SOCIOECONOMIC ANALYTICS

A Systematic Mapping on Information Technology Solutions for Security in the Context of Smart Cities

Alixandre Thiago Ferreira de Santana[1*]
Assuero Fonseca Ximenes[2]
Ednaldo Dantas de Carvalho Júnior[3]
[1]Computer Science, Federal University of Agreste of Pernambuco, Garanhuns, Brazil.
Email: alixandre.santana@ufape.edu.br *Corresponding author
[2]Computer Science, Federal University of Agreste of Pernambuco, Garanhuns, Brazil.
Email: assuero.ximenes@ufape.edu.br
[3]Computer Science, Federal University of Agreste of Pernambuco, Garanhuns, Brazil.
Email: ednaldo.dantas@ufape.edu.br

RESEARCH ARTICLE

Socioeconomic Analytics
https://periodicos.ufpe.br/revistas/SECAN/
ISSN Online: 2965-4661

Submitted on: 01.04.2025.
Accepted on: 28.12.2025.
Published on: 29.12.2025.

Abstract

Population growth is directly linked to a series of social and urban challenges, and among these challenges, one of the most concerning is the increase in violence, which can be driven by factors such as social inequality, resource scarcity, and, mainly, the lack of adequate infrastructure. In light of this, this study seeks to examine security solutions in smart cities by investigating academic and technical publications from various sources, such as articles, journals, conferences, and reports, to understand the main areas of interest and to learn how the computational solutions already implemented can provide valuable insights for the formulation of public safety policies. In this way, existing security solutions were analyzed that demonstrated the benefits generated by their application and that can be used to improve security in cities, providing a basis for future work and for the creation of more effective strategic actions in the context of smart and safe cities.

Keywords

Smart Cities; Security; Computational Solutions; Literature Review.

1. Introduction

According to the UN, more than 50% of the world's population lives in urban areas, and this number is expected to reach nearly 75% by 2050 (UN, 2019). As urbanization intensifies, reflecting the growth of cities, improving security and protection measures for citizens becomes a priority for many of them (BANG *et al.*, 2019). In other words, as this growth occurs, the management challenges for government authorities to deal with various urban problems arising from high population density also increase (MENDONÇA *et al.*, 2016). According to studies conducted by ethnologists in the 1950s, it was observed that an increase in group size resulted in a reduction of individual territoriality, which in turn increased stress levels and the likelihood of violent behavior (OLIVEIRA, C. S. DE *et al.*, 2014).

In light of this, some countries have started initiatives related to smart cities, aimed at solving urban challenges or contributing to the advancement of essential technologies focused on providing services in highly connected urban environments (BANG *et al.*, 2019). In this sense, Information and Communication Technologies (ICT) are enabling the transformation of conventional cities into smart cities (MOHANTY; CHOPPALI; KOUGIANOS, 2016), focusing on the application of new

technologies and innovation aimed at improving the quality of life in cities and creating new services, as well as economic opportunities.

In this context, smart cities have played a central role in modifying various spheres of human existence, influencing areas such as transportation, health, energy, and education (HASHEM *et al.*, 2016). Within the smart city paradigm, a Safe City is an urban tactic that enhances the efficiency of operations in the area of security through the application of technologies (BANG *et al.*, 2019). Thus, smart and safe metropolises make use of a comprehensive variety of IT solutions to strengthen public security systems, employing Information and Communication Technology (ICT) and the Internet of Things (IoT) to assist in combating crime (SILVA, P. I. M.; SANTOS; NASCIMENTO, 2020).

It is worth noting that security solutions in smart cities include video surveillance systems that are an evolution of Closed-Circuit Television (CCTV), and in this system, the front camera is the main source of data, which is sent to the control center (ZHANG *et al.*, 2020). This may also encompass the use of drones, assisting the police in tracking a criminal's escape as noted by Alsamhi *et al.* (2019). Another common solution is facial recognition systems, aimed at identifying individuals, as mentioned by Joh (2019). In addition, there are also smart lighting systems, composed of LED lights with a network of components and sensors, making it a key cyber-physical system for smart cities (JIN *et al.*, 2016). Another example is the systems that are available in desktop format (CARVALHO *et al.*, 2018), mobile (FERNANDEZ *et al.*, 2020), and web (COLLA; SANTOS, 2019), providing information that can assist in offering safety for the population. Such solutions may include the use of social networks as a way to disseminate and investigate events (OLIVEIRA, V. A. T.; SANTOS, 2019) as well as serve as a means of reporting crimes (JOH, 2019), among others.

Smart cities are the result of strategic urban planning that uses technology and innovation to improve the quality of life, efficiency, and sustainability of cities (FERNANDEZ *et al.*, 2020), given that violence in cities can happen at any moment, making human monitoring an inefficient way to deal with these cases (ABDALI; AL-TUMA, 2019). Therefore, smart cities aim to improve the quality of life of the population, but still face challenges such as security, which is a constant concern (FERNANDEZ *et al.*, 2020).

Currently, in Brazil, it becomes evident that the rates of violence and crime exceed the acceptable limits for a safe and balanced society. This scenario reflects multiple factors, such as social inequality, impunity, and weaknesses in the public safety system. According to Tavares (2016), the escalation of violence not only surpasses the parameters considered normal but also directly impacts the quality of life of the population. Furthermore, the increase in crime undermines the socioeconomic development of the country, creating a climate of widespread insecurity.

How smart cities represent an urban model based on the integration of technology, efficient governance, and sustainability to promote quality of life and security for the population and, according to Townsend (2013), the development of these cities depends on the implementation of innovative solutions, such as monitoring by artificial intelligence, optimized resource management, and active citizen participation. In Brazil, however, the lack of investments, the precariousness of infrastructure, and ineffective management hinder the adoption of this model, maintaining persistent urban challenges. Moreover, social inequality and violence hinder the creation of safer and more connected urban spaces. For the country to move in this direction, it is essential to formulate strategic public policies, combined with the smart use of technology, ensuring sustainable and inclusive development.

Thus, little is known about the state of the art of the application of information technologies in the context of security in smart cities in Brazil. Therefore, it seeks to identify in the literature the security solutions implemented in different urban contexts with a direct impact on citizens' lives and on the transformation of safer cities, also contributing to the advancement of scientific knowledge on the subject.

The differential of this research lies in the application of a methodological strategy that encompasses multiple national and international databases, without temporal restrictions, and with rigorous inclusion criteria that require proof of implementation of the solutions. Furthermore, the categorization of solutions by security domains, combined with the analysis of benefits and demographic characteristics, provides a multifaceted and unprecedented view of the use of IT in the security of smart cities, which is not commonly found in other studies.

Although there are reviews and systematic mappings on safety in smart cities, the literature lacks a comprehensive analysis that integrates different geographical contexts, ranging from cities with high to low Human Development Index, and that evaluates not only the technological solutions but also the reported benefits and challenges of their implementation. This research gap demonstrates the need for a study that connects the technical and social aspects of smart urban safety, providing an integrated and updated view of the state of the art.

Thus, the objective of this study was to conduct a Systematic Mapping of the Literature to gain an overview of what the main security solutions being used in smart cities are and what security problems these solutions aim to address, seeking to identify the main solutions available in the field of security in smart cities, their subfields or security issues addressed by these solutions, understand the demographic characteristics of the smart cities that use such security solutions, and describe the main benefits obtained from the implementation of security solutions in smart cities.

To achieve the proposed objective, this study was divided into five sections. The theoretical background is presented in the next section. Section 3 shows how the research was conducted. Then, in Section 4, the results obtained from the research are presented, along with the extraction and summarization of the data. Finally, in Section 5, there are considerations about the proposals to help solve the research problem, the difficulties encountered along the way, as well as possible future work.

2. Theoretical Background

2.1 *Internet of Things*

The concept of the “Internet of Things” (IoT) was introduced by Kevin Ashton in 1999 to describe the connection of physical objects to the Internet through sensors (ROSE; ELDRIDGE; CHAPIN, 2015). In IoT, a “thing” is any object or entity with the ability to connect to the Internet, directly or indirectly (GRANELL *et al.*, 2020). Although it is a recent term, the idea of monitoring and controlling devices through networks is old (ROSE; ELDRIDGE; CHAPIN, 2015).

There is no single and consensual definition of IoT, with different interpretations of the concept (MAGRANI, 2021; DINIZ, 2006). IoT represents a new form of connectivity, allowing communication not only between people but also between objects (MAGRANI, 2018). The rapid evolution of IoT is expanding its applications and presence in various areas of everyday life (GRANELL *et al.*, 2020). IoT devices connect daily, enabling the exchange, processing, storage, and analysis of large volumes of data (MAGRANI, 2018).

2.2 Smart Cities

According to Cunha *et al.* (2016), the concept of smart city has been gaining popularity. Gibson, Kozmetsky, and Smilor (1992, cited in RIZZON *et al.*, 2017) describe that, in the 1990s, “Smart City” referred to cities that use technologies to economically improve urban life. Giffinger *et al.* (2007, cited in RIZZON *et al.*, 2017) proposed a Smart City model with six fundamental characteristics: Economy, people, governance, mobility, environment, and life, emphasizing the efficient combination of resources and self-managed activities.

A smart city aims to enhance the efficiency of urban services, improve the quality of life, and improve interactions between public agencies, businesses, and citizens, optimizing resource use and reducing operational costs (CUNHA *et al.*, 2016; Zanella, Bui, and Castellani, 2014 *apud* RIZZON *et al.*, 2017). According to Cunha *et al.* (2016), there is no consensus on the concept of a smart city, but four common elements are frequently mentioned: A holistic vision that permeates all areas of the city; the use of technology as a disruptive factor, in addition to digitalization; and a new model of relationships based on collaborative economy, citizen engagement, and more flexible and transparent urban policies.

2.3 Public Security

Currently, one of the main concerns of both the population and the government focuses on the issue of public safety, due to the uncontrolled growth of violence, drug trafficking, corruption, and organized crime (COSTA; LIMA, 2014). The concept of public safety is as broad as the complex multiplicity of public safety in Brazil, including the entities involved, their functions, and responsibilities (MENDES; AGUIAR, 2014), being yet another among the various public services to be provided to citizens, treated as clients (SILVA VEIGA, DA; SANTOS SOUZA, DOS, 2018). In this context, social participation plays a crucial role in the construction of public safety, aiming to achieve its effective implementation and improvement, as highlighted by Mendes and Aguiar (2014).

In the Federal Constitution, Brazil (1988, Art. 144), in its Chapter III, Art. 144, it states: "Public security, a duty of the State, a right and responsibility of all, is exercised for the preservation of public order and the safety of persons and property (...)."

The challenge of public safety is not restricted solely to crime, but involves a combination of various factors, including political, social, economic, ethical, cultural, administrative, and historical aspects, as mentioned by Costa and Lima (2014). Like other public services, public safety should be guided by constitutional principles, such as that of efficiency, which implies providing the highest quality service with the most rational use of available resources (LIMA, DE; MARINHO, 2017).

2.4 Security in Smart Cities

The authors Laufs, Borrion, and Bradford (2020) state that governments are increasingly using ICTs to make cities smarter in order to address the challenges arising from population growth. Surveillance devices, such as closed-circuit television (CCTV) systems, cameras, and smartphones, play a significant role in observing human activities, behavior, and in capturing constantly changing information (CHUI; VASANT; LIU, 2019).

According to Hartama *et al.* (2017 *apud* LAUFS; BORRION; BRADFORD, 2020), a safe city is characterized by the combination of technologies with the natural environment, optimizing the ability to face criminal and terrorist threats, with the aim of creating a healthy environment for the inhabitants and ensuring a quick response in emergency situations. Ní Loideain (2017) states that smart and safe cities must explore the opportunities offered by Information and Communication Technology (ICT) and the Internet of Things (IoT) as means to combat crime and promote public safety.

In his work, Alam (2021) reports that the smart city approach, supported by the Internet of Things (IoT), offers resources for monitoring, analysis, and immediate actions aimed at improving public safety. Through this technology, security systems can predict criminal activities by analyzing data from sensors and surveillance cameras, which are integrated into the information flows from social networks. As a result of these security implementations, law enforcement authorities have the ability to discourage or punish offenders, thanks to advances in security strategies.

The use of personal data for surveillance is not limited to corporations, as socio-technological sets of a Safe City are also involved in this process (KORAĆ, 2021). "This idea of a Safe City integrates the technology of the fourth industrial revolution and big data with urban governance and surveillance to

reduce crime rates and increase the safety of citizens in urban áreas" (CAO, 2016, *apud* KORAĆ, 2021). Thus, the smart city with applications in public safety is made up of a large number of interconnected devices, and security and privacy solutions must be developed with an emphasis on a protection system for the well-being of the community as a whole (BRAUN *et al.*, 2018).

2.5 Information and Communication Technologies in Public Security

In their work, Liu and Yuan (2015) tell us that the dissemination of information and communication technology (ICT) in government institutions began to gain prominence around the 1990s, driven by the efforts of government agencies to deal with the increasing volume of data storage and processing. Innovation related to Information and Communication Technology (ICT) plays a fundamental role in advancing various areas, including industry, health, education, among others, and its impact on public safety is no different (SPANHOL; LUNARDI; SOUZA, 2016). Cilliers and Flowerday (2014) state that local authorities are using ICTs to make their cities smarter in order to make more effective and efficient use of existing resources.

Spanhol, Lunardi, and Souza (2016) say that ICTs can improve public safety, both in administrative and operational management. They can facilitate communication and collaboration among security agents, increase the efficiency of services provided to the population, and promote the well-being of employees. In their publication, Kapucu and Haupt (2016) state that the implementation of various technologies follows a sequential pattern, in which each new technology is first adopted at the federal level before being progressively disseminated to state and local agencies. They also note that the size of the agency plays a significant role in the dissemination of Information and Communication Technologies (ICT) in this context.

According to Raty (2010) and da Silva (2008), public safety and internal security are concerns that receive special attention from governments around the world, as they involve the protection of the population and the critical infrastructures that support the functioning of the State. The role of the State includes the creation of an infrastructure capable of meeting the diverse demands of citizens, from the simplest to the most complex. Security plays a central role in maintaining the modern rule of law, and information technology plays an important role in shaping this structure today. Silva *et al.* (2008) state that the public power is increasingly using technologies to curb the actions of criminals. They argue that this use is based on a new paradigm of the information society, which seeks efficiency in the use of technologies for the benefit of citizens.

2.6 Internet of Things in Public Safety

Ahlgren, Hidell, and Ngai (2016) state that the Internet of Things (IoT) is a promising technology with great potential to face many social challenges. The Internet of Things (IoT) has extended to various areas, including industrial systems, public transportation, public safety, urban lighting, and other metropolitan applications, covering various public and private sectors (ALAM, 2021). Cities like London and New York are seeing a significant increase in demand and interest from public sectors in using IoT technologies to enhance traffic, reduce pollution and energy consumption, as well as collect data to improve policing operations (AHLGREN; HIDELL; NGAI, 2016).

According to Magrani (2018), IoT has been receiving significant investments from the private sector and emerges as a possible solution to the new challenges in public management, promising, through the use of integrated technologies and massive data processing, more effective solutions to problems such as pollution, congestion, crime, productive efficiency, among others.

This technology is integrated into a comprehensive range of products, systems, and networked sensors, leveraging advances in processing capability, electronic miniaturization, and network connectivity, providing new capabilities that were previously not feasible (ROSE; ELDRIDGE; CHAPIN, 2015).

According to Hamada and Nassif (2018), the Internet of Things (IoT) can be used in public safety to integrate a variety of data collection devices, such as speed radar cameras, GPS systems in mobile patrols, monitoring of ERBs, public surveillance cameras, CCTV systems, and residential surveillance cameras focused on public streets. This integration can improve the efficiency and effectiveness of public safety through the collection and analysis of real-time data.

2.7 Related Works

In the study by Silva, Santos, and Nascimento (2020), the researchers conducted a systematic mapping of the literature, examining computational solutions used by smart cities to mitigate events that deviate from the norm, with the goal of maintaining a safe environment for the population. It is noteworthy that Brazil and China have paid special attention to the use of cameras and systems due to high rates of violence and population density in their respective countries. In the United States, there was an emphasis on the use of systems and sensors. Among the benefits reported with the adoption of these solutions, there is a reduction in the need for interventions by authorities in critical situations. One of the main differences from this study is that it uses a smaller number of databases and a shorter search string, resulting in the analysis of 1,575 works, almost half the number of works considered in the current research. In addition, it differs in the approach of considering proposed solutions, but not effectively implemented.

Laufs, Borrion, and Bradford (2020) conducted a Systematic Mapping of the Literature on security in smart cities. The study identified various security interventions and suggested modifications, categorizing them into three main groups: (1) use of sensors with traditional approaches to detect and prevent crime; (2) transformation of existing systems into smart systems to improve processes and integrate solutions; and (3) introduction of new functionalities with modern approaches, such as crowdsourcing. The authors highlighted that improvements do not always require completely new systems, as long as they become intelligent.

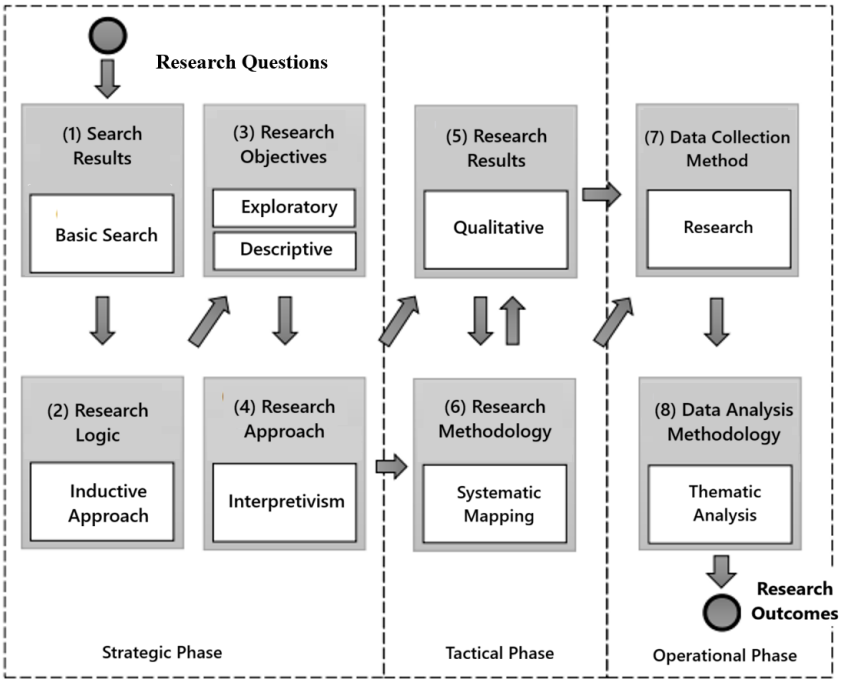
The article by Kawthalkar *et al.* (2020) analyzes technological solutions for the prevention and enhancement of existing security structures. It examines crime mapping techniques and predictive policing, with various approaches to classify and predict crimes. The study highlights the importance of integrating criminological theories with technological techniques to improve security, emphasizing that this combination increases the chances of success.

Although it presents small similarities, this work differs from others in several points, listed as follows: Search string: A string with various synonymous terms in Brazilian Portuguese and English; database: the work considers six databases in the search for research to be evaluated throughout the execution, resulting in a higher number of evaluated works; period: For the research, an effort was made not to limit the interval in which the studies were published; exclusion criteria: Works with proposals that have not yet been implemented were not considered; benefits: The main gains after the implementation of the computational solution in different locations are outlined; geographical characteristics: It takes into account the HDI of the regions, seeking to understand the reason for investing or not in computational solutions for security.

3. Methodological Aspects

This research is classified as basic research, inductive, descriptive-exploratory, interpretative, qualitative and follows the guidelines of Kitchenham (2004), which provide a set of procedures as a reference for conducting a Systematic Literature Mapping. Figure 1 illustrates the conceptual structure of decision-making, adapted from the work of Wohlin and Aurum (2015):

Figure 1 - Research Design Flowchart.



Source: Adapted from Wohlin and Aurum (2015).

3.1 Systematic Mapping of the Literature (SML)

According to Kitchenham (2004), the results of a mapping study have the ability to indicate appropriate areas for conducting Systematic Literature Reviews, as well as areas where a primary study would be more appropriate. The research question of this work was defined as follows: "What IT solutions in the area of security in smart cities can be found in the literature?" To answer this, a Mapping Study was conducted to identify the main security solutions in smart cities that have been implemented and used in various locations around the world. There was no restriction regarding the year of publication of the work, with research being conducted in four of the largest international databases and one national journal, in order to broaden the range of solutions for the present research.

In the present mapping, the main question that will guide the research has been defined as follows:

What are the existing IT solutions in the area of public security in smart cities found in the literature?

To reinforce a more precise exploration of the research topic, the central question was broken down into three more detailed inquiries, as follows:

Q1: *What security solutions in smart cities are applied in the context of public safety?*

Q2: *What are the demographic characteristics of smart cities that use such security solutions?*

Q3: *What are the main benefits mentioned in the application of these solutions?*

For the present work, the applications of strings in the databases were carried out in 2022, the choice was made due to their relevance and free access through CAFe (Federated Academic Community - *Comunidade Acadêmica Federada*), sources in Portuguese or English that are from proceedings, conferences, or journals. In addition to addressing security solutions in smart cities and having its complete version available for viewing, the articles should be written in Brazilian Portuguese or

English, as these are the languages the author is most familiar with. To conduct the automated searches, the databases used were as follows:

- ACM (https://dl.acm.org/);
- IEEE (https://www.ieee.org/);
- SBC OpenLib (https://sol.sbc.org.br/);
- Science Direct (https://www.sciencedirect.com/);
- Scopus (https://www.scopus.com/home.uri).

For the research in the databases, the central terms were established as follows, with adaptations to be made according to the search mechanism to be employed as shown in table 1.

After the completion of the planning stage, the research was initiated, starting the execution of automated searching in the chosen databases, followed by the application of inclusion and exclusion criteria, and finally, the extraction of data containing the necessary information to address the research questions.

Table 1 - Search string used in the research.

(“cidade inteligente” OR “cidades inteligentes” OR “*smart city*” OR “*smart cities*”)
AND
(segurança OR proteção OR salvaguarda OR preservação OR vigilância OR defesa OR “ordem pública” OR “saúde pública” OR paz OR polícia OR policial OR “política pública” OR “public security” OR “public safety” OR peace OR “public order” OR “law and order” OR “public policy” OR “safe city” OR safer OR policing)

Source: Elaborated by the authors.

During the implementation of the Systematic Literature Mapping, inclusion and exclusion criteria will be applied to determine whether the previously selected works will be considered for the next phase of the process. The established criteria are as follows:

• **Inclusion criteria:**

o **CI01 -** Written works in one of the accepted languages (pt-BR e en-US);

o **CI02 -** Works that address existing solutions in the field of security in smart cities;

o **CI03 -** Works that reference technologies in the field of security in smart cities;

o **CI04 -** Works for which the complete version is available for viewing in one of the searched scientific databases.

• **Exclusion criteria:**

o **CE01 -** Works that do not address security in smart cities;

o **CE02** - Works in which the summary/abstract is not presented;

o **CE03** - Works that are not written in one of the accepted languages;

o **CE04** - Works in which the full version is not available for viewing;

o **CE05 -** Repeated work (only the first occurrence will be considered);

o **CE06** - Works such as: Summary, course, tutorial.

The selection process of the studies went through four phases, they are:

• Phase 1 - Initial search: Executing the **search string** in the previously selected search engines, with the exclusion of duplicate results, if any appear;

• Phase 2 - Initial selection: Stage in which the title and the abstract of the works are examined, when deemed appropriate, in order to carry out an initial selection, categorizing them later as approved or rejected;

• Phase 3 - Intermediate Selection: Reading the Introduction and Conclusion of the works;

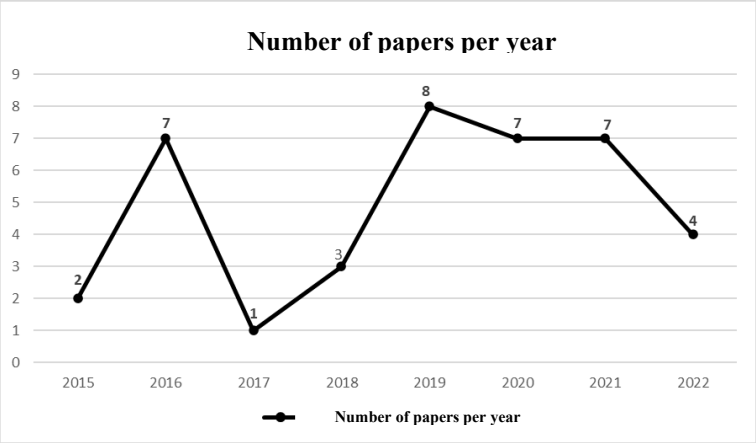
• Phase 4 - Final selection: Comprehensive reading carried out to avoid the exclusion of relevant studies, followed by the information collection process.

4. Results and Discussion

4.1 Metadata

Figure 2 shows the distribution of articles that were accepted, according to the year of publication.

Figure 2 - Number of articles accepted per year.



Source: Elaborated by the authors.

Until 2014, no work was identified in the selected databases, with a study appearing only in 2015 that meets the basic research requirements. From 2019, the year with the highest number of accepted publications, there was a slight drop in 2020, remaining constant in 2021, with seven selected studies, and falling again in 2022.

Table 2 shows the distribution of countries where the reported computational solutions are implemented:

Table 2 - Solutions according to geographical location.

Country	Cited city	Number of solutions mentioned by country	Population (inhabitants)	Population density (inhabitantes/km²)
Argentina	Buenos Aires	1	3,1M	15,346.5
	Tigre		447,785	1,243.84
Australia	Unspecified city	1	Unspecified city	Unspecified city
Brazil	See Table 3	12	See Table 3	See Table 3
China	Shanghai	4	25M	3,947.5

	Guangzhou		20,5M	2,757.6
Colombia	Medelin	1	2,3M	6,302.68
South Korea	Unspecified city	2	Unspecified city	Unspecified city
Denmark	Copenhagen	1	653,664	7,254.8
United Arab Emirates	Dubai	2	3.5M	862.8
Spain	Granada	1	233,680	2,653.6
United States	Chicago	7	2,7M	4,746.3
	Memphis		633,104	825
	San Diego		1,3M	1,643.2
	San Leandro		91,008	2,638
	Unspecified city		Unspecified city	Unspecified city
Estonia	Unspecified city	1	Unspecified city	Unspecified city
Holland	Eindhoven	1	238,326	2,708
India	Chennai	4	4,6M	26,553
	Pilani		40,590	12,000
	Surat		6M	1,337
England	London	2	9M	5,726.7
Iran	Unspecified city	1	Unspecified city	Unspecified city
Malaysia	Skudai	1	218,980	2,807
Portugal	Tomar	1	40,677	115.81
United Kingdom	Sheffield	2	556.500	1,513
	Unspecified city		Unspecified city	Unspecified city
Singapore	Singapore	2	5,6M	7,887.32
Global	--	9	--	--

Source: Elaborated by the authors.

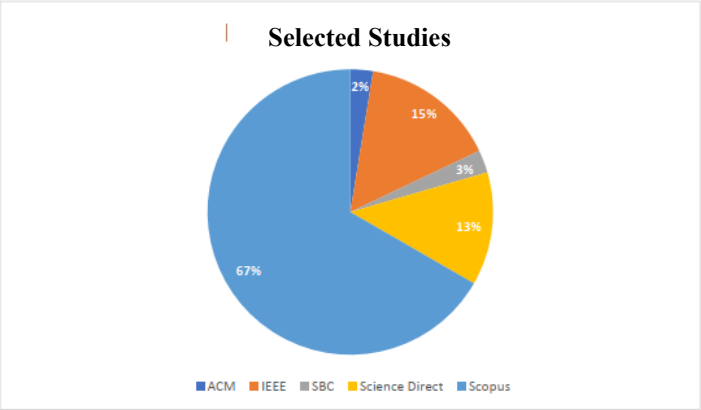
Table 3 - Solutions found according to the location within Brazilian territory.

Brazilian city	**Number of solutions mentioned**	**Population (people)**	**Population density (Inhabitant /km²)**
Brasília (DF)	1	2,817.068	489.01
Pato Branco (PR)	2	91,836	170.35
Rio de Janeiro (RJ)	2	6,211.423	5,174.77
Natal (RN)	4	751,300	4,488.03
São Paulo (SP)	3	11,451.245	7,527.76

Source: Elaborated by the authors.

In Phase 4 of the methodology, a complete reading of the remaining 72 papers was carried out, 33 articles were rejected, which resulted in a total of 39 accepted studies, according to the inclusion criteria, for the data extraction stage, with 26, 6, 5, 1, and 1 for the databases Scopus, IEEE, Science Direct, SBC, and ACM, respectively. The distribution is illustrated in Figure 3 below:

Figure 3 - Selected studies in each database.

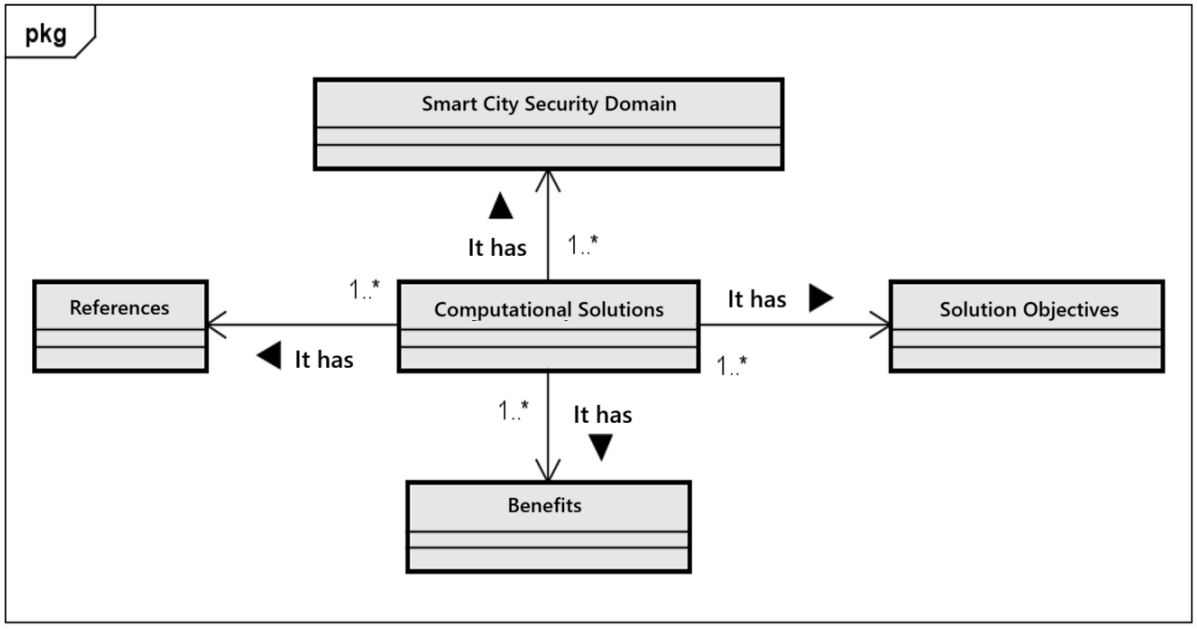


Source: Elaborated by the authors.

4.2 Interest Data

Figure 4 below represents the relationship of the concepts created to classify the studies. A Computational Solution has one or more security Domain(s) in smart cities; it also has one or more objective(s); it is connected with one or more reported Benefit(s); in addition to having one or more Reference or study that published the solution.

Figure 4 - Conceptual model during data extraction.

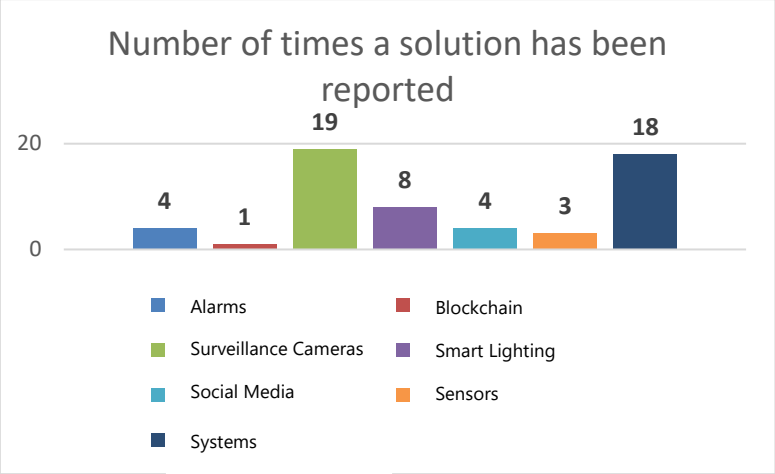


Source: Elaborated by the authors.

4.2.1. Computational solutions found

Figure 5 displays the number of times a given solution is reported in the studies. The same work may present one or more solutions, as can be observed.

Figure 5 - Number of solutions reported.



Source: Elaborated by the authors.

The solution that was mentioned the most times was the use of surveillance cameras (which also includes the use of drones for this purpose), appearing on 19 occasions. For example, in their research, Bang *et al.* (2019) present the Safe City Test Bed project, which was implemented by the government of Singapore, in response to the need to increase investments in ICT equipment in order to enhance the security of the population that has grown exponentially in recent decades.

Surveillance systems have been used to detect unusual scenarios, in addition to the possibility of being integrated with other systems, such as facial recognition, contributing to identifying potential offenders.

Another solution that also stood out for the number of times mentioned was the use of systems as a way to contribute to the safety of the population, where 18 studies reported its implementation in different locations. Such systems can be available in desktop, web, and mobile versions. Among the studies, Coelho *et al.* (2016) present the system called Rota, which has been used in the city of Natal-RN, designed to integrate various systems and thereby achieve two main objectives: Better use of information for higher management levels and better coordination of resources at both individual and organizational levels, increasing, since its implementation, the safety and operational efficiency of the police force.

Four solutions were reported a similar number of times, being 8, 4, 4, and 3 for Smart Lighting, Alarms, Social Networks, and Sensors, respectively. For Blockchain, only one work mentioned its implementation as a way to contribute to the security of a smart city, which was the solution that was listed the least.

The solutions found and their relationships with other concepts are in Table 3. The second column briefly presents the central objective of the described solution, which can be: Management, identification, prevention, and tracking. The benefits reported from the implementation of the solutions are described in the third column. Finally, the fifth and last one contains the references from which the information for filling out the table was extracted. Taking the first domain of security as an example, following alphabetical order, we have crimes against sexual dignity. For this type of crime, three main computational solutions were identified, which aim to positively contribute to mitigating such practices, namely: Surveillance cameras, intelligent lighting system, and mobile system (application). The objectives include the prevention and identification of this type of offense.

Among the reported benefits, it was possible to identify the following: assistance in crime prevention and investigation; reduction in response time to incidents; monitoring of anomalies and suspicious events/behaviors; helping policing to anticipate crowd behavior and movement in enclosed environments such as subways, railways, and transit stations; a sense of security; the possibility of

integration with other solutions, in the case of smart lighting; perception of suspicious behavior in busy environments; decline in crime; generation of alerts and tracking of individuals in danger; reduction in response time to incidents. All studies analyzed and approved are categorized in Table 4.

Table 4 - Solutions, goals, and reported benefits.

Computational solution	Solution objective	Reported benefits
Alarm	- Prevention.	- Assistance in the prevention/inhibition of crimes.
Blockchain	- Prevention; - Identification.	- Identity verification of citizens in transactions; - Fraud inhibition.
Surveillance camera	- Prevention; - Identification.	- Assistance in the prevention, inhibition, and investigation of crimes; - Decrease in response time to occurrences; - Monitoring of anomalies and suspicious events/behaviors; - Help the policing to anticipate the behavior and movement of crowds in enclosed spaces such as subways, railways, and transit stations.
Smart lighting	- Prevention.	- Sense of security; - Integration with other computing solutions; - Perception of suspicious behavior in crowded environments; - Decline in crime.
Social network	- Prevention; - Identification; - Management.	- Dissemination and investigation; - Information that assists the decision-making process; - Reporting of crimes.
Sensor	- Prevention; - Identification.	- Detection of unusual scenarios; - Information gathering; - Prevention, inhibition; - Monitoring citizens and their activities.
Desktop and web system	- Management; - Prevention.	- Obtaining information that aids the decision-making process; - Obtaining statistical data on crimes; - Predictive policing; - Insights to understand and solve complex operational problems, particularly in the areas of complex emergency planning and response; - Better management of human and material resources; - Information that aids the decision-making process; - Agility in response time to requests; - Analysis of areas with higher risk of occurrences; - Assisting in the management of vehicles on city rounds.
Mobile system	- Prevention; - Tracking.	- Generation of alerts and tracking of people in danger; - Decrease in response time to incidents; - Alerts to friends/family when in danger; - Tracking.

Source: Elaborated by the authors.

From the data extraction, conceptual categories were also created to classify the analyzed studies. There are types of security problems that can be influenced by the reported Computational Solution, referred to as the Security Domain in Smart Cities, and described in the table that follows. To better understand, consider the example combining the data from Tables 4 and 5, stating that Property Crimes can be prevented through the use of intelligent lighting systems and cameras, inhibiting criminal action.

Table 5 - Security domains and their respective computational solutions.

Security domain	Computational solution
Crimes against sexual dignity	Surveillance camera
	Smart lighting
	Mobile system
Crimes against public faith	Blockchain
Crimes against public safety	Surveillance cameras
	Social networks
Crimes against the person	Surveillance cameras
	Smart lighting

	Sensors
	System
Crimes against the environment	Surveillance cameras
Crimes against property	Alarm
	Surveillance cameras
	Smart lighting
	Sensors
	System

Source: Elaborated by the authors.

4.2.2. Practical Implications

From a practical point of view, the research findings provide support to improve public safety policies in smart cities, suggesting that the adoption of already tested solutions can be expanded to new contexts, always considering the balance between cost and benefit. Among the identified barriers are budget limitations, cultural resistance, and lack of adequate infrastructure, which can be overcome through public-private partnerships, training programs, and investments in connectivity. Furthermore, urban managers can use the insights from this study to prioritize solutions with greater preventive impact and to create integrated strategies that combine different technologies, promoting a safer and more efficient environment.

4.2.3. Theoretical Implications

The results of this systematic mapping contribute to the advancement of theories on security in smart cities by demonstrating that the integration of multiple IT solutions, such as surveillance cameras, smart lighting, and mobile systems, reinforces the holistic approach advocated by recent theoretical models. The study confirms the relevance of prevention as a central strategy and points out conceptual challenges, such as the need to balance surveillance and the protection of personal data. Furthermore, the findings engage with theories of urban governance and digital security, emphasizing the importance of interoperability and citizen participation. Thus, these conclusions may guide future investigations to explore new hybrid models that combine operational efficiency and ethical safeguards.

5. Final Considerations

In this work, a Systematic Literature Mapping (SLM) was conducted to identify Information Technology (IT) solutions applied to public security. The study addressed the question: “What are the IT solutions available in the field of public security found in the literature?” A total of 39 studies were selected after going through four reading phases: 1) execution of the search string and removal of duplicates; 2) reading of titles and abstracts; 3) reading of introductions and conclusions; 4) complete reading of the texts.

The analysis revealed that smart cities have adopted computational solutions to tackle problems related to population growth, especially violence and urban insecurity. For the so-called Security Domains, solutions were found that mainly relate to Crimes Against the Person, aimed at preventing and identifying harmful acts to human lives, such as assaults, homicides, and attempts. There are also Crimes Against Property, such as theft and burglary, with a good portion applicable to both domains, making use of surveillance cameras, smart lighting, systems, for example.

Among the main solutions found, the use of surveillance cameras stands out, which can be explained by the fact that they facilitate the monitoring of a perimeter from a distance and can be used with other systems such as facial recognition, sensors, etc. The use of systems also stood out, presenting itself in different forms, whether in its desktop and web version providing information for the decision-making process; or in the mobile version, contributing to the provision of information when the user and potential victim find themselves in an abnormal situation, using location sharing features in the face of

a threat that will consequently reduce the response time of public safety agents. There are solutions that interconnect with each other, offering a more robust proposal to enhance something already in use.

A large part of the solutions implemented aims to act preventively. This situation can be justified as it is better to avoid than to deal with its consequences, for several reasons, such as the protection of lives, operational costs, impact on quality of life, among others. These reasons affect both individuals and society as a whole. Another goal that was frequently identified is the identification of the offending individual, mainly carried out through the use of cameras linked with facial recognition systems. The identification contributes to the application of justice and the prevention of future crimes, based on solid evidence and respecting legal principles.

Among the main benefits of these solutions are the improvement in the distribution of human and material resources, greater efficiency in responding to incidents, and quick responses to crimes. In addition, the identification of offenders through cameras and facial recognition contributes to the enforcement of justice and the prevention of future crimes.

The most prominent institutions in research are the Federal University of Rio Grande do Norte (*Universidade Federal do Rio Grande do Norte*) and the Technological University of Paraná (*Universidade Tecnológica do Paraná*), both with four publications each, in addition to the Electronics and Telecommunications Research Institute of South Korea. It was noted that most solutions are implemented in regions with high Human Development Index (HDI), such as Europe and Asia, while little was found in Africa, which has low HDI.

In Brazil, solutions are concentrated in the south and southeast regions, which have a higher HDI, except for Rio Grande do Norte, which, despite having the lowest HDI, presented four relevant studies. Solutions in regions with low HDI could benefit from investments in research to reduce costs and replicate successful models.

The MSL revealed that security in smart cities is an emerging theme with an increasing number of publications, reflecting concerns about the safety of the population. Despite a recent decrease in the number of accepted papers, this does not indicate disinterest, but rather that some recent studies did not meet the inclusion criteria, mainly because they did not present implemented solutions.

The limitations of the work include the exclusion of gray literature and the need to explore other sources, such as government documents and non-reviewed literature. Future work could expand the search to include unimplemented solutions and address cybersecurity, in addition to using techniques such as forward snowballing and backward snowballing to broaden the research scope. The recommendation is to share the solutions found with public safety authorities to encourage implementation and obtain feedback on the necessary requirements for adopting these technologies.

To enhance the practical applicability of this study, it is recommended that security solutions in smart cities be analyzed in a segmented manner according to the socioeconomic profile of the cities, distinguishing between low and high HDI contexts. For cities with less technological infrastructure, it is suggested to prioritize frugal, scalable, and low-cost models, while in more developed cities, the emphasis may be on integrated and advanced solutions, such as interoperability between surveillance systems and predictive data analysis. In addition, three priority issues for future research are highlighted: (i) to assess the ethical and legal limits of using blockchain in urban services without violating data protection norms; (ii) to investigate governance strategies to balance operational efficiency and citizen privacy; and (iii) to explore mechanisms for social participation in designing and accepting security technologies.

Conflict of Interest Declaration

The authors have no conflicts of interest to declare or financial interests to report.

References

1. Abdali, A.-M. R., & Al-Tuma, R. F. (2019). Robust real-time violence detection in video using CNN and LSTM. *2nd Scientific Conference of Computer Sciences (SCCS)*.
2. Ahlgren, B., Hidell, M., & Ngai, E. C.-H. (2016). Internet of things for smart cities: Interoperability and open data. *IEEE Internet Computing, 20*(6), 52–56.
3. Alam, T. (2021). Cloud-based IoT applications and their roles in smart cities. *Smart Cities, 4*(3), 1196–1219.
4. Alsamhi, S. H., Ma, O., Ansari, M. S., & Gupta, S. K. (2019). Collaboration of drone and internet of public safety things in smart cities: An overview of QoS and network performance optimization. *Drones, 3*(1), 13.
5. Alsamhi, S. H., Ma, O., Ansari, M. S., & Almalki, F. A. (2019). Survey on collaborative smart drones and internet of things for improving smartness of smart cities. *IEEE Access, 7*(1), 128125–128152.
6. Alshawish, R. A., Alfagih, S. A. M., & Musbah, M. S. (2016). Big data applications in smart cities. *International Conference on Engineering & MIS (ICEMIS)*.
7. Araújo, A., et al. (2016). Emergency plans support systems: Integration of safety and security operational procedures. *11th Iberian Conference on Information Systems and Technologies (CISTI)*.
8. Arikuma, T., & Mochizuki, Y. (2016). Intelligent multimedia surveillance system for safer cities. *APSIPA Transactions on Signal and Information Processing, 5*(1), 3.
9. Bang, J., et al. (2019). AR/VR-based smart policing for fast response to crimes in safe city. *IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct)*.
10. Braun, T., et al. (2018). Security and privacy challenges in smart cities. *Sustainable Cities and Society, 39*(1), 499–507.
11. Cacho, N., et al. (2016). A smart city initiative: The case of Natal. *IEEE International Smart Cities Conference (ISC2)*.
12. Carvalho, G. A., et al. (2018). Plataforma ROTA: Histórico, desafios e soluções para segurança pública em cidades inteligentes. *Anais do I Workshop Brasileiro de Cidades Inteligentes*.
13. Chang, J., et al. (2022). Gendering the smart city: A case study of Sejong City, Korea. *Cities, 120*(1), 103422.
14. Chui, K. T., Vasant, P., & Liu, R. W. (2019). *Smart city is a safe city: Information and communication technology–enhanced urban space monitoring and surveillance systems*. Elsevier.
15. Cilliers, L., & Flowerday, S. (2014). Information security in a public safety participatory crowdsourcing smart city project. *World Congress on Internet Security (WorldCIS 2014)*.
16. Civil, C., & Others. (1988). *Constituição da República Federativa do Brasil de 1988*. Presidência da República.
17. Coelho, J., et al. (2016). ROTA: A smart city platform to improve public safety. In *New Advances in Information Systems and Technologies*.
18. Colla, M., & Santos, G. D. (2019). Public safety decision-making in the context of smart and sustainable cities. *Procedia Manufacturing, 39*(1), 1937–1949.
19. Dal Magro, D., & Fortes, V. B. (2021). Facial recognition in smart cities and the guarantee of the rights to privacy and personal data protection. *Brazilian Journal of International Law, 18*(1), 302.

20. Dameria, C., & Fuad, A. H. (2021). Enhancing female pedestrians' safety perceptions through the permeability of building frontages. *IOP Conference Series: Earth and Environmental Science*.
21. Dizon, E., & Pranggono, B. (2022). Smart streetlights in smart city: A case study of Sheffield. *Journal of Ambient Intelligence and Humanized Computing, 13*(63), 1–16.
22. Fernandez, Z. A. M., et al. (2020). Challenges of smart cities: How smartphone apps can improve the safety of women. *2020 4th International Conference on Smart Grid and Smart Cities (ICSGSC)*.
23. Ferreira, J. E., et al. (2017). Smart services: A case study on smarter public safety by a mobile app for the University of São Paulo. *IEEE SmartWorld Conference Proceedings*.
24. Gil, A. C. (2008). *Métodos e técnicas de pesquisa social* (6th ed.). Atlas.
25. Granell, C., et al. (2020). Internet of things. In *Manual of Digital Earth*.
26. Hamada, H. H., & Nassif, L. N. (2018). Perspectivas da segurança pública no contexto de smart cities. *Perspectivas em Políticas Públicas, 11*(22), 189–213.
27. Hildmann, H., & Kovacs, E. (2019). Using UAVs as mobile sensing platforms for disaster response and public safety. *Drones, 3*(3), 59.
28. Jiang, M. (2020). An integrated situational awareness platform for disaster planning and emergency response. *IEEE International Smart Cities Conference (ISC2)*.
29. Jin, D., et al. (2016). Smart street lighting system: A platform for innovative smart city applications. *The Electricity Journal, 29*(10), 28–35.
30. Joh, E. E. (2019). Policing the smart city. *International Journal of Law in Context, 15*(2), 177–182.
31. Kapucu, N., & Haupt, B. (2016). ICT use for public safety in the United States. *Frontiers in Communication, 1*(1), 8.
32. Kawthalkar, I., et al. (2020). A survey of predictive crime mapping techniques for smart cities. *2020 National Conference on Emerging Trends on Sustainable Technology and Engineering Applications (NCETSTEA)*.
33. Korać, P. (2021). Data (de)colonization: Case of the "Safe City" project in Belgrade.
34. Labib, N. S., et al. (2021). The rise of drones in IoT. *IEEE Access, 9*(1), 115466–115487.
35. Laufs, J., Borrion, H., & Bradford, B. (2020). Security and the smart city: A systematic review. *Sustainable Cities and Society, 55*(1), 102023.
36. Lima, F. S. de, & Marinho, E. (2017). Public security in Brazil. *Economia, 18*(1), 129–145.
37. Magrani, E. (2018). *A internet das coisas no Brasil*. FGV Editora.
38. Meijer, A., & Thaens, M. (2018). Quantified street. *Information Polity, 23*(1), 29–41.
39. Mendonça, M., et al. (2016). Improving public safety at fingertips. *IEEE International Smart Cities Conference (ISC2)*.
40. Mohanty, S. P., Choppali, U., & Kougianos, E. (2016). Smart cities and IoT. *IEEE Consumer Electronics Magazine, 5*(3), 60–70.
41. Munoz, V., Vallejo, M., & Aedo, J. E. (2021). Exploratory analysis of crime behavior in Medellín. *Sustainable Cities Latin America Conference (SCLA)*.
42. Ní Loideain, N. (2017). Cape Town as a smart and safe city. *International Data Privacy Law, 7*(4), 314–334.
43. Oliveira, C. S. de, et al. (2004). Violência e cidade. *O Público e o Privado, 2*(4), 87–101.
44. Oliveira, V. A. T., & Santos, G. D. (2019). IT acceptance in public safety. *Procedia Manufacturing, 39*(1), 1929–1936.
45. O'Malley, P., & Smith, G. J. D. (2022). Smart crime prevention? *Theoretical Criminology, 26*(1), 40–56.

46. Paasche, T. F., & Klauser, F. R. (2015). Surveillance and privacy. *International Encyclopedia of the Social & Behavioral Sciences, 23*(1), 727–732.
47. Räty, T. D. (2010). Survey on contemporary remote surveillance systems. *IEEE Transactions on Systems, Man, and Cybernetics, Part C, 40*(5), 493–515.
48. Rivera, F. M. la, Matos, B. Á. E. Ç. A. de, & Lozano-Igualt, V. (2021). Municipal IoT implementation strategy for Brasília. *WIT Transactions on Ecology and the Environment, 253*(1), 451–462.
49. Samsudin, S., et al. (2021). Assessing safety level of UTM campus. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 46*(1), 479–488.
50. Shenoy, M. V., et al. (2021). A holistic framework for crime prevention. *IEEE Access, 9*(1), 66188–66207.
51. Silva, P. I. M., Santos, V. M., & Nascimento, R. P. C. do. (2020). Systematic mapping of computational solutions. *Proceedings of the 10th EuroAmerican Conference on Telematics and Information Systems*.
52. Silva Veiga, C. C. P. da, & Santos Souza, J. dos. (2018). O conceito de segurança pública. *Revista Brasileira de Segurança Pública, 12*(2), 48–65.
53. Spanhol, F. J., Lunardi, G. M., & Souza, M. V. de. (2016). *Tecnologias da informação e comunicação na segurança pública e direitos humanos*. Blucher.
54. Tavares, E. A. (2016). O aumento da criminalidade no Brasil. *Synthesis: Revista Digital FAPAM, 7*(1), 229–239.