Descriptive Analysis Dashboard for Health and Safety Monitoring in Smart Buildings Using IoT Sensor Data

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ABSTRACT

Safety and Health in smart buildings especially in terms of the air monitoring, can be enhanced through IoT sensor data that support effective safety measures and environmental monitoring. However, the existing system often lacks the ability to analyze the historical IoT sensor data and are limited by the absence of descriptive visual analytics. This gap prevents the ability to identify long-term safety trends and patterns in smart buildings. Therefore, this study aims to study the environmental factors and safety parameters in health and safety monitoring of smart buildings using IoT sensor data. It involves collecting relevant data and designing a descriptive analysis dashboard using Microsoft Power BI to support better decision-making. Using Microsoft Power BI, IoT sensor data such as CO_2 levels, temperature, humidity, motion detection (PIR), and light intensity are analyzed to identify patterns and visualize safety related trends. In addition, this study aims to identify and recommend appropriate mitigation strategies based on the levels of health and safety indicators displayed in the dashboard for actionable decision-making. The expected results from the proposed interactive dashboard will provide valuable insights to help safety officers and facility managers detect risks, improve air quality, optimize lighting, and enhance ventilation

INTRODUCTION

This chapter introduces the research topic and the background of the study with a clear problem statement, research question and objectives. This chapter also highlights the important of research significance, research scope, and explain an overview of a descriptive analysis dashboard for health and safety monitoring in smart building using IoT sensor data. The chapter conclude with the definition of key terms used in this study.

Health and safety measures are essential for maintaining occupant well-being. The health and safety of occupants depend on environmental aspects such as air quality and temperature as well as humidity and lighting conditions. The quality of indoor environments that fails to meet acceptable standards leads to respiratory illnesses plus severe headaches while causing employees and occupants to become less productive. Smart building safety management becomes crucial because it extends beyond regular health practices due to complex automated structures and permanent environmental monitoring requirements. The growing need for smart buildings creates difficulties in health and safety management thus requiring systems capable of collecting and analyzing historical environmental data over time according to (Ghahramani et al., 2022). The Internet of Things technology provides a system which enables environmental factor tracking and optimization leading to reduced health risks while providing secure working and living spaces.

A descriptive analysis dashboards present historical recorded data while offering useful insight into patterns and trends over times. The descriptive dashboard gathers historical data to create broad performance and safety perspectives rather than focusing on real-time conditions through dashboards. The descriptive analysis dashboards serve building managers well because they enable safe and comfortable decision-making through long-term pattern monitoring capabilities and emerging issue detection. Building managers and officers can assess the future development of health and safety issues by using descriptive analysis dashboards to analyze historical data correlations across different variables (Zhao, Zhang, & Lee, 2022). This complex data help stakeholders produce data-based choices through historical analysis.

IoT sensor data refers to the data collected by interconnected devices embedded within the infrastructure of a smart building. This sensor monitors and assesses different environmental factor including temperature, humidity along with CO_2 readings and measurements of light conditions and building occupancy. Smart buildings use IoT sensor data as an essential component for monitoring current health and safety conditions. Building performance measurement is conducted in real-time through IoT sensors which activate automatic systems to reach optimal condition levels. Historical IoT data enables the identification of enduring safety concerns together with environmental issues by revealing long-term trends that may be hidden from instant observation. Building managers obtain the power to implement prompt security measures through data-driven strategies which enhances occupant safety (Singh, Tan, & Bakar, 2022).

This research focus on integrating IoT sensor data and utilize Microsoft Power BI to a project-based development of a descriptive analysis dashboard for health and safety monitoring in smart buildings. By leveraging IoT sensors to gather data on key environmental factors and safety parameters utilize Microsoft Power BI to analyze and visualize this data, building managers and officers can gain a deeper understanding of building conditions over time. This approach provides valuable insights into the historical performance of a building, enabling proactive management of health and safety risks. By combining IoT data with advanced visualization tools like Power BI, the proposed system aims to improve the safety, comfort, and well-being of building occupants.

LITERATURE REVIEW

Health and Safety in Smart Buildings

Health and safety in smart buildings focus to ensure occupant well-being by monitoring environmental factors and safety parameters that may pose risks. According to (Kumar, Chandra, & Agarwal, 2023) discussed real-time and historical data sensor input can uncover problems such as excess number of people or poor ventilation. Additionally, their research highlights complex event processing can be used to predict and mitigate risks, emphasizing the importance of analyzing patterns helps improve safety systems and readiness for emergencies. Furthermore, according to (Ha, Lee, & Kim, 2020), discussed using sensor data fusion to monitor air quality inside buildings is connected to the health of the occupants. By using multiple sensors data, the study indicates that it is possible to see all aspects of the indoor environment early on and catch issues such as poor air quality or high pollution.

IoT Sensors and Environmental Parameters

Several studies have demonstrated the effectiveness of IoT sensors in tracking essential environmental parameters:

Table 1.1: IoT Sensors and Environmental Parameters

Parameter	Purpose in Smart Building Safety
CO_2 Level	Carbon dioxide (CO_2) levels are a critical indicator of indoor air quality in smart buildings. Elevated CO_2 levels, often caused by poor ventilation and high occupant density, can lead to headaches, fatigue, and difficulty concentrating. IoT-based CO_2 monitoring enables building managers to assess air quality and optimize ventilation systems to maintain a healthy indoor environment (Li & Chen, 2023).
Temperature	Temperature is a key environmental factor affecting occupant comfort, productivity, and well-being. Prolonged exposure to excessively high or low temperatures may cause discomfort, reduced productivity, heat exhaustion, or hypothermia. IoT temperature sensors provide real-time data that support HVAC optimization, ensuring comfortable and energy-efficient indoor conditions (Singh, Tan, & Bakar, 2022).
Humidity	Humidity significantly influences indoor air quality and occupant health. High humidity levels can promote the growth of mold, bacteria, and dust mites, increasing the risk of respiratory illnesses and allergies. Low humidity may cause skin irritation and dryness of the eyes, throat, and skin. Smart building systems use humidity sensors to maintain optimal indoor conditions and improve air quality (Ghahramani, Arroyo, & Klein, 2022).

PIR Motion	Passive Infrared (PIR) sensors detect human movement by sensing infrared radiation. These sensors enable automated control of lighting, HVAC, and security systems based on occupancy. By ensuring that building systems operate only when spaces are occupied, PIR sensors improve energy efficiency and enhance operational effectiveness (Zhou, Wang, & Zhang, 2022).
Light Intensity	Light intensity is an important factor affecting visual comfort, productivity, and safety within smart buildings. IoT-based light sensors collect and analyze illumination data to identify areas that are excessively dim or overly bright, conditions that may contribute to eye strain and safety hazards. Monitoring historical lighting trends helps maintain a comfortable and safe indoor environment (Ghahramani, Becerik-Gerber, & Kichkaylo, 2022).

Source: Adapted from Li and Chen (2023); Singh, Tan, and Bakar (2022); Ghahramani, Arroyo, and Klein (2022); Zhou, Wang, and Zhang (2022); and Ghahramani, Becerik-Gerber, and Kichkaylo (2022).

High CO_2 levels (>1000 ppm) are associated with poor ventilation and health risks, while temperature outside the comfort range (20–26°C) can reduce cognitive performance. Humidity levels below 30% or above 60% may cause dryness or fungal growth, affecting health.

Visualization Tools Comparison

While real-time monitoring is common, descriptive analytics remains less explored. Descriptive analytics examines historical data to detect patterns, correlations, and recurring anomalies. Studies highlight the importance of using data visualizations to support preventive safety management rather than reactive responses. In this section, present a comparative analysis of three popular tools used for data analysis and visualization such as Microsoft Power BI, Tableau, and Python. Each tool is evaluated based on its capabilities and strengths, highlighting how they cater to different needs in data processing, visualization, and reporting. The comparison aims to identify the most suitable tool for a project-based development of a descriptive analysis dashboard for health and safety monitoring in smart buildings using IoT sensor data.

Table 2.2: Comparative Analysis of Selected Tools

Function	Microsoft Power BI	Tableau	Python	Proposed Solution
Data Connection & Integration	✓	✓	✓	✓
Data Preparation & Cleaning	✓	✗	✓	✓
Descriptive Data Analysis	✓	✓	✓	✓
Interactive Visualizations	✓	✓	✓	✓
Publishing & Sharing	✓	✓	✗	✓
Real-Time Data Monitoring	✓	✓	✓	✗
Custom Dashboard Development	✓	✓	✓	✓

Power BI stands out in industry applications for transforming IoT data into interactive dashboards accessible to decision-makers without programming expertise.

Research Gap

In this section, the research gap is discussed by identifying what has not been fully explored in previous studies. Although there has been considerable progress in related fields, some important areas remain under-researched or only partially addressed. By reviewing existing literature, this section highlights the missing elements or limitations in past research, such as lack of focus, limited scope, or absence of practical tools.

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Author (Year)	Safety & Health Issue / Component / Element	Data Type	Parameters					IoT Sensor Data	Tools Utilization	Summary of Findings
			Air Quality (CO_2)	Temperature	Humidity	Motion (PIR)	Light Intensity			
Kumar, S. S., Chandra, R., & Agarwal, S. (2023). A real-time approach for smart building operations prediction using rule-based approach.	✓	Real-Time	✗	✓	✗	✓	✓	✓	Rule-Based	Created real-time operational prediction for building systems.
Ha, J., Lee, S., & Kim, H. (2020). Sensing data fusion for enhanced indoor air quality monitoring.	✓	**Historical**	✓	✓	✓	✗	✗	✓	Sensor Fusion	Fused sensor data improves IAQ analytics in buildings.
Cano-Ortega, A., Cano-Ortega, R., & Cano-Ortega, I. (2023). Implementation of an Internet of Things architecture to monitor indoor air quality.	✓	Real-Time	✓	✓	✓	✗	✗	✓	Web Dashboard	Enabled real-time IAQ data tracking and display.

Table 2.3: Research Gap

However, limited work focuses on descriptive data analytics for historical trend interpretation and safety decision-making. There is also a lack of integrated dashboards combining multi-parameter IoT data (CO_2, humidity, temperature, motion, and light) into a unified health and safety monitoring system.

METHODOLOGY

Research Design

This study adopts a project-based development approach combined with elements of the Software Development Life Cycle (SDLC). The process focuses on designing and producing a descriptive analysis dashboard for health and safety monitoring in smart buildings. The development consists of five main phases:

Research Activity

Planning Phase

The initial phase, in this study explores the feasibility and foundational requirements for developing a descriptive analysis dashboard for health and safety monitoring in smart buildings using IoT sensor data. Moreover, this phase highlights that the growth of IoT technology in building management systems collects environmental factors and safety parameters data such as CO_2 levels, temperature, humidity, motion detection (PIR), and light intensity. However, the gap identified tools that effectively analyze and visualize historical IoT data to support decision-making for health and safety compliance.

After that, through literature review of a range of sample datasets, this study points out the main key environmental factors and safety parameters for monitoring, as well as explores whether Microsoft Power BI can meet the needs for clear visualization. These findings make it easier to design a dashboard that delivers valuable information on construction safety which supports better management and promotes early mitigation strategies.

System Analysis Phase

In this phase, Kaggle Smart Building IoT dataset was examined to determine the main environmental and safety measures, including CO_2 levels, temperature, humidity, motion detection (PIR) and light intensity. Normalization was done by data profiling to identify inconsistencies, outliers, and missing values. The environmental determinants of concern were identified and mapped to health and safety issues, including inadequate ventilation and a low level of light. The logical data model was created to establish connections between variables and risks, which allowed the importation, cleaning, and transformation of data in Microsoft power BI. The dashboard subsequently presented such insights as CO_2 average and temperature changes. The needs of the experts were addressed in the SRS document so that the architecture of the dashboard could be developed without any trouble.

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Designing Dashboard Prototype Phase

A literature review was conducted to identify actionable strategies for designing the dashboard prototype, focusing on mitigation approaches for varying health and safety levels. The keywords used to search included, CO_2 thresholds, PIR-based occupancy risk, which were searched in Scopus, IEEE Xplore and ScienceDirect. The threshold limits (e.g. CO_2 >1500 ppm = Critical) were established according to the ASHRAE and WHO. The dashboard was also informative and action-driven with each level (Safe, Warning, Critical) being associated with the corresponding measures such as HVAC settings or security checks. Based on these results, the dashboard design and mitigation scheme were constructed in such a way that they would be able to visually emphasize safety indicators and respond promptly

Figure 3.2: Mock-up Dashboard

Summary of Power BI Visual Components Used in the Dashboard:

Table 3.1: Summary of Power BI Visual Components Used in the Dashboad

Visual Type	Description	Example Usage
Line Chart	Show trends of CO_2, temperature, humidity, and light intensity over time.	Track or observe temperature and CO_2 across days and hours to see fluctuation patterns.
Scatter Plot	Compare the relationship between two variables by analyzing how they are connected.	Compare CO_2 levels vs occupancy (motion detection or temperature vs humidity.
Filter Panel – Slicers	Time, Date/Hour, Room/Zone, Sensor Type	Allow user to filter the data dynamically
Gauge Chart	CO_2 Level vs Threshold (800 ppm)	Show current CO_2 level relative to risk threshold
Donut Chart	Percentage % Time in Safe vs Risk Zones	Visualize the proportion of safe vs risky time periods

Developing the Dashboard Phase

In this section, discuss Microsoft Power BI as the primary tools of identifying, transforming, and visualizing the IoT remote sensor data in the aspect of smart building health and safety monitoring. Microsoft Power BI enables the development of a descriptive analysis dashboard that helps building managers and safety officers analyze historical data on environmental parameters and safety risks using historical data

The process starts by opening up the Microsoft Power BI Desktop, then selecting the "Get Data", in order to import the CSV dataset retrieved from Kaggle dataset "Smart Building". The dataset that includes various environmental factors and safety parameters including CO_2, temperature, humidity, motion detection (PIR), and light intensity is previewed and loaded into the system. In the next step, the Power Query Editor will be used to clean the dataset. This includes removing blank rows, renaming columns for clarity such as renaming ("CO2 (ppm)" to "CO_2 Level"), converting data types to numeric or date and time, and filtering out null or corrupted records. After the data is prepared, it is applied and saved for modeling.

In the modelling stage, relationships are defined between tables using the "Model View" from Microsoft Power BI. For instance, fields like Room ID, are related across tables to define a logical structure. DAX (Data Analysis Expressions) formulas are then defined to derive such values as average CO_2 measures, maximum temperature, and safety risk categories above threshold values ("High" risk when CO_2 > 800 ppm).

The report view is then applied in design and build of the visual components of the dashboard. Various visuals include cards to indicate the key metrics, gauge charts for comparison of thresholds, line charts for trends of time series, scatter plots to correlational analysis, matrix tables for a detailed look, and donut charts which describe the percentage of time spent under the safe or risky conditions. There are slicers which enable the users to filter the dashboard based on room, type of sensors, and period of time involved.

For the user's increased interactivity, drill-through and conditional formatting properties are adopted. Visuals are organized with clear layout KPIs, accompanied by charts in the midpoint, and filters on either sides. Consisting color coding are used to show safe (green), moderate (yellow), and risky (red) conditions.

Evaluation Phase

The dashboard will be evaluated by the academic experts and industry professionals to test its performance, functionality, and suitability to the research objectives. The Microsoft Power BI dashboard will be accessed by experts and will present parameters of the environment and safety (CO_2, temperature, humidity, motion (PIR), and light intensity) and will feed the experts using a Google Form consisting of Likert-scale and short-answer questions. The analysis is aimed at evaluating the environmental and safety parameters, gathering the corresponding IoT sensors data, and evaluating the design of the dashboard of the descriptive analysis in Power BI. Professionals will consider such interactive tools as filters, slicers, color-coded risk indicators to determine trends and possible safety concerns. The outcomes will show how the dashboard is effective in meeting its goals and what areas can be improved, which confirms it as a useful and convenient tool of health and safety monitoring in smart buildings, and the detailed review questions will be found in the appendix.

RESULTS AND DISCUSSION

Introduction

This chapter presents the results obtained from the project-based development of a descriptive analysis dashboard for health and safety monitoring in smart buildings using IoT sensor data. The findings are structured to address the research objectives, (i) to study the environmental factors and safety parameters in health and safety monitoring of smart buildings using IoT sensor data, (ii) to collect and analyze relevant IoT data, (iii) to design a descriptive analysis dashboard, and (iv) to identify appropriate mitigation strategies. The dataset used for this study is the Kaggle "Smart Building System" dataset, which provides historical sensor readings of CO_2 levels, temperature, humidity, motion detection (PIR), and light intensity. These parameters are visualized through various dashboard components to highlight environmental trends, safety levels, and parameter correlations that support data-driven decision-making in smart building management.

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Dashboard Development Result

The Smart Building Health and Safety dashboard is based on the Microsoft Power BI to visualize and analyze the IoT sensor data of the Kaggle Smart Building dataset. The dashboard consolidates multiple safety related parameters into a one platform, allowing for interactive analysis and clear presentation of results. It also includes KPI cards, gauge indicators, donut charts, scatter plots, and time-series graphs each of which identifies a particular aspect of the environment or safety. The combination of these images gives a full picture on the building environmental performance and safety status.

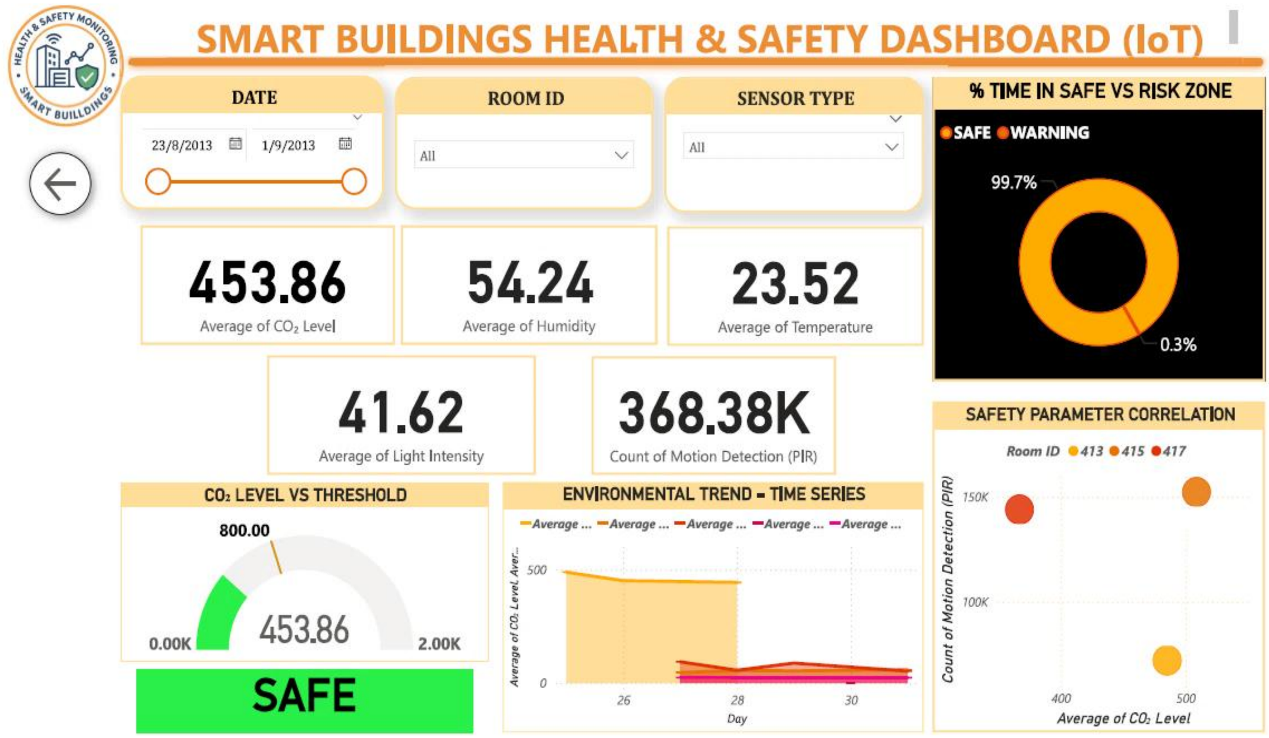

Figure 4.1: Smart Building Health & Safety Dashboard (Overall View)

Analyze IoT Sensor Data

Key Environmental Parameters

The dashboard provides a comprehensive information on the most important environmental parameters that will affect the state of health and safety in smart buildings. These are the level of (CO_2) level, temperature, humidity, light intensity, and motion detection (PIR). All parameters have been compared with the pre-determined standard of safety and comfort (ASHRAE, WHO) to assess the fact whether the environment in the building was within acceptable parameters and thresholds.

The results show that all environmental parameters fall within the acceptable safety ranges, indicating a healthy and safe indoor environment.

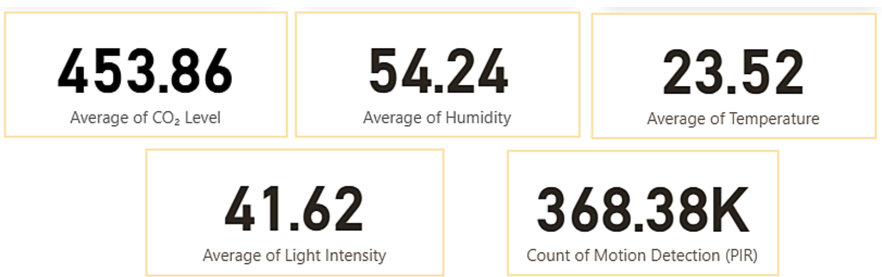

Figure 4.2: Key Performance Indicators for Environmental Parameters (CO_2, Temperature, Humidity, Light, PIR)

Table 4.1: Average Reading

Parameter	Description	Average Value	Recommended / Safety Range	Reference	Status
CO_2 Level (ppm)	Indicates indoor air quality	453.86	< 800 ppm	ASHRAE	Within safe range
Temperature (°C)	Measures thermal comfort	23.52	20–26 °C	—	Within comfort zone
Humidity (%)	Reflects indoor moisture	54.24	40–60%	WHO	Within recommended range
Light Intensity (Lux)	Measures brightness level	41.62	300–500 Lux	Indoor workspace guideline	Below recommended level
Motion Detection (PIR)	Detects occupancy or movement	368,380 counts	N/A	—	Indicates consistent occupancy

Safe vs Risk Zone Analysis

To illustrate a better picture of environmental condition distribution, the dashboard also has a donut chart that identifies data in safe and risk areas according to preset threshold values. The analysis reveals that of the 100 monitored periods, 99.7% were of safe conditions and only 0.3% were of warning zones. It means that the environmental management is fairly effective in the building, and the CO_2, temperature, and humidity levels are safe. Nevertheless, such a low percentage in the warning zone demonstrates the significance of constant monitoring because even the slightest variations may change the comfort or safety of occupants when they are not taken care of.

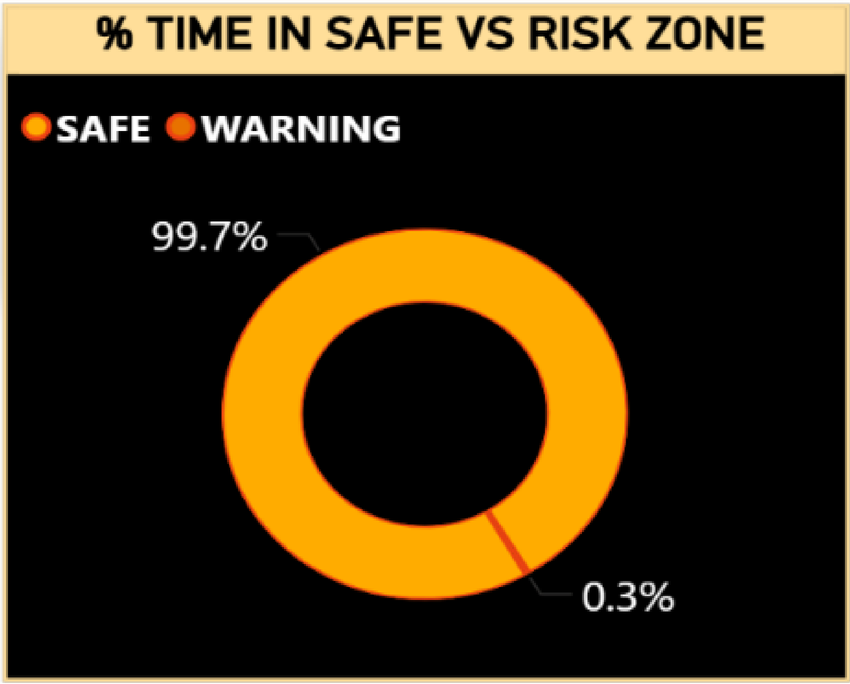

Figure 4.3: Percentage of Time Spent in Safe versus Risk Zones

Table 4.2: Safe vs Risk Zone Analysis

Aspect	Value	Interpretation
Safe Zone	99.7%	Conditions remained within safe limits
Warning Zone	0.3%	Minor fluctuations detected
Overall Condition	Mostly safe	Environment well-maintained
Implication	Stable parameters	Small variations require monitoring

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Environmental Trend – Time Series

Time-series line chart is included in the dashboard to show the variation of environmental parameters over the period of monitoring. The measurements have shown that the CO_2 and temperature remained relatively constant with no serious changes out of the recommended limits of indoor comfort and safety. By contrast, humidity also had relative fluctuations which showed the variation of environmental factors which could be affected by the occupancy trends or ventilation trends. Temporal changes are the most critical aspects to be visualized to recognize recurring patterns and possible risk conditions.

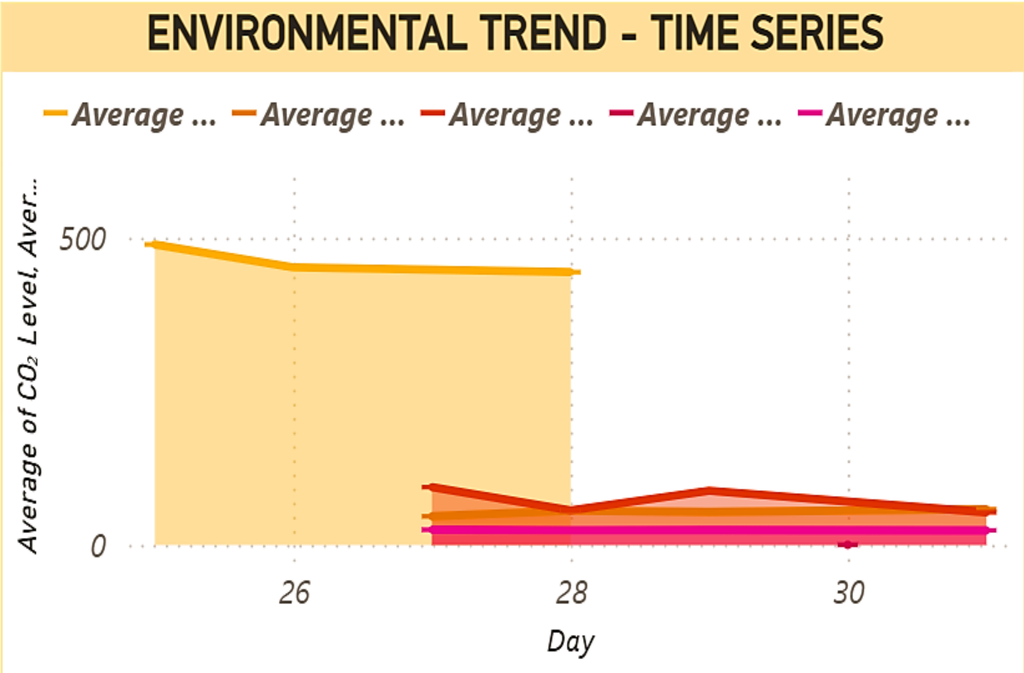

Figure 4.4: Environmental Trends in CO_2, Temperature, and Humidity Over Time

Table 4.3: Environmental Trend – Time Series

Parameter	Average Value	Observed Trend	Recommended Range (ASHRAE/WHO)	Interpretation
CO_2 Level (ppm)	453.86 ppm	Decreased Day 25–28, then stable	< 1000 ppm (ASHRAE)	Safe; good ventilation and air circulation.
Temperature (°C)	23.52°C	Stable throughout	18–26°C (WHO/ASHRAE)	Within comfort range; no thermal issues.
Humidity (%)	54.24%	Minor fluctuations (Day 27–29)	40–60% (WHO)	Acceptable; small changes due to occupancy/ventilation.
Light Intensity (Lux)	41.62 lux	Consistently low	300–500 lux (Indoor standard)	Below recommended lighting; insufficient illumination.
Motion (PIR)	368,380 counts	Spikes on Day 27 & 29	N/A	Higher occupancy activity on certain days.

Safety Parameter Correlation

In order to further analyze the correlation between occupancy and indoor air quality, a scatter plot was created in order to test the correlation of the variables motion detection (PIR) and the CO_2 level at different room ID. The findings indicate that increased occupancy events (counts of motion) were related to a bit higher CO_2, supporting the well-established link between the fact that human presence strongly correlates with higher CO_2 amounts. Ventilation strategies in the facilitation of air quality are emphasized by this relationship, especially in high or long-occupancy spaces.

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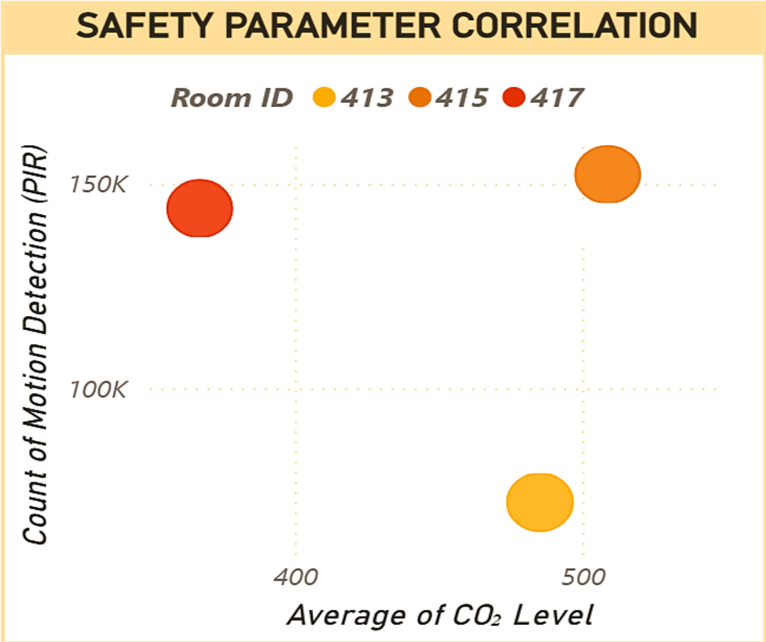

Figure 4.5: Correlation between Motion Detection (PIR) and CO_2 Levels across Rooms

Table 4.4: Safety Parameter Correlation

Room ID	**Average CO_2 Level (ppm)**	**PIR Activity (Motion Count)**	**ASHRAE Recommended CO_2 Range**	**Interpretation**
413	400 ppm	150K	< 1000 ppm	CO_2 well below ASHRAE limits; occupancy-linked increase observed.
415	450 ppm	100K	< 1000 ppm	Lower occupancy results in lower CO_2; aligns with ASHRAE.
417	500 ppm	150K	< 1000 ppm	Higher occupancy increases CO_2 slightly but still within ASHRAE range.

Evaluation Result

This section presents the evaluation results obtained from academic experts and industry professionals regarding the developed Smart Building Health and Safety Dashboard. The test was intended to determine the functionality, usability, visual design and the overall functionality of the dashboard in fulfilling the targeted goals. The questionnaire was distributed in the form of a Google Form to expert panels and the industry professionals. The feedback collected analyzed both quantitatively and qualitatively in order to determine areas where strengths and improvements were made.

Evaluation Criteria

The evaluation will be based on ten (10) major criteria, which were measured on the basis of the 5-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree). The criteria were crafted to assess the usability, functionality, visual effectiveness, and overall value to the Smart Building Health and Safety Dashboard in helping to monitor the environment and safety.

Table 4.5: Evaluation Criteria and Descriptions

Criteria	Description
Q1	Interactivity and ease of use
Q2	Layout organization and user-friendliness
Q3	Appropriateness of color coding (Safe/Warning/Risk)
Q4	Relevance of displayed parameters (CO_2, temperature, humidity, light, motion)

Q5	Effectiveness and clarity of visualizations
Q6	Usefulness for safety-related decision-making
Q7	Filtering and user control features
Q8	Achievement of monitoring objectives
Q9	Information sufficiency and readability
Q10	Open-ended feedback and improvement suggestions

A total of four (4) expert respondents who took part in the evaluation one academic expert Universiti Malaysia Pahang Al-Sultan Abdullah (UMPSA) and three industry professionals from TNB GENCO. The evaluation was aimed to determine how well the dashboard works, the ease of use, its stylish look and general efficiency in facilitating the process of smart building health and safety monitoring.

Summary of Feedback

A total of four (4) expert respondents participated in the evaluation process: one academic expert from Universiti Malaysia Pahang Al-Sultan Abdullah (UMPSA) and three industry professionals from TNB GENCO. The purpose of the evaluation was to assess the dashboard's functionality, usability, visual design, and overall effectiveness in supporting smart building health and safety monitoring.

The experts provided feedback through a 5- points Likert scale (1 Strongly Disagree to 5 Strongly Agree) by filling out a Google Form questionnaire. Quantitative ratings mean was calculated to explain the dashboard overall performance and the open-ended comments were analyzed qualitatively to reveal areas of improvement.

Table 4.6: Summary of Expert Evaluation Feedback

Participant	Type	Organization	Average Rating (Q1–Q9)	Feedback Summary
Imran (Facility Manager)	Industrial Professional	TNB GENCO	4.22	Suggested improving color scheme for better visibility.
Rakeesh (Facility Manager)	Industrial Professional	TNB GENCO	4.22	Recommended trying additional visualization styles.
Erma (Safety Officer)	Industrial Professional	TNB GENCO	3.56	Suggested adding more variety in charts and visuals.
Dr. Zetty (Academic Expert)	Academic Expert	UMPSA	4.89	Recommended including predictive trends and clearer labeling.

Average Overall Rating: 4.22/5.00. In general, the findings reveal that the dashboard was innovative, convenient, and efficient in displaying environmental and safety information. The evaluators agreed that the system met its goal and could be further refined to be more color contrasting, visually diverse, and with the predictive analytics functionalities.

Graphical Representation

In order to make the expert evaluation results more informative, the feedback obtained was visualized in a bar chart which was depicted in Figure 4.6. The figure shows the average rating given by each of the three evaluators of TNB GENCO who are industrial professionals, as well as one academic expert of UMPSA given the evaluation criteria mentioned in Section 4.4.1.

The analysis shows that all respondents gave positive ratings, ranging between 3.56 and 4.89 out of 5.00. The academic experts gave the highest rating of 4.89 which focused on analytical of the dashboard, visualization, and layout design. The industrial professionals provided uniform scores of a mean of 4.22 that they were satisfied with the dashboard capability, ease of use, and applicability to safety monitoring at the workplace.

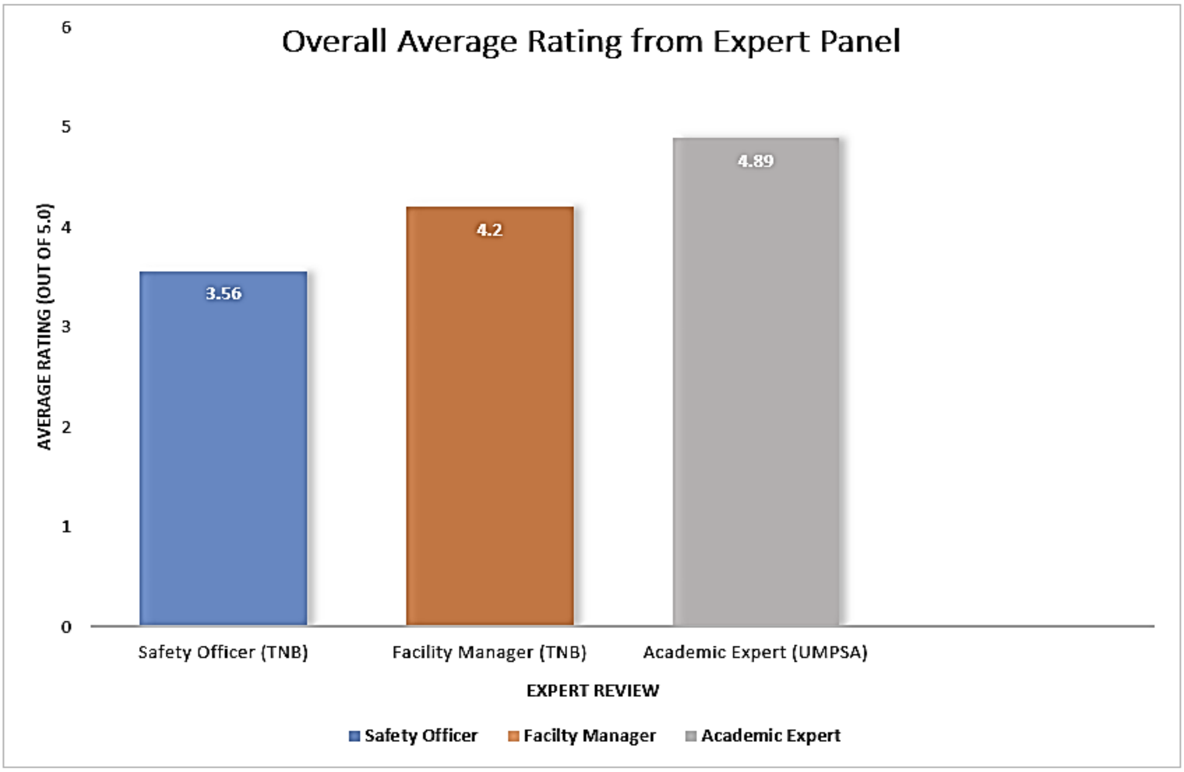

Figure 4.6: Expert Evaluation Rating for Smart Building Health and Safety Dashboard

Overall, the graphical results indicate that both academic and industry experts perceived the dashboard as useful, user-friendly, and reliable for environmental and safety analysis. Minor recommendations on the optimization of the system design and performance were offered, including the enhancement of the data visualization possibilities and the balance of colors.

DISCUSSION OF EVALUATION FINDINGS

The evaluation findings demonstrate that the Smart Building Health and Safety Dashboard successfully fulfilled its intended objectives as outlined in the research. The overall expert rating of 4.22 out of 5.00 indicates a positive acceptance from both academic and industrial professionals, confirming that the dashboard effectively supports data visualization and safety monitoring in smart buildings**.**

The feedback provided by the industrial experts (TNB GENCO) indicated the functionality, simplicity, and applicability of the dashboard to the actual workplace situations. The color-coded signs and the choice of environmental parameters proved helpful to them in determining the safe and dangerous conditions in structures. Some minor enhancement recommendations were made, including the improvement of color contrast and the use of more diversified chart types to make the data visualization more diverse.

The academic expert highlighted the strength of the dashboard to utilize descriptive analytics with the use of Microsoft Power BI and its applicability in the research and teaching settings. In response, recognized the clarity and layout design of the dashboard, and suggested adding predictive or trend analysis to the work in the future to add depth to the work

The findings in general confirm that the dashboard has achieved the SDLC evaluation phase requirements in the area of usability, interactivity, visual clarity, and effectiveness in terms of environmental conditions monitoring. The fact that all the criteria have the same ratings serves as one more confirmation that the dashboard is not only academically, but also practically relevant in the context of the health and safety awareness promotion in smart buildings.

Overall, Google Form questionnaire with the raw feedback and response summary from the academic expert and industrial professionals, is included in Appendix A and Appendix B to support the evaluation findings.

DISCUSSION

Introduction

This chapter presents the overall discussion of the research findings in relation to the research objectives. It interprets the results obtained from Chapter Four, highlights the proposed mitigation strategies, and discusses both the academic and practical contributions of the study. In addition, this chapter outlines the limitations encountered during the research and provides several recommendations for future improvement. The chapter concludes by summarizing how all research objectives were successfully achieved.

Discussion of Findings

CO_2 Level (ppm)

Average CO_2 is 453.86 ppm, which is lower than the ASHRAE limit of 1000ppm, and the changes in time-series curves are consistently stable and only slightly raised at the time of PIR activity. According to ASHRAE 62.1, CO_2 less than 1000 ppm means there is good air quality. Zhang et al. (2020) concluded that occupancy only heightens CO_2 in the poorly ventilated areas. There is good ventilation and no unsafe CO_2 levels are formed by occupancy.

Temperature (°C)

The average indoor temperature was constant during the time of monitoring, and there were minor changes. The readings were maintained to a range of commonly accepted on comfort in indoor environment. According, Thermal Comfort Model of Fanger (1970) and ISO 7730, the temperature conditions in the stable environment offer a great chance to increase the comfort of occupants and decrease the thermal stress. The authors observe that smart buildings normally have a steady temperature because of the automated HVAC systems (Al Horr et al., 2016). The building has an efficient and uniform temperature control. The fact that it is stable implies that the HVAC system is operating correctly and has a comfortable indoor environment to occupants.

Humidity (%)

The average level of humidity was 52-57% and there were slight changes in the trend of time-series. Such values are within the suggested humidity level of indoors. ASHRAE advocates 40% to 60% of humidity in the indoors to prevent the growth of microbes and ensure comfort. As Arundel et al. (1986) underline, maintaining humidity at this level helps to avoid health problems and increases respiratory comfort. The humidity levels show that there is a healthy indoor environment. According to the readings, the moisture control systems are operating properly and have no possibility of causing discomfort and mould growth.

Light Intensity (Lux)

There was a significant variation in light intensity as showed by the daylight variation and operational usage patterns. Nevertheless, the values were quite reasonable to use in the general indoor illumination. According to the illuminating engineering society (IES) and Boyce et al. (2003) natural variations in light levels in the inside occur with time of the day, type of activity, and daylight entry. This variation is most normal and is anticipated in most indoor spaces. The lighting situations are in line with the normal building operations. The difference does not imply any safety or comfort issue and is part of normal every day lighting action.

Motion Detection (PIR)

Here are evident occupancy trends in the motion data. The PIR activity is associated with the slight enhancement of CO_2, which proves the relationship between human presence and the changes in the environment. As noted in studies by Persily and de Jonge (2017), the occupancy can be regarded as one of the most effective factors impacting the indoor air quality. Berge et al. (2019) also highlight that PIR sensors are valid devices in identifying occupancy patterns in smart buildings. The movement parameter is capable of describing the fluctuations in CO_2 levels. It supports the view that the occupancy is a direct determinant of indoor environmental factors, and the sensors can be used in the efficient capturing of behavioural patterns.

SUMMARY OF DISCUSSION

Table 5.1: Summary of Environmental Parameter Findings

Parameter	Key Findings	Standards / References	Interpretation
CO_2 (ppm)	Average 453.86 ppm; stable trend; slight increases during PIR activity	ASHRAE 62.1 (<1000 ppm); Zhang et al. (2020)	Good air quality; ventilation effective; occupancy does not cause unsafe CO_2 levels.
Temperature (°C)	Stable readings; small fluctuations; within comfort range	Fanger (1970); ISO 7730; Al Horr et al. (2016)	HVAC system works efficiently; indoor temperature remains comfortable and consistent.
Humidity (%)	52–57%; minor fluctuations; within recommended range	ASHRAE (40–60%); Arundel et al. (1986)	Healthy humidity; moisture control effective; no mould or discomfort risk.
Light Intensity (Lux)	Noticeable fluctuations due to daylight and usage	IES; Boyce et al. (2003)	Normal illumination variation; reflects typical indoor lighting dynamics; no safety issue.
Motion (PIR)	Clear occupancy patterns; correlates with slight CO_2 increases	Persily & de Jonge (2017); Berge et al. (2019)	PIR sensor reliably detects occupancy; confirms human presence influences environmental conditions.

Discussion of Evaluation Findings

The evaluation results indicate that the Smart Building Health and Safety Dashboard was able to achieve its targeted goals. The overall expert rating of 4.22/ 5.00 is positive acceptance by the academic and industrial professionals, which implies that the dashboard is applicable in environmental and safety monitoring.

Industrial experts (TNB GENCO) found that the dashboard were effective, easy to use, and suitable to the real workplace conditions. They emphasized that the color-coded signals and the chosen parameters were beneficial when it comes to detecting safe and unsafe situations. It can be proposed that minor enhancements, such as more contrast colors and the usage of a broader range of types of charts, are possible.

The academic expert highlighted that the dashboard has been highly user-friendly in the descriptive analytics in power BI and its applications in research and education. One of the suggestions was to use predictive or trend analysis in future.

Altogether, the assessment proves that the dashboard fits SDLC standards of the usability, interactivity, clarity, and effectiveness of monitoring. Appendix A and Appendix B contain the Google Form questionnaire and feedback of the two experts.

Mitigation Strategies

Based on the findings of the developed Power BI dashboard, the environmental factors and safety parameters of the smart building were observed to be within safe limits of most of the indicators. The dashboard showed the average level of CO 2 is 453.86 ppm, humidity 54.24%, and temperature of 23.52°C, which are all in the healthy and comfortable ranges. The 368.38K value of motion detection shows normal occupancy activities. Nevertheless, the mean light intensity of 41.62 lux is lower than recommended meaning that there is not

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sufficient indoor illumination. In response to these results, mitigation strategies were incorporated into the dashboard to assist in the decision-making of environmental factors and safety parameters that are not within the safe limits. Table 5.1 indicates the planned measures on the actual dashboard findings.

Table 5.2: Mitigation Strategies Based on Dashboard Results

Parameter	Dashboard Result	Condition	Recommended Mitigation Strategy
CO_2 (ppm)	453.86	Safe (below 800 ppm)	Maintain current ventilation and air circulation systems to preserve air quality.
Humidity (%)	54.24	Safe (30–60%)	Maintain current humidity control; schedule HVAC maintenance to prevent moisture imbalance.
Temperature (°C)	23.52	Safe (18–25°C)	Continue monitoring; adjust HVAC settings during peak occupancy periods.
Light Intensity (Lux)	41.62	Low (below 300 lux)	Install additional light fixtures or increase luminance to ensure adequate visibility.
Motion Detection (PIR)	368.38K	Normal occupancy pattern	Continue regular monitoring; verify unusual motion signals for security purposes.

The above mitigation framework reflects the actual outcomes that are visualised in the dashboard and ensure that the users can take corrective actions immediately in order to put the conditions back to normal.

Table 5.1 represent the overall condition of the building, a combination of data for rooms 413, 415, and 417. Nevertheless, room-level analysis based on Room ID filter and CO 2 vs Motion correlation chart are also supported in the dashboard. The visualisation revealed that the CO_2 and motion detection (PIR) of Room 417 were slightly higher than those of Rooms 413 and 415, because of a higher number of occupants activity. Thus, despite the general building state being referred to as safe, room-specific solutions, including the ability to increase or decrease the intensity of ventilation or the presence of light, can be taken in order to achieve a higher level of efficiency. This feature proves that the dashboard does not only allow the general monitoring, but also allows making decisions related to a particular room.

Contributions

This study provides both practical and academic contributions to the field of smart building management and safety monitoring.

This study provides academic and practical contributions. From academic perspective, show that how descriptive analytics can be used to analyze the IoT-based environmental factors and safety parameters in smart building safety monitoring. The study leaves a research gap that has been existing, as it concentrates on past and descriptive analysis as opposed to predictive or real-time systems. It also confirms that Microsoft Power BI is an efficient tool in visualizing the results of the IoT sensor and offers a systematic structure of incorporating the IoT data with the visualization sites in research and academic application.

In practical standpoint, the research has value due to the design of an interactive and user-friendly dashboard that facilitates safety monitoring in smart buildings. The color code safety indicator and the recommended mitigation strategies in the system also enable the users such as facility managers and safety officers to act swiftly and efficiently in regards to the altering environmental conditions. With the assistance of this dashboard, it is possible to convert complex IoT data into simple and understandable information, increasing awareness of how data visualization could be used to facilitate a sustainable and safe indoor environment. Overall, the project can be discussed as beneficial to the research community and practical applications in smart building management.

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Limitations

Although the research has met its intended purposes, there are a number of limitations that were experienced. First and foremost, the research has based itself on secondary data, which was available in the ‘Kaggle Smart Building dataset’, as opposed to real-time sensor data. This restricted the possibilities of testing the dashboard in real life conditions. Second, this study only analyzed five environmental parameters which include carbon dioxide, temperature, humidity, light intensity and motion detection (PIR) but limited in other crucial safety parameters which include particulate matter (PM2.5), volatile organic compounds (VOCs) and noise levels. Third, the dashboard was evaluated by a small number of people with most of them being academics and technical experts. It might be possible to obtain more in-depth feedback by incorporating a wider user test of real building occupants. Finally, the existing system does not have predictive or automated alerts, as it only concentrates on the descriptive analysis, which can be enhanced in the future studies.

Recommendations for Future Work

In order to make the proposed dashboard more effective and user-friendly, a number of recommendations are provided on how it can be improved in the future. To start with, we can suggest incorporating real-time data from the IoT into the dashboard to be able to monitor the environmental conditions and update them continuously. Second, predictive analytics with machine learning algorithms would enable the system to predict the risks of any danger and automatically create early warnings prior to the development of unsafe conditions. Third, the system needs to be extended to measure VOCs, PM2.5, carbon monoxide and noise levels in order to have a more thorough safety evaluation in future versions of the system. Also, the web-based or mobile version of the dashboard might be created to enhance the accessibility and enable users to track the conditions at the building remotely. Finally, it would be a good idea to perform more extensive usability testing with facility managers, building occupants, and safety professionals in order to enhance the functionality of the system and the experience of its users.

CONCLUSION

This study developed a descriptive analysis dashboard for health and safety monitoring in smart buildings using IoT sensor data. The work addressed the need to better understand indoor environmental conditions by analysing historical data that reveal trends and potential risks not always visible in real-time monitoring.

All research objectives were successfully achieved. The parameters of critical environmental and safety parameters CO_2, temperature, humidity, light intensity, and motion detection were observed and verified as significant factors affecting the health and comfort of occupants. The Smart Building System IoT sensor data were collected, cleaned, and analysed to have reliable visual outputs.

An interactive dashboard of Power BI was then created with charts and indicator cards, colour-coded risk levels, and filtering functions of the data, allowing the apparent observation of trends in the environment and the state of safety and not-safety.

Mitigation strategies according to the recognised standards (ASHRAE, WHO) was included to guide users to the abnormal readings. Academic and industry reviews confirmed that the dashboard is usable and effective, and its further enhancement, including additional visual stimulation and predictive analysis, may be necessary.

Overall, the research revealed that both descriptive analytics and IoT data visualisation can be used to enhance safety monitoring in smart buildings to a great extent. The dashboard helps to be more conscious, anticipate the mitigation of risks, and make decisions based on data. Next steps and improvements in the work can be implemented to use real-time data, introduce predictive and anomaly-detection models, and deploying the dashboard in a live building environment

REFERENCES

1. Almasi, S., Bahaadinbeigy, K., Ahmadi, H., Sohrabei, S., & Rabiei, R. (2023). Usability evaluation of dashboards: A systematic literature review of tools. BioMed Research International, 2023, Article ID 9990933. https://doi.org/10.1155/2023/9990933
2. ASHRAE. (2019). ANSI/ASHRAE Standard 62.1-2019: Ventilation for acceptable indoor air quality. American Society of Heating, Refrigerating and Air-Conditioning Engineers.
3. Cheah, C. Q. (2022). A visualized analysis on student performance by using cloud business intelligence (Bachelor's thesis, Universiti Tunku Abdul Rahman). Universiti Tunku Abdul Ra11111hman Institutional Repository.
4. Chen, L., Chen, Y., & Sun, Y. (2020). Indoor air quality monitoring systems based on Internet of Things: A systematic review. Journal of Sensors, 2020, Article ID 8862046. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7400061/
5. Chourasia, D., Patel, A., & Yadav, D. (2023). IoT-based indoor air quality monitoring system. ResearchGate. https://www.researchgate.net/publication/389632095_IOT-Based_Indoor_Air_Quality_Monitoring_System
6. Cano-Ortega, A., Cano-Ortega, R., & Cano-Ortega, I. (2023). Implementation of an Internet of Things architecture to monitor indoor air quality. Sensors, 23(6), 1683. https://www.mdpi.com/1424-8220/23/6/1683
7. Deloitte. (2023). The future of smart building data analytics: Trends, challenges, and opportunities. Deloitte Insights. https://www2.deloitte.com/content/dam/insights/articles/us175897_tech-trends-2023/DI_tech-trends-2023.pdf
8. Ferreira, A. J., Marques, G., Pitarma, R., & Garcia, N. M. (2024). Low-cost IoT-based indoor air quality monitoring. International Journal of Smart Technology and Learning, 6(1), 44–59. https://www.tandfonline.com/doi/full/10.1080/24751448.2024.2405403
9. Ghahramani, A., Arroyo, L., & Klein, L. (2022). Smart buildings and indoor environmental quality: A review of sensor applications for health and safety. Building and Environment, 221, 109325. https://doi.org/10.1016/j.buildenv.2022.109325
10. Ghahramani, M., Becerik-Gerber, B., & Kichkaylo, T. (2022). Smart building health and safety monitoring using IoT and machine learning: A review. Automation in Construction, 135, 104127. https://doi.org/10.1016/j.autcon.2022.104127
11. Ha, J., Lee, S., & Kim, H. (2020). Sensing data fusion for enhanced indoor air quality monitoring. https://arxiv.org/abs/2001.01976
12. Hong, D., Gu, Q., & Whitehouse, K. (2017). High-dimensional time series clustering via cross-predictability. Proceedings of the 20th International Conference on Artificial Intelligence and Statistics (AISTATS). https://arxiv.org/abs/1703.03952
13. Henson, R. (2020). Learning Tableau: A Data Visualization Tool. Journal of Economic Education, 51(4), 433-440. https://doi.org/10.1080/00220485.2020.1804503
14. Honeywell. (n.d.). Healthy buildings dashboard. Honeywell Building Technologies. Retrieved June 20, 2025, from https://buildings.honeywell.com
15. Iqbal, S., Noor, M., & Ahmad, R. (2022). Evaluating Power BI for IoT data analytics in built environments. Journal of Applied Data Science, 3(4), 201–210. https://doi.org/10.1007/s42452-022-04567-8
16. Kumar, A., & Lee, J. (2022). IoT—A promising solution to energy management in smart buildings: A systematic review, applications, barriers, and future scope. Buildings, 14(11), 3446. https://doi.org/10.3390/buildings14113446
17. Kabir, M. A., & Ahmed, M. R. (2024). Python for data analytics: A systematic literature review of tools, techniques, and applications. Academic Journal on Science, Technology, Engineering & Mathematics Education. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=5051680
18. Kumar, S. S., Chandra, R., & Agarwal, S. (2023). A real-time approach for smart building operations prediction using rule-based complex event processing and SPARQL query. https://arxiv.org/abs/2309.10822
19. Li, H., & Chen, W. (2023). Development of an IoT-based indoor air quality monitoring system for smart buildings. Journal of Building Engineering, 57, 104837. https://doi.org/10.1016/j.jobe.2023.104837

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue V May 2026

20. Mohammed, A. K., & Ansari, M. A. (2024). The impact and limitations of AI in Power BI: A review. International Journal of Multidisciplinary Research and Publications (IJMRAP), 7(7), 23–27. https://ijmrap.com/wp-content/uploads/2024/12/IJMRAP-V7N6P136Y24.pdf
21. Singh, A., Tan, Y. C., & Bakar, H. (2022). Application of IoT sensors in monitoring indoor environments for health and safety. Sensors and Actuators A: Physical, 341, 113602. https://doi.org/10.1016/j.sna.2022.113602
22. Schneider Electric. (n.d.). EcoStruxure™ Building Operation. Retrieved June 20, 2025, from https://www.se.com/ww/en/work/products/buildings/ecostruxure-building/
23. World Health Organization. (2021). WHO housing and health guidelines. https://www.who.int/publications/i/item/9789241550376
24. Zhou, Y., Wang, S., & Zhang, X. (2022). Real-time indoor environmental quality monitoring and feedback system for smart buildings. Energy and Buildings, 258, 111831. https://doi.org/10.1016/j.enbuild.2022.111831
25. Zhao, Y., Zhang, J., & Lee, H. (2022). Descriptive analytics and dashboards in smart city management. Smart Cities, 5(3), 320–338. https://doi.org/10.3390/smartcities5030018