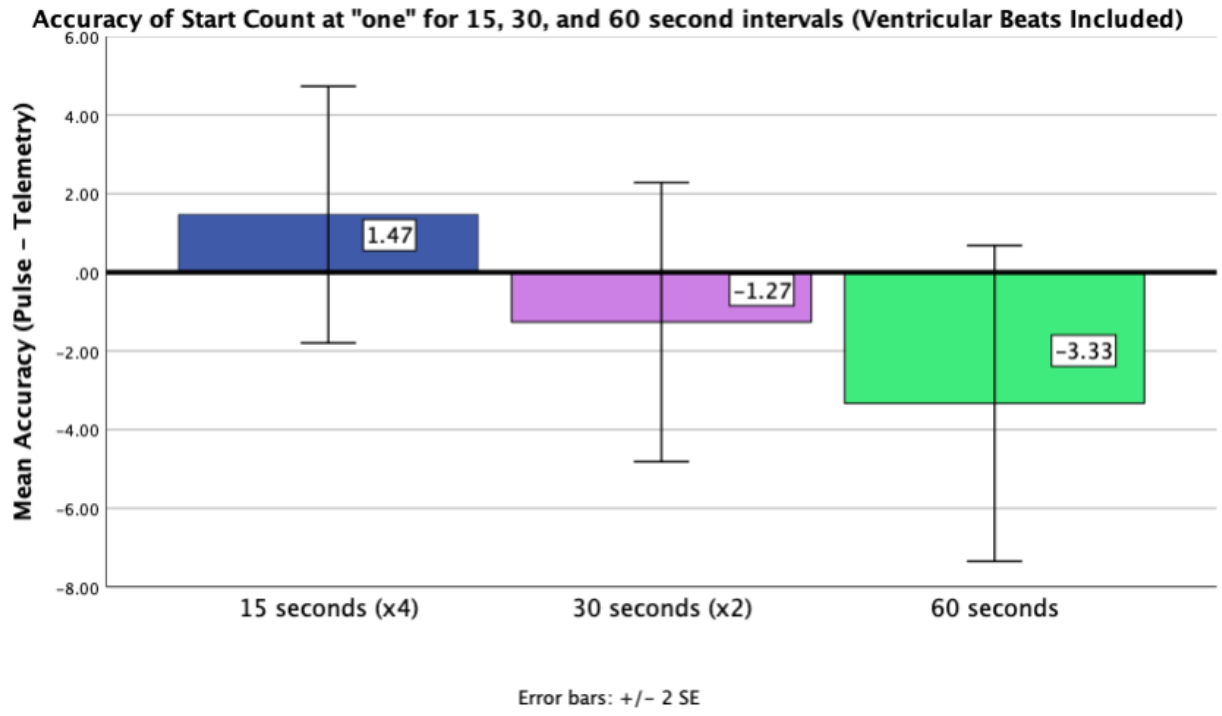
The researchers ran a one-way within subjects ANOVA to test for a significant difference in accuracy (pulse palpation - telemetry) based on measuring intervals (15, 30, and 60 seconds) when the start number was “one,” as seen in Table 8. Figure 5 demonstrates the one-way ANOVA when starting the count with “one.”

When starting the count with “one”, there was a significant difference in accuracy across measuring times, $F(1.16, 33.61) = 24.96$, $p < 0.001$ (as seen in Table 7). Overall significance and follow-up pairwise comparisons with Bonferroni adjustment showed a significant difference between all 3 interval accuracy measures. There is 1.47 bpm overestimate to 3.33 bpm underestimate when the count begins with “one.”

Researchers conducted a follow up dependent *t*-test to determine if the accuracy significant from no error (zero). Three dependent t-tests were run, one for each counting interval beginning with “one”. There was no significant difference when counting with different intervals. Accuracy does not differ from no error (zero) for each interval. See Appendix E for more details.

Figure 5

One-way ANOVA: Start Count at "One" and 15, 30, and 60 second intervals, Ventricular Beats Included



Discussion

Although a small sample size (n = 30) may have limited the number of statistically significant findings, it is important to recognize a clinically relevant trend: the smallest mean difference (in beats) was identified between telemetry with ventricular beats excluded and the pulse count beginning with "zero" (versus "one"). Furthermore, starting the count with "one" and counting for 15 seconds and then multiplying by 4 was the least accurate, as evidenced by the greatest mean difference (-3.47 beats, $p < 0.001$). This finding was likely due to beginning the pulse count at "one" being amplified by four. Additionally, any error occurring in the 15 seconds was multiplied by 4. The effect of beginning the pulse count at "one" is amplified at this counting interval, because the 15 second value is multiplied by four.

The data suggest starting at “zero” and counting for 15 or 30 seconds and multiplying to achieve beats per minute was the most accurate method. An important trend to focus on is that counting for 60 seconds was found to be the most inaccurate for both start times of “zero” and “one.” This finding was demonstrated by the largest mean difference and standard deviation occurring when counting for 60 seconds. Specifically, the mean difference and standard deviation when starting with “zero” was -2.33 beats (*SD* = 7.341), and when starting with “one” was -1.33 beats (*SD*= 7.341). The count could be off as much as 7 beats (as evidenced by the *SD* of 7.34) when starting with “zero” or “one” and counting for 60 seconds, as compared to the telemetry monitor without ventricular beats. When comparing the count to the 60 seconds including ventricular beats, the count can be off as much as 11 beats (as evidenced by the *SD* of 11.0) when counting for 60 seconds.

Understanding the theme of inaccuracy surrounding the 60 second interval is important as it contradicts other existing recommendations to count for an entire 60 seconds, especially in patients with abnormal cardiac rhythms (Jarvis, 2020). The researchers hypothesize that the count may have been more inaccurate when counting for 60 seconds because the co-investigator has a higher chance of losing count or becoming distracted with a longer counting interval.

The one-way ANOVAs demonstrated that whether including or omitting ventricular beats, beginning the count at “one” resulted in a significant difference from telemetry across all measuring intervals. Specifically, there was a significant difference between each count interval when beginning the count with “one.” This significant difference between each counting interval demonstrated that when beginning the pulse count with “one” and counting for different intervals, the results compared among those intervals cannot be assumed to be equal. On the

other hand, when the count begins with “zero” there was not a significant difference in accuracy between each count interval, and therefore it was more accurate.

Limitations and Strengths

As is customary for a pilot, the sample was intentionally small (n=30). The small sample size (n=30) likely made it challenging to achieve significant p-values. A larger sample could have increased the generalizability of the study and achieved more significant values. Additionally, the participant population was older, more chronically ill, and had more irregular cardiac rhythms than the average population. The demographics of the study sample (i.e., largely white and older persons) limit generalizability. However, this particular sample is still clinically relevant since the majority of hospitalized patients are older adults with at least one comorbidity. Additionally, the researchers relied on participants to self-report their medications and diagnoses. The use of self-report instead of accessing hospital records means some of the data collected may be inaccurate. For example, one participant verbally reported hyperthyroidism, but the researchers noted the participant was taking levothyroxine and verbally confirmed the participant actually had hypothyroidism. Previously mentioned threats to validity include a nursing student (less experienced) assessing the pulse and the use of an untested demographic questionnaire.

One strength of the study lies in the cardiac status of the sample population. Many of the recent studies completed include healthy young adults and limited to no cardiac problems. The use of older participants with cardiac rhythms other than normal sinus rhythm increased the generalizability of the findings to cardiac patients. The comparison of the palpated pulse to the telemetry monitor ensured the comparison was accurate.

Recommendations and Implications

Clinical Practice

Assessment of pulse may be more accurate when counting for shorter intervals of time, rather than the suggested 60 seconds. More specifically, although Jarvis (2020) recommends counting for 60 seconds for abnormal cardiac rhythms, this action may have yielded more inaccurate results. More emphasis should be placed on the idea that not all count intervals are equal, and counting for longer may be more inaccurate. Furthermore, when the pulse assessment began with "one" each counting interval was found to be significantly different from one another. This significance means that counting for 15 seconds and multiplying by 4, counting for 30 seconds and multiplying by 2, and counting for 60 seconds cannot be assumed to be equal (when the pulse count starts with "one").

The data continues to support the idea of counting the count with "zero" and not "one", which is consistent with Hargest (1974), Jarvis (2020), Hollerbach & Sneed (1990), and Stankute (2022). Despite Jarvis (2020) instructing to begin the pulse count from "zero," in clinical practice, many healthcare professionals begin the count with "one" (Hwu et al., 2020). Counting from "zero" would work to include the entire cardiac cycle, rather than starting with "one".

Although researchers have not collected enough data to make a clinical recommendation on what interval is the most accurate when assessing pulse rate, they anticipated that further research with a larger sample size could more definitively demonstrate two findings suggested by the current study: counting for 60 seconds may actually be less accurate, and counting for 15 seconds (especially when the count is started with "one") may be less accurate as compared to counting for 30 seconds and starting at "zero." Further research also needs to be done to determine the most accurate interval to count for when working with cardiac patients or patients who are tachycardic.

For patients with ventricular beats or ventricular rhythms, it may be beneficial for healthcare professionals to utilize the pulse reading on the screen from the telemetry monitor or an ECG. However, healthcare professionals need to also palpate the patient's radial pulse due to the fact that ventricular beats may or may not be fully perfused. Healthcare professionals must understand that the palpated pulse is reflective of the pulses that are actually perfusing blood through the body. For example, if a patient is in ventricular bigeminy, the monitor counting the patient's QRS may say 80 bpm, but when assessing the patient's radial pulse, the nurse may only count 40 bpm (i.e., the patient's actual perfused pulse rate could be significantly lower than what the monitor is reading). This discrepancy can mean organs are not receiving enough oxygenated blood. If the nurse relies solely on the telemetry monitor and does not count the patient's pulse, the nurse may administer a medication that could further lower an already bradycardic pulse or fail to recognize a significant change in patient's condition.

Future Research

External validity could be enhanced with a larger sample size for power and significance as well as an even distribution of well and hospitalized participants. Similarly, research needs to include a more even distribution across age and racial groups. Having multiple researchers palpate the pulse may also improve the generalizability of the findings, provided there is verification of interrater reliability. Future researchers would also benefit from conducting a power analysis, which the current researchers did not do because of the pilot nature of the study. Additionally, statistical analysis in the future may be easier to run and interpret if researchers did not compare each number to the same telemetry number (with or without ventricular beats). For example, if researchers measured the patient's pulse beginning with "zero" for one minute, and then a few minutes later took the patient's pulse and began the count with "one". Taking the

patient's pulse in this way would allow the researchers to compare the pulse count beginning with "one" to a separate one-minute telemetry recording.

Additionally, having a larger sample of patients without ventricular beats and with ventricular beats may allow for a better comparison of the impact ventricular beats have on the accuracy of pulse count. Future research could also be dedicated to counting pulse rates when a patient is tachycardic to determine if the elevated pulse rate impacts the counting accuracy. Future research could also focus on tachycardia and if there is a more accurate counting interval or if beginning the pulse count with "zero" or "one" yields the most accurate results.

When only using telemetry, the researchers are unable to tell what QRS complexes result in a palpable pulse. For example, it is not possible by looking at a ventricular beat on telemetry on even a 12-lead ECG to know if the beat has been perfused or not. Dedicated research needs to focus on the issue of non-perfused beats, specifically ventricular beats, and how they should be accounted for when running statistical analyses. Future research may be more accurate if it included both electrical heart rate and pulse waveform analysis through the use of pulse oximetry. Pulse oximetry would measure the pulse at the exact same time as it is being palpated and could help to address the issue of a pulse deficit, because a non-perfused or poorly perfused beat could possibly be detected on a pulse waveform analysis.

Conclusion

The researchers found that counting for 60 seconds may not yield the most accurate results when the patient has cardiac abnormalities. The counter may be off as much as -1.33 beats per minute when beginning the pulse count with "one", and as much as -2.33 beats per minute when beginning with "zero". However, the researchers' findings do support Jarvis (2020) and Hargest's (1974) recommendation to start the count with "zero" and not "one". Additionally,

the researchers found that beginning the pulse count with “one” counting for 15 seconds and then multiplying by 4 was the least accurate method, as evidenced by a mean difference of -3.47 beats per minute. Further research about counting interval needs to take place to ensure the most accurate assessment is taking place, and also include a variety of heart rates and rhythms.

As telemetry monitors are becoming more common, many nurses may be abandoning the practice of actually palpating their patients’ pulse rates. However, this study reinforced the need for this essential skill, especially since ventricular beats that are poorly perfused or non-perfused are still counted in the heart rate by telemetry. Pulse palpation is still a crucial skill that determines safe clinical judgment and nursing care.

Acknowledgements

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Appendix A

Subject Recruitment Script

Hello [subject name]. My name is [insert name], and I am a [nurse/ exercise physiologist] at X Hospital, specifically on the [Cardiac Rehab/ CVCU floor}. I am helping conduct research at Illinois Wesleyan University, run by Dr. Lydia Bertschi from the Nursing Department. This study is about radial pulse assessment.

The researchers are hoping to better improve the care that patients receive, specifically by increasing the accuracy of how health care providers count your pulse rate. For example, if a nurse has counted a patient's pulse inaccurately, a patient may be given a medication that is not needed or not receive a needed medication.

This study includes having researchers from Illinois Wesleyan University count your pulse for one minute aloud and compare it to the heart monitor you are wearing. Your participation in the study includes signing an informed consent, filling out a confidential Demographic Data and Health Questionnaire, and then having the researcher count the pulse on your wrist for one minute. To count your pulse, the researchers will help you to sit in a chair if possible. After counting your pulse rate, the researchers will compare that number with heart rate from the telemetry monitor on your chest. We anticipate your participation should take about 15 to 20 minutes, and is a one-time commitment. You will not be paid for participating in this study.

Participation in this study is voluntary, and your identity as a participant will be protected before, during, and after the time that study data is collected. The signed consent forms will be kept in a locked cabinet at Carle and the other forms will not have patient identifiers on them, and will be kept in the same locked cabinet.

Do you have any questions I can answer or the researchers can answer? If you have questions you may ask Dr. Lydia Bertschi or Abigail Mathis, who will conduct the consent process and the study activities with you.

Would you like to participate in this study?

Appendix B

Demographic and Health History Form

IRB Number: 22CRU3724
Date: 01-26-23

Accurate Pulse Assessment by Radial Artery Palpation: A Pilot Study
Participant Data and Health History Form

Basic Information

What is your age?

- ☐ 18-30
- ☐ 31-40
- ☐ 41-50
- ☐ 51-60
- ☐ 61-70
- ☐ 71-80
- ☐ 81 and older

Indicate how you identify yourself:

- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ White
- ☐ Prefer not to say

Indicate your sex assigned at birth:

- ☐ Male
- ☐ Female
- ☐ Intersex
- ☐ Prefer not to say

Past Medical History

If you have each listed diagnosis or problem, please place a check in the box.

General History

- ☐ Drink alcohol
- ☐ Smoke tobacco currently
- ☐ Used to smoke tobacco
- ☐ Other tobacco products (chewing, vaping)
- ☐ Use other drugs (for example, marijuana or cocaine)
- ☐ Overweight or obesity
- ☐ Chronic pain

Lungs and Breathing

- ☐ Asthma
- ☐ COPD
- ☐ Emphysema
- ☐ Lung cancer
- ☐ Tuberculosis
- ☐ Use oxygen at home
- ☐ Sleep apnea
- ☐ Other_____

IRB Number: 22CRU3724
Date: 01-26-23

Brain and Nervous System

- ☐ Stroke
- ☐ Transient ischemic attack, or mini-stroke
- ☐ Brain tumor
- ☐ Traumatic brain injury
- ☐ Seizures
- ☐ Parkinson's disease
- ☐ Dementia
- ☐ Multiple sclerosis
- ☐ Myasthenia gravis
- ☐ Spinal cord injury
- ☐ Hearing loss
- ☐ Depression
- ☐ Anxiety
- ☐ Other_____

Genitourinary and Kidneys

- ☐ Enlarged prostate
- ☐ Urinary incontinence
- ☐ Kidney failure or disease
- ☐ Dialysis
- ☐ Other _____

Gastrointestinal (stomach, liver, bowels)

- ☐ Acid reflux or GERD
- ☐ Ulcers
- ☐ Gastrointestinal bleeding
- ☐ Bowel obstruction
- ☐ Ostomy
- ☐ Pancreatitis
- ☐ Hepatitis
- ☐ Cirrhosis
- ☐ Liver failure
- ☐ Other_____

Heart and Blood Vessels

- ☐ Coronary artery disease
- ☐ Heart attack
- ☐ Congestive heart failure
- ☐ Heart valve disease
- ☐ Atrial fibrillation or atrial flutter
- ☐ History of cardiac arrest
- ☐ Implanted pacemaker or defibrillator
- ☐ Other heart rhythm problems _____
- ☐ High blood pressure, or on medications to treat high blood pressure
- ☐ Low blood pressure, or on medications to treat low blood pressure
- ☐ Peripheral arterial disease (blocked arteries to your legs)
- ☐ Carotid artery stenosis (narrowing of carotid arteries)
- ☐ Renal artery stenosis (narrowing of arteries to your kidneys)
- ☐ History of deep vein thrombosis (blood clot in the legs or a major vein)
- ☐ History of pulmonary embolism (blood clot in the lungs)
- ☐ Other _____

IRB Number: 22CRU3724
Date: 01-26-23

Other Medical Problems

- ☐ Cancer (indicate type of cancer _____)
  - ☐ Currently have cancer
  - ☐ Cancer in remission or cured
- ☐ Diabetes
- ☐ Hypothyroidism (low thyroid)
- ☐ Hyperthyroidism (overactive thyroid)
- ☐ Blood clotting disorder (for example, Von Willebrand disease or Factor V Leiden)
- ☐ Autoimmune disease (for example, psoriasis, rheumatoid arthritis, or lupus)
- ☐ Osteoarthritis (painful joints from "wear and tear")
- ☐ Anything else you would like us to know about

_____
_____
_____
_____

Current Medications

Please list your medications to the best of your ability.

_____
_____
_____
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_____

Appendix C

Full Results: Health History by Self-Report

Category	Specific behavior or diagnosis	n (% of 30 participants)
Lifestyle factors	Drink alcohol	8 (26.67%)
	Current tobacco use	1 (3.33%)
	Previous tobacco use	6 (20%)
	Marijuana use (smoke)	1 (3.33%)
	Overweight or obesity	11 (36.67%)
Cardiovascular	Coronary artery disease	13 (43.33%)
	History of heart attack	8 (26.67%)
	CHF	5 (16.67%)
	Heart valve disease	10 (33.33%)
	Atrial fibrillation or flutter	2 (6.67%)
	History of cardiac arrest	2 (6.67%)
	Implanted pacemaker or defibrillator	8 (26.67%)
	Other heart rhythm problems	4 (13.33%)
	Hypertension	19 (63.33%)
	Low blood pressure	3 (10%)
	Carotid artery stenosis	2 (6.67%)
	History of DVT	3 (10%)
	History of pulmonary embolism	1 (3.33%)
	Other	
	Hypertrophic cardiomyopathy	1 (3.33%)
	Congenital heart failure	1 (3.33%)
Pulmonary disorders	Asthma	10 (33.33%)
	COPD/emphysema	6 (20%)
	Home oxygen use	4 (13.33%)

	Sleep apnea	5 (16.67%)
	Interstitial lung disease	2 (6.67%)
Neurological disorders	Stroke	2 (6.67%)
	Traumatic brain injury	1 (3.33%)
	Multiple sclerosis	1 (3.33%)
	Spinal cord injury	1 (3.33%)
	Hearing loss	7 (23.33%)
	Depression	1 (3.33%)
	Anxiety	2 (6.67%)
	Essential tremors	1 (3.33%)
Genitourinary and kidneys	Enlarged prostate	1 (3.3%)
	Urinary incontinence	2 (6.67%)
	Kidney failure or disease [a]	2 (6.67%)
Gastrointestinal	Acid reflux or GERD	6 (20%)
	Ulcers	1 (3.33%)
	GI bleeding	1 (3.33%)
Other medical problems	Cancer current	1 (3.33%)
	Cancer in remission or cured	8 (26.67%)
	Diabetes	7 (23.33%)
	Hypothyroidism	8 (26.67%)
	Hyperthyroidism	1 (3.3%)
	Autoimmune disease [b]	9 (29.93%)
	Osteoarthritis	1 (3.3%)
	Chronic pain	6 (20%)
	Other (free response) [c]	6 (20%)

[a] No patients reported receiving dialysis treatments.

[b] Self-report included psoriasis, rheumatoid arthritis, and lupus.

[c] One report each of prediabetes, gout, increased IgA, muscular dystrophy, sarcoidosis, and fibromyalgia.

Appendix D

Paired Sample *t*-Tests: Pulse Count Compared to Heart Rate by Telemetry, Ventricular Beats Excluded

Start Point	Count time	Mean Difference (*SD*)	*t* (29)
0	15 seconds x4	-0.54 (3.80)	-0.768
	30 seconds x2	-1.27 (5.356)	-1.295
	60 seconds	-2.33 (7.341)	-1.741
1	15 seconds x4	3.47 (3.80)	4.993*
	30 seconds x2	0.73 (5.356)	0.750
	60 seconds	-1.33 (7.341)	-0.995

*$p < 0.001$

Appendix E

Paired Sample *t*-Tests: Pulse Count Compared to Heart Rate by Telemetry, Ventricular Beats Included

Start Point	Count time	Mean Difference (*SD*)	*t* (29)
0	15 seconds x4	-2.533(8.939)	-1.552
	30 seconds x2	-3.261(9.72)	-1.840
	60 seconds	-4.33(11.0)	-2.157*
1	15 seconds x4	1.467(8.939)	0.899
	30 seconds x2	-1.26(9.72)	-0.714
	60 seconds	-3.33(11.0)	-1.659

*****$p < 0.05$