Abstract – Accurate and reliable pain management in newborn infants has been a challenging task that has been investigated extensively in the neonatal infant population. Today, several scales and measures are available to evaluate pain; however, instruments and techniques that are absolutely valid, reliable and clinically feasible are not yet in place. There is lack of research in the area of physiological indicators and their usability in measuring pain and its validity. For this reason, this design approach will review and analyse how physiological parameters can aid in identifying an abnormal response such as pain.

I. INTRODUCTION

Pain management in neonatal infants has proven to be a highly challenging task. There remains a challenge in how we can better recognize and respond to neonatal pain. There is lack of research in the area of physiological indicators and their usability in measuring neonatal pain accurately. Since the scales in place currently are not fully equipped to provide most accurate results, it is important to re-design the approach. To do this, focus on the continually altering physiological variables can be used. Pain measurement scales in use today are highly based on behavioural indicators. These behavioural indicators tend to at times become inadequate as the premature infants are mostly heavily sedated or are not able to move due to under-development. Behaviour indicators are sensitive to fear or anxiety as well as pain, and they may underrate pain intensity relative to self-report measures in patients with persistent pain [1]. It will be immensely useful to have objective signs of subjective change; however, at present, these signs are not being utilized precisely. If pain assessments were to be performed as frequently as heart rate, temperature, and respiratory rate, patients would benefit. Evidently then, we can use these objective physiological indicators to carefully quantify abnormalities or pain in the premature infants.

The main objective of the proposed research design will be to evaluate the impact of physiological parameters in the assessment of neonatal pain. Neonatal pain scoring can perhaps be improved by closely analyzing patterns in physiological data streams of these neonatal patients. This approach will be carried out by prospectively reviewing three different neonatal pain scales (PIPP, CRIES, and BPSN) and analysing the physiological variables: heart rate, respiratory rate, oxygen saturation and amplitude-electroencephalogram patterns. The Artemis platform will be used to prospectively collect physiological data. The scales and physiological data will be correlated and analysed to demonstrate the positive usability of physiological parameters within the domain of neonatal pain management.

II. PREVIOUS RESEARCH

Until the 1990’s, newborns in some clinical centres were undergoing surgery with minimal anaesthesia as it was believed that neonates are not able to feel pain. In addition, newborns received little or no pain management postoperatively or for painful procedures such as lumbar punctures or circumcisions [2]. Since then, there have been greater advances and awareness amongst clinicians that pain may be experienced from the earliest stages of postnatal life [2]. Lowery and colleagues state in a study that Connections to the thalamus begin at 14 weeks and are completed by 20 weeks, and thalamocortical connections are present from 13 weeks and are more developed by 26 to 30 weeks [3]. These findings go to show that premature infants are indeed able to feel pain. Despite of these revelations, it is a substantial challenge to measure how much pain infants are experiencing if the assessment is majorly focused on behavioural factors.

One of the most used physiological parameters in the domain of neonatal pain is that of heart rate (HR). Changes in HR are widely used as markers of reactivity to a painful event in preterm and term infants. Characteristic increases in HR following a painful event can be readily identified because HR is easy and relatively inexpensive to acquire. For this reason, HR signal is often considered a useful measure of pain reactivity in clinical settings where distress signals are frequently nonspecific and ambiguous. Even the most premature infants have the capacity to increase their HR in response to a painful or distressing event, which reflects generalized central nervous system (CNS) arousal and in particular

Design of an Approach for Detection of Pain by Investigating Abnormalities in Physiological Responses in Premature Infants
Tanvi Naik¹, Carolyn McGregor²

¹Faculty of Health Science, ²Faculty of Business and Information Technology
University of Ontario Institute of Technology, Oshawa, ON
Tanvi.naik@uoit.ca

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sympathetic nervous system activation [4]. Systems that tend to control cardiovascular functions are closely linked to mechanisms that modulate pain reactivity, thereby, making HR responses a potentially useful physiological index of reactivity to painful events in infants [4].

The systems modulating the perception of pain are coupled closely with the cardiovascular system. Therefore, the most common physiological pain responses usually include those that are coupled with the stress response. These responses include: increases in heart rate, respiratory rate, blood pressure, intracranial pressure, palmar sweating, and decreases in vagal tone, heart rate variability, oxygen saturation, carbon dioxide levels, and peripheral blood flow [5]. Neonates usually tend to show increase in heart rate and decrease in heart rate variability (HRV) when exposed to a pain stimuli. During a study done on heel lancing, it was shown that the HR increased and the total HRV and the spectral power of the low frequency band decreased in preterm infants during heel lancing and squeezing of the heel [6]. Thus, analysis of HRV may offer a possibility of grading the level of distress caused by pain [7]. This can prove to be a useful tool in determining the intensity of pain from mild to severe. The background research by Stevens and Johnston in 1994 also showed that the heel prick was able to give rise to an increased heart rate and decreased oxygen saturation in preterm infants.

III. PROPOSED METHOD

To assess the hypothesis of neonatal pain scoring improvement by closely analysing physiological data streams; the proposed study will be designed as a prospective cohort study. Data will be acquired and recorded by a decision support system named Artemis. Artemis platform is a framework for concurrent multi-patient, multi-diagnosis and multi-stream temporal analysis in real-time for clinical decision support and both prospective and retrospective clinical research [8]. This clinical platform is able to store the raw physiological data from multiple infants at the rate the data are generated. Thus, Artemis will acquire real-time data from several bedside monitors. Heart rate, respiratory rate, blood oxygen saturation, and blood pressure will be captured continuously using the Artemis platform for this study. Artemis employs IBM’s InfoSphere Streams, a streaming middleware that processes data in real-time enabling data storage within the Data Persistence component. In addition to this, three most frequently used neonatal pain scales will be used. Premature Infant Pain Profile (PIPP), Bernese Pain-Scale for Neonates (BPSN) and CRIES (C: crying; R: requires increase oxygen administration; I: Increased vital signs; E: expression; S: sleeplessness) will also be measured as they are some of the most frequently used pain measurement tools in the Neonatal Intensive Care Units (NICU).

IV. CONCLUSION

It has been a challenge to standardize the practice of neonatal pain scoring till date. The challenge has been to bridge the gap between research and clinical practice and devising a method that is suitable in all circumstances and conditions. Despite the fact that the scientific community has moved past misconceptions, the neonatal population still lacks a ‘gold standard’ to measure pain precisely. Pain management scales today are highly focused on behavioural changes such as crying and body movements. However, premature infants have multiple factors that limit or prevent the demonstration of these behavioural changes. For this reason, it is important to evaluate this novel approach to closely analyse patterns in the various physiological variables to quantify neonatal pain more accurately.

V. REFERENCES