Efficacy of a Remote Home-Based Security System on Residential Estate Safety in Minna Metropolis, Niger State, Nigeria

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Abstract
The need to secure home facilities and equipment against theft and robbery in contemporary society has been acknowledged by environmental and security experts. One way of achieving safety within residential estates is the use and deployment of smart home security device that monitor and report, security breaches. This study was aimed at determining the efficacy of a smart home security system on the safety of residential estates in Minna Metropolis. To guide the study, four (4) research questions were raised from the objective of the study. The study consisted of M. I. Wushishi, Talba and Oduoye estates all located within Minna with an estimated population of 48,450 residents. The sample for the study is made up of 30 households randomly selected within three (3) estates in Minna. The design for the study was a survey using structured interview and a 4-point Likert scale questionnaire for data collection. The instruments were subjected to face, content and construct validation by two environmental experts. The reliability coefficient values of the instruments were 0.84 and 0.79 for interview and questionnaires respectively. The instrument was administered on the respondents and retrieved after one week. The opinion responses were coded and analyzed using the mean and standard deviation statistics. The finding shows that smart home security device was highly effective in curbing security breaches an d vandalization of properties within the estates. The study also identified some constraints implementation gap on the use of smart security device to include network failure, power supply, software stagnation and harsh weather condition among others and suggest strategies for addressing them. The paper recommends the inclusion of fingerprint authentication on the main user interface to block falsification of identity in addition to the use of lithium coin cell battery to solve the challenge of power outage within the estates.

Keywords: Efficacy, Remote Home, Smart Security, Residential Estates, Safety.

Introduction
The rise in the cost of living occasioned by hyper-inflation and economic recession has led to several incidences of theft, rape, robbery, kidnapping and physical assault on the residents at broad daylight or when everybody is asleep. The proactiveness of the security personnel in the safety of lives and properties is limited owing to inadequate resources and manpower shortage. Urban cities are worse but by the deviant activities of the unemployed youths thereby causing havoc to economic and social activities within residential and commercial estates. In order to curb incessant, theft, rape and robbery within residential estates, there is need to adopt a cheap easy-to-use and portable technology based security device using an open-source electronic prototype called Arduino (Suleiman, 2020). Remote home security system or smart home are typically equipped with different kinds of sensors and tracing devices for context-aware service provisioning. It is a fact that many smart home devices provide home automation technology, but the smart home security system offers many benefits that can ensure the safety of the homeowners and facilities within the building. Thus, a remote home security system protects residents from anticipated dangers such as intruders, fire outbreak and health problems. This is best done using digital camera and motion detectors that protect the outside of a home and alert family members on impeding dangers or consequences. The remote home based security device is built using Arduino Uno, ultrasonic sensor and GSM module for efficient monitoring of intruders and sending of SMS alert to the home owners at a point of intrusion which is made possible through the internet of things network (Abdullahi, 2020).

Remote home-based security system (RHSS) is designed to become an integral part of the user's home environment that is seamlessly embedded into the smart home software infrastructure that help to enforce privacy to buildings on behalf of home owners. One of the essential features of RHSS is the user authentication system that differentiate between genuine and fake home owners through voice, facial image or biometric fingerprint. In residential home that is fully automated whenever, the security device detects someone who is unknown/strange, it provides the video of the visitor in order to allow home owner take appropriate decision. Unwelcome visitors can be ignored and individuals attempting to break into the home by force is immediately reported to the police for prompt action and safety (Joseph, 2022). Studies have shown that many residential estates in developing and undeveloped nations are faced with security threats that is not limited to theft and robbery attacks, but unauthorized disclosure of confidential information using modern technology. Thus, the integration of automated security system had minimized and contained sporadic cases of crime in estates either in the day time or at night. Installation of street lights and closed-circuit cameras had help in no small measure to compliment the effort of the security personnel that are overwhelmed with political and economic crises (Adebiyi, 2019; Godspower, 2022). The use of remote home-based security in residential buildings had had some operational challenges ranging from shortage of hardware and software, power outage, harsh weather condition, technical manpower, difficulty in routine maintenance among others. These have adversely affected surveillance and monitoring activities of the security device in residential estates. To enhance operational efficiency of home automated system, Shehu (2019) stated that homeowners must be familiar with the technology and has the ability and competencies to deploy relevant command that will assist in tracking and apprehending criminal elements within the society. Thus, effective operation of remote home-based security is hinged on the homeowner's ability to watch and monitor digital device installed from remote locations. The need to investigate and improve working status of RHSS has been a major concern of stakeholders particularly the security agents, thus the need for the present study.

Statement of the Problem
The growing number of crimes with in residential and commercial estates in Nigeria is threatening peaceful co-existence of residents and thus affecting the safety of properties. Effort by, government and individuals at curtaining the menace through mass deployment of security agents and admonishment by religious has not yielded desire results (Tobi, 2022). The only option left is the use of technology-based devices that are affordable, portable, easy to use and can proactively track criminals. One of such technology equipment is the remote home-based security system (RHSS) using open-source Arduino Uno board, passive infrared sensor, tamper, liquid crystal display and a piezo buzzer powered by a 9V battery. Home security has dominated discussions in the last few decades by experts and suggestions were proffered on how best properties and lives can be safeguarded using technology. There is limited literature on the efficacy of automated devices currently used for home security with mixed findings. Study of this nature is required for in-depth analysis into the cost-effectiveness, operational efficiency and proactiveness of remote home-based security devices for maximum protection, thus the need for the present study on the efficacy of a remote home-based security system using Arduino Mega software.

Aim and Objective of the Study
This study was conceived with the following objectives, which include to:
1. Find out the operational efficiency of remote home-based security systems on the safety of residential buildings/estates.
2. Investigate implementation challenges to the use of RHSS for the safety of home infrastructures in estates.
3. Suggest ways of improving the quality of service delivery of RHSS to home users within estates in Minna.

Research Questions
The following research questions were raised to guide the study
1. To what extent does a remote home-based security system protect lives and properties within residential estates in Minna Metropolis?
2. What are those constraints to the effective implementation of the remote home-based security system within residential estates in Minna Metropolis?
3. How can identified constraints to the use of RHSS in the protection of residential estate buildings be addressed within Minna Metropolis?
4. What are those strategies for sustaining operational efficiency of remote home based security systems used in residential estates in Minna Metropolis?

Methodology

This study employed a descriptive survey design using questionnaire and interview as source of data collection from a large group of respondents within a limited period of time. The choice of descriptive survey design is justified by the fact that the data can be collected analysis and interpreted using small group while the result of findings can be generalized. This study was conducted in M. I. Wushishi , Oduoye and Talba Estates within Minna Metropolis. The M. I. Wushishi estate is located at the eastern part of Minna with an estimated residential building of 125, while Oduoye and Talba estates are located in the central and North-Western part of Minna respectively. The number of residential houses for Oduoye and Talba estates are 59 and 198 respectively. The estimated inhabitant of the three estimates is 48,450 and these estates had security post, clinic and a fire station for emergency situation. The target population are all residential estates in Minna specifically the M. I. Wushishi, Oduoye estate, Bosso Estate, Airport quarters and Talba estate with an estimated population of 255,000 people. A simple random sampling was used to select 25 houses within the three (3) major estates located in Minna. The breakdown is Talba (15), M. I. Wushishi (9) and Oduoye (6), while the household head were chosen for the structured interview. The sample size for the study is 25 households across the 3 estates. The instruments used for data collection were Security Assessment and Evaluation Questionnaire (SAET) and the Structured Interview on Remote Home-based Security Device (SIRHSS). The SAET was designed using Likert 4-point scale, while SIRHSS consist of 20 structured questions focusing on operational efficiency of the security automated device. Both instruments were subjected to face, content and construct validity by two professionals. The comment and suggestions of the validators had helped to improve the clarity of language, relevance of the content to the objective of the study and selection of appropriate statistical tool for data analysis. The questionnaire was administered on all the subjects within the residential estates used for the study and retrieved after two (2) weeks. Each household was invited for an interview and their opinion responses coded in preparation for data analysis. Descriptive statistics using mean and standard deviation was used to analyzed data collected and to answer the research questions.

Results

Research Question 1: To what extent does the use of RHSS protect lives and properties within residential estates in Minna Metropolis?

Table 1.1: Mean and Standard Deviation on the extent to which RHSS guarantee safety of lives and properties.

S/N	Item	$\overline{\text{X}}$	SD	Remark
1.	The remote security device offers information on the activities of intruders within the estates	3.22	0.46	Agree
2.	Closed circuit camera revealed images of people and record their movement and engagement	2.95	0.51	Agree
3.	The Arduino micro-controller in RHSS send an SMS messages promptly to home-users notifying them of potential unauthorized access	3.04	0.32	Agree
4.	RHSS works perfectly day and night in our estates within minimal cost and intervention	3.28	0.77	Agree
5.	The digital security device provides essential details about estate dwellers and their visitors. Thus, ensuring effective surveillance.	3.65	0.88	Agree
	Grand mean	**3.23**	**0.59**	**Agree**

Table 1.1 above revealed the mean and standard deviation of 1 – 5 on the extent to which remote home-based security system protect lives and properties in residential estates. The mean values of 3.22, 2.93, 3.04, 3.28 and 3.65 for items 1, 2, 3, 4 and 5 respectively are above the threshold of 2.5, this indicates that majority of the respondents are in agreement that the use of RHSS in the estates has minimized criminal activities and ensure sanity. Thus, the working efficacy of the RHSS in the protection and safety of infrastructure within the estates is high. Consequently, the use of digital security tools in curbing crime within residential estates was acknowledged.

Research Question 2: What are those constraints to the effective implementation of RHSS within residential estates in Minna?

Table 1.2: Mean and Standard Deviation on constraints to the implementation of RHSS as home safety device

S/N	Item	$\overline{X}$	SD	Remark
6.	RHSS's efficiency is often affected by the harsh weather condition within the estates in particular and Minna in general	3.59	0.33	Agree
7.	Sporadic network failure hinders smooth SMS communication between the device and home-users	2.89	0.66	Agree
8.	The use of 9V battery to drive the buzzer alarm and siren often limit the volume and speed of sound from the device	3.78	0.09	Agree
9.	Difficult in identifying heat energy in form of infrared by the motion sensor sometimes limit RHSS capacity to track and record actions of passerby.	3.15	1.03	Agree
10.	The systemic approach of criminals towards theft, robbery and rape provide setback to operational efficiency of RHSS	3.48	0.57	Agree
	Grand mean	**3.38**	**0.54**	**Agree**

Table 1.2 above shows the mean and standard deviation of items 6 – 10 on the constraints to effective implementation of RHSS. Thus, the mean values of 3.59, 2.89, 3.78, 3.15 and 3.48 for items 6, 7, 8, 9 and 10 respectively were above 2.5. This mean that the respondents were in agreement that harsh weather, network failure 9V battery, heat energy and monitoring technique were envisaged setbacks to effective implementation of RHSS for protection of lives and properties within the estates.

Research Question 3: How can identified challenges to effective usage of RHSS in protecting residential estates/building be addressed in Minna Metropolis?

Table 1.3: Mean and Standard Deviation on strategies for addressing identified challenges to the use of RHSS

S/N	Item	$\overline{X}$	SD	Remark
11.	Regular surveillance of installed home-based security systems to guard against vandalization	3.75	0.478	Agree
12.	Periodic update and maintenance of both hardware and software components in order to enhance operational efficiency	3.25	0.927	Agree
13.	Installation of solar powered digital security device to solve network and power related problems.	3.92	1.126	Agree
14.	The use of high speed sensors, micro controllers and GSM module for efficient monitoring of intruders and sending of SMS alerts.	2.88	0.561	Agree
15.	Frequent review of the GSM based security alarm system using a passive infrared sensor that trigger sound and SMS once an intruder is noticed within the estates	3.64	0.997	Agree
	Grand mean	**3.49**	**0.82**	**Agree**

The result in Table 1.3 above revealed the mean and S.D. values of items 11 – 15 on strategies for addressing challenges to the implementation of RHSS. The mean values of 3.75, 3.25, 3.92, 2.88 and 3.64 for items 11, 12, 13, 14 and 15 respectively indicated that the respondents agreed that regular surveillance, period update and maintenance, installation of solar powered switches, high precision sensors and frequent review of GSM based security alarm are essential for addressing identified shortcomings in the use of RHSS. The fact that RHSS uses microcontrollers to send and receive signals via the security system and the homeowners, there is a need for periodic upgrading of the relevant components.

Research Question 4: What are those strategies for sustaining the operational efficiency of the Remote home-based security systems used in residential estates?

Table 1.4: Mean and Standard Deviation on strategies for improving and sustaining operational efficiency of RHSS

S/N	Item	$\overline{X}$	SD	Remark
16.	Standardization of programing language used in RHSS for optimization	3.63	0.51	Good
17.	The use of heat resistance junpur-wire for interconnectivity of component devices on the Arduino board	3.96	1.25	Excellent
18.	Regular testing and reviewing of the local intrusion detection system installed.	3.32	0.68	Excellent
19.	Protection of RHSS from dry sun radiation and heat	2.93	0.45	Good
20.	The use of integrated optical fiber cable for signal, transmission and high subscriber identity module care for recording and storage	3.05	0.89	Excellent
	Grand mean	**3.38**	**0.75**	**Agree**

Table 1.4 above revealed mean opinion responses of the subjects on items 16 – 20 on strategies for improving operational efficiency of the RHSS. The mean values of 2.63, 3.96, 3.32, 2.93 and 3.05 for items 16, 17, 18, 19 and 20 respectively shows standardization, use of heat resistance junpur wire, installation of intrusion-detection system and integrated optical fiber cable as ways of sustaining good working condition of the RHSS. Enhancement of the RHSS in detection and control of crime within residential estates would have help in elimination of criminal activities and foster good neighbourliness among dwellers.

Discussion

The findings of this study demonstrate that the Remote Home-Based Security System (RHSS) is highly effective in enhancing the safety of residential estates in Minna Metropolis. The respondents agreed that the system provides timely information on intruders, records movements via closed-circuit cameras, and sends prompt SMS alerts to homeowners, thereby minimizing criminal activities. These results align with the work of Abdullahi (2020), who highlighted the efficiency of Arduino-based alarm systems in deterring intruders and ensuring residential safety. Similarly, Adebiyi (2019) emphasized the role of technology in home security, noting that automated systems significantly reduce theft and vandalism, which corroborates the current study's findings on the efficacy of RHSS. However, the study also identified challenges such as network failures, power supply issues, and harsh weather conditions, which hinder the optimal performance of RHSS. These constraints resonate with the observations of Shehu (2019), who pointed out that technical and environmental factors often limit the functionality of digital security systems in developing regions. To address these challenges, respondents suggested strategies like regular system maintenance, solar-powered installations, and the use of high-speed sensors. These recommendations are consistent with the solutions proposed by Joseph (2022), who advocated for robust and adaptable security technologies to overcome operational barriers.

Conclusion

The rise in crime rate across the globe especially in residential estates had call for concerted effort by stakeholders using technology as a catalyst. The use of remote home-based security system has proved to be effective and efficient in curbing crime around public and workplaces through tracking movement to recording of activities of home intruders. Home automation despite envisaged challenges has minimized petty crimes in residential estates across the North-Central Nigeria and proved to be user-friendly, cheap and flexible. Home-users are now being communicated with via SMS and ringing alarm, so that appropriate action can be taken against potential intruders. Thus, the working efficacy of remote security system used in residential estates is commendable based on the result of the study.

Recommendations

Based on the findings of the study, it is recommended that;
1. Government and other stakeholders while designing smart security system should integrate fingerprint authentication on the main user interface to achieve greater efficiency.

2. Security personnel should ensure maximum surveillance of installed gadgets to scare away vandals and unauthorized access to home facilities while the homeowners are away for one reason or the other.
3. Government at all levels should collaborate to provide sufficient funds and technical support towards the use of technology based security equipment as a way of ensuring safety of lives and properties within residential environment.
4. Home-users should be encouraged to use lithium cono cell battery (CR42136mAh) that can be used to power the device for over 15years without external 9V power.
5. Engineers and technicians should incorporate serial camera of high precision and SD card that are Arduino compatible and can guarantee portability and accuracy.

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