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Women Safety Solutions

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ABSTRACT

This paper presents a comprehensive review of existing women safety systems, with a focus on their development, implementation, and effectiveness in providing protection against safety threats. As concerns about women's safety continue to rise, various technological solutions have emerged, primarily through mobile applications and surveillance systems. These systems typically feature real-time location tracking, emergency alerts, and direct communication with emergency services. This review evaluates these solutions by examining their strengths, weak- nesses, and their applicability in diverse real-world settings. It also discusses the integration of advanced technologies such as artificial intelligence, machine learn- ing, and Internet of Things (IoT) to enhance system performance and reliability. Additionally, the paper highlights the challenges faced by these systems, including privacy concerns, user accessibility, and the ability to function effectively in different environments. By critically analyzing these technologies and their limitations, this survey aims to contribute to the ongoing efforts to improve women's safety through technological advancements.

Keywords: Women Safety Systems, Mobile Applications, Emergency Alerts, Location Tracking, Safety Solutions, User Accessibility

1. Introduction

Ensuring the safety and security of women in public and private spaces has become a pressing issue globally. With the increasing frequency of safety threats such as harass- ment, assault, and violence, technological solutions have emerged as a potential means to address these concerns. Over the years, several women safety systems have been developed, primarily in the form of mobile applications and surveillance technologies, aimed at providing immediate assistance during dangerous situations. These systems often incorporate features such as real-time location tracking, emergency alerts, and seamless communication with emergency responders.

This paper aims to provide a detailed survey of the existing women safety sys- tems, shedding light on the various solutions that have been implemented to improve women's safety. By examining the functionalities, effectiveness, and challenges faced by these systems, the paper offers valuable insights into their practical application. Additionally, it discusses the role of emerging technologies like artificial intelligence, machine learning, and IoT, which are increasingly being integrated into safety sys- tems to enhance their performance and responsiveness. Despite their promise, these systems face several barriers, including privacy concerns, accessibility issues, and the need for widespread adoption to be truly effective.

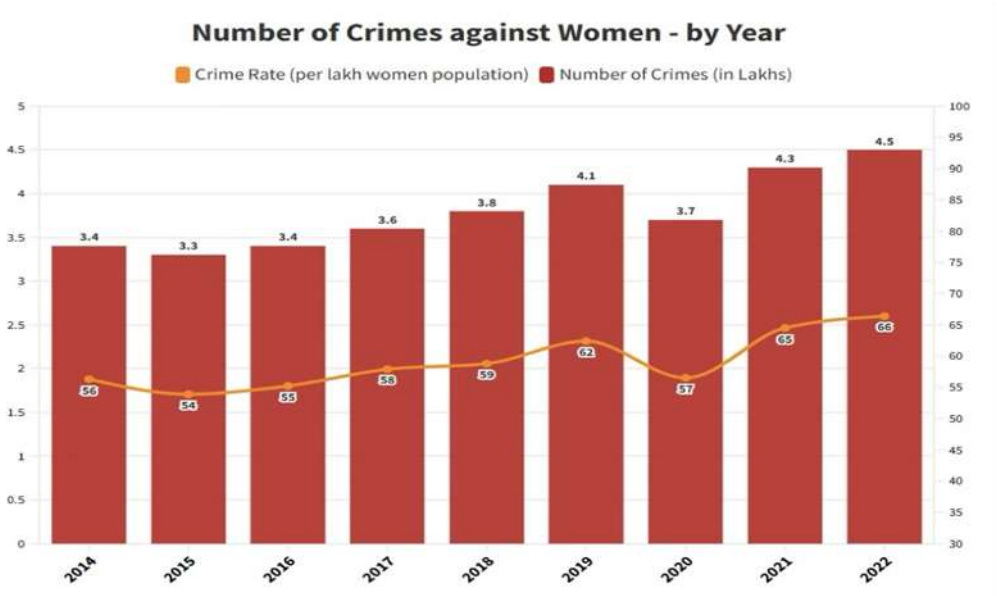

Fig. 1: Crime Rate against Women [47]

Figure 1, The figure provides a concerning view of the rising crimes against women in India from 2014 to 2022. It shows that the number of reported cases has steadily increased from 3.4 lakhs in 2014 to a worrying 4.5 lakhs in 2022. Alongside this, the crime rate per lakh women population has followed a similar upward trend, moving from 56 in 2014 to 66 in 2022. While there were slight dips in the crime rate in 2015 and 2020, the numbers surged significantly in recent years, especially after 2020, with the rate jumping from 57 to 65 in 2021 and reaching 66 in 2022. These statistics under- score the growing safety challenges faced by women and highlight the pressing need for innovative solutions, stronger enforcement, and collective efforts to ensure their protection and well-being.

With the rising concerns regarding women's safety, technological advancements have led to the development of innovative solutions aimed at ensuring protection in emer- gency situations. A major breakthrough has been the use of Internet of Things (IoT) technology, artificial intelligence (AI), and wireless sensor networks (WSNs) to create smart safety systems. These systems utilize various sensors integrated into wearable devices or mobile applications to detect potential threats and provide immediate alerts. One such advancement is the design of an IoT-based women protective system using AI-enabled smart sensors, which allows for real-time monitoring and response to safety concerns [1].

Mobile applications have also gained traction as an effective means of enhancing women's safety. Applications like SAKHI provide women with a platform to quickly alert emergency contacts through real-time location tracking, ensuring rapid responses during distress situations [2]. Additionally, AI-powered systems such as WoExP offer the ability to monitor and respond to abnormal behavior, ensuring that safety threats are promptly addressed by sending automatic alerts to designated contacts [3].

Furthermore, wearable devices integrated with safety applications have become crucial in emergency situations. For example, systems designed by researchers like Artamadja et al. use wearable sensors to detect conditions such as falls or high-stress levels and automatically notify emergency contacts, thereby reducing response time and improving safety outcomes [4].Additionally, mobile apps like Myguard provide intu- itive interfaces for women to share their real-time location and send distress signals during critical situations [5].

The increasing need for women's safety has led to the development of gesture-based applications that offer discreet and effective ways of seeking help in emergency sit- uations. These applications utilize sensors embedded in wearable devices or mobile phones to detect specific gestures made by users, triggering a response such as sending an alert to emergency contacts or authorities. The use of gestures allows individuals to silently signal for help in situations where speaking out is not possible. This innova- tive approach focuses on user convenience and safety, ensuring that help is summoned without the need for manual interaction with the device, making it particularly effec- tive in critical and high-risk scenarios [6].

Real-time surveillance systems have emerged as a crucial technology in enhancing pub- lic safety, particularly in urban spaces. These systems utilize cameras, motion sensors, and AI algorithms to monitor public areas and detect potential threats or suspicious behavior. The real-time aspect of these systems allows authorities to receive immedi- ate alerts, enabling a rapid response to prevent or mitigate crimes. The integration of AI in these systems aids in accurately identifying unusual activities, distinguishing between normal and suspicious events, and ensuring timely intervention. Such surveil- lance systems play a vital role in reducing the risk of crimes against women in public spaces, providing a sense of security to individuals and communities [7].

Existing systems have incorporated wearable devices equipped with sensors like pres- sure and temperature detectors to identify distress situations and enable discreet activation mechanisms for sending alerts [8]. Mobile applications have been devel- oped to facilitate GPS-based location tracking and emergency message transmission, allowing users to seek help with minimal effort. Such systems often integrate with law enforcement databases or local

emergency contacts to optimize response times [9, 10]. Additionally, some solutions provide continuous location updates and real-time plot- ting on digital maps to enhance monitoring and ensure timely assistance [10].

The increasing prevalence of AI and machine learning in safety applications enables features like predictive analytics and personalized security solutions [17, 21]. Such advancements, when combined with community-driven initiatives and ethical design practices, pave the way for a safer and more inclusive society [20]. These studies col- lectively underline the critical role of technology in empowering women and creating secure environments globally.

1.1 Problem Statement

Despite the increasing number of women safety systems being developed globally, there remains a significant gap in their widespread adoption, effectiveness, and ability to address diverse safety threats in real-time. Existing solutions, including mobile applications and surveillance systems, face challenges such as privacy concerns, limited accessibility, and inconsistent performance across different environments. Additionally, many of these systems lack the integration of advanced technologies that could enhance their capabilities, such as artificial intelligence and machine learning. This survey aims to identify and analyze the key shortcomings of current women safety systems, evaluate their effectiveness in addressing the unique challenges faced by women in various contexts, and explore the potential for integrating emerging technologies to improve their overall impact and usability.

1.2 Motivation

Women face daily challenges when it comes to safety, with many living in constant fear of harassment, assault, or violence. While technological solutions, such as safety apps and surveillance systems, have emerged to address these concerns, they often fall short in terms of reliability, accessibility, and real-world effectiveness. Despite the good intentions behind these systems, there is still a significant gap in ensuring that they provide the protection and peace of mind that women need.

This survey paper is motivated by the need to better understand these gaps and the limitations of existing safety systems. By exploring the current landscape, we aim to shed light on what works, what doesn't, and where improvements can be made. The goal is to identify opportunities to integrate emerging technologies, like artificial intelligence, machine learning, and IoT, to enhance the effectiveness of safety solu- tions. Ultimately, this paper hopes to contribute to the development of more intuitive, accessible, and impactful systems that can genuinely help protect women in today's world.

1.3 Objective

Women's safety remains a significant concern worldwide, with many existing solutions failing to effectively address the diverse challenges faced by women in real-life situ- ations. While various women safety systems have been developed, issues related to accessibility, reliability, and privacy continue to persist. The integration of advanced technologies such as artificial intelligence, machine learning, and IoT holds promise for improving the effectiveness of these systems, yet a comprehensive understanding of their potential remains underexplored. This survey paper aims to fill this gap by systematically reviewing and analyzing the current state of women safety systems, highlighting their strengths, limitations, and opportunities for enhancement. Through this review, we seek to provide valuable insights into emerging trends and propose directions for future developments to create smarter, more reliable safety systems for women.

1.4 Related Work

In the field of women's safety applications, several advancements have been made, leveraging technologies like IoT, AI, and real-time monitoring systems. Traditional safety systems primarily relied on basic panic buttons or simple mobile apps that only sent location data to emergency contacts. However, these solutions often lacked accuracy, responsiveness, and adaptability in complex or unpredictable situations. To overcome these limitations, modern systems integrate IoT-based sensors with machine learning algorithms to provide real-time situational analysis and ensure more effective responses [1].

For instance, an IoT-based women protective system was developed that utilizes smart sensors such as motion detectors, pressure sensors, and GPS trackers. The system's methodology involves detecting unusual behavior or emergency situations and trigger- ing real-time alerts to emergency contacts. The integration of AI algorithms enhances the accuracy and speed of the detection process, ensuring prompt responses in diverse real-world environments where traditional systems might fail due to sensor inaccura- cies or delayed communication [2].

Similarly, another application called SAKHI focuses on providing women with a smartphone-based solution for personal safety. The application employs GPS tracking, real-time alerts, and an SOS feature to ensure that emergency services and contacts can be notified immediately during a crisis. The primary advantage of SAKHI is its real-time tracking and ability to function on existing mobile infrastructure, making it widely accessible and easy to use. Despite its simplicity, the key innovation of SAKHI lies in the ability to send distress signals to a wide range of contacts, including local authorities, ensuring a quick response when time is critical [3].

Additionally, a system called WoExP, which uses wearable sensors integrated with machine learning algorithms for predictive threat detection, was developed. The sys- tem analyzes sensor data to identify suspicious activities or potential threats, providing real-time notifications to the user and their

emergency contacts. The use of wearable sensors allows for continuous monitoring, even when the user is unable to interact with the app directly, providing an extra layer of security [4].

These advancements illustrate a significant shift from traditional safety systems to more intelligent, adaptive solutions. However, challenges remain in terms of battery consumption, user accessibility, and system reliability, particularly in remote or low- connectivity environments. Ongoing work in this field focuses on optimizing these systems for real-world deployment, enhancing their scalability, and integrating more advanced AI-driven capabilities [5].

In addition, real-time surveillance systems have been implemented in public spaces to monitor women's safety. These systems use cameras, motion sensors, and AI to detect suspicious activity. The system is capable of identifying unusual behavior and notify- ing authorities, significantly improving safety in public areas. This proactive approach ensures that potential threats are identified and addressed before they escalate [7].

Moreover, gesture-based women's safety applications have emerged, where women can trigger an emergency response by performing specific gestures. This method is particularly useful when verbal communication is not possible due to environmental constraints. The system uses real-time processing to detect these gestures and send alerts to the authorities or emergency contacts, providing a quick and discreet way to report a situation [6]. Historical efforts, such as FEMME and Abhaya, emphasized the need for wearable safety devices and mobile apps tailored for women's security [8, 9]. Studies have also shed light on how advanced technologies, including GIS-based crime mapping and hotspot analysis, can support proactive measures [16, 19]. Additionally, data analysis on crime trends, literacy rates, and digital threats offers valuable insights into understanding and addressing underlying causes [12, 13, 15].

2. Literature Survey

Table 1: Literature Survey

S.no	Title	Author(s)	Journal & Year	Methodologies	Key Findings	Gaps
1.	Empowering Safety: Design- ing of an IoT-based Women Protective System using AI-enabled Smart Sensors [1]	Sonia, R., Kumar, T.R., Naresh, G., Devi, S.D., and Juliet, N	2024	IoT-based women pro- tection system using Arduino, GPS, GSM, temperature & vibration sensors. - Real- time monitoring and violence detection	IoTPWP sys- tem offers higher precision and efficiency (97.86%) compared to traditional BWSS.Features include live video streaming, loca- tion tracking, and emergency alerts.	Need for fur- ther research and innovation to expand the system's scope to include more surveillance tools and improve user experience

S.no	Title	Author(s)	Journal & Year	Methodologies	Key Findings	Gaps

2.	Development of A Women Safety Smart- phone Application- SAKHI [2]	Agarwal, A.V., Singh, V., Kamboj, A., Sirohi, A., and Mehto, A.	2023	SOS alerts, GPS track- ing, live video streaming, video storage on Firebase, and PIN-based device locking	The SAKHI app aims to provide a quick response in emergency situations. It fea- tures real-time location shar- ing and an SOS button, which sends alerts with location data to contacts	The app lacks advanced pre- dictive features such as AI-based threat detection, and it could ben- efit from better integration with IoT devices for more compre- hensive safety monitoring.
3	(WoExP) Women Express- Artificial Intelli- gence based women security and Safety System [3]	Navaneethakr M., Kalai- yarasi, R., Mohanaprak T.A., Abi- rami, B.B., Prakaash, A.S., and Malathi, V.	i2sh02n3an, ash,	AI-based app using Deci- sion Tree and KNN for threat detection; real-time location tracking; user, admin, and counseling modules.	Centralized plat- form for women to report crimes, access coun- seling, learn self-defense, and share experiences.	Limited acces- sibility for non-technical users; needs extensive real-world testing.
4	Designing Women's Safety Applica- tion for Emergency Situations [4]	Artamadja, D., Faza, T.H., Irena, F., Maulana, M.I., Tob- ing, G.L., and Wid- ianto, M.H.	2023	The system includes an ini- tial setup page for user data, a dashboard with accessible emer- gency features, a message and location feature for sending pre- drafted alerts, an SOS alarm for emergencies, and a set- tings page for customization.	Successfully implemented features like pre- drafted messages, loca- tion sharing, and an SOS alarm to pro- vide users with quick, efficient, and accessi- ble emergency support	The application lacks advanced AI features for threat prediction and may require further testing in real-life emer- gency scenarios for comprehen- sive validation .
5	A Mobil e Applica- tion for Women's Safety: Myguard [5]	Mishra, N., Puri, A., and Singh, M.	2023	Voice-activated panic alerts, route tracking, SOS notifi- cations, and psychological help resources	Combines safety and mental health support, enhancing safety beyond physical threats	Needs improve- ment in scalabil- ity and predic- tive analytics for proactive safety

S.no	Title	Author(s)	Journal & Year	Methodologies	Key Findings	Gaps

6	Development of Gesture- Based Women Safety Appli- cation [6]	Mohamad Amirul Syafiq Bin Peer Mohamed, Dahlila Putri Dahnil	2021	Developed Safe-Cloud, a mobile app using gesture-based activation. Real-time GPS tracking and SOS alerts via shaking the phone. and Loud alerts to scare attack-ers and notify bystanders	Provides instant communication with emergency contacts and police. Real-time GPS sharing ensures faster response from patrol units. Simple gesture- based activation improves acces- sibility in emergencies.	Limited real-world testing results and No discussion on scalability. Inte- gration with law enforcement systems needs improvement
7	Real-Time Surveil- lance System for Women's Safety and Crime Detection in Public Area [7]	Dr. Sachin Singh, Bhuve-nashwar Swaroop, Sandeep Kumar, Arjun Singh, Atishay Jain, Dr. Khoobs- ingh	2023	Convolutional Neural Net- works (CNN): For detect- ing suspicious activities from real-time surveillance video.	Enables real- time detection of harassment and violence. Auto-mates alerts for surveillance teams with visual cues. Aims to reduce crime rates in public spaces and workplaces	Computationally expensive for large-scale deployment. Potential for false posi-tives/negatives
8	Women Safety Device and Application-FEMME [8]	Monisha, D.G., Mon-isha, M., Pavithra, G., and Sub- hashini, R.	2016	Wearable device with sensors (pressure, tem-perature) for distress detec- tion. Trigger mechanism via discreet switch. Communica-tion through SMS and GPS location tracking.	Provides real- time distress alerts with location data. Integrates wear- able technology with mobile applications for compre-hensive safety. Continuous loca- tion tracking for effective monitoring.	Dependence on wearable device increases cost and limits acces- sibility. Relies on SMS, which may fail in poor net-work conditions. Sensor-based detection could lead to false pos-itives. Potential high battery consumption due to continuous GPS tracking.

S.no	**Title**	**Author(s)**	**Journal & Year**	**Methodologies**	**Key Findings**	**Gaps**
9	Abhaya: An Android App for the Safety of Women [9]	Ravi Sekhar Yarrabothu, Brama- rambika Thota	2015	GPS-based location track- ing. Continuous message updates to reg-istered contacts every 5 min- utes. Immediate call initiation to primary contact	Provides real- time location updates. Ensures continuous tracking until stopped. Sends alerts	Limited to Android devices. Requires active GPS and network con-nectivity. No integration with law enforcement databases.

					via SMS and call for enhanced response.	
10	A Mobile Application for Women's Safety: WoSApp [10]	Dhruv Chand, Sunil Nayak, Karthik S. Bhat, Shivani Parikh, Yuvraj Singh, Amita Ajith Kamath	2015	Trigger via shaking phone 40 times or pressing PANIC button. Sends SMS with GPS location and user details to police. Integrates with police via Google Maps.	Effective emergency response via location tracking and SMS. Integration with police for quick action. Open-source design for scalability.	Trigger method may be impractical or prone to accidental activation. Limited to Android devices. Relies solely on SMS, which may fail in poor connectivity. Emergency contacts notified indirectly through police.

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Table 2: Comparison of Key Features in Women Safety Systems

Feature/Application	**GPS Tracking**	**SOS Alerts**	**Real-Time Monitoring**	**Gesture-Based Activation**	**AI Integration**
IoT-Based System	Yes	Yes	Yes	No	Yes
SAKHI App	Yes	Yes	Yes	No	No
WoExP	Yes	Yes	Yes	No	Yes
MyGuard App	Yes	Yes	No	Yes	No.
Gesture-Based System	Yes	Yes	No	Yes	Yes
Surveillance System	No	Yes	Yes	No	Yes
112 India	Yes	Yes	Yes	No	No
My Safetipin	Yes	No	Yes	No	No
Abhaya	Yes	Yes	Yes	No	No
T-Safe	Yes	Yes	Yes	No	Yes

Table 2,write about this table 2

3. Performance and Analysis

The performance of women safety systems is a critical factor in determining their effectiveness and practical application in real-world scenarios. From wearable devices to AI-based applications, each system employs specific technologies and methodologies designed to optimize safety, response time, and user experience. This section evaluates the performance of these systems based on various metrics, highlighting their strengths and limitations.

The IoT-based women protective system demonstrates significant reliability in threat detection by leveraging AI-enabled sensors. It achieves high accuracy in identifying abnormal conditions and sends timely notifications to emergency contacts. The system's rapid response time ensures that alerts are received within seconds, while its user-centric design enhances usability, even under stressful situations. The integration of smart sensors allows for continuous monitoring without compromising energy efficiency, making it a dependable solution in emergencies [1].

The Women Safety Smartphone Application-SAKHI exhibits commendable performance with its GPS-enabled tracking system and motion sensors. It effectively detects potential threats and alerts pre-configured emergency contacts promptly. Usability tests have shown positive results, as the application is designed to be intuitive for users. However, the app's energy consumption is a key consideration, as continuous tracking can impact battery life during

prolonged use [2]. Similarly, the Women Express (WoExP) system excels in real-time threat detection, utilizing AI and advanced monitoring technologies to provide accurate alerts. Its real-time capabilities ensure immediate action, making it a valuable tool for enhancing secu- rity [3].

Other existing women safety applications, such as basic SOS alert systems and GPS trackers, perform well in delivering location-based alerts. However, they often lack the integration of advanced analytics or AI-based capabilities, limiting their ability to identify threats proac- tively. Additionally, many traditional systems rely on manual activation, which may not be feasible in high-stress or dangerous situations. The performance of these systems, while use- ful, highlights the need for more innovative solutions that combine automation with high accuracy and swift responses.

The emergency application designed for real-time alerting and location sharing achieves notable success in ensuring precise geolocation tracking. Its seamless communication with emergency contacts and authorities contributes to its practicality. Moreover, the system's straightforward design allows users to activate alerts efficiently, ensuring immediate support during emergencies [4]. MyGuard, a mobile application, demonstrates high performance by integrating GPS tracking, gesture-based activation, and emergency alert systems. The appli- cation's real-time navigation support for rescue teams further underscores its effectiveness in critical scenarios [5].

The gesture-based women safety system leverages real-time gesture recognition technology to detect emergencies. Its performance is evaluated based on recognition accuracy and the speed of alert generation. With minimal false positives, the system ensures reliable activation in high-pressure situations, while its integration of GPS coordinates into alerts adds preci- sion to its location-sharing capabilities [6].

Finally, the real-time surveillance system for women's safety and crime detection showcases advanced performance metrics by employing CNNs and deep learning algorithms. The sys- tem processes video feeds in real time, identifying suspicious activities with high accuracy. It

minimizes false alarms and sends actionable alerts to security teams, enhancing its reliability for public safety applications. The quick response times and effective monitoring capabilities make this system a robust solution for large-scale deployments in urban spaces [7].

In summary, the performance of women safety systems varies based on their technological advancements and intended applications. While traditional systems focus on providing basic alerts and location sharing, modern solutions incorporate AI, gesture recognition, and real- time surveillance to enhance safety. These advancements demonstrate the growing potential of technology to create reliable and user-friendly systems that address the diverse challenges faced in ensuring women's security.

4. Limitations and Future Directions

While women safety systems have made significant strides in leveraging advanced technolo- gies, they still face several limitations that must be addressed to enhance their efficacy. One prominent challenge is the lack of real-time safety interventions provided by surveillance cameras. Although these systems can monitor activities and detect potential threats, they often fail to provide immediate assistance, as they rely on post-incident analysis rather than proactive measures [1, 5]. Additionally, many systems are highly dependent on internet con- nectivity, which limits their functionality in rural or remote areas with poor network coverage [8, 39]. Energy inefficiency is another concern, as wearable devices and mobile applications consume significant battery power due to the continuous operation of GPS, sensors, and com- munication modules. This limitation renders them unreliable in extended emergencies [39]. Moreover, the high cost of implementing advanced safety technologies, such as IoT-enabled devices or AI-powered systems, restricts their accessibility to economically disadvantaged groups, particularly in developing nations [27, 43]. Privacy concerns further exacerbate these challenges, as continuous tracking and data sharing pose risks to user data security and raise ethical questions [44, 46]. To overcome these challenges, the future scope of women safety systems lies in the development of innovative and inclusive solutions. Addressing the lack of real-time safety interventions, integrating AI-driven predictive models with IoT-enabled devices can allow for immediate alerts and actions during potential threats, rather than rely- ing solely on post-incident data analysis [7, 45]. Offline functionality through peer-to-peer communication or mesh networks can also ensure reliable operations in areas with limited connectivity [1, 5]. Energy-efficient designs, such as low-power sensors and optimized algo- rithms, can significantly improve battery life, making wearable devices more dependable in emergencies [39]. Furthermore, advancements in AI can minimize false positives by incorpo- rating context-aware models and real-time feedback loops, thereby increasing user trust in these systems [7, 44]. To reduce costs, open-source platforms and affordable hardware solu- tions can democratize access to safety technologies, extending their reach to underserved communities [27, 43]. Privacy concerns can be addressed by establishing global standards for data encryption and secure communication between devices and platforms [46]. Future sys- tems could also leverage smart city infrastructures, integrating public surveillance cameras with emergency response mechanisms to create a unified safety framework [45]. Finally, intu- itive interfaces, such as voice and gesture recognition, can enhance usability, ensuring that users can access safety features even in high-stress situations. Cross-platform compatibil- ity and multi-language support can further promote global adoption, making these systems accessible and effective for diverse demographics [6, 33]. These advancements collectively pave the way for more inclusive, reliable, and proactive women safety solutions.

5. Conclusion

Women's safety is an issue of utmost importance, demanding both societal and technological attention. Over the years, technology has emerged as a vital tool to address this challenge, bringing forward solutions such as mobile applications, AI-driven surveillance systems, IoT- enabled wearables, and safe navigation tools. These advancements have empowered women by providing mechanisms to alert, inform, and protect in times of need. However, as promising as these technologies are, they often focus more on reactive measures rather than proactive prevention. Moreover, challenges like real-time

intervention, accessibility, and user privacy remain areas needing improvement. The progress made so far demonstrates the potential of technology when it aligns with the goal of creating safer environments. From predictive ana- lytics warning of unsafe areas to wearable devices that trigger instant alerts, these systems offer hope and reassurance. Yet, for these solutions to truly make a difference, they must evolve further. The focus should be on designing systems that are more intuitive, inclusive, and capable of providing real-time protection without intruding on personal privacy or being cost-prohibitive. This survey emphasizes that the future of women's safety lies in collabora- tion—between technologists, policymakers, and the community. By addressing current gaps and leveraging advancements in AI, IoT, and real-time monitoring, we can create holistic solutions that not only respond to threats but actively prevent them. Ultimately, ensur- ing women's safety is about more than technology; it's about fostering a world where every woman feels secure to live, work, and thrive without fear. With continued innovation and a commitment to inclusivity, we can take meaningful steps towards making safety a universal reality, not just a technological promise.

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