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# PAIN MANAGEMENT AND ASSESSMENT USING TECHNOLOGY: A SYSTEMATIC LITERATURE REVIEW

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## ABSTRACT

In order to reduce or manage pain, strategies and treatments must be put into practice. It incorporates a multidisciplinary strategy that takes into account psychological, social, and cultural elements in addition to the physiological aspects of pain. An essential part of successful pain management is pain evaluation. In order to gain a deeper understanding of the patient's experience, it entails methodically assessing and analyzing the degree, duration, location, and aspects of pain. Technology offers measurable and reliable ways to quantify pain. Healthcare practitioners can get real-time data through wearable devices, biosensors, and imaging techniques, which improves the accuracy of pain diagnosis. In situations where subjective self-reporting may be difficult, for as in non-verbal groups or people with cognitive disabilities, objective assessments are very helpful. This literature study examines the field of pain treatment and evaluation through the lens of technology by synthesizing the results of 44 research publications that were sourced from reputable sources, such as IEEE, ACM, ScienceDirect, and Springer. The study uses a methodical technique to classify information taken from the papers into a table that outlines the different kinds of pain, the populations it is intended for, and the particular technological solutions used. This study provides a comprehensive overview of the present and future potential of technology-driven approaches in pain management and evaluation, making it an invaluable resource for researchers, technologists, and healthcare practitioners.

**Keyword:** Pain management, pain assessment, technology-based solution

## INTRODUCTION

Pain is a prominent and significant reason to seek medical assistance for individuals. Pain can have significant wider consequences on wellbeing when it lasts for weeks or months.(Gureje et al., n.d.) When pain is untreated and persistent, it negatively impacts almost every element of a patient's life. It causes worry and mental anguish, compromises wellbeing, obstructs functioning, and makes it more difficult to carry out social, professional, and familial responsibilities. It seems obvious that pain would have the effect of lowering quality of life with such wide-ranging effects (Katz, 2002).

A World Health Organization study found that people who experience chronic pain are more than twice as likely to struggle at work and are four times more likely to experience anxiety or depression than people who do not.(Gureje et al., n.d.) The subjective character of pain makes both diagnosis and assessment extremely difficult. As an individual and personal experience, pain is challenging to evaluate, particularly in individuals who have trouble communicating effectively, including those suffering from dementia or cognitive impairment.(Breivik et al., 2008)

An increasing number of people are realizing that objective pain measurements are necessary due to the shortcomings of subjective pain assessment. Assessing pain objectively is essential for early diagnosis, tracking the course of a disease, and determining the effectiveness of treatment, especially when it comes to managing chronic pain.(Xu & Huang, 2020)

An increasing body of research supports the use of digital health for pain treatment, diagnosis, and assessment.(Hadjiat & Arendt-Nielsen, 2023) Digital medical devices, wearable technology, virtual reality, and electronic pain assessment tools are just a few of the technologies that are currently being employed in pain evaluation and management. It has been demonstrated that these technologies improve higher-quality pain assessment, which improves patient outcomes and experiences.(Afolalu et al., n.d.)

The goal of this review of the literature is to look into how technology, assessment, and pain management are interacting. This review aims to provide meaningful insights into the dynamic evolution of pain management and assessment through the integration of technology by closely examining the current state of pain management, the technologies being used, current challenges, and the potential role of technology in overcoming these obstacles.

## *1.* Background

Pain is a complicated, multidimensional experience that affects people's physical, psychological, and social well-being and has major consequences for healthcare. "An unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage" is how the International Association for the Study of Pain defines it.(Xu & Huang, 2020)

Acute pain has a useful biological purpose. It is the body's typical response to harm from conditions like diseases, injuries, and surgeries. The wound heals and the discomfort lessens with time. Usually lasting less than three months, acute discomfort goes away on its own with little to no help.(Goesling et al., 2018a)

Pain is deemed chronic if it lasts for more than three to six months. There is no one element that determines who may experience chronic pain, despite the identification of a number of risk factors. Unlike acute pain, which subsides within a typical amount of time, chronic pain lacks a biological cause and is far more closely linked to psychological issues.(Goesling et al., 2018a)

Globally, the costs of chronic pain are increasing for both individuals and society, underscoring the necessity of precise pain assessment for early diagnosis, tracking the course of a disease, and assessing the effectiveness of treatment.(Xu & Huang, 2020)

Since pain is a subjective feeling by definition, assessing it can be difficult due to its subjective character. A subjective method called the "gold standard" is one of the subjective techniques used to evaluate pain.

The "gold standard" for assessing pain is based on a patient's self-report of their level of pain on a scale from 0 to 10, where 0 denotes no pain and 10 denotes the most severe pain. Tools like the Verbal Rating Scale (VRS), Visual Analogue Scale (VAS), and Numerical Rating Scale (NRS) are used for this. These one-dimensional assessment instruments, nonetheless, have drawn criticism and discussion for being overly simplistic and having little practical use.(Kasaeyan Naeini et al., 2019a)

Therefore, creating an objective pain assessment tool is essential to enhancing non-communicative patients' treatment processes and overall well-being. With a more precise diagnosis and quicker treatment, this kind of instrument can also help other patient populations.(Kasaeyan Naeini et al., 2019a)

In order to measure pain more precisely and consistently, efforts have been undertaken to create objective instruments for the purpose. A method for measuring and documenting pain is to use mobile applications.(Abahussin et al., 2020a) Certain wearable technology allows for continuous and objective pain evaluation by analyzing physiological information in real time.(Yang et al., 2019a)Another kind of workable option is to assess pain based on information about facial muscle action.(Guo et al., 2021a)

With the help of these technological developments, pain management and evaluation will become more objective and all-encompassing, and healthcare providers will have access to more accurate and trustworthy data to guide clinical judgment calls and enhance patient care.

## 2. Research methodology

### 3.1 Search String Selection

The research methodology used a thorough process to find relevant research data on the subject of technology-assisted pain management and assessment. Boolean combinations (AND/OR) of these keywords were used to reduce the retrieval of irrelevant literature, and a range of important terms was created to assure maximum coverage. We use search terms like "pain management and assessment and technology," on all of the databases that were chosen and searched the relevant literature.

### 3.2 Research questions

**RQ 1:** What kinds of pain are covered by the research article, and whose groups are the subjects of interest from the year 2018 to 2023?
**RQ 2:** Which specific technologies are employed in the studies for pain evaluation and management, such as wearables, mobile applications, and virtual reality and what are their application in term of pain management?
**RQ 3:** Which outcome metrics, such as reduced pain, enhanced function, and patient satisfaction, are used to assess how well pain management technologies work?

**RQ 4:**

### 3.3 Research Database Selection

The ACM, IEEE, ScienceDirect, and Springer databases were specifically chosen to guarantee a thorough approach to locating appropriate literature on the subjects of technology, evaluation, and pain management. These databases are well-known for their broad coverage of transdisciplinary research, computer science, engineering, and healthcare, which makes them ideal for gathering material on the nexus between technology and pain treatment.
A wide variety of literature was found in the search results from these databases. This wide range of literature demonstrates how well the databases that were chosen were able to gather literature from a variety of fields, adding insightful information and insightful results to the literature study from a variety of angles and sources.

### 3.4 Search Results Retrieval

The search terms "pain management" AND "assessment" AND "technology" produced a total of 25 papers from IEEE, 126 articles from ACM, 10,106 articles from ScienceDirect, and 220 articles from Springer in the first search results from the databases that were chosen.

### 3.5 Inclusion and exclusion

**Inclusion:**

- English must be the study's published language.
- The research needs to be easily obtainable.
- The study has to concentrate on how technology such as wearables, smartphone apps, and virtual reality is used to manage pain.

**Exclusion:**

- The study must not be released before 2018, as there have been considerable developments in technology since then.
- This literature review focuses on primary research publications, hence the study cannot be a conference paper or a book.

### 3.6 Filtering

The number of articles that obtain from each database following the application of the first title filter are as follows: There are 25 articles from IEEE, 126 from ACM, 52 from ScienceDirect, and 220 from Springer. Once we integrated only the research papers from each database, we have 130 articles from Springer, 14 articles from ScienceDirect, and 74 articles from ACM.
A filter for publications published between 2018 and 2023 used in order to further refine the search results. As a result, 83 publications from Springer, 4 from ScienceDirect, 13 from ACM, and 17 from IEEE were produced. The systematic process of refinement guarantees that the literature evaluation covers a specific and timely set of academic publications, improving the accuracy and relevance of our investigation into the relationship between pain management, assessment, and technology.

### 3.7 Duplicate Removal:

After using filtration to extract search results, we found and eliminated duplicate papers using Excel. There were 117 papers in total, but no duplicates were discovered.

### 3.8 Relevance Assessment:

After evaluating 117 publications using the relevance assessment, we found 40 articles that were useful to

our analysis of the literature. We were able to reduce the number of articles on the list and concentrate on the most appropriate research thanks to this thorough evaluation approach, which also laid a strong basis for the literature's evaluation.

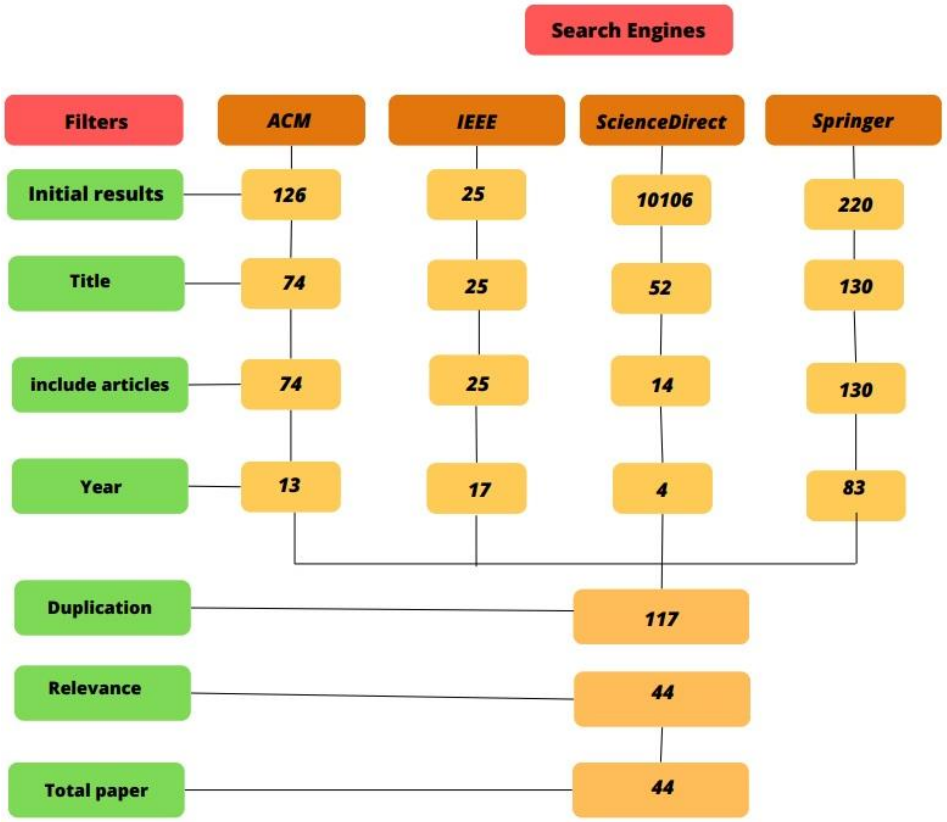


*Figure 1.1 Literature Searching using database*

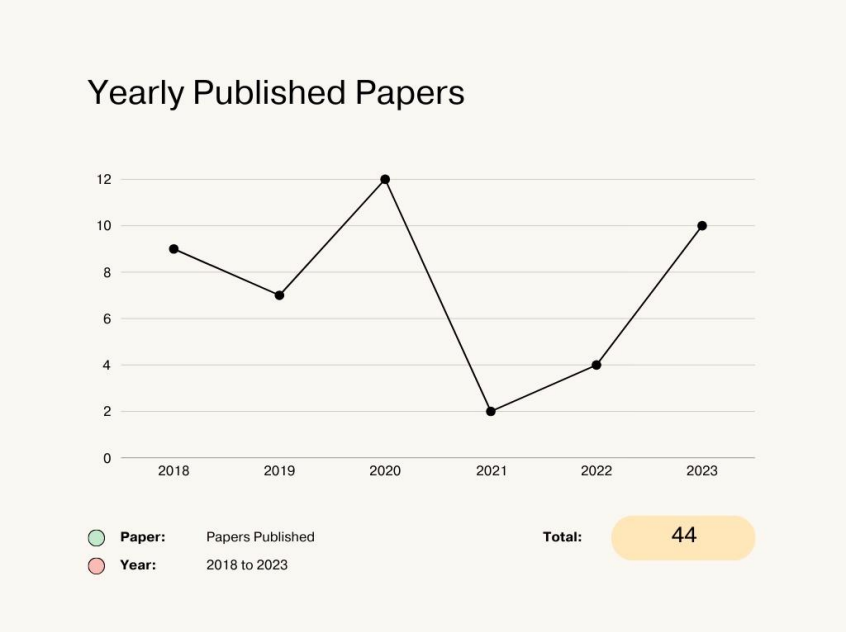


**Figure 1.2 Yearly published paper**

## *3.* Discussion

**RQ: 1**

**What kinds of pain are covered by the research article, and whose groups are the subjects of interest from the year 2018 to 2023?**

**Table 1.1 Kind of pain and targeted population**

| No. of articles | *Year* | *Kind of pain* | *Targeted population* |
|---|---|---|---|
| *Article-1* (Goesling et al., 2018b) | *2018* | *Chronic pain* | *Individuals living with chronic pain and comorbid mental health issues* |
| *Article-2* (Zhao et al., 2019) | *2019* | *Chronic pain* | *Individuals living with chronic pain* |
| *Article-3* (Perales et al., 2019) | *2019* | *All kinds of pain* | *Not explicitly mentioned* |
| *Article-4* (Yang et al., 2019b) | *2019* | *pain associated with sickle cell disease (SCD), which can include various types of pain, including acute, chronic, and breakthrough pain* | *Patients with sickle cell disease* |
| *Article-5* (Kasaeyan Naeini et al., 2019b) | *2019* | *All kinds of pain* | *Non-communicative patients including infants, preverbal toddlers, patient under anesthesia, persons with intellectual disabilities, and patient at the end of life* |
| *Article-6* (Abahussin et al., 2020b) | *2020* | *Cancer pain* | *Cancer patient* |
| *Article-7* (El-Tallawy et al., 2020) | *2020* | *Chronic pain* | *Individuals suffering with chronic pain* |
| *Article-8* (Hofmeister et al., 2020) | *2020* | *Chronic pain, which can include various types of pain, including neuropathic pain, musculoskeletal pain* | *Patients suffering with chronic pain* |
| *Article-9* (AlMazrou et al., 2020) | *2020* | *chronic low back pain* | *Patients experiencing chronic low back pain of age > 17 years* |
| *Article-10* (Moscato et al., 2022) | *2020* | *Cancer pain* | *Cancer patient* |
| *Article-11* (Løhre et al., 2020) | *2020* | *Cancer pain* | *Cancer patient* |
| *Article-12* (Guo et al., 2021b) | *2021* | *Assessment of pain levels of different types of pain, including acute, chronic, and procedural pain* | *Not explicitly mentioned* |
| *Article-13* (Zhang et al., 2021) | *2021* | *Cancer pain including acute, chronic, and breakthrough pain* | *Cancer patients* |

| | | | |
|---|---|---|---|
| *Article-14* (Subramaniam & Dass, 2021) | *2021* | *Nociceptive pain* | *Not explicitly mentioned* |
| *Article-15* (El-Tallawy et al., 2023) | *2023* | *Both acute and chronic pain which may be under-recognized and undertreated* | *Individuals with intellectual disabilities,* |
| *Article-16* (Lam et al., 2023) | *2023* | *Chronic pain* | *Community-dwelling older people living with chronic pain,* |
| *Article-17* (Law et al., 2023) | *2023* | *Focuses on migraine, a common health issue among youth, and the associated pain and sleep disturbances* | *Adolescents with migraine* |
| *Article-18* (Ozturk & Toruner, 2023) | *2023* | *Pain associated with cancer treatment including acute, chronic, and procedural pain* | *Children and adolescents receiving cancer treatment* |
| *Article-19* (Vu et al., 2023) | *2023* | *Chronic pain* | *Health professionals* |
| *Article-20* (Ju et al., 2023) | *2023* | *Digital pain, which refers to pain experienced in the fingers, hands, or other areas of the upper extremities.* | *Patients with psychotic disorders who experience digital pain* |

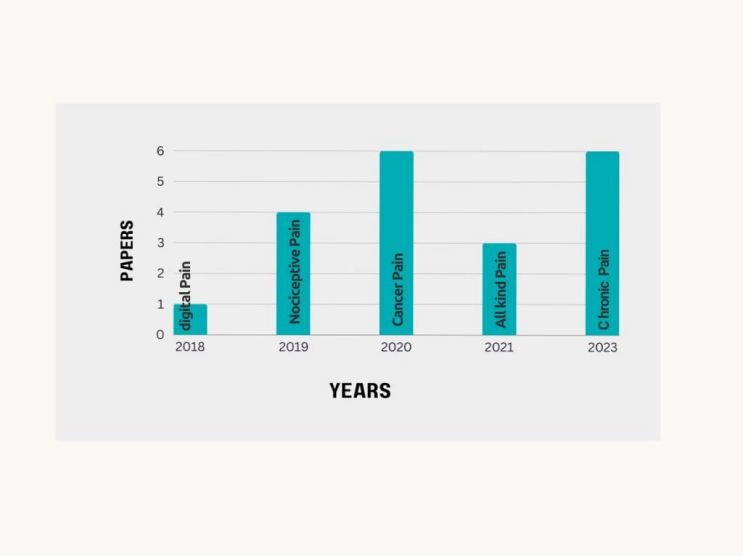


***Figure 1.1 Paper publication year based on type of pain***

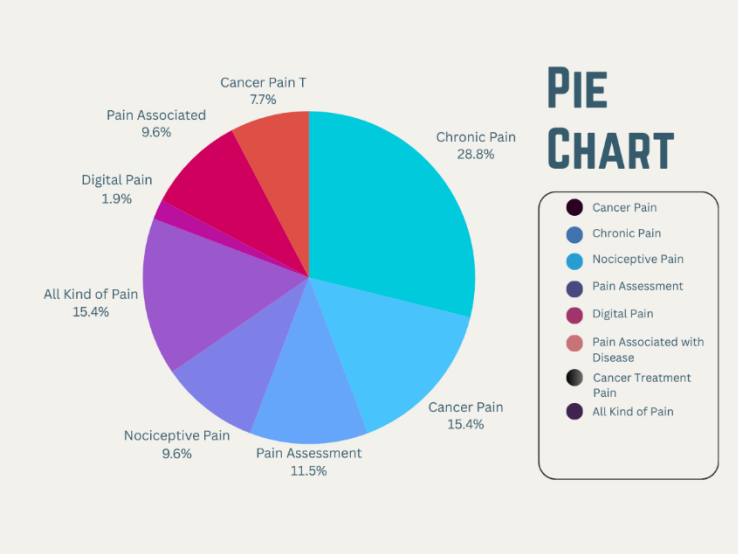


**Figure 1.2 Different types of pain**

Table 1.1 lists the various types of pain and the study paper's intended audience along with the year. Next, we make a (figure 1.1) graph to show the many forms of pain that have been studied based on the year. Additionally, in 2020 and 203, chronic pain was the most targeted form of pain. Next, using the preceding table as a guide, we create a pie graph (figure 1.2) to show the percentage of various pain kinds.

**RQ: 2**

**Which specific technologies are employed in the studies for pain evaluation and management, such as wearables, mobile applications, and virtual reality and what are their application in term of pain management?**

**Table 1.2 Employed technology and application in pain management**

| **No. of articles** | ***Technology used*** | ***Application in pain management*** |
|---|---|---|
| *Article-1* (Goesling et al., 2018b) | *Cognitive behavioral therapy* | *Addressing the biopsychosocial dimensions of chronic pain.* |
| *Article-2* (Zhao et al., 2019) | *Mobile application* | *Evaluate the content and functionality of mobile pain management apps.* |
| *Article-3* (Perales et al., 2019) | *Virtual reality* | *Uses binaural acoustic stimulation to evaluate pain perception in a controlled VR environment* |
| *Article-4* (Yang et al., 2019b) | *Wearable devices and mobile app* | *Pain assessment* |
| *Article-5* (Kasaeyan Naeini et al., 2019b) | *IOT devices / Wearable device* | *Real time pain monitoring to provide energy efficiency and accuracy for long-term monitoring.* |
| *Article-6* (Abahussin et al., 2020b) | *Mobile Application* | *Focus on the design and development of m-health based pain recording system* |

| | | |
|---|---|---|
| *Article-7* (El-Tallawy et al., 2020) | *Not explicitly mentioned* | *Discuss impact of covid-19 on pain and pain interventions* |
| *Article-8* (Hofmeister et al., 2020) | *Neurostimulation Technologies* | *Measure effectiveness of Neurostimulation for the management of chronic pain* |
| *Article-9* (AlMazrou et al., 2020) | *Systematic review* | *Management of low back chronic pain using PMS* |
| *Article-10* (Moscato et al., 2022) | *VR / wearable device* | *Automatic pain assessment method based on the analysis of physiological signals* |
| *Article-11* (Guo et al., 2021b) | *Facial actions* | *Pain assessment using AUs and Bayesian network* |
| *Article-12* (Subramaniam & Dass, 2021) | *Deep learning algorithm* | *Measuring acute nociceptive pain taking place inside the body such as tissue damage.* |
| *Article-13* (Law et al., 2023) | *Cognitive-behavioral therapy* | *Insomnia and pain management in adolescents suffering with migraine* |
| *Article-14* (Ozturk & Toruner, 2023) | *Virtual Reality* | *Pain management of cancer treatment receiving patients* |
| *Article-15* (Ju et al., 2023) | *Deep Transcranial Magnetic Stimulation* | *Digital pain management* |

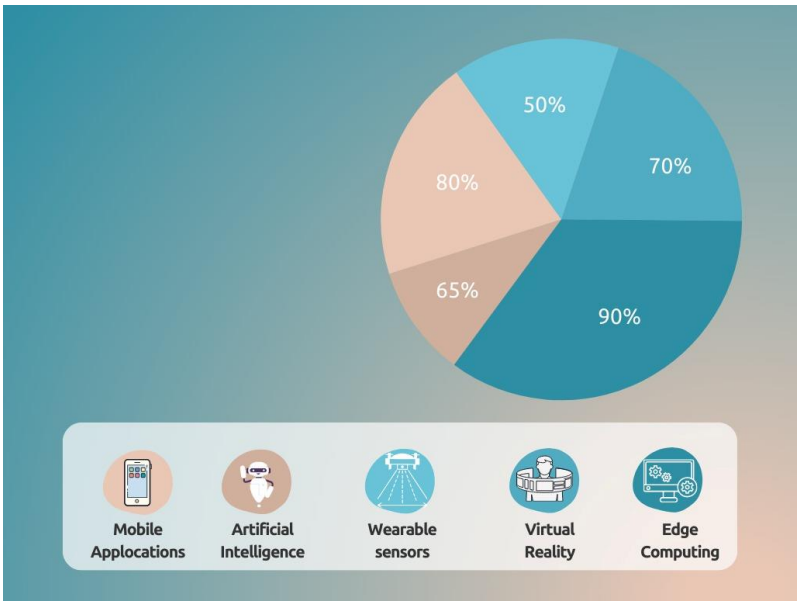


***Figure 1.2 Technology used for pain management and assessment***

Table 1.2 provides an explanation of the technology being employed and the particular area of management that the research article focuses on. We next create a pie chart figure 1.2 showing the percentage of the various kinds of technology that is utilized in research papers.

**RQ: 3 Which outcome measures are frequently used to evaluate how well pain management technology reduce pain and improve patient satisfaction?**

| No. of articles | Performance Enhancement | Medication Adherence and Adverse Reactions | Real-Time Pain Monitoring System | Tailored Pain Relief | Virtual Reality (VR) Therapy | Pain Management | Healthcare Professionals | AI in Clinical Practice: | Future Improvements |
|---|---|---|---|---|---|---|---|---|---|
| *Article-1* (Abahussin et al., 2020b) | ✓ | ✓ | | | | | | | |
| *Article-2* (Kasaeyan Naeini et al., 2019b) | ✓ | | ✓ | | | | | | |
| *Article-3* (Yang et al., 2019b) | | | | ✓ | | | | | |
| *Article-4* (Ozturk & Toruner, 2023) | | | | | ✓ | | | | |
| *Article-5* (Zhao et al., 2019) | | | | | | ✓ | | | |
| *Article-6* (Le et al., 2023) | | | | | | ✓ | | | |
| *Article-7* (Shaygan & Jaberi, 2021) | | | | | | ✓ | | | |

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|---|---|---|---|---|---|---|---|---|---|
| *Article-8* (Argüello Prada, 2020) | | | | | | | ✓ | | |
| *Article-9* (Wibowo et al., 2023) | | | | | | | | ✓ | |
| *Article-10* (Cascella et al., 2023) | | | | | | | | | ✓ |

**Table 1.2 Pain reduction and patient satisfaction metrics**

**RQ: 4**
**What particular outcome measurements are used to quantify improvements in functionality brought about by pain management technologies?**

**Table 1.3 Enhanced function metrics**

| No. of articles | Quantitative Improvements in Pain Assessment and Management | Energy Consumption Reduction in IoT Devices | Model Performance for Continuous Pain Assessment | Virtual Reality Intervention for Anxiety Relief | Pain Treatment Apps and Clinical Usage | Colorectal Cancer Follow-up Rate | High Adherence and Satisfaction with Smartphone | IoT-Enabled Solutions | Flexible "Hybrid" Strategy for Quality of Care | Feasibility of System for Patient Pain Intensity |
|---|---|---|---|---|---|---|---|---|---|---|
| *Article-1* (Abahussin et al., 2020b) | Assessment from 42% to 71% management from 59% to 97% | | | | | | | | | |
| *Article-2* (Kasaeyan Naeini et al., | | 64% | | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2019b) | | | | | | | | | | |
| *Article-3* (Yang et al., 2019b) | | | Model's root mean-square error: 1.526 Model's Pearson correlation:0.618 | | | | | | | |
| *Article-4* (Oztur k & Torun er, 2023) | | | | Effect size (g = − 0.60) for anxiety relief High total heterog eneity (I2 = 69.1%) Signific ant at p < 0.05 | | | | | | |
| *Article-5* (Zhao et al., 2019) | | | | | Many PM apps that aren't meant for doctor s to use | | | | | |
| *Article-6* (Le et al., 2023) | | | | | | 50% of colore ctal cancer patien ts do not obtain a follow-up. | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Article -7* (Shaygan & Jaberi, 2021) | | | | | | | High level of adherence (78.12 %) Satisfaction mean: 26.45, Satisfaction SD: 6.45 with the smartphone | | | |
| *Article -8* (Argüello Prada, 2020) | | | | | | | | IoT-enabled solutions can achieve high usability, accuracy, and compliance levels | | |
| *Article -9* (Wibowo et al., 2023) | | | | | | | | | maximize the quality of care and enduring pain | |
| *Article -10* (Cascella et al., 2023) | | | | | | | | | | Feasibility assessment in 30 days |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Cohen's Kappa = 0.70, 95% CI 0.68-0.72 for patient pain intensity Effect size (g = −0.60) for anxiety relief |

### *4. Conclusion*

We have conducted a thorough examination of research articles in order to identify the technological interventions used, identify the targeted areas of pain treatment, and comprehend the body of work that has already been done. Researchers have looked into creative ways to improve the general well-being of people who are experiencing pain, from acute pain to chronic diseases. Mobile applications shown their ability to offer easily navigable and accessible user interfaces. The inclusion of physicians and caregivers as users in these apps, promotes cooperation and communication throughout the healthcare system.

Wearable technology has become a powerful tool for recording data in real time and providing insightful information about physiological markers associated with pain. Our analysis points to the possibility of future developments in pain treatment as a result of continued attempts to improve and optimize these devices. Though it's being used on a limited scale right now, virtual reality (VR) can also offers an interesting way to practice relaxing techniques.

To improve the lives of people who experience pain, we must continue to expand on the body of information that already exists, improve technological treatments, and encourage teamwork in order to progress in the area of pain management.

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