

## Systematic Literature Review of Near Field Communication Technology Acceptance for Daily Life Appliance

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### Abstract

*In the era of Internet of Things (IoT) development, there are many technologies that support the digital ecosystem, one of which is Near Field Communication (NFC). The basic standards for NFC devices have been developed since 2004. However, the practical and academic use of NFC is still limited. To address these issues, many researchers propose prototypes and the use of NFC. As a result, this study was designed to delve deeper into the findings of NFC-themed research. This study uses a systematic literature review method. This study aims to classify and examine the latest topics from various research results with the theme of NFC, which are classified into eight areas of use for the period 2018–2022. The results of this study found 9 articles (15.8%) related to medical appliances, 12 articles (21.1%) related to security issues, 9 articles (15.8%) related to education appliances, 7 articles (12.3%) related to mobile payments, 6 articles (10.5%) related to communication appliances, 7 articles (12.3%) related to business administration, 4 articles (7.0%) related to tourism support, and 3 articles (5.3%) related to infrastructure appliances. This finding can be a trigger for further researchers to raise the theme of NFC related to infrastructure appliances.*

**Keywords:** *Near Field Communication; NFC; Internet of Things; IoT; infrastructure appliances; RFID*

### Abstrak

Pada era perkembangan *Internet of Things (IoT)*, terdapat banyak teknologi yang mendukung ekosistem digital, salah satunya *Near Field Communication (NFC)*. Standar dasar perangkat *NFC* telah dikembangkan sejak tahun 2004. Namun, penggunaan *NFC* secara praktis dan akademis masih terbatas. Untuk mengatasi masalah tersebut, banyak peneliti mengusulkan prototipe dan penggunaan *NFC*. Oleh karena itu, penelitian ini dirancang untuk menggali lebih dalam temuan penelitian bertema *NFC*. Penelitian ini menggunakan metode tinjauan literatur sistematis. Penelitian ini bertujuan untuk mengklasifikasikan dan mengkaji topik-topik terkini dari berbagai hasil penelitian bertema *NFC* yang diklasifikasikan menjadi delapan bidang penggunaan periode 2018–2022. Hasil penelitian ini menemukan 9 artikel (15,8%) terkait peralatan kesehatan, 12 artikel (21,1%) terkait masalah keamanan, 9 artikel (15,8%) terkait peralatan pendidikan, 7 artikel (12,3%) terkait pembayaran seluler, 6 artikel (10,5%) terkait peralatan komunikasi, 7 artikel (12,3%) terkait administrasi bisnis, 4 artikel (7,0%) terkait penunjang pariwisata, dan 3 artikel (5,3%) terkait peralatan infrastruktur. Temuan ini dapat menjadi pemicu bagi peneliti selanjutnya untuk mengangkat tema *NFC* terkait peralatan infrastruktur.

**Kata Kunci:** *Near Field Communication; NFC; Internet of Things; IoT; infrastructure appliances; RFID*

### I. Introduction

In the era of Internet of Things (IoT) development, there are many technologies that support the digital ecosystem, one of which is Near Field Communication (NFC). Conceptually, NFC is a technology based on Radio Frequency Identification (RFID) that operates at a frequency of 13.56 MHz [35]. The connectivity range of NFC devices is effective at a distance of 4–10 cm, with transfer speeds up to 424 Kbps. Because it transports contactless devices, NFC is regarded as one of the future's technologies. NFC has a power transfer capability of about 10mW. This power is used to power most low-power electronic devices, including microcontrollers and

sensors. NFC devices do not require batteries, and NFC tags can be mass-produced. NFC is a technology that bridges the technology gap that cannot be filled by WiFi or Bluetooth, to achieve IoT implementation.

The basic standards for NFC devices have been developed since 2004. However, the practical and academic use of NFC is still limited. Practically, NFC is prepared as one of the supporting technologies for payment systems [49]. Devices that use NFC are still limited. For example, most smartphone manufacturers have not made NFC a standard technology in their products. NFC seems to be a foreign technology in everyday life. Academically, many studies on NFC have begun. Review [35] classifies the use of NFC into eight areas. The proposed classification needs to be reviewed in light of the latest developments. This is based on the idea that the COVID-19 pandemic is a catalyst for IoT development.

This study will examine the issues surrounding the NFC model that is implemented in everyday life. This study explores issues related to the use of NFC in the fields of Medical Appliance, Security Issues, Education Appliance, Mobile Payment, Communication Appliance, Business Administration, Tourism Support, and Infrastructure Appliance. The research will concentrate on which industries have used NFC. In addition, the study is also directed at finding NFC research topics that have not been studied in depth.

## **II. Methodology**

The research conducted is included in the category of exploratory research. This research was conducted to explore data and information related to the latest issues and topics that were used in the context of deepening or further research. This study aims to identify more in-depth research questions and then answer them in later research or follow-up research. Researchers generally use exploratory research to gain adequate knowledge for the design and implementation of systematic follow-up studies. An exploratory investigation is a research procedure that delves into themes or issues that have not yet been thoroughly investigated by previous researchers [34].

This exploratory research aims to classify and examine the latest topics from various research results with the theme of Near Field Communication (NFC) which is applied in everyday life in various fields such as the Internet of Things (IoT), payments, education, and tourism. This study obtained information sources from the results of research related to Near Field Communication (NFC) compiled from the Google Scholar page with the keywords Near Field Communication and NFC for the period 2018–2022. This study was conducted to explore and study the research results in depth. Near Field Communication (NFC) and identify the need for additional research in the context of wireless access devices. Thus, studies with the theme of Near Field Communication (NFC) are in line with industry needs, especially in the dimension of wireless communication between devices in a system.

A systematic literature review is a method for identifying, evaluating, and interpreting the findings of a research topic in order to answer research questions that have been determined. In general, a systematic literature review consists of planning, conducting, and reporting stages. However, in this research, it has been developed into five stages. First, the determination of search keywords. Second, based on these keywords, data searches are carried out via the Google Scholar search engine application. Third, we conducted a brief review (title, abstract, and conclusion) of each selected article to group the data by field. Fourth, we analyze each area of NFC application, which aims to identify the topics studied. Fifth, we draw up research conclusions to answer research questions related to the results of the systematic literature review model based on the field of use and topics that are the focus of research in each field of utilization.

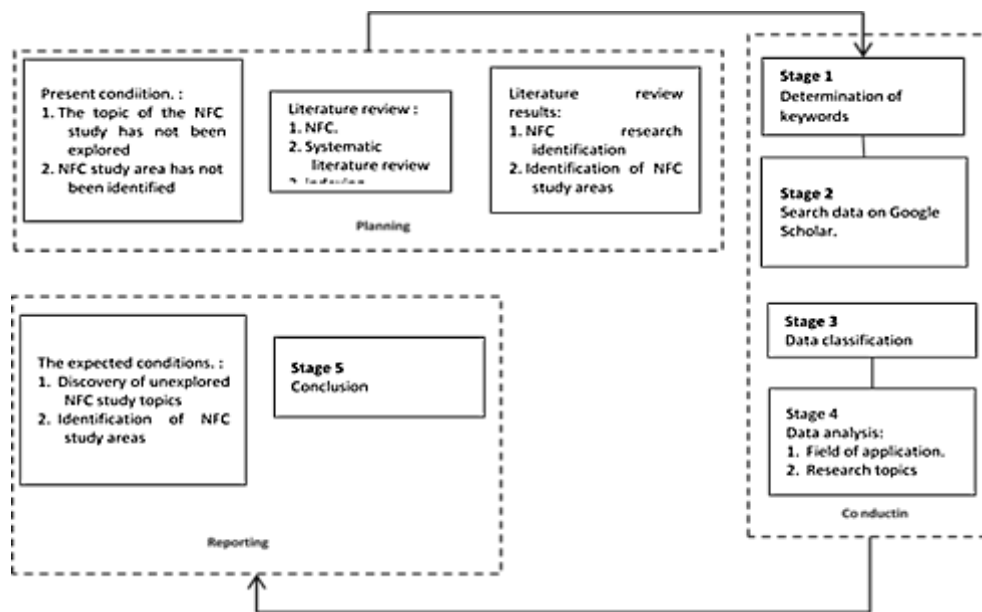


Figure 1. Research Framework

### III. Result and Discussion

A Google Scholar search using certain keywords yielded 67 papers. Based on our research findings, 57 publications will be investigated further. Meanwhile, ten articles contain discussions that are inappropriate for the study environment and are closed access.. We classified the 57 articles based on eight fields, namely Medical Appliance, Security Issue, Education Appliance, Mobile Payment, Communication Appliance, Business Administration, Tourism Support, and Infrastructure Appliance. The number of classifications is the same as the study [35], but with mostly different classifications. The classification results are as shown in Figure 2. While the articles that are not related to the subject matter, namely [13], [19], [27], [35], [36], [47], [49], [53], [56], and [60]. Some of these studies remain relevant for us to understand the basic concepts of NFC, such as studies [27], [35], [36], and [47]. We gained insight into the potential of NFC through studies [19], [49], and [56]. For the electronic components used for NFC, we obtained them from studies [13], [47], and [53].

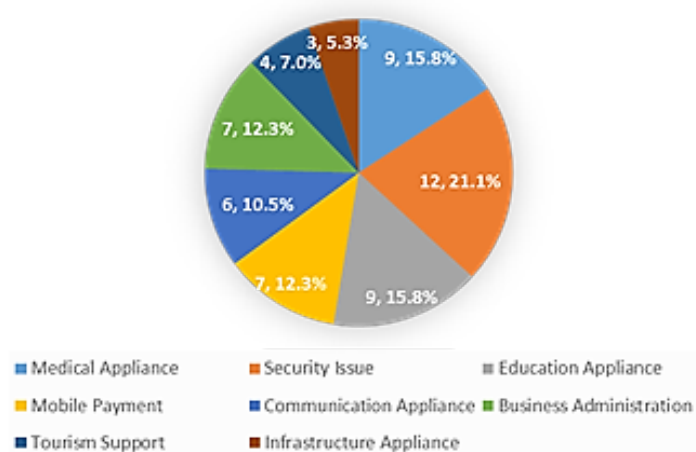


Figure 2. Classification of Articles Based on Research Fields

We found 9 articles (15.8%) related to Medical Appliance, 12 articles (21.1%) related to Security Issue, 9 articles (15.8%) related to Education Appliance, 7 articles (12.3%) related to Mobile Payment, 6 articles (10.5%) related to Communication Appliance, 7 articles (12.3%) related to Business Administration, 4 articles (7.0%) related to Tourism Support, and 3 articles (5.3%) related to Infrastructure Appliance.

(7.0%) related to Tourism Support, and 3 articles (5.3 %) related to Infrastructure Appliance. These results indicate that there is no dominant field of use for NFC.

After classifying the application areas, we classify the articles based on the conclusions of the research articles related to NFC. We divide the conclusions of the articles into three categories, namely criticism of NFC, proposed use of NFC, and proposed prototype, as shown in Figure 3. We found 5 articles (8.8%) providing identification of NFC security holes, especially in the security field, 22 articles (38.6%) proposing the use of NFC, and 30 articles (52.6%) proposing a prototype using NFC.

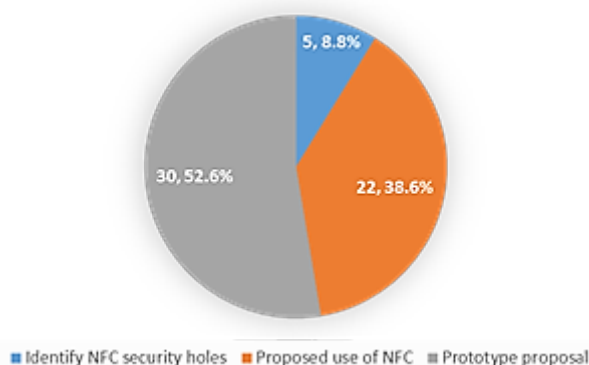


Figure. 3. Conclusion of Research Results

#### A. Research Topics related to Medical Appliance

One of the research topics that we found a lot was related to the use of NFC for medical appliances, with a total of 9 articles (15.8%). Based on the study conducted on all articles for this theme, the researcher divided the research topics into two types of themes, namely the use of NFC to support Electronic Medical Record (EMR) and NFC as a sensor aid. There are three studies that use NFC to support EMR. While five studies have been conducted on the use of NFC as a health sensor.

Studies [26] and [37] examine the use of NFC to support mobile application-based EMR. However, the two studies differ somewhat in terms of research conclusions. Study [26] proposes an NFC prototype that can be used for EMR systems, while study [37] is still at the stage of proposing the use of NFC to support EMR data. This is somewhat different from the study [17] which proposed a replacement prototype for the MySejahtera App for the purpose of tracing COVID-19 transmission. The proposed prototype is used to collect information on locations that have been visited by individuals who have been confirmed positive for COVID-19.

NFC as a sensor tool in the health sector has been found in studies [31], [38], [39], [44], [45], and [52]. The use of NFC as this sensor is specific for the treatment of certain body parts, for example in research [45] or supporting general health sensors such as temperature sensors [39]. Research is generally directed at sensors that indicate general health levels [31] [38] [44] [52]. Escobedo et al., [39] proposed a prototype smart band that can display indicators to determine whether a person has a respiratory infection or not. In the era of the COVID-19 pandemic, the prototype proposed by this research can help the tracing process. The study [44] discusses in more detail the use of NFC in the biomedical field, namely temperature and pressure sensors, electrophysiology sensors, blood flow sensors, sweat sensors, and hospital applications. For the purposes of making health-related decisions, NFC technology can be assisted by knowledge-based decision support [52].

#### B. Research Topics related to Security Issue

On the topic of this research, 12 articles (21.1%) were found that discussed security issues. Security-related issues are an interesting field of study, especially since NFC has begun to be widely used to facilitate payment transactions. In the field of payment transactions, studies [6] and [41] identified four NFC security loopholes, namely data manipulation and corruption, interception attack, NFC worm, and eavesdropping. Experimental testing using a wormhole exploit successfully exploited contactless credit cards, Google Pay, and Apple Pay [41]. In the implementation of a payment system that uses NFC, it is necessary to consider the mitigation of the security vulnerability of the interception attack because this method uses a higher level of technology than other security vulnerabilities.

Discussions related to NFC security vulnerabilities are generally reviewed in studies [7], [9], [23], and [40]. The research generally discusses the identification of security vulnerabilities encountered based on experiments. With a signal of 13.56 MHz, study [7] was able to jam at a maximum distance of 9 cm between the scanner and the NFC tag. Denial of service (DOS) and data corruption attacks can be mitigated using ECMA-386 cryptographic algorithms [23]. The risk assessment uses the Analytical Hierarchy Process (AHP) approach. The study [40] goes into more detail regarding potential attacks on NFC devices. If, in general, there are four NFC security holes, the study adds the potential for skimming attacks, spoofing attacks, and relay attacks. Meanwhile, with the proposed application [9], mobile phones can act as Point of Sales (POS) machines, and then only random text strings will be visible in unauthorized access to databases. This ensures system reliability and security when using NFC.

Studies related to security issues are not only related to the identification of security holes. Several studies have proposed a prototype for secure access control using NFC devices. The prototype is applied to various devices such as vehicles [20], houses [30], the Arduino Uno [50], and access systems [15] [54] [66]. Subowo and Yulianti, [20] investigated the use of NFC for the validation of ignition relays on motorcycles. When the card is not scanned for registration, the relay cannot connect the motorcycle ignition system. This is intended to reduce the risk of vehicle theft in parked conditions. NFC can also be applied to smart doors [30]. The application of NFC on smart doors will support the implementation of the Internet of Things (IoT) so that when unauthorized access occurs to the door of the house, the homeowner gets a notification. Utilization of NFC for security purposes can also be applied to office security systems using the Arduino Uno [50]. The use of NFC has the same goal, which is to avoid unauthorized access to certain rooms in the office. For prototypes related to access control, the studies we found were more directed at using a cryptographic methodology using NFC to build a good access control protocol system. The methodologies used are generally Data Encryption Standard (DES), Triple Data Encryption Standard (3DES), and Symmetrical Key. The study that we found was more directed at the use of a cryptographic methodology using NFC to build a good access control protocol system. The methodologies used are generally Data Encryption Standard (DES), Triple Data Encryption Standard (3DES), and Symmetrical Key. The study that we found was more directed at the use of a cryptographic methodology using NFC to build a good access control protocol system. The methodologies used are generally Data Encryption Standard (DES), Triple Data Encryption Standard (3DES), and Symmetrical Key.

### C. Research Topics related to Education Appliance

Based on the research results, the number of articles related to this field is nine (15.8%). We discovered that the majority of the articles [21], [25], and [33] proposed the use of NFC to support presence in the learning process. The use of NFC makes it easier for educational institutions to record historical student attendance data during the learning series. The use of NFC makes it easier to record because the data is directly encapsulated in a database on the server. The devices used to build the system are NFC tags and smartphones [21]. The use of NFC provides at least two advantages, including minimizing data manipulation and being error-free [25]. With the application of an NFC-based attendance system, managerially, student attendance management increases, administrative work decreases, and the student attendance ratio increases. On a more complex level, NFC is expected to be a tool for exchanging learning materials when the internet network is disrupted. However, the study [33] is still only a concept and has not yet proposed a full prototype to answer the needs of the exchange of learning materials. This is a promising research opportunity.

The use of NFC in education can be found in the learning process, such as the Examination Monitoring System [24], Mobile Learning System [51], and U-Learning [59]. Use of NFC for the Examination Monitoring System to reduce staff time in administering examinee data. Checking administrative data becomes more efficient, and students are more focused on working on exam questions. The use of NFC encourages learning activities such as games [51]. Based on the Analytical Hierarchy Process (AHP), it appears that optimism is the most important factor for implementing U-Learning using NFC technology, followed by innovation and accessibility [59].

NFC can also be used to support library activities. The use of NFC in libraries is directed at self-service activities for borrowing books, of course assisted by 2FA (two-factor authentication) so that the security of borrowed books is maintained [10]. According to figures from the Central Statistics Agency, Indonesia will have 8,956,184 active students in 2021. Universitas Indonesia is one of Indonesia's largest institutions, with about 36,000 active students and a 1.5 million-volume library collection. With such a huge library collection, using NFC in conjunction with 2FA can reduce the administrative burden on librarians in terms of library collection management, as well as lending and borrowing activities. The use of NFC is more efficient in terms of resource use because it requires fewer operators to manage library business processes [32]. The use of NFC is in line with the Smart Library (S-Library) concept [46]. S-Library allows librarians to process multiple transactions with just



a mobile smartphone. The S-library can be connected to the learning management system (LMS) so that library data can be integrated with student academic data.

#### **D. Research Topics related to Mobile Payment**

Mobile payments research topics are one of the NFC implementations in supporting the digital economy ecosystem. We got seven articles (12.3%) related to the topic. Two articles on mobile payments [55, 63] proposed NFC as a component in a parking payment system. The use of NFC in the parking payment system minimizes parking receipt fraud. This is because the NFC Card is directly connected to the banking system, so parking payments will be directly received by the manager's account without going through a parking interpreter intermediary. From the parking service user's point of view, the use of NFC can reduce waiting times when paying for parking and provide reminders of vehicle parking locations. Based on research [67], the payment transaction time using NFC is 0.48 seconds, much faster than the average transaction time using cards offered by card-based Q-Park machines, which takes around 4 seconds.

NFC can improve the user's shopping experience at conventional stores as easily as shopping on e-commerce platforms [11]. The use of NFC can make it easier for consumers to find out the details of the goods to be purchased, simply by using an NFC scan, and can be connected to an online shopping cart so that the payment process is easier. This cashless payment system is in line with the implementation of the COVID-19 health protocol, which advises avoiding physical contact [43]. At a further level, a study [14] proposed NFC to replace debit cards used in ATM machines. This means that NFC is not only focused on the shopping sector but can also be applied to the banking sector. NFC could be part of the solution to consumer demands for privacy, customer satisfaction, convenience, and speed [34].

#### **E. Research Topics related to Communication Appliance**

NFC was originally a technology intended for communication between two devices without the use of wired (wireless) media. Communication between these two devices is related to the read and write processes. The important thing in the communication process between the two devices is the exchange of data. This type of data exchange is typically used for access control authentication [22], [58], [62], and [65]. The thing that distinguishes the topic of security issues lies in the perspective of exchanging data between devices, not always aiming to avoid unauthorized access.

NFC can be used to help monitor visitors at places of worship [22]. Managers can monitor the number of visitors to places of worship. This can be used as material to communicate to potential visitors to adjust the timing of visits to places of worship so that there are no crowds that increase the risk of COVID-19 transmission. Effective communication between two NFC devices can use the half-duplex communication method [58]. Android-based devices are an alternative option for effectively implementing NFC device communication [62]. The main problem in achieving effective data exchange between the two NFC devices is the software dimension, because references to the source code used for NFC are still limited, although challenges from the hardware side also need to be considered.

Communication, which is the topic of research, is not limited to device communication but can include broader communications such as corporate and vendor communications. Study [65] proposes a prototype of an NFC-based SLA (Service Level Agreement) monitoring and personalization system. The proposed prototype allows communication between the company and the vendor without having to meet face-to-face. Companies can monitor vendor performance based on the data collected from the system. If there is a decrease in the performance of a vendor's work, the company can communicate this to the vendor and discuss mitigation measures. Even one study [68] proposed a prototype of a complete sensor system using harvested energy that could be used for wireless, battery-less body temperature monitoring. This prototype can exchange data without using batteries. For the use of operational frequency, experimental study results [64] suggest 13.56 MHz and a maximum reading distance of 10 cm. At these frequencies, the antenna can transfer power and data more effectively.

#### **F. Research Topics Related to Business Administration**

NFC as a technology to speed up the process of financial transactions have begun to be widely applied. In its development, NFC is not only intended for payment transactions, but it can play a greater role in the business administration of a company. For this topic, we get 7 articles (12.3%). The use of NFC to support business administration includes the dimensions of accounting [16], staffing [18], product packaging [29] [57], managerial [42] [48], and industrial machinery management [61].

NFC could be used as a means of validating income, costs, and cash received from the company's business activities [16]. In public transportation companies, the application of NFC helps to automate cost accounting calculations so that variable costs can be controlled. In the dimension of personnel management, NFC could be a means to find out where employees work [18]. NFC could display employee locations so that if there are employees who are not at work, they can be immediately identified. For the integration of NFC in product packaging, studies generally lead to digital products such as gadgets. The addition of the NFC feature to this digital product has the potential to reach consumers in Generation Z [29]. For the utilization of NFC in product packaging, a study is proposed [57].

On the managerial side, the application of NFC offers many conveniences. NFC provides convenience for data transfer, policy evaluation, and contactless installments [42]. Study [48] offers a design to build a simple and effective agricultural IoT information application service system. However, the system built is specifically for family farms in China that implement IoT for smart agriculture. While the proposed prototype [61], has a NFC e-textile wearable antenna that can be placed in almost any place on clothing and is able to communicate at an operating frequency of 13.56 MHz, The maximum read range of e-textile wearable NFC tags is 5.6 cm.

#### **G. Research Topics related to Tourism Support**

Over the past two years, the COVID-19 pandemic has hit the tourism sector hard. The tourism sector is a less developed sector, even NFC research related to tourism is not very extensive. We only found 4 articles (7.0%) related to the use of NFC in this sector. The NFC that is studied in the articles we get, generally discusses the development of the tourism system. For the tourism sector, contactless technologies, especially NFC, can help improve service quality, branding, and marketing [1]. Study [2] proposes a proposal to provide information and services to tourists, as well as access to business networks that can be used by local people or by tourists in various locations. To support the proposal, an NFC device is needed as an alternative location pointer. NFC is one of the technologies that is the backbone for implementing Smart Tourism [3]. For example, for the sake of accommodation (hotels), NFC could be implemented as a hotel room door access device or to know the schedule of local cultural performances. The use of NFC increases customer satisfaction related to the four components of tourism (heritage attractions, catering, accommodation, and transportation) [8]. In the context of Smart Tourism, NFC supports accessibility to various locations within a tourist area. The use of NFC increases customer satisfaction related to the four components of tourism (heritage attractions, catering, accommodation, and transportation) [8]. In the context of Smart Tourism, NFC supports accessibility to various locations within a tourist area. The use of NFC increases customer satisfaction related to the four components of tourism (heritage attractions, catering, accommodation, and transportation) [8]. In the context of Smart Tourism, NFC supports accessibility to various locations within a tourist area.

#### **H. Research Topics related to Infrastructure Appliance**

The government-related infrastructure sector can be said to be a research field that has not been studied extensively. Studies related to the use of NFC in this sector, based on the data we have collected, are the areas with the fewest studies. We only obtained 3 articles (5.3%). For government-related infrastructure, NFC is an important component for the implementation of e-voting infrastructure [5]. PKI (public key infrastructure) is a supporting component of NFC that ensures data security. In addition, NFC is also used for the simulation of smart nuclear infrastructure [4]. NFC is simulated to be connected with tubes, rooms, gloveboxes, tools, and equipment on the smart nuclear infrastructure. While research [12] proposed using NFC to monitor and limit the city's drinking water supply.

### **IV. Conclusion**

The research topic that is most widely raised in NFC research is security issues, with a total of 12 articles (21.1%). Meanwhile, journals related to infrastructure appliances are among the research topics that have received little attention. This finding can be a trigger for further researchers to raise the theme of NFC related to infrastructure appliances, considering that the infrastructure sector is a sector that dominates the lives of many people in their daily lives. In addition, based on an analysis of the research conclusions, most conclusions provide prototype proposals that use NFC. We found this conclusion in 30 articles (52.6%). The proposed prototype is quite diverse according to the field of study. While the conclusion that identifies NFC security gaps, especially in the security sector, was only found in five articles (8.8%).

We recommend research fields that have not been studied much, such as tourism support and infrastructure appliances, as an option for research related to NFC. This is because NFC research references in these two fields are still limited. By raising these topics for study, it will certainly enrich the treasures of knowledge in the NFC

field.

For future research, there are several studies that require follow-up. For example, study [33] needs to follow up on the concept of a learning system that has been created. Research [49], which is still limited to a preliminary study, can be continued to the stage of making an NFC prototype for mobile payments. Research related to NFC device security issues is also still limited and requires a more comprehensive study. For the field of study, further research can focus on tourism support and infrastructure appliances.

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