Higher Nationals - Summative Assignment Feedback Form

Student Name/ID	MOHAMMED MAHROOF MOHAMMED AASHIK/E230667		
Unit Title	Unit 16: Computing Research Project -Pearson Set		
Assignment Number	1 of 2	**Assessor**	Ms Imalka
Submission Date	05.05.2025	**Date Received 1st submission**	
Re-submission Date		**Date Received 2nd submission**	

Assessor Feedback:

LO1 Examine appropriate research methodologies and approaches as part of the research process

Pass, Merit & Distinction Descripts	P1	☐	P2	☐	M1	☐	D1 ☐

LO2 Conduct and analyse research relevant to a chosen computing research project

Pass, Merit & Distinction Descripts	P3	☐	P4	☐	M2	☐	D1 ☐

LO3 Communicate the outcomes of a research project to identified stakeholders

Pass, Merit & Distinction Descripts	P5	☐	M3	☐	D2	☐	

LO4 Reflect on the application of research methodologies and concepts

Pass, Merit & Distinction Descripts	P6	☐	P7	☐	M4	☐	D3 ☐

Assessor Feedback:

* Please note that grade decisions are provisional. They are only confirmed once internal and external moderation has taken place and grades decisions have been agreed at the assessment board.

Grade:	**Assessor Signature:**	**Date:**
Resubmission Feedback:		
Grade:	**Assessor Signature:**	**Date:**
Internal Verifier's Comments:		
Signature & Date:		

Pearson
Higher Nationals in
Computing

Unit 16: Computing Research Project
Project Proposal

Important Points:

1. It is strictly prohibited to use textboxes to add texts in the assignments, except for the compulsory information. eg: Figures, tables of comparison etc. Adding text boxes in the body except for the before mentioned compulsory information will result in rejection of your work.
2. Avoid using page borders in your assignment body.
3. Carefully check the hand in date and the instructions given in the assignment. Late submissions will not be accepted.
4. Ensure that you give yourself enough time to complete the assignment by the due date.
5. Excuses of any nature will not be accepted for failure to hand in the work on time.
6. You must take responsibility for managing your own time effectively.
7. If you are unable to hand in your assignment on time and have valid reasons such as illness, you may apply (in writing) for an extension.
8. Failure to achieve at least PASS criteria will result in a REFERRAL grade .
9. Non-submission of work without valid reasons will lead to an automatic RE FERRAL. You will then be asked to complete an alternative assignment.
10. If you use other people's work or ideas in your assignment, reference them properly using HARVARD referencing system to avoid plagiarism. You have to provide both in-text citation and a reference list.
11. If you are proven to be guilty of plagiarism or any academic misconduct, your grade could be reduced to A REFERRAL or at worst you could be expelled from the course
12. Use word processing application spell check and grammar check function to help editing your assignment.
13. Use **footer function in the word processor to insert Your Name, Subject, Assignment No, and Page Number on each pag**e. This is useful if individual sheets become detached for any reason.

STUDENT ASSESSMENT SUBMISSION AND DECLARATION

When submitting evidence for assessment, each student must sign a declaration confirming that the work is their own.

Student name: MOHAMMED AASHIK	Assessor name: Ms Imalka	
Issue date:	Submission date: **05.05.2025**	Submitted on: **05.05.2025**
Programme: HND in Computing		
Unit: 16 – Computing Research Project		
Assignment number and title: 1 -research proposal | Computing Research Project on Artificial Intelligence		

Plagiarism

Plagiarism is a particular form of cheating. Plagiarism must be avoided at all costs and students who break the rules, however innocently, may be penalised. It is your responsibility to ensure that you understand correct referencing practices. As a university level student, you are expected to use appropriate references throughout and keep carefully detailed notes of all your sources of materials for material you have used in your work, including any material downloaded from the Internet. Please consult the relevant unit lecturer or your course tutor if you need any further advice.

Guidelines for incorporating AI-generated content into assignments:

The use of AI-generated tools to enhance intellectual development is permitted; nevertheless, submitted work must be original. It is not acceptable to pass off AI-generated work as your own

Student Declaration

Student declaration

I certify that the assignment submission is entirely my own work and I fully understand the consequences of plagiarism. I understand that making a false declaration is a form of malpractice.

Student signature: E230667 Date:11.03.2025

Higher National Diploma in Computing

Assignment Brief

Student Name /ID Number	MOHAMMED MAHROOF MOHAMMED AASHIK/E230667
Unit Number and Title	Unit 16 – Computing Research Project (Pearson set)-
Academic Year	2024/25
Unit Tutor	Ms .Imalka
Assignment Title	AI IN HOSPITAL WASTE MANAGEMENT
Issue Date	
Submission Date	05.05.2025
IV Name & Date	

Submission format
• **Research Project Proposal**- The submission is in the form of an individual written report. This should be written in a concise, formal business style. You are required to make use of headings, paragraphs and subsections as appropriate, and all work must be supported with research and please provide a references list using the Harvard referencing system.
Unit Learning Outcomes:
LO1. Examine appropriate research methodologies and approaches as part of the research process. **LO2. Conduct and analyse research relevant to a chosen computing research project** **LO3. Communicate the outcomes of a research project to identified stakeholders** **LO4. Reflect on the application of research methodologies and concepts**
Trasferrable skills and Competencies developed

Computing related cognitive skills

- Understand the scientific method and its applications to problem-solving
- Demonstrate knowledge and understanding of essential facts, concepts, principles and theories relating to computing and computer applications
- Methods and tools: deploy appropriate theory, practices and tools for the design, implementation and evaluation of computer-based systems
- Recognise the professional, economic, social, environmental, moral and ethical issues involved in the sustainable exploitation of computer technology and be guided by the adoption of appropriate professional, ethical and legal practices

Computing related practical skills

- The ability to specify, design and construct reliable, secure and usable computer based systems
- The ability to plan and manage projects to deliver computing systems within constraints of requirements, timescale and budget
- The ability to deploy effectively the tools used for the construction and documentation of computer applications, with particular emphasis on understanding the whole proces involved in the effective deployment of computers to solve practical problems
- The ability to critically evaluate and analyse complex problems, including those with incomplete information, and devise appropriate solutions, within the constraints of a budget

Employability skills

- Intellectual skills: critical thinking; making a case; numeracy and literacy
- Self-management: self-awareness and reflection; goal setting and action planning; independence and adaptability; acting on initiative; innovation and creativity
- Interaction: reflection and communication
- Contextual awareness e.g. the ability to understand and meet the needs of individuals, business and the community, and to understand how workplaces and organisations are governed

Assignment Brief and Guidance:

Research Theme: Artificial Intelligence

Artificial intelligence is at the forefront of innovation within Computer Science that uses a combination of logic, algorithms and large data sets to produce an AI model. The AI model is created to perform specific tasks or make predictions on supplied sets of input data, for example identifying patterns in weather data, internet search data or analysis of medical data. Artificial intelligence is predicted to generate a potential impact to the global economy of $13 – $15 Trillion by 2030, with sales of AI related hardware, software and services predicted to see a global revenue of $900 billion. It is predicted that AI will boost the GDP of China by a little over 26% by 2039, and of North America by 14.5%. AI requires the input of structured and labelled data, where the outputs are already known. The input data sets to the AI model are intrinsically linked to study field to which the AI engine is to be applied. The AI model can then be used to identify and recognise patterns and relationships within the input data. This identification step is referred to as 'training' the AI model. Once this training is completed, the model can then be used to make predictions and identify patterns within brand new data sets. This new data set can then be added to the existing data set, so that the AI model keeps 'growing'. As the model data set keeps expanding, and the AI algorithms are modified and refined, this gives the impression that the AI is 'learning' and demonstrating 'intelligence'. AI has been used extensively to analyse and process large and complex datasets produced by big data systems, often in real time and using Computer Vision to extract data from image sources.

Developing Artificial Intelligence required a range of knowledge and skills across a broad range of computer science disciplines. AI developers need to be familiar with the algorithms and techniques in fields such as machine learning, natural language processing, computer vision and data science. Knowing the required computing skills will help organisations recruit the correct resources to help develop and extend AI systems. Artificial Intelligence has a range of benefits across many industry sectors. In the finance industry, AI is rapidly becoming a game changer, using advanced algorithms, models and machine learning to carry out predictive analytics on large, rapidly changing financial datasets to provide more accurate financial predictions. In the field of business operations, AI automation is helping to support and enhance labour. productivity, leading to greater cost savings and increased efficiency. AI is also revolutionising the way businesses interact with their customers, by providing AI driven expert systems to help customers resolve queries as well as providing personalised recommendations based on customer choices and preferences. In the field of

biomedical science, AI models help in the development of new drug treatments for a range of diseases by searching and processing large scale medical and DNA datasets.

While Artificial Intelligence has numerous benefits in the analysis and processing of large data sets to solve problems, there are some clear risks to the application technology. AI systems respond to the data fed into the model, and so if this data is not representative of the problem area under study, there is a likelihood that the output of the AI model will be biased. In addition, there are security and privacy concerns on the source and storage of the large datasets used for AI. The rise of the Deepfake image and the manipulation of the human voice is also a concern because of the spread of misinformation. The wide-ranging effects of these risks mean that they can only be dealt with by a diverse range of stakeholders, including computer scientists, law makers, governments, and industry leaders. There are also incidental risks of AI in business, for example the increasing adoption of AI based systems may increase unemployment across a range of sectors and workforce demographics.
(Pearson, 2024)

Task

You have been given the task of conducting research related to artificial Intelligence and its impact on the field of computing, a chosen organization or an industry. Your task is to conduct research with appropriate evidence by following suitable research philosophies and methods available. You then must evaluate the outcomes of the research project and suggest improvements to the chosen industry, organization or to the field of computing in general.

Choosing a research objective/question

You can choose your own research topic for this unit. Strong research projects are those with clear, well focused and defined objectives. A central skill in selecting a research objective is the ability to select a suitable and focused research objective. One of the best ways to do this is to put it in the form of a question.

The range of topics discussed on Artificial Intelligence could cover the following areas:

- Ethical implications in AI development
- Transparency in AI models
- AI applications
- AI perspectives on governance and regulations
- Bias and fairness in AI algorithms
- AI in cybersecurity; threats and countermeasures

Activities

Activity1 – Project Proposal

Project Proposal should cover the following areas.

1. Definition of research problem or question.
2. Provide a literature review giving the background and conceptualisation of the proposed area of study. (This would provide existing knowledge and benchmarks by which the data can be judged)
3. Clearly defined research objectives, questions or hypotheses supported by the reviewed literature.
4. Critical evaluation of the research process /different research methodologies that can be applied to computing research project by demonstrating an understanding of the pitfalls, ethical issues, and limitations. choose a suitable research methodology and justify the selection based on theoretical/philosophical frameworks.

Recommended resources

Textbooks

Cornford, T., Smithson S. (2005) *Project Research in Information Systems: A Student's Guide*. Paperback. Palgrave Macmillan.
Costley, C., Elliott, G. and Gibbs, P. (2010) *Doing Work Based Research: Approaches to Enquiry for Insider-researchers.* London: SAGE.
Fink, A. (2020) *Conducting Research Literature Reviews: From the Internet to Paper*. 5th edn. Sage Publications Inc.
Flick, U. (2020) *Introducing Research Methodology: A Beginner's Guide to Doing a Research Project.* London: Sage Publications Ltd.
Gray, D.E. (2009) *Doing Research in the Real World.* 2nd edn. London: SAGE.
Saunders, M., Lewis, P. and Thornhill, A. (2012) *Research Methods for Business Students.* 6th edn. Harlow: Pearson.
Wellington, J. (2000) *Educational Research: Contemporary Issues and Practical Approaches*. Continuum International Publishing Group Ltd.

Journals

International Journal of Quantitative and Qualitative Research
Qualitative Research

Links

This unit links to the following related units:
Unit 3: Professional Practice
Unit 6: Planning a Computing Project (Pearson-set)
Unit 7: Software Development Lifecycles.

Useful links

Resource Number	Type of Resource	Resource Titles	Links
1	Article	artificial intelligence (AI)	https://www.techtarget.com/searchenterpriseai/definition/AI-Artificial-Intelligence
2	Article	The Ultimate Guide to Understanding and Using AI Models (2024)	https://viso.ai/deep-learning/ml-ai-models/
3	Blog	What is Labeled Data?	https://www.datacamp.com/blog/what-is-labeled-data
4	Article	A Complete Guide to Data Labeling for AI	https://levity.ai/blog/guide-data-labeling-for-ai
5	Article	What Is Computer Vision? Meaning, Examples, and Applications in 2022	https://www.spiceworks.com/tech/artificial-intelligence/articles/what-is-computer-vision/
6	Article	What is Pattern Recognition? A Gentle Introduction (2024)	https://viso.ai/deep-learning/pattern-recognition/

7	Blog	Artificial Intelligence for Big Data Analytics	https://www.vpon.com/en/blogs/artificial-intelligence-for-big-data-analytics/
8	Article	Machine learning, explained	https://mitsloan.mit.edu/ideas-made-to-matter/machine-learning-explained
9	Article	What is natural language processing?	https://www.ibm.com/topics/natural-language-processing
10	Article	A COMPLETE GUIDE TO Natural Language Processing	https://www.deeplearning.ai/resources/natural-language-processing/
11	Article	Artificial Intelligence in Data Science: 5 Definitive Facts	https://hevodata.com/learn/artificial-intelligence-in-data-science/
12	Article	Artificial intelligence: Development, risks and regulation	https://lordslibrary.parliament.uk/artificial-intelligence-development-risks-and-regulation/
13	Blog	The risks of Artificial Intelligence	https://jarnoduursma.com/blog/the-risks-of-artificial-intelligence/
14	Blog	Shedding light on AI bias with real world examples	https://www.ibm.com/blog/shedding-light-on-ai-bias-with-real-world-examples/
15	Report	Increasing Threat of Deepfake Identities	https://www.dhs.gov/sites/default/files/publications/increasing_threats_of_deepfake_identities_0.pdf
16	Journal	The impact of artificial intelligence on human society and bioethics	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7605294/
17	Article	How artificial intelligence is transforming the world	https://www.brookings.edu/articles/how-artificial-intelligence-is-transforming-the-world/
18	Journal	Large AI Models in Health Informatics: Applications, Challenges, and the Future	https://ieeexplore.ieee.org/abstract/document/10261199
19	Journal	Situating methods in the magic of Big Data and AI	https://www.tandfonline.com/doi/abs/10.1080/03637751.2017.1375130
20	Journal	Challenges and opportunities: from big data to knowledge in AI 2.0	https://link.springer.com/article/10.1631/FITEE.1601883

21	Journal	Computer Vision and Image Processing: A Paper Review	https://ijair.id/index.php/ijair/article/view/42
22	Journal	Progress in Neural NLP: Modeling, Learning, and Reasoning	https://www.sciencedirect.com/science/article/pii/S2095809919304928
23	Journal	Taking AI risks seriously: a new assessment model for the AI Act	https://link.springer.com/article/10.1007/s00146-023-01723-z
24	Journal	Confronting the risks of artificial intelligence	https://www.sipotra.it/wp-content/uploads/2019/05/Confronting-the-risks-of-artificial-intelligence.pdf
25	Journal	Governing AI: Understanding the Limits, Possibility, and Risks of AI in an Era of Intelligent Tools and Systems	https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3681088
26	Journal	Foundations of AI: The big issues	https://www.sciencedirect.com/science/article/abs/pii/000437029190048O
27	Journal	Formal theories of knowledge in AI and robotics	https://link.springer.com/article/10.1007/BF03037076
28	Book	Principles of Artificial Intelligence	https://link.springer.com/book/9783540113409
29	Report	National AI Strategy	https://assets.publishing.service.gov.uk/media/614db4d1e90e077a2cbdf3c4/National_AI_Strategy_-_PDF_version.pdf
30	Report	Explaining decisions made with AI	https://ico.org.uk/media/about-the-ico/consultations/2616434/explaining-ai-decisions-part-1.pdf
31	Report	Guidelines for secure AI system development	https://www.ncsc.gov.uk/files/Guidelines-for-secure-AI-system-development.pdf
32	Report	GLOBAL OPINIONS AND EXPECTATIONS ABOUT ARTIFICIAL INTELLIGENCE	https://www.ipsos.com/sites/default/files/ct/news/documents/2022-01/Global-opinions-and-expectations-about-AI-2022.pdf
33	Draft AI Act	Artificial intelligence act	https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/698792/EPRS_BRI(2021)698792_EN.pdf

34	Report	Understanding artificial intelligence ethics and safety	https://www.turing.ac.uk/sites/default/files/2019-06/understanding_artificial_intelligence_ethics_and_safety.pdf
35	Presentation	AN INTRODUCTION TO ARTIFICIAL INTELLIGENCE	https://www.uc.edu/content/dam/uc/ce/docs/OLLI/Page Content/ARTIFICIAL INTELLIGENCEr.pdf
36	YouTube AI Channel	Two Minute Papers	https://www.youtube.com/@TwoMinutePapers
37	YouTube AI Channel	Sentdex	https://www.youtube.com/@sentdex/featured
38	Webinar	Referencing and writing a bibliography	https://youtu.be/gouEeFKs1xI
39	Webinar	Free Harvard Citation Generator	https://www.citethisforme.com/cit ation-generator/harvard
40	Webinar	Structuring extended writing	https://youtu.be/o1NMN98GfQc

Pass	Merit	Distinction
LO1 Examine appropriate research methodologies and approaches as part of the research process		**LO1 and LO2** **D1** Critically evaluate research methodologies and processes in application to a computing research project to justify chosen research methods and analysis.
P1 Produce a research proposal that clearly defines a research question or hypothesis, supported by a literature review. **P2** Examine appropriate research methods and approaches to primary and secondary research.	**M1** Analyse different research approaches and methodology and make justifications for the choice of methods selected based on philosophical/theoretical frameworks.	
LO2 Conduct and analyse research relevant to a computing research project		
P3 Conduct primary and secondary research using appropriate methods for a computing research project that consider costs, access and ethical issues. **P4** Apply appropriate analytical tools, analyse research findings and data.	**M2** Discuss merits, limitations and pitfalls of approaches to data collection and analysis.	

Pass	Merit	Distinction
LO3 Communicate the outcomes of a research project to identified stakeholders		
P5 Communicate research outcomes in an appropriate manner for the intended audience.	**M3** Analyse the extent to which outcomes meet set research objectives and communicate judgements effectively for the intended audience	**D2** Evaluate outcomes and make valid, justified recommendations.
LO4 Reflect on the application of research methodologies and concepts		
P6 Discuss the effectiveness of research methods applied, for meeting objectives of the computing research project. **P7** Discuss alternative research methodologies and lessons learnt in view of the outcomes.	**M4** Analyse results in recommended actions for improvements and future research considerations.	**D3** Demonstrate reflection and engagement in the resource process, leading to recommended actions for future improvement.

Appendix 1 – Project proposal template

Research Proposal Form

Student Name	MOHAMMED MAHROOF MOHAMMED AASHIK		
Student number	E230667	**Date**	10.02.2025
Centre Name	KANDY		
Unit	Computing Research Project		
Tutor	Ms.Imalka		
Proposed title			
Application of Ai image detection for hospital waste management in Asiri hospital private limited			

Section One: Title, objective, responsibilities
Title or working title of research project (in the form of a question, objective or hypothesis): Research project objectives (e.g. what is the question you want to answer? What do you want to learn how to do? What do you want to find out?): Introduction, Objective, Sub Objective(s), Research Questions and/or Hypothesis

Section Two: Reasons for choosing this research project
Reasons for choosing the project (e.g. links to other subjects you are studying, personal interest, future plans, knowledge/skills you want to improve, why the topic is important): Motivation, Research gap

Section Three: Literature sources searched
Use of key literature sources to support your objective, Sub Objective, research question and/or hypothesis: Can include the Conceptual Framework

Section Four: Activities and timescales	
Activities to be carried out during the research project (e.g. research, development, analysis of ideas, writing, data collection, numerical analysis, tutor meetings, production of final outcome, evaluation, writing the report) and How long this will take:	
Milestone	**Propose completion data**
Project Initiation	
Planning Stage	
Execution Stage	
Monitoring and Control and Project Closure	

Section Five: Research approach and methodologies
Type of research approach and methodologies you are likely to use, and reasons for your choice: What your areas of research will cover: Research Onion; Sample Strategy/Method; Sample Size

Comments and agreement from tutor					
Comments (optional):					
I confirm that the project is not work which has been or will be submitted for another qualification and is appropriate.					
Agreed	Yes ☐ No ☐	Name		Date	

Comments and agreement from project proposal checker (if applicable)					
Comments (optional):					
I confirm that the project is appropriate.					
Agreed	Yes ☐ No ☐	Name		Date	

Research Ethics Approval Form

All students conducting research activity that involves human participants or the use of data collected from human participants are required to gain ethical approval before commencing their research. Please answer all relevant questions and note that your form may be returned if incomplete.

Section 1: Basic Details	
Project title:	Application of Ai image detection for hospital waste management in Asiri hospital private limited
Student name:	MOHAMMED MAHROOF MOHAMMED AASHIK
Student ID number:	E230667
Programme:	CRP
School:	Esoft Metro campus Kandy
Intended research start date:	10.02.2025
Intended research end date:	05.05.2025

Section 2: Project Summary

Please select all research methods that you plan to use as part of your project

- Interviews: ☐
- Questionnaires: ☒
- Observations: ☐
- Use of Personal Records: ☐
- Data Analysis: ☒
- Action Research: ☐
- Focus Groups: ☐
- Other (please specify): ☐ .....

Section 3: Participants

Please answer the following questions, giving full details where necessary.

Will your research involve human participants?

Who are the participants? Tick all that apply:

Age 12-16 ☐ Young People aged 17–18 ☒ Adults ☒

How will participants be recruited (identified and approached)?

By Filling a Google form

Describe the processes you will use to inform participants about what you are doing:

Studies involving questionnaires:

Will participants be given the option of omitting questions they do not wish to answer?

Yes ☐ No ☒

If **"NO"** please explain why below and ensure that you cover any ethical issues arising from this.

Because all are liker scale questions

Studies involving observation:

Confirm whether participants will be asked for their informed consent to be observed.

Yes ☒ No ☐

Will you debrief participants at the end of their participation (i.e. give them a brief explanation of the study)?

Yes ☐ No ☒

Will participants be given information about the findings of your study? (This could be a brief summary of your findings in general)

Yes ☒ No ☐

Section 4: Data Storage and Security

Confirm that all personal data will be stored and processed in compliance with the Data Protection Act (1998)

Yes ☒ No ☐

Who will have access to the data and personal information?

Researcher

During the research:

Where will the data be stored?

Researcher's personal computer

Will mobile devices such as USB storage and laptops be used?

Yes ☐ No ☒

If **"YES"**, please provide further details:

After the research:

Where will the data be stored?

Researcher's personal computer

How long will the data and records be kept for and in what format?

For 12 month in a excel sheet

Will data be kept for use by other researchers?

Yes ☐ No ☒

If **"YES"**, please provide further details:

Section 5: Ethical Issues

Are there any particular features of your proposed work which may raise ethical concerns? If so, please outline how you will deal with these:
Section 6: Declaration
I have read, understood and will abide by the institution's Research and Ethics Policy: Yes ☒ No ☐ I have discussed the ethical issues relating to my research with my Unit Tutor: Yes ☒ No ☐ **I confirm that to the best of my knowledge:** The above information is correct and that this is a full description of the ethics issues that may arise in the course of my research.

Name:	Mohammed mahroof Mohammed Aashik
Date:	25.03.2025

Please submit your completed form to: ESOFT Learning Management System (ELMS)

THE RESEARCH PROPOSAL

Application of AI Image Detection for Hospital Waste Management in Asiri Hospital Private Limited.

By

M.M.M AASHIK
E230667

Research Proposal Submitted in accordance with the requirements for the

COMPUTING RESEARCH PROJECT MODULE OF PEARSON'S HND IN COMPUTING PROGRAMME

at the

ESOFT METRO CAMPUS

Name of research Tutor: Ms.Imalka

ACKNOWLEDGMENT

I am deeply grateful for the assistance and guidance I received from numerous esteemed individuals, which was instrumental in the successful completion of my task. I would like to express my sincere appreciation to ESOFT for providing a conducive workspace that facilitated the completion of my task. I am delighted to announce the successful completion of the proposal. I am particularly indebted to **Ms.Imalka** for the invaluable guidance throughout my third semester assignments. Lastly, I extend my heartfelt gratitude to my family members and classmates whose unwavering support greatly contributed to the timely completion of this project. Thank you all for your immense contribution!

EXECUTIVE SUMMARY

The increasing volume of medical waste generated in hospitals poses significant environmental, health, and regulatory challenges. Asiri Hospital Private Limited, like many healthcare institutions, faces difficulties in managing, sorting, and disposing of hospital waste efficiently. Traditional waste management methods, which rely on manual sorting, are often slow, error-prone, and costly, leading to improper disposal of hazardous materials and non-compliance with environmental regulations. To address these issues, this research proposal explores the application of AI-powered image detection in hospital waste management, focusing on its potential to enhance waste sorting accuracy, improve operational efficiency, and ensure compliance with health and safety standards.

The study investigates how AI-driven image recognition and machine learning algorithms can automate waste classification, reducing reliance on human intervention. By utilizing AI to identify different waste types such as medical, hazardous, recyclable, and general waste the hospital can minimize errors, optimize recycling processes, and lower disposal costs. Additionally, AI can provide predictive insights by analyzing waste generation patterns, enabling better planning and resource allocation.

This research aims to assess the feasibility, benefits, and challenges of integrating AI-based image detection into Asiri Hospital's waste management system. It will analyze case studies of AI applications in healthcare waste management, evaluate the hospital's current waste disposal methods, and propose an AI-driven framework tailored to its operational needs. The expected outcomes include enhanced efficiency in waste segregation, reduced environmental impact, improved regulatory compliance, and cost savings in waste disposal.

By implementing AI in waste management, Asiri Hospital can establish itself as a leader in sustainable healthcare practices, setting an example for other medical institutions to follow. The research will provide valuable insights into how technology can revolutionize hospital waste management, ultimately contributing to a cleaner, safer, and more efficient healthcare environment.

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ABSTRACT

This research proposal explores the application of AI-powered image detection in enhancing hospital waste management at Asiri Hospital, Kandy. As healthcare facilities generate diverse and potentially hazardous waste daily, the integration of artificial intelligence offers a promising solution for improving waste segregation accuracy, operational efficiency, and regulatory compliance. The study aims to assess the effectiveness of AI-based image recognition systems in identifying and categorizing various types of medical waste in real-time. It further examines the implementation challenges, technological infrastructure, and the environmental and safety benefits of such a system within the hospital setting. Through a comprehensive analysis, this research seeks to contribute valuable insights into the ethical, practical, and technological implications of using AI in healthcare waste management. The findings are expected to support healthcare administrators and policymakers in adopting intelligent waste management strategies that promote sustainability, safety, and efficiency in medical environments.

SECTION 01 - INTRODUCTION

1.1. Introduction

Hospital healthcare plays a vital role in ensuring the well-being of individuals and communities by providing essential medical services, advanced treatments and preventive care. Hospital waste management is a crucial aspect of healthcare operations, directly impacting environmental sustainability, regulatory compliance, and overall operational efficiency. AI enables hospitals like Asiri Hospital Private Limited to analyze medical data, interpret diagnostic images and predict patients outcomes with incredible accuracy. Asiri Hospital Private Limited, a leading healthcare provider, generates various types of waste, including medical, electronic, and general waste. Traditional waste management methods rely on manual sorting, which is time-consuming, prone to errors, and inefficient. This research explores how AI-powered image detection can enhance waste sorting, optimize disposal processes, and contribute to environmental sustainability while ensuring compliance with health and safety regulations.

Figure 1 ai to solve waste problem

1.2. Purpose of research

The purpose of this research is to explore and evaluate the application of AI image detection technology for improving hospital waste management practices at Asiri Hospital Private Limited. Hospital waste, especially biomedical and hazardous materials, requires accurate classification and disposal to ensure safety, regulatory compliance, and environmental protection. This study aims to investigate how AI-powered image recognition can automate and enhance the waste sorting process, reduce human error, and improve operational efficiency within the hospital's waste

management system. By identifying the effectiveness, challenges, and potential benefits of integrating AI into this process, the research provides insights into how technology can support sustainable and safe waste handling practices in a healthcare setting.

1.3. Significance of the Research

This research will provide valuable insights into the potential of AI in transforming hospital waste management. By automating waste sorting, Asiri Hospital can improve efficiency, reduce costs, and minimize environmental impact. The study will also contribute to the broader adoption of AI technologies in the healthcare sector, setting a precedent for sustainable waste management practices.

1. **Improved Waste Sorting and Classification**

The study will demonstrate how AI-powered image detection systems can significantly enhance the accuracy and efficiency of sorting medical and non-medical waste. This results in better waste classification, reducing the chances of hazardous materials being mixed with regular waste, thus improving safety for both hospital staff and patients.

2. Enhanced Operational Efficiency

By automating the waste sorting process, the AI system can reduce the time spent by hospital staff on manual waste management tasks. The result will be a more streamlined waste management system, which can contribute to better utilization of hospital resources and personnel.

3. Cost Savings for the Hospital

The reduction in manual labor and the improvement in waste sorting accuracy can lead to cost savings for the hospital. With fewer errors in waste handling, the hospital can reduce fines for improper disposal and avoid additional costs for waste treatment and disposal services.

4. Compliance with Environmental Regulations

Hospitals are required to comply with stringent regulations regarding medical waste disposal. This study will show how AI can aid in ensuring that hospital waste management systems are compliant with these regulations, minimizing the risk of legal and environmental violations. This is crucial for maintaining the hospital's reputation and ensuring the safety of surrounding communities.

5. Sustainability and Environmental Impact

Effective waste management has a direct impact on sustainability efforts. By ensuring proper segregation of waste, AI systems help minimize the environmental footprint of the hospital. The study can contribute to the broader goals of sustainability within the healthcare sector by promoting eco-friendly waste disposal practices.

6. Scalability and Adaptability

The results of this study will show how AI image detection can be applied not only in Asiri Hospital but also in other healthcare institutions. The scalable nature of AI systems can make them a viable solution for hospitals of different sizes, enhancing the overall healthcare waste management landscape.

7. Improved Staff and Patient Safety

By preventing hazardous waste from being improperly handled or disposed of, the AI system ensures a safer environment for hospital staff and patients. It also minimizes the risk of exposure to potentially infectious materials, contributing to better overall health and safety protocols.

8. Contribution to AI and Healthcare Research

The study will add to the growing body of knowledge on the application of AI in healthcare, particularly in waste management. It will serve as a case study for future research and development of AI applications in hospital operations and environmental health.

9. Data-Driven Decision Making

The integration of AI in waste management provides the hospital with data-driven insights on waste production, types, and disposal patterns. This allows for better decision-making in terms of resource allocation, waste reduction, and operational improvements.

10. Future Technological Integration

This study will lay the groundwork for further exploration into AI technologies and their potential to revolutionize hospital operations beyond waste management, such as in patient care, administrative functions, and operational logistics.

1.4. Research objectives

The primary objective of this research is to explore the application of AI-powered image detection technology to improve the efficiency and effectiveness of hospital waste management at Asiri Hospital Private Limited.

1.5. Research other objectives

Other Objectives,

1. To evaluate the current hospital waste management practices at Asiri Hospital Private Limited
2. To investigate the potential of AI image detection for automating waste sorting in a hospital environment
3. To assess the benefits of AI implementation in hospital waste management
4. To identify the challenges and barriers to the integration of AI image detection technology into Asiri Hospital's waste management system
5. To evaluate the impact of AI-powered waste management on environmental sustainability and regulatory compliance
6. To propose AI-driven strategies for enhancing sustainability in hospital waste management.

1.6. Research questions

The proposed research aims to explore the potential of AI image detection technology in improving the hospital waste management system at Asiri Hospital Private Limited. The following research questions will guide the investigation into the feasibility, benefits, and challenges of implementing AI-powered waste segregation:

1. What are the current challenges faced by Asiri Hospital in managing and segregating hospital waste?
2. How can AI image detection technology be integrated into the hospital's existing waste management system?
3. What is the accuracy of AI image detection in identifying and categorizing different types of hospital waste compared to manual sorting?
4. What are the potential benefits of using AI image detection for hospital waste management at Asiri Hospital?

5. What are the potential challenges and limitations of implementing AI image detection for waste management in a hospital setting?

1.7. Background of the issue

Waste management in healthcare settings, particularly in hospitals, is an ongoing challenge. Effective waste segregation, disposal, and recycling are essential to minimize the environmental impact of waste, ensure public health safety, and comply with stringent health regulations. Asiri Hospital Private Limited, one of the leading healthcare institutions in Sri Lanka, generates a significant amount of medical and non-medical waste daily. Mismanagement of this waste can result in serious environmental pollution, health hazards, and legal consequences.

The increasing volume of hospital waste has raised concerns about environmental pollution and public health risks. Improper disposal of medical waste can lead to contamination, disease transmission, and legal consequences. Many hospitals, including Asiri Hospital, face challenges in managing waste effectively due to high patients turnover and the complexity of segregating different types of waste. AI-driven image detection offers a potential solution by automating waste classification and enabling precise sorting, thereby improving efficiency and sustainability in hospital waste management

1.8. Background of the Sri Lankan Healthcare industry

The healthcare industry in Sri Lanka plays a vital role in providing accessible and cost-effective medical services to its population. The government has historically prioritized public healthcare, investing in infrastructure, human resources, and public health initiatives to improve national health outcomes (Govindaraj, 2014). Sri Lanka's healthcare system operates through a dual structure comprising public and private healthcare providers. The public sector manages a vast network of hospitals, clinics, and primary care facilities that offer free or subsidized services, while the private sector represented by hospitals like Asiri Hospital caters to patients seeking specialized care and advanced medical technologies (Govindaraj, 2014).

Asiri Hospital in Kandy is part of this expanding private healthcare network, delivering high-quality medical care and embracing technological innovation. One such innovation gaining traction is the implementation of AI-powered image detection systems, particularly in operational

areas like hospital waste management. With growing concerns about biomedical waste handling, environmental safety, and regulatory compliance, hospitals are exploring artificial intelligence as a tool for optimizing waste segregation and minimizing human error.

Sri Lanka's health sector has already begun integrating digital health tools such as electronic medical records, telemedicine, and data analytics. Building on this foundation, AI image detection offers a new frontier in automating routine but critical tasks such as identifying and classifying various waste types ranging from general to hazardous medical waste. The use of AI in hospitals like Asiri Kandy aligns with the broader national goal of leveraging technology to enhance healthcare service delivery, promote sustainability, and protect both patients and healthcare workers from waste-related risks.

This shift toward AI-driven operational efficiency reflects Sri Lanka's commitment to innovative healthcare solutions, reinforcing core values such as universal access, quality care, and responsible environmental management.

1.9. Research Location

The research will be conducted at Asiri Hospital, located in the scenic city of Kandy in central Sri Lanka. Asiri Hospital Kandy is part of the renowned Asiri Health group, which is recognized for its commitment to delivering high-quality, patient-centered medical care across the country. Known for its state-of-the-art infrastructure, advanced diagnostic and surgical capabilities, and highly skilled medical professionals, Asiri Hospital stands out as a leading private healthcare provider in the region.

The hospital offers a full range of healthcare services, including primary, secondary, and tertiary care, supported by modern medical equipment and digital healthcare systems. In line with its vision for continuous improvement and technological advancement, Asiri Hospital Kandy has shown a growing interest in adopting AI-based technologies to enhance operational efficiency and clinical safety.

This makes it a highly relevant and suitable setting for this research, which explores the application of AI image detection in hospital waste management. The hospital's active pursuit of innovation and quality improvement aligns well with the study's objective of assessing how artificial intelligence can support accurate waste categorization, improve regulatory compliance, and promote environmental sustainability in the healthcare sector. The research at Asiri Hospital will

contribute valuable insights into how private healthcare institutions in Sri Lanka can effectively integrate AI to solve complex operational challenges.

1.10. Problem Identification

Waste management in healthcare settings is an inherently complex and critical issue, particularly in large hospitals like Asiri Hospital Private Limited, where diverse types of waste are generated daily. The challenge lies not only in managing the vast volume of waste but also in ensuring that each type is correctly identified, segregated, and disposed of according to health and environmental standards. The manual sorting of hospital waste at Asiri Hospital is inefficient, leading to misclassification, increased costs, and non-compliance with environmental regulations. Inadequate waste management contributes to pollution and poses risks to hospital staff, patients, and the community. The lack of advanced technological intervention in waste management highlights the need for AI-based automation to address these challenges.

SECTION 2 – LITERATURE REVIEW

2.1. Literature Review

Artificial intelligence (AI) has attracted attention because it has the potential to completely transform the way waste is disposed of, recycled, and classified. The developments, uses, challenges, and limitations of AI-based waste management are examined in this literature review, with a focus on the implications for medical institutions such as Asiri Hospital

2.1.0. AI Image Detection in Hospital Waste Management at Asiri Hospital Kandy

The integration of AI image detection in hospital waste management is emerging as a transformative approach, particularly relevant for healthcare facilities like Asiri Hospital Kandy. This technology employs computer vision and machine learning algorithms to automatically identify and classify various types of medical waste, enhancing the efficiency and safety of waste segregation processes (Imagga, 2024).

AI-powered systems can process vast amounts of visual data in real-time, surpassing human capabilities in speed and accuracy. By analyzing images captured from waste disposal areas, these systems can differentiate between hazardous, recyclable, and general waste, ensuring proper categorization and disposal (API4AI, 2024). This automation reduces the risk of human error, minimizes exposure to hazardous materials, and ensures compliance with health and environmental regulations.

Implementing AI image detection at Asiri Hospital Kandy can lead to significant operational benefits. For instance, smart waste bins equipped with AI technologies can automatically sort waste, reducing the time staff spend on waste management and allowing them to focus more on patient care (MedicalExpo, 2024). Furthermore, these systems can provide real-time data analytics, offering insights into waste generation patterns and enabling more informed decision-making regarding waste reduction strategies (Restackio, 2025).

However, the deployment of AI image detection systems must be approached with consideration for data privacy and ethical concerns. Ensuring that the AI systems do not inadvertently capture sensitive information and that data is handled in compliance with privacy regulations is paramount. Additionally, staff training and change management are crucial to ensure the successful adoption of AI-based waste systems (Labellerr, 2023).

AI image detection presents a viable and forward-thinking approach to hospital waste management at Asiri Hospital Kandy. By automating waste segregation, enhancing compliance, and providing actionable insights, this technology can significantly improve operational efficiency and environmental sustainability. However, its success depends on strategic implementation, robust data governance, and continuous stakeholder engagement.

2.1.1. Artificial intelligence

Artificial intelligence is a rapidly advancing technology that is gaining popularity in various industries, particularly waste management (Abdullah etal. 2020). The incorporation of artificial intelligence and robotics in the design and operation of urban waste treatment plants can revolutionize how solid waste is managed, leading to increased operational efficiency and more sustainable waste management practices (Goutam Mukherjee etal. 2021; Yigitcanlar and Cugurullo 2020). Artificial intelligence technologies, particularly for sorting and treating solid waste, are increasingly critical in waste management (Andeobu etal. 2022; Wilts etal. 2021). Therefore, artificial intelligence is critical in developing sustainable waste management models, particularly for transitioning to a "zero waste circular economy" while considering social, economic, and environmental factors (Osman etal. 2022). Waste management should be considered when examining the problems facing different geo-graphic areas and economic sectors, including smart cities. For instance, researchers have proposed various models for sustainable waste management, such as a model for meg-acities that considers waste treatment, recycling, and reuse options (Liamputtong 2009).

2.1.2. Artificial intelligence in waste management

The utilization of artificial intelligence has the potential to bring about a revolution in municipal waste management by enhancing the effectiveness of waste collection, processing, and classification. Artificial intelligence-based technologies like intelligent garbage bins, classification robots, predictive models, and wireless detection enable the monitoring of waste bins, predict waste collection, and optimize the performance of waste processing facilities. The details are by leveraging artificial intelligence, municipalities bin reduce costs, improve safety, and reduce environmental impacts associated with waste management. Smart bin systems Conventional garbage bins solely collect waste, and sanitation workers must carry out manual inspections to assess the trash level in the bins.

This approach is not efficient for routine waste disposal inspections. Moreover, due to the frequent filling of the containers, disease-causing organisms and insects tend to breed on them (Noiki etal. 2021). There-fore, designing intelligent garbage bin monitoring systems to manage garbage is essential in constructing smart cities. Numerous research studies on intelligent garbage bins have focused on two key functions: automatic waste classification and monitoring. These studies offer a potential solution for cities to achieve an effective garbage collection system. An intelligent garbage bin can be created by utilizing a system on a chip produced by the Expressive systems (ESP 8266) module, automatically detecting objects and setting thresholds within the bin. The information gathered can then be transmitted to another node for further analysis and processing (Praveen etal. 2020b). For example, Praveen etal. (2020a) designed a garbage bin with two main pin the trigger pin connected to the sensor and the echo pin. An ultrasonic sensor is placed at the top and bottom of the cover.

Rajathi G etal. (2020) designed a robot garbage bin with two sensors installed at the bottom, which moves along a straight line. An obstacle sensor is embedded on one side of it, which can sense black and emit a buzzer sound to indicate that the garbage has stopped storing for some time. In addition, an ultrasonic sensor can be placed at the bin's edge to detect the waste level (Mbom etal. 2022). The status of the container will be updated on the web page via the wireless fidelity module, showing whether it is full or empty. Some researchers design bins that separate and monitor garbage using Arduino and wireless fidelity (Samann 2017). It has an automatic metal and non-metal separator.

Using NodeMCU, the bin's water level can be monitored in real time and sent to the cloud for further analysis and processing (Saranya etal. 2020). In summary, the research on smart garbage bins mainly focuses on automatically monitoring the garbage filling level and notifying users in time. The information is primarily received by sensors and transmitted through the network. Intelligent bin systems can potentially increase the efficiency of garbage collection, reduce the spread of diseases, and enhance the city's overall environment. However, the cost of implementing smart garbage bins is relatively high, making it challenging to promote them widely. To address this issue, the government could consider funding policies to reduce the cost of smart garbage bins, making them more accessible to the general public. Furthermore, the regular operation of these bins can be affected by environmental factors such as temperature and humidity. Thus, dedicated personnel must regularly check and maintain the garbage bins. Therefore, it is crucial to focus on developing and promoting smart garbage bins in the future.

Waste-sorting robots Garbage classification is strongly recommended for municipal solid waste management, and using robots can substantially enhance the efficiency of garbage classification. However, robots require advanced visual and operational skills to function in highly heterogeneous, complex, and unpredictable industrial environments for garbage classification (Koskinopoulou etal. 2021). Recent research has focused on improving the accuracy and efficiency of garbage classification robots, which requires the development of better sensors and cameras to identify different types of waste, as well as improved artificial intelligence algorithms for classifying waste. Utilizing hyperspectral images to locate the target region of interest is a promising approach (Xiao etal. 2020).

2.1.3. AI Applications in Waste Management

- **Smart Sorting Systems**

  AI-powered sorting systems, utilizing computer vision and machine learning, can identify and separate recyclable, non-recyclable, and hazardous materials with high precision. For instance, systems like Zen Robotics and AMP Robotics use sensors and AI algorithms to sort waste more efficiently than manual processes. (al, 2020)

- **Hazardous Waste Management**

  In healthcare, where proper disposal of hazardous medical waste is critical, AI can detect and handle infectious or dangerous materials using sensors and automated systems. AI also ensures compliance with environmental and safety regulations. (Gupta & Sharma, 2021)

- **Predictive Analytics**

  AI-driven analytics tools can forecast waste generation trends, enabling better planning and resource allocation. For hospitals, this can optimize waste collection schedules and reduce costs. (al., 2019)

- **IoT Integration**

  Internet of Things (IoT) devices, combined with AI, can monitor waste bins in real-time, ensuring timely collection and reducing overflow issues. (al., 2022)

2.1.4. How AI is being used in waste management by business

Facility managers may benefit from new AI-powered technologies that can efficiently detect and control the sources of site waste. Both of these solutions operate at a high level, assisting managers

in making more sensible decisions, and they operate immediately in the production line, assisting floor employees in locating and eliminating waste. Machine Vision for Automated Waste Recognition and Sorting.

A London-based AI business called Grey parrot has developed one unique approach that combines robotics and AI advances. The business creates a machine vision tool that can recognize and classify various waste materials, including "glass, paper, cardboard, newspapers, cans, and different types of plastics." Workers can be given information from the sorting algorithm to help them more successfully separate waste goods into distinct trash streams that can be recycled more readily. The company's trash identification API may also be used in conjunction with a robot arm or other device to sort waste autonomously with little to no human intervention required. This technology paired with facility robots might considerably speed up garbage management while also making the process cheaper for organizations who now recycle but spend a large amount of time, labor, and money sorting rubbish for recycling. A comparable technology is provided by a startup called Winnow Vision and is intended for use in industrial kitchens and food processing plants. Their machine vision technology monitors and quantifies food waste by putting a cash value on all the materials and food that a company sends to the garbage before utilizing it all.

Reducing Waste by Improving Product Quality Products of poor quality can contribute significantly to waste. Low-quality materials and manufacturing flaws can produce faulty goods that companies have spent money on yet are unable to sell. Recycling and other initiatives can help recover some of the resources used in a product, but it is always more cost-effective to stop waste before it starts. Pattern recognition models and machine vision are used in AI quality control systems to identify faulty items earlier in the production process. These control systems can enhance waste-reduction production processes, such as the Lean manufacturing methodology, when paired with other Industry 4.0 technologies (such IoT devices).

Top-Down AI Approaches to Facility Waste Instead of being integrated directly into the manufacturing process like a machine vision waste detection system, an increasing number of companies now provide AI technologies that assist in top-down analysis of business processes. One of these firms is WINT Water Intelligence, which creates a water management system using AI. Leaks are one of the main causes of water waste, and a WINT AI solution helps combat them.

Because facility plumbing is sometimes intricate and difficult to monitor, tiny leaks may go unnoticed for extended periods of time, resulting in severe water wastage. AI pattern-matching makes it feasible to more efficiently track and find water leaks as they happen. Businesses might

use the technology to drastically cut water waste without having to make big modifications to facility operations. Waste management is often a challenge for industrial facilities, but new AI tools can help reduce the labor necessary to minimize waste. Waste recognition and sorting systems, AI for quality control and facility monitoring technology may all help to reduce waste in a facility.

2.1.4.0. AI and Image Detection in Waste Segregation

AI image detection refers to the use of computer vision and deep learning algorithms to identify, classify, and interpret visual data. This technology is increasingly being utilized to automate the process of waste segregation, particularly in environments like hospitals, where accuracy and safety are paramount.

2.1.4.1. AI-Powered Image Recognition Systems

Image recognition systems utilize machine learning and deep learning models, particularly convolutional neural networks (CNNs), to classify objects within images. In healthcare settings, AI systems can be trained on large datasets containing images of different types of waste. These models can then automatically categorize waste into categories such as infectious, recyclable, or general waste, based on its appearance and characteristics.

For example, Jain et al. (2020) proposed a deep learning-based image recognition system that could classify hospital waste into various categories. The system used labeled images of different types of medical and non-medical waste to train the model. The findings showed that AI systems could achieve high levels of accuracy (over 90%) in identifying medical waste, which is crucial for reducing contamination and ensuring that waste is correctly segregated.

2.1.5. Advantages of AI-Based Waste Segregation

- **Efficiency and Accuracy**

AI reduces human error and increases efficiency in waste sorting and recycling processes. By automating the classification of different types of waste, such as hazardous materials, recyclable materials, and medical waste, artificial intelligence (AI) technology can improve waste management at Asiri Hospital. It simplifies material storage and ensures efficient waste management by reducing human error, speeding up the process, and gradually increasing accuracy.

- **Cost-Effectiveness**

Automated systems cut labor costs and optimize resource use. By decreasing manual labour, boosting productivity, and improving waste disposal, Asiri Hospital can save money by implementing AI to automate waste sorting and management. More sustainable waste management techniques and financial savings result from this.

- **Time and Labor Efficiency**

AI-powered waste segregation reduces the manual labor required to identify and sort waste. This allows healthcare staff to focus on more critical tasks while ensuring that waste is disposed of in the correct manner.

- **Environmental Impact**

By optimizing waste management, AI can reduce the hospital's environmental footprint, making processes more sustainable. AI aids in reducing landfill dependency and improving recycling rates, contributing to sustainability goals.

- **Safety Improvements**

AI systems can minimize human exposure to hazardous materials, enhancing the safety of hospital staff.

- **Data-Driven Decisions**

By gathering information on waste types and disposal techniques, identifying areas for waste reduction strategy improvement, monitoring regulatory compliance, and enabling proactive changes to waste management policies for more efficient and sustainable practices, artificial intelligence (AI) can assist Asiri Hospital in analysing waste patterns.

- **Resource Optimization**

AI can predict the appropriate amount of resources required, optimise resource utilisation in waste management, increase cost-efficiency, guarantee timely waste processing, and uphold regulatory compliance.

- **Improved Compliance**

With regulatory frameworks often governing hospital waste disposal, AI systems can help ensure that waste is disposed of according to legal standards, reducing the risk of non-compliance.

- **Increased Accuracy**

Traditional methods of waste segregation rely on human judgment, which can lead to errors, especially in high-pressure hospital environments. AI systems, once trained, can sort waste with much higher accuracy.

- **Reduction in Hazardous Waste Exposure**

By automating the segregation process, AI helps minimize the risk of exposure to hazardous or infectious materials. This is particularly important in hospitals, where improper waste handling can lead to infections or other health risks.

2.1.6. AI-Based Waste Segregation in Healthcare

Several studies and pilot projects in hospitals have demonstrated the potential of AI and image detection for waste segregation.

European Hospitals (Nassif et al., 2020) A study by Nassif et al. (2020) explored the deployment of an AI-powered image recognition system in hospitals across Europe. In the study, hospitals utilized cameras and sensors installed in waste disposal areas to capture images of waste being disposed of. These images were then analyzed by AI models to classify the waste into categories like recyclable, infectious, and general waste. The system achieved an accuracy rate of 92% in sorting waste correctly. The researchers concluded that AI-powered waste management systems could significantly improve efficiency and accuracy in hospital waste segregation.

Asian Healthcare Facilities (Kiran et al., 2021) In a study conducted in Asia, hospitals implemented AI and IoT-based waste management systems. The waste bins in the healthcare facilities were equipped with cameras and sensors capable of detecting the type of waste being disposed of. The AI system identified hazardous medical waste, sharps, and general waste, categorizing them accordingly. The system also monitored the fullness of the bins and provided real-time feedback to hospital staff. The study highlighted that AI systems not only improved waste sorting accuracy but also contributed to better environmental sustainability by optimizing waste recycling processes.

U.S. Healthcare Settings (Bhagat et al., 2022) In the United States, hospitals have adopted AI systems for waste segregation as part of broader environmental sustainability efforts. Bhagat et al. (2022) found that AI-driven waste management systems were successful in identifying hazardous

medical waste and preventing contamination. These systems used deep learning-based image recognition to sort medical waste, including needles, syringes, and contaminated materials. The study demonstrated that AI-based segregation systems reduced human errors and minimized the risk of improper disposal of dangerous materials.

2.1.7. Challenges and Limitations of AI-Based Waste Segregation in Healthcare

While AI-based waste segregation shows considerable promise, there are several challenges and limitations that must be addressed to ensure successful implementation in healthcare settings.

- **Data Quality and Dataset Availability**

AI systems rely on large datasets for accurate predictions and classifications, which may not always be available.AI systems require large, high-quality datasets to effectively train image recognition models. However, obtaining comprehensive and diverse datasets of hospital waste can be challenging, particularly given the wide variety of waste materials found in hospitals. Jain et al. (2020) noted that the success of AI models depends on the availability of well-labeled datasets that cover all waste types encountered in healthcare facilities. Hospitals may need to invest in curating these datasets to improve the accuracy of AI systems.

- **Integration with Existing Hospital Systems**

The integration of AI waste segregation systems with existing hospital infrastructure can be complex and costly. Many hospitals lack the necessary hardware, such as high-definition cameras or IoT-enabled sensors, to support AI systems effectively. Additionally, the AI systems must be integrated with the hospital's waste management protocols to ensure seamless operation. Sarkar et al. (2019) highlighted the technical challenges associated with integrating AI into existing healthcare systems, suggesting that hospitals should plan for substantial infrastructure upgrades to support AI implementation.

- **Real-Time Processing and Speed**

Hospitals require fast and efficient waste segregation to prevent overcrowding and contamination. While AI image detection systems are capable of classifying waste accurately, there may be delays in processing images, especially when dealing with large volumes of waste. Ensuring real-time processing with minimal latency is a key challenge for implementing AI solutions in healthcare waste management.

- **High Initial Costs**

The upfront investment required to implement AI image detection systems in hospitals can be significant. Costs include hardware (e.g., cameras, sensors), software, system integration, and staff training. While these systems are expected to reduce long-term operational costs by improving waste management efficiency, the initial investment may be a barrier for some healthcare facilities.

- **Technical Limitations**

Errors in waste classification and system malfunctions can occur, especially when dealing with mixed or unstructured waste

- **Large Volume of Waste**

The volume of waste produced by its large patient base, including general, medical and electronic waste, has become too much for Asiri Hospital. The volume and hazardous nature of medical waste makes its management and disposal difficult, requiring effective methods and resources. Hospital waste management is made more difficult by compliance with health and safety laws.

- **Rising Costs**

Inefficient waste management at Asiri Hospital is leading to increased costs in several areas. This includes increased labor costs for waste management, waste of valuable resources such as recyclable materials, and higher landfill fees for mixed waste. By streamlining the process, increasing sorting accuracy, and reducing unnecessary resource use, AI-based waste management systems can help hospitals save a lot of money. The implementation of AI systems can be expensive, particularly for specialized sectors like healthcare.

2.1.7. Future Directions and Research Areas

The application of AI in waste segregation is still in its early stages, and further research is needed to enhance the scalability and effectiveness of AI-powered waste management systems. Some promising areas of future research include

- Improving Model Accuracy and Robustness

  Research is needed to improve the robustness of AI models, especially in dealing with ambiguous or mixed types of waste. Deep learning models could be further optimized to handle more complex waste categories or materials that are difficult to distinguish visually.

- Real-Time Monitoring and Feedback Systems

  Developing AI systems that provide real-time feedback to hospital staff regarding waste segregation could help improve compliance and operational efficiency. Future research could explore the integration of AI with IoT-based waste bins that not only detect waste types but also monitor bin fullness and waste collection schedules.

- Ethical and Privacy Considerations

  AI systems implemented in hospitals, such as the AI image detection system at Asiri Hospital Kandy, must adhere to strict standards concerning data privacy and security. Although this technology is used for waste segregation, it such as HIPAA in the U.S. or GDPR in Europe.

Conclusion

The literature review offers valuable insights into the application of AI image detection technology in hospital waste management, with a specific focus on its potential deployment at Asiri Hospital Kandy. The integration of AI into waste segregation processes emerges as a transformative innovation that can significantly enhance the efficiency, safety, and environmental sustainability of healthcare operations. Advanced image recognition systems, supported by machine learning algorithms, are capable of accurately identifying and classifying diverse types of medical waste in real time, which is essential for ensuring proper disposal and reducing risks associated with hazardous materials.

While these developments represent a major step forward in hospital waste management, the literature also highlights important challenges—particularly those relating to data privacy, system accuracy, and operational integration. In the context of AI systems that may involve surveillance or image capture, it is essential to safeguard staff privacy and ensure that no personally identifiable information is inadvertently collected or misused. Moreover, the successful implementation of AI-driven waste detection systems requires secure and robust infrastructure, comprehensive staff training, and ongoing system maintenance to guarantee reliability and efficiency in a high-stakes healthcare environment.

The reviewed studies emphasize the need for high-quality training data and well-calibrated models to avoid misclassification of waste, which could lead to compliance violations or health hazards. Additionally, the lack of AI literacy among healthcare personnel and limited infrastructure in some

regional hospitals may pose barriers to adoption, requiring strategic planning and phased implementation. At Asiri Hospital Kandy, these challenges can be addressed through targeted investments in technology, interdisciplinary collaboration, and policy development tailored to Sri Lanka's healthcare context.

In conclusion, while the use of AI image detection in hospital waste management is still emerging, the literature clearly identifies its potential to transform existing practices by reducing human error, enhancing regulatory compliance, and contributing to a safer and more environmentally responsible healthcare system. However, these advantages can only be fully realized when accompanied by strong ethical guidelines, privacy safeguards, and continuous stakeholder engagement. As such, Asiri Hospital Kandy stands to benefit significantly from adopting AI-based waste management systems, provided that implementation is thoughtful, inclusive, and grounded in both technological and organizational readiness.

2.2. Conceptual framework

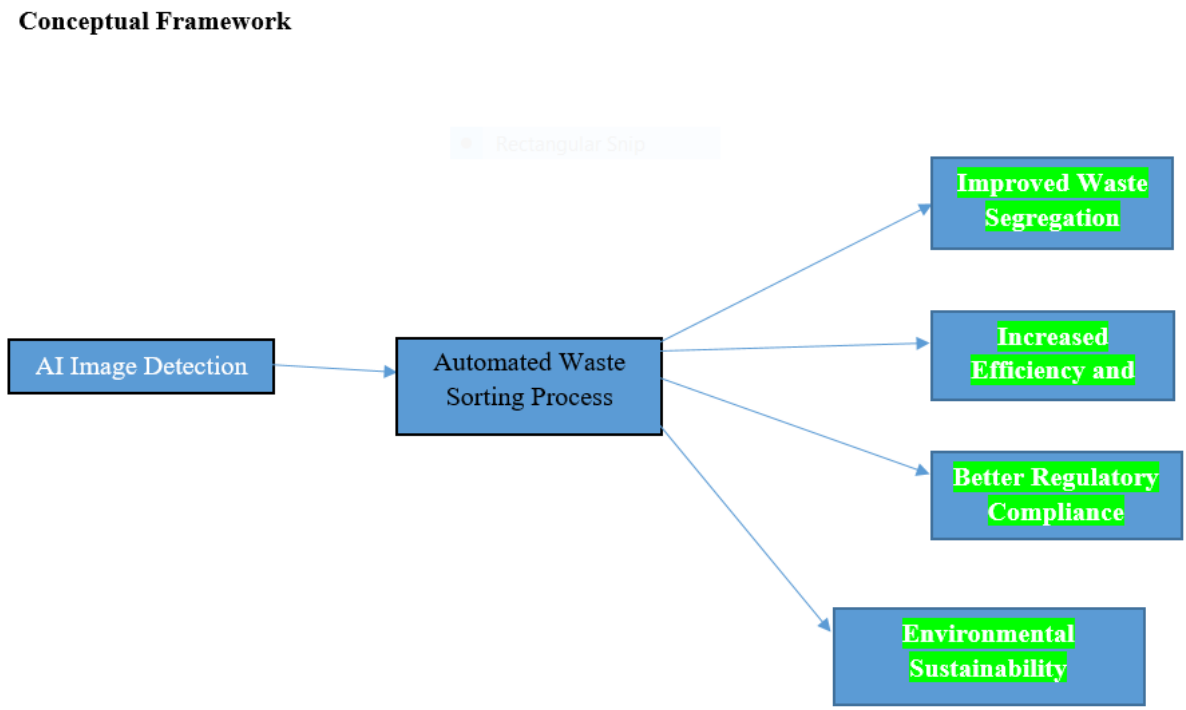

Figure 2 conceptual framework

2.3 Hypothesis

1. **H1:** AI-powered image detection improves the accuracy of hospital waste segregation.
2. **H2:** AI-powered image detection enhances the efficiency of the hospital waste management process.
3. **H3:** AI implementation in waste management leads to better regulatory compliance.
4. **H4:** AI-based waste detection contributes to improved environmental sustainability.
5. **H5:** The successful integration of AI in hospital waste management depends on hospital staff's readiness and training.

(H0) There is no significant relationship between AI-powered image detection and hospital waste segregation.

(H1) There is a significant relationship between AI-powered image detection and hospital waste segregation.

(H0) There is no significant positive relationship between AI-powered image detection and efficiency of the hospital waste management process.

(H1) There is a significant positive relationship between AI-powered image detection and efficiency of the hospital waste management process.

(H0) There is no significant positive relationship between AI implementation in waste management and better regulatory compliance.

(H1) There is a significant positive relationship between AI implementation in waste management and better regulatory compliance.

(H0) There is no significant positive relationship between AI-based waste detection and environmental sustainability.

(H1) There is a significant positive relationship between AI-based waste detection and environmental sustainability.

SECTION 3 – METHODOLOGY

3.0. Research Onion

Saunders' research onion outlines the various decisions you'll encounter when formulating a research methodology – this could be for your dissertation, thesis, or any other structured research project. As you navigate from the outer layers to the inner core of the onion, you'll be faced with a spectrum of choices that evolve from abstract and philosophical to strategic and pragmatic in nature. (Warren, 2021)

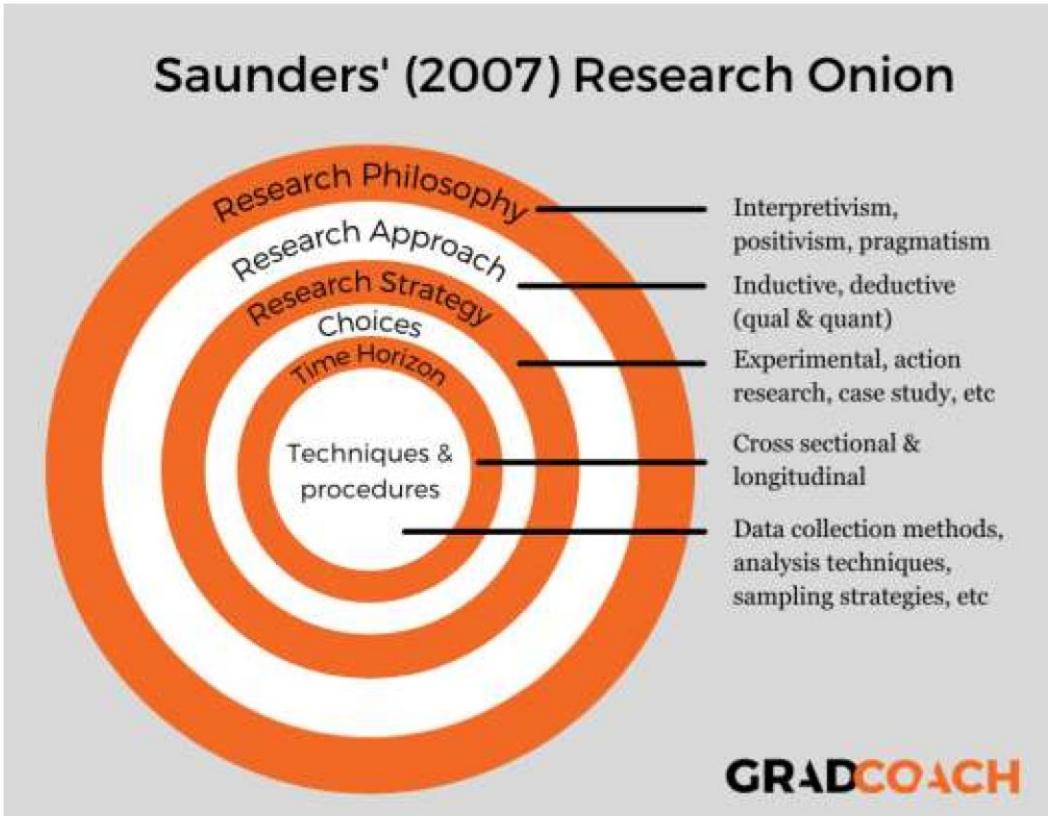

Figure 3 Research onion

3.1. Research philosophy

This is the foundation of any study as it describes the set of beliefs the research is built upon. It can be described from either an ontological or epistemological point of view. Three main research philosophies are Positivism, Interpretivism, and Pragmatism (Warren, 2021).

- **Positivism,** This philosophy takes the stance that knowledge exists outside of the subject being studied and can only be understood objectively, without the influence of personal opinions or viewpoints. It relies on empirical research based on measurement and observation.

- **Interpretivism,** This approach emphasizes the influence of social and cultural factors on individuals. It focuses on understanding people's thoughts and ideas within their socio-cultural context, requiring the researcher to play an active role in the study.

- **Pragmatism,** Pragmatism is about using the best tools possible to investigate phenomena, where knowledge is not fixed but constantly questioned and interpreted. It involves an element of researcher involvement and subjectivity, especially when drawing conclusions based on participants' responses and decisions.

Selected research philosophy

Positivism is a research philosophy based on the idea that knowledge is derived from observable and measurable facts. It emphasizes objective reality, quantifiable data, and scientific methods. When applying positivism to the use of AI image detection in hospital waste management, such as in Asiri Hospital Private Limited, the focus would be on empirically measuring the efficiency, accuracy, and outcomes of the AI system. Positivism research philosophy is an appropriate choice in this context since it is based on phenomena observed and analyzed objectively, which is in line with the quantitative nature of the study. Academics who adhere to positivism insist on applying the systematic and fair methods of data collection and analysis to identify generalizable patterns and associations within the scope of the research. AI image detection systems can be objectively tested and measured by quantifying parameters such as:

- Detection accuracy of waste types (e.g., biohazardous vs. general waste)
- Reduction in misclassification of waste
- Efficiency improvements (e.g., faster segregation, reduced human error)

A positivist study may pose hypotheses such as:

- "AI image detection reduces hospital waste sorting errors by 30%."
- "The use of AI leads to faster response times in handling hazardous waste."

Positivism leads to using the quantitative methods like surveys, experiments and statistical analysis, which are good at analyzing the connections between variables and hypothesis testing. Data collected from AI system outputs, hospital records, waste management logs, and efficiency metrics would be analyzed statistically. Surveys or observation records could support comparisons of pre- and post-AI implementation performance.

Research would follow a structured methodology, possibly using experiments or quasi-experiments, with controlled variables to determine the effect of the AI system.

Reasons for not selecting other philosophies

I do not consider that the Interpretivism and pragmatism research philosophies are relevant for that study as they focus on subjective interpretation and mixed methods approaches; and those might not match the applicability and goals of the study.

1. Interpretivism

Interpretivism, on the other hand, gives priority to getting a feel for what social phenomena mean from the position of those who are actually experiencing it, applying such qualitative methods as interviews, participant-observation, and text-analysis.

Reason for Rejection: Interpretivism focuses on understanding human experiences, perceptions, and social constructs through qualitative methods.

Why Not Suitable: AI image detection is a technical application that relies on objective data (image inputs, machine learning models, and accuracy rates), not subjective human interpretation. Interpretivism lacks the empirical basis needed for such analysis.

2. Constructivism

Reason for Rejection: Constructivism emphasizes how knowledge is constructed through social and cultural experiences.

Why Not Suitable: The project centers on the development and application of an AI system to detect hospital waste, requiring measurable performance metrics, not knowledge construction through social contexts.

3. Critical Theory

Reason for Rejection: Critical theory aims to critique and change society, often with a focus on power structures, inequality, or social justice.

Why Not Suitable: While hospital waste management has ethical and environmental implications, the project's main goal is efficiency and accuracy in detection not a socio-political critique or reform.

4. Pragmatism

Reason for Rejection (if not selected): Pragmatism values practical outcomes and combining different methods.

Why Not Chosen: Although suitable in some tech-based research, a more structured, data-driven paradigm (like positivism) may offer clearer frameworks for testing, accuracy evaluation, and reproducibility of AI algorithms, which are crucial in healthcare applications.

3.2. Research approach

A research approach refers to the systematic and structured way that researchers use to conduct research. It is based on the nature of the research problem being addressed and it differs in terms of their underlying logic and methods of inquiry (Hassan, 2024). The three main types of research approaches are:

- Deductive Approach: This approach starts with a theory or a hypothesis, and the researcher tests the hypothesis through the collection and analysis of data. The goal of this approach is to confirm or reject the hypothesis.
- Inductive Approach: This approach starts with the collection and analysis of data. The researcher develops a theory or an explanation based on the patterns and themes that emerge from the data. The goal of this approach is to generate a new theory or to refine an existing one.
- Abductive Approach: This approach is a combination of deductive and inductive approaches. It starts with a problem or a phenomenon that is not fully understood, and the researcher develops a theory or an explanation that can account for the data. The researcher then tests the theory through the collection and analysis of more data. The goal of this approach is to generate a plausible explanation or theory that can be further refined or tested

Selected Approach

As this research involves testing hypotheses derived from current theories, it is suitable for the deductive approach to be used, just as well it aligns with the structured and hypothesis driven character of the study. The deductive process always begins with a theory or a hypothesis, and then the researcher uses appropriate research methods to support the reliability of the hypotheses by empirical evidence. A deductive approach is a wise choice as it provides a basis to develop specific hypotheses from existing theoretical and empirical findings and then verify these assumptions with concrete numbers.

A deductive approach begins with general theories or principles and narrows down to specific observations or applications. In the case of Asiri Hospital, the deductive method involves applying established AI theories and image recognition principles to solve the specific problem of waste management in a healthcare setting.

The deductive approach to applying AI image detection for hospital waste management at Asiri Hospital Private Limited begins with the general principle that artificial intelligence, particularly computer vision and deep learning, is capable of accurately identifying and classifying objects based on visual data. From this theoretical foundation, the hospital deduces that these technologies can be effectively applied to solve the specific problem of improper waste segregation, which poses risks to safety, hygiene, and regulatory compliance. By employing pre trained AI models such as convolutional neural networks (CNNs) and object detection frameworks like YOLO, the system is designed to recognize various categories of hospital waste such as infectious, pharmaceutical, recyclable, and sharps in real time. This application assumes that integrating such models into the hospital's waste disposal process will reduce human error, enhance operational efficiency, and ensure safer handling of hazardous materials. The system is implemented through smart cameras installed at disposal points, and its effectiveness is evaluated through measurable outcomes such as reduced misclassification incidents, improved compliance rates, and more efficient waste management workflows. Thus, the deductive approach enables Asiri Hospital to translate broad AI capabilities into a targeted, evidence-based solution tailored to its specific operational needs.

The deductive method of research offers a structured approach for testing hypotheses and analyzing relationships between variables. In the context of this study, which explores the application of AI image detection in hospital waste management at Asiri Hospital Kandy, the goal is to examine how independent variables such as the use of AI technology affect dependent variables like waste segregation accuracy, operational efficiency, environmental compliance, and staff safety. Since the research adopts a quantitative approach, the deductive method is particularly suitable. It enables the use of statistical analysis to evaluate correlations and draw general conclusions that can be applied to broader healthcare settings. This method provides a clear framework for collecting and interpreting data to confirm or refute the proposed hypotheses related to AI implementation in waste management systems.

Deductive method contributes to the validity of research through its transparent and reproducible procedures, which include clear and explicit disclosures of the theoretical rationale and the underlying hypotheses. Through the rigorous application of deductive methods, they can hold their

results firm on the solid ground of the sound theory and they can be easily generalized to larger whole under study. This is especially useful for healthcare research, so implications for practice and policy can be much more substantial. a study will thus start from the point of general theories or hypothesis that would be empirically tested using the data that is quantitative leading to the generation of results that are reliable and valid, which in return will contribute to the individuals' understanding on this particular issue.

Reasons for not selecting other approaches

Asiri Hospital Private Limited did not select other approaches such as the inductive, abductive, and heuristic methods due to their inherent limitations in meeting the precision and reliability required in medical waste management. The inductive approach, which depends on observations to form general rules, requires extensive data collection and may lead to inconsistent results during the early phases of implementation posing safety risks in a hospital setting. The abductive approach, based on inferring the most likely explanation from incomplete data, can lead to assumptions that are not always accurate or verifiable, which is unacceptable when dealing with hazardous and infectious waste. Meanwhile, heuristic or rule-based systems lack the flexibility and adaptability of AI learning models, and may fail when encountering new or unstructured waste types. Given the hospital's need for a systematic, scalable, and error-minimizing solution, these approaches were considered unsuitable compared to the more structured and theory-driven deductive approach, which provides a reliable framework grounded in proven AI technologies.

Other approaches to applying AI image detection for hospital waste management such as inductive, Abductive, or heuristic methods were not selected by Asiri Hospital Private Limited due to specific limitations in reliability, scalability, and precision required in a high-risk healthcare environment. The inductive approach, which relies on drawing general conclusions from specific observations, was deemed less suitable because it requires extensive trial-and-error and data accumulation before forming accurate models posing a risk of inaccuracies during the early stages of implementation.

Similarly, the Abductive approach, which involves forming the most likely explanation from incomplete data, lacks the certainty and structured logic necessary for a critical process like hazardous waste classification, where errors can lead to severe health and legal consequences. Heuristic or rule-based systems, while simpler to implement, do not offer the adaptability and learning capability of deep learning models and may struggle with the visual variability of waste in real-world hospital settings. Therefore, these alternative methods were set aside in favor of the

deductive approach, which allows Asiri Hospital to apply well-established AI theories to design a robust, predictive, and systematic solution tailored to its operational and regulatory requirements.

Deduction and abduction are very useful approaches in many research fields, but they are not applicable to the focal problem. Inductive method is based on the process of generating hypotheses that are deductive from existing theories.

Abductive kind of reasoning is trying to explain the given observations by creating the hypotheses. Abductive reasoning is open-ended, and allows for more creativity and flexibility as compared to the empirical based research. However, this method may not be applicable to this research due to the need of proving empirical evidences and hypothesis testing. The very complex and diverse factors of privacy in healthcare need more organized systems to be used for data collection and analysis, which maybe will not be sufficiently handled by abductive reasoning alone.

3.3. Research strategy

Research strategies are the expansive plans or strategies that analysts use to lead their concentrate effectively. The methods and procedures used to collect, examine, and analyze data in order to answer research questions or achieve research objectives are outlined in these approaches. Different exploration methodologies can be utilized, contingent upon the idea of the review and the examination's goals. Here are some common strategies for research

- **Experiment**

To lay out circumstances and logical results connects, an examination includes changing factors and assessing their outcomes in a controlled climate.

- **Survey**

broad example of individuals is reviewed to study their perspectives, assessments, ways of behaving, or different attributes.

- **Interview/Center Gathering**

Top to bottom bits of knowledge, perspectives, or encounters on a specific issue are gotten through meetings or center gatherings, which utilize direct correspondence with members either exclusively or in a social environment.

- **Observation**

The systematic study of individuals, groups, or occurrences in their natural environments to comprehend their actions, interactions, or occurrences without directly intervening is referred to as observation.

- Contextual investigation

Contextual investigation is a careful examination of a specific individual, gathering, association, or occasion fully intent on offering an exhaustive knowledge and top to bottom examination of the subject.

Selected research strategy

A survey research strategy is highly appropriate for this study on the use of AI-powered image detection in hospital waste management at Asiri Hospital Kandy. This strategy allows for the systematic collection of data from key stakeholders, such as doctors, nurses, waste handling staff, administrative personnel, and technical support teams. The aim is to gather clear insights into the current waste management practices, identify challenges, and evaluate attitudes toward the integration of AI technologies.

The survey will use both structured questionnaires and targeted interviews to collect quantitative and qualitative data. It will examine aspects such as user awareness, acceptance of automated waste segregation, system usability, and perceived benefits of AI-based waste identification. These inputs will help assess the readiness of the hospital environment and its workforce to adopt AI solutions effectively.

One key strength of this method is its ability to gather a wide range of feedback efficiently and cost-effectively from a diverse group of respondents. The nature of the research requires input from multiple departments, and surveys make it possible to reach all relevant stakeholders regardless of their role or availability.

Moreover, surveys ensure consistency and reliability in data collection by using standardized questions, minimizing bias and allowing for accurate comparisons across groups. This is critical in a healthcare setting, where informed and evidence-based decisions are essential for maintaining safety and compliance with waste regulations.

Another advantage is the non-intrusive nature of surveys. Respondents can complete them anonymously and at their convenience, which encourages honest responses especially when addressing operational challenges or system limitations. This ensures that valuable insights can be obtained without disrupting hospital workflows or compromising privacy.

In conclusion, the survey research strategy offers a practical, reliable, and inclusive approach to evaluating the implementation of AI image detection in hospital waste management at Asiri Hospital Kandy. It supports informed decision-making and helps tailor the AI system to meet both institutional goals and staff needs.

Reasons for not selecting other Strategy

The research strategies of experiment, interview, and observation were not selected for the application of AI image detection in hospital waste management at Asiri Hospital Private Limited due to practical and methodological limitations. The experimental strategy, which involves controlled testing of variables, was deemed unsuitable as the hospital environment is dynamic and does not allow for strict control over conditions without disrupting essential medical operations. Moreover, implementing controlled experiments in real-time waste handling could pose safety and ethical concerns.

The interview method, while useful for gaining in-depth insights, was not selected as the primary strategy because it limits the ability to gather large-scale, quantifiable data needed to assess user readiness, system acceptance, and operational impact across different departments. Relying solely on interviews could also introduce personal bias and subjectivity. The observation strategy, though valuable for understanding behavior and workflows, was not chosen as it is time-consuming, may intrude on sensitive medical areas, and does not provide the structured, scalable data required for evaluating a technological solution like AI. Therefore, to ensure a broader, more efficient, and data-driven understanding of stakeholder perspectives and system impact, strategies like survey and case study were prioritized.

Even the three research methods (Experiment, Interview, and Observation) may not paint the picture of a curved diversity among the stakeholders. Because of the multifaceted characteristic of the research subject, requiring the input of different actors, a survey research method is more implementable and pragmatic for collecting quantitative data on a large scale, while confidentiality and response bias are also secured. However, the applied experiments, interviews and the observation research strategies can find out the truth in some research areas. A survey research strategy is a more aligned and conducive tool in terms of gathering quantitative data from different stakeholders who are equally important and ensure ethical standards are met.

3.4. Research Choice

A research study's approach or design is referred to as the research choice.

Types of research Choice

- Mono research is a method of research in which a single method of research is used throughout the entire study. It centers on utilizing one explicit technique, like overviews, trials, or meetings, to gather information and answer research questions. A focused and consistent method for data collection and analysis is provided by this strategy.

- Mixed research joins both subjective and quantitative examination techniques in a solitary report. It includes gathering and examining both mathematical and non-mathematical information to acquire an extensive comprehension of the exploration point. This approach permits specialists to catch a great many points of view, investigate complex peculiarities, and give a more all-encompassing perspective on the exploration subject.

- Multi research includes utilizing various exploration techniques, either inside a solitary examination stage or across various stages, to examine an exploration subject. This approach gives adaptability in information assortment and examination by using different strategies, like studies, meetings, perceptions, or record investigation. It improves the research's overall reliability and validity by allowing for triangulation and validation of findings.

Selected research Choice

The mono-quantitative research approach was adopted for the application of AI image detection in hospital waste management at Asiri Hospital Private Limited to focus on collecting and analyzing numerical data that measures the effectiveness, efficiency, and user response to the AI system. This approach relies on structured data collection methods such as surveys with closed-ended questions, system performance metrics, error rate analysis, and usage statistics. By employing quantitative tools, the research aims to evaluate key indicators such as the accuracy of waste classification, reduction in misclassification incidents, staff compliance rates, and the time saved through automation.

The mono-quantitative method is particularly suitable in this context because it provides objective, measurable insights that can guide evidence-based decision-making and system refinement. Additionally, it allows for easy comparison of results before and after implementation, enabling the hospital to assess the direct impact of the AI solution on waste management operations. This

focused, data-driven approach ensures clarity, consistency, and statistical validity in evaluating the success of the technology in a complex healthcare setting.

Reason for not selecting other research choices

The mixed research and multi-research methodologies were not selected for the application of AI image detection in hospital waste management at Asiri Hospital Private Limited due to their complexity and the specific focus required for evaluating the AI system's performance. The mixed research methodology, which combines both qualitative and quantitative data, was deemed unnecessary because the study's primary goal was to obtain clear, numerical data on the effectiveness of the AI system, such as classification accuracy, operational efficiency, and compliance rates.

Integrating qualitative insights would have added layers of complexity without significantly enhancing the understanding of the system's technical performance, which is the key area of interest. Additionally, multi-research methodologies, involving multiple research strategies or paradigms, were considered overly broad and resource-intensive for this particular application. This approach would have required more time, effort, and coordination across various methods, which could lead to logistical challenges and complications in data analysis. Instead, a mono-quantitative research approach was selected because it offered a streamlined, focused, and measurable way to evaluate the AI system's impact on waste management, allowing for clear conclusions based on objective, data-driven results. The mixed research and multi-research methodologies might not be appropriate for the study.

3.5. Time Horizon

The time horizon in research refers to the timeframe relevant to the study. It is the period in which the researcher is interested in studying the population. The researcher determines the time horizon depending on the research objectives and the type of investigation. (Alamgeer, 2023)

There are two types of research based on the time horizon

- Cross-Sectional Research: This type of research involves studying samples at a certain point in time. The researcher collects data from samples only once, interested in studying the characteristics of the population at a certain point in time. There is no repetition of

gathering data from samples in cross-sectional research. For instance, a researcher might be interested in studying the financial performance of airline companies in a specific year.

- Longitudinal Research: In contrast, longitudinal research involves studying samples over a period of time. The researcher gathers data from samples at different intervals. The purpose of a longitudinal study is to examine changes in attitude, behavior, process, or phenomenon over a period of time. The scope and time horizon of longitudinal research are not restricted to a certain point. For example, a researcher might be interested in studying the impact of a new teaching method on student performance over several years.

Selected Time horizon

Time Horizon of the Study

A cross-sectional time horizon is suitable for this study on the application of AI image detection in hospital waste management at Asiri Hospital Kandy. This method allows data to be collected at a single point in time, making it possible to assess the current status of AI implementation, waste handling practices, and operational efficiency within the hospital.

Given the evolving nature of healthcare technology and environmental regulations, a cross-sectional approach helps capture a real-time snapshot of how AI is being used to support proper waste classification and disposal. It also allows for the identification of existing gaps, challenges, and success factors in AI adoption within hospital operations.

This approach makes it possible to gather input from various stakeholders such as hospital administrators, waste management staff, IT specialists, and environmental health officers all at once. Collecting data across these groups helps build a broad understanding of the effectiveness, acceptance, and challenges of AI-powered waste solutions, improving the relevance and generalizability of the findings.

Though cross-sectional studies do not track changes over time or establish causality, they are effective for establishing baseline insights. These insights can inform future improvements, guide policy development, and help other hospitals adopt similar AI tools. The method also supports identifying factors such as operational bottlenecks, training needs, or system limitations, enabling evidence-based recommendations.

In summary, the cross-sectional time horizon offers a practical and efficient way to explore how AI image detection is currently impacting waste management at Asiri Hospital, helping drive innovation while maintaining safety and compliance.

Reason for not selecting other time horizons

A longitudinal time span may not be appropriate for the research. Other time horizons, such as longitudinal and retrospective, were not selected for the application of AI image detection in hospital waste management at Asiri Hospital Private Limited due to their complexity, resource requirements, and the specific goals of the research. A longitudinal time horizon, which tracks data over an extended period, was considered unnecessary for the initial evaluation of the AI system, as it would require more time, resources, and continuous data collection that could delay actionable insights.

Moreover, it would not have been practical for assessing the immediate and direct impact of the AI system, which was the main focus of the research. A retrospective time horizon, which analyzes past data to understand trends or patterns, was also unsuitable because it would not provide real-time insights into how the AI system functions within the current waste management processes at the hospital. The cross-sectional time horizon was chosen because it allows for a timely and focused assessment of the AI system's performance at a specific point in time, offering immediate feedback and helping identify areas for improvement in the short term, without the need for long-term data tracking.

A longitudinal study takes a comprehensive approach which involves considerable resources, time, and coordination to gather and process data across multiple time bouts. As a matter of fact, the complexity and scope of the subject of the research may go astray data collection, ends, and use the monitoring. So, this may be a great challenge logistically.

A longitudinal study may not be suitable for providing timely insights for decision-makers in the evolving landscape of hospital waste management using AI image detection. In a fast-paced technological environment, particularly in healthcare settings like Asiri Hospital in Kandy, delays in research outcomes could hinder the timely implementation of innovative waste management solutions. Since long-term studies require extended periods to yield results, there is a risk that by the time findings are available, the technology or regulatory framework may have already evolved, rendering the insights less practical or outdated. Although longitudinal research offers valuable benefits in tracking changes and trends over time, its limitations in delivering prompt data make it

less ideal for exploring the immediate applicability and effectiveness of AI-based waste detection systems. Therefore, in the context of this study, a more time-efficient approach is necessary to inform rapid development and integration of AI solutions in waste management at Asiri Hospital.

3.6. Techniques and Procedures

1. Descriptive Analysis

Descriptive analysis is a study that refers to the summarization and displaying the features of variables. The descriptive analysis of the application of AI image detection for hospital waste management at Asiri Hospital Private Limited focuses on providing a detailed overview of the system's implementation, functionality, and impact. The AI image detection system is designed to automatically identify and classify various types of hospital waste, including sharps, infectious materials, pharmaceuticals, and general waste, using advanced computer vision techniques.

The system employs convolutional neural networks (CNNs) and object detection algorithms like YOLO to process images captured by strategically placed cameras at waste disposal points. The analysis highlights how the AI system helps staff segregate waste more accurately and efficiently, reducing human error and minimizing the risk of cross-contamination. Additionally, the system provides real-time feedback, alerting staff when waste is incorrectly disposed of, ensuring better compliance with safety and regulatory standards.

The descriptive analysis also examines the operational integration of the system within the hospital’s existing waste management processes, the initial training and adaptation period for staff, and the system's overall contribution to improving waste management efficiency, reducing hospital waste volume, and ensuring adherence to environmental sustainability goals.

2. Questionnaire Surveys

Those questionnaire surveys widely employed to gather the quantitative date from a huge sample of the respondents have become a hand. The questionnaire surveys for the application of AI image detection in hospital waste management at Asiri Hospital Private Limited aim to gather structured feedback from key stakeholders, including hospital staff, waste management personnel, and administrative teams.

The surveys are designed to assess the effectiveness, usability, and impact of the AI system on daily waste handling processes. Key areas of focus include the accuracy of waste classification, user satisfaction, perceived ease of use, and the system’s influence on reducing waste

mismanagement incidents. The questionnaire includes both Likert-scale questions to quantify responses on a scale (e.g., from "strongly agree" to "strongly disagree") and open-ended questions to capture detailed feedback on potential challenges, suggestions for improvement, and insights on the system's integration into existing workflows.

By gathering this feedback, the survey provides valuable insights into how well the AI system is being received by staff, the system's alignment with hospital waste management goals, and any barriers or areas for improvement in its implementation. The findings from the survey will help refine the AI system, ensuring it meets both operational and regulatory requirements while fostering greater staff compliance and engagement.

In this research we may use to administer questionnaire surveys to healthcare professionals, patients, policymakers, and other audience groups to obtain data about their attitudes, perceptions, and experiences.

3. Descriptive Statistics

The use of descriptive statistics in the application of AI image detection for hospital waste management at Asiri Hospital Private Limited plays a critical role in summarizing and interpreting the quantitative data collected during the system's implementation. These statistics help provide a clear overview of the AI system's performance by presenting data such as the number of waste items correctly classified, percentage of classification accuracy, frequency of misclassification incidents, and staff compliance rates.

Measures such as mean, median, mode, percentages, and standard deviation are used to analyze key variables, offering insights into the central tendencies and variability of the system's outcomes. For instance, the average time taken to classify waste before and after AI implementation can be compared to assess efficiency improvements. Similarly, the percentage of staff who found the system user-friendly can indicate user acceptance levels. By converting raw data into meaningful metrics, descriptive statistics allow stakeholders to easily understand the impact of AI on waste segregation processes and support evidence-based decisions for further optimization and scaling of the system within the hospital.

4. Inferential Analysis

The inferential analysis in the application of AI image detection for hospital waste management at Asiri Hospital Private Limited is used to draw conclusions and make predictions about the broader impact of the system based on sample data collected during its implementation. By applying statistical techniques such as hypothesis testing, confidence intervals, and correlation analysis, the study evaluates whether observed improvements such as increased waste classification accuracy, reduced disposal errors, or higher staff compliance are statistically significant and not due to random chance.

For example, inferential analysis may be used to determine whether the AI system significantly reduces the rate of hazardous waste misclassification compared to traditional manual sorting methods. It can also explore the relationship between user training levels and system usage efficiency, or the correlation between staff feedback scores and actual system performance metrics. This analysis supports generalizing findings from a sample group of hospital staff to the larger hospital population, enabling data-driven decisions about future investments, staff training programs, or broader deployment of the AI system across other departments or facilities. Ultimately, inferential analysis provides the evidence needed to validate the AI system's effectiveness and justify its continued use and potential expansion.

Techniques like hypothesis testing, analysis of variance (ANOVA) and chi square tests are some of the useful statistical methods that can be utilized to evaluate the significance of findings from the study and to reach conclusions to test the aim of the study.

5. Correlation and Regression Analyses

The correlation and regression analyses applied in the study of AI image detection for hospital waste management at Asiri Hospital Private Limited are essential for understanding the relationships between key variables and predicting outcomes based on those relationships. Correlation analysis is used to examine the strength and direction of associations between variables such as staff training levels and waste classification accuracy, or system usage frequency and reduction in misclassification rates.

A positive correlation, for instance, may indicate that better-trained staff are more likely to use the AI system effectively, leading to improved waste segregation. Meanwhile, regression analysis allows the study to predict dependent outcomes such as classification accuracy or time saved in waste sorting based on independent variables like user experience, system usage hours, or department workload.

By constructing regression models, researchers can quantify the extent to which various factors influence the success of the AI system and identify which variables have the greatest impact. These analyses provide deeper insights beyond basic descriptive statistics, supporting strategic decision-making and helping Asiri Hospital optimize system deployment, training efforts, and resource allocation to maximize the benefits of AI-assisted waste management.

Correlation and regression analyses are essential for examining the linear relationship between variables and predicting the value of one variable based on another. In this study, such analytical techniques can be used to assess the strength, direction, and nature of the relationship between the implementation of AI image detection systems and various factors related to hospital waste management. These factors may include operational efficiency, accuracy in waste categorization, staff responsiveness, and environmental compliance. By applying correlation analysis, the study can determine how closely the adoption of AI correlates with improvements in waste handling practices, while regression analysis can help predict the potential outcomes of broader AI integration at Asiri Hospital in Kandy.

3.7. Data analysis

Data analysis is a vital process that involves examining, modifying, and presenting data to extract meaningful information and reach important conclusions. It is typically categorized into two main types: descriptive analysis and inferential analysis. Descriptive analysis aims to present and summarize the main features of a dataset using statistical measures such as mean, median, mode, and standard deviation, as well as visual aids like histograms or bar charts. It focuses on describing the data without making any assumptions or predictions about a larger population. (Rawat, 2021)

On the other hand, inferential analysis extends beyond the data collected and attempts to infer or test hypotheses about a larger population based on a sample (Hassan, 2024). It employs statistical methods to estimate or infer characteristics of the population. Inferential analysis includes two subcategories: correlation and regression. Correlation analysis is a statistical method used to determine the relationship between two variables, which is assessed by the correlation coefficient. Regression analysis, on the other hand, aims to model the relationship between a dependent variable and one or more independent variables. It helps predict or estimate the value of the dependent variable based on the values of the independent variables, making it useful for forecasting and trend analysis as it demonstrates how the independent variables impact the dependent variable

3.7.1. Type of Data

- Primary Data: Surveys, interviews, and direct observations of waste sorting processes, Smart Cameras in Waste Bins, Hospital Staff Observations, Waste Management Staff Reports , Staff Questionnaires and Interviews with Waste Management Team
- Secondary Data: Hospital waste reports, AI implementation case studies, and regulatory guidelines , Previous compliance reports, Previous studies on AI in waste management

3.8. Variable Analysis

Independent Variable

AI-powered Image Detection

AI-powered image detection serves as the independent variable, meaning it is the primary factor that influences the outcomes of hospital waste management. The AI system processes images of waste and classifies them into different categories, impacting overall waste segregation efficiency, compliance, and environmental safety.

AI-powered image detection refers to the use of artificial intelligence (AI) algorithms, such as machine learning models, to identify, classify, and sort various types of hospital waste based on images captured through cameras or sensors installed in waste disposal areas. This technology relies on deep learning models, trained on large datasets of labeled images, to recognize waste items and differentiate between hazardous and non-hazardous waste.

The independent variable, AI-powered image detection, is the primary factor being manipulated in this study to assess its impact on hospital waste management. The efficiency and accuracy of the AI model in identifying waste directly influence the outcomes related to waste sorting, cost savings, regulatory compliance, and environmental sustainability.

Dependent Variables

1. **Waste Sorting Accuracy**

The accuracy with which the AI system correctly identifies and classifies different types of hospital waste, including medical and non-medical waste, hazardous and non-hazardous waste. Accuracy can be measured by the percentage of correctly classified waste items compared to the total waste sorted by the AI system.

The better the AI image detection model performs, the higher the waste sorting accuracy will be. Efficient AI systems can reduce human error and misclassification, leading to improved accuracy in waste management.

2. **Cost Efficiency**

The reduction in costs associated with waste management due to the automation provided by the AI system. This includes savings from fewer personnel required for manual sorting, reduced waste treatment costs, and avoidance of fines for improper waste disposal. This can be measured by comparing the operational costs before and after implementing the AI-powered system. Cost reductions are measured in terms of labor costs, waste disposal costs, and fines for non-compliance.

A well-performing AI system can reduce the need for manual labor and improve the accuracy of waste disposal, leading to overall cost savings for the hospital.

3. **Compliance**

The extent to which the hospital's waste management system adheres to environmental and regulatory standards set by health authorities and environmental agencies. Compliance can be assessed by reviewing the number of violations or non-compliance incidents before and after implementing the AI system. This may include audits or inspections.

AI systems help ensure that waste is properly classified and disposed of according to regulations, reducing the risk of non-compliance. Improved waste classification accuracy can directly lead to better regulatory adherence.

4. **Sustainability**

The impact of the AI system on improving the environmental sustainability of the hospital's waste management practices. This includes reducing the hospital's environmental footprint by promoting proper waste segregation, recycling, and minimizing hazardous waste mishandling.

Sustainability can be measured by tracking the volume of waste diverted from landfills (recycled), the reduction in hazardous waste mishandling, and the overall carbon footprint associated with waste disposal. The application of AI for better waste classification supports more effective recycling and proper disposal, which contributes to the hospital's sustainability goals and reduces its environmental impact.

Impact of AI Image Detection on Dependent Variables

Dependent Variable	Effect of AI Image Detection	Example in Asiri Hospital
Waste Segregation Efficiency	AI ensures correct disposal of biomedical, general, and recyclable waste.	The system identifies a plastic syringe in the general waste bin and alerts staff.
AI Detection Accuracy	More training data improves AI's ability to classify waste correctly.	AI correctly classifies 95% of waste images collected from different hospital departments.
Error Rate	Reduces the risk of misclassification of hospital waste.	AI mistakenly classifies a used mask as recyclable, prompting a need for retraining.
Compliance with Regulations	AI detects non-compliant waste disposal and provides real-time alerts.	AI flags improper disposal of hazardous waste in a general waste bin and informs hospital management.
Operational Costs	AI minimizes labor-intensive waste segregation, reducing costs.	The hospital reduces the need for manual sorting staff, saving resource

Table 1 - Impact of AI Image Detection on Dependent Variables

3.9. Data Collection Method

The primary data collection method for the application of AI image detection in hospital waste management at Asiri Hospital Private Limited is the use of structured questionnaire surveys. This method was chosen to gather quantifiable, consistent, and large-scale feedback from key stakeholders, including medical staff, waste management personnel, and administrative staff. The questionnaires are designed with closed-ended questions using Likert scales and multiple-choice formats to assess variables such as user satisfaction, system usability, accuracy of waste classification, and impact on workflow efficiency.

This method supports the research's mono-quantitative approach by enabling statistical analysis and comparison across different departments and user groups. Additionally, the structured format ensures that data collection is efficient and minimally disruptive to hospital operations. It also allows for easy aggregation and interpretation of results, helping researchers draw meaningful conclusions about the system's performance and acceptance. The chosen method aligns with the

overall research objective of evaluating the operational effectiveness of the AI system through measurable, objective feedback from those directly interacting with the technology.

The data collection tool of Questioners will be used, which is a well-known, easy, and very effective survey method of gathering information from a big variety of respondents. The survey should be expected to collect the quantitative information of healthcare professionals who work at Asiri hospital in Kandy, Sri Lanka and who are going in charge of Application of AI Image Detection for Hospital Waste Management in Asiri Hospital Private Limited. For the survey, we will use the Likert scale which is a popular scale used in the studies for measuring the level of agreement or disagreement of the participants concerning their research goals. The Likert scale has a variety of response choices namely, "Strongly Agree", "Agree", "Neutral", "Disagree" and "Strongly Disagree". The respondents should choose the response that closely matches their opinions on different elements of the use of Application of AI Image Detection for Hospital Waste Management in Asiri Hospital Private Limited

A questionnaire is going to be designed very carefully to make absolutely sure that it is easy to understand, relevant, and comprehensive. It will consist of elements that are carefully nurtured to meet the research goals and sub-goals. The survey may also collect demographic questions to get the information on the participants' roles, how many years of experience they have, and their department affiliation.

This information help contextualize for data analysis and interpretation. With online survey format and the Likert scale rating system, the study intends to get needed data in a timely and convenient fashion, commonly with only a limited number of questions, and receive rich quantitative data needed for analysis. This way of analysis will bolster analytical work and make closer to each effect of AI Image Detection for Hospital Waste Management in Asiri Hospital Private Limited.

Justification for not selecting other data collection methods

Other data collection methods such as focus groups, direct observation, and document analysis were not selected for the study on the application of AI image detection for hospital waste management at Asiri Hospital Private Limited due to their limitations in effectively supporting the research objectives. Focus groups, while useful for gathering diverse opinions, were avoided due to the potential for biased discussions, dominance of certain participants, and difficulty in quantifying results, which is essential in this study’s quantitative-focused approach. Direct observation, though valuable for capturing real-time behavior, was considered impractical in a hospital setting where waste handling involves health and safety risks, and continuous observation could disrupt clinical workflows. Additionally, observation lacks the depth of structured feedback

necessary to assess user satisfaction and system usability. Document analysis, such as reviewing existing hospital waste records or policy documents, was not prioritized as it does not provide real-time or user-specific insights related to the AI system's performance. Instead, questionnaire surveys were selected as the primary data collection method because they allow for standardized, scalable, and quantifiable feedback across a broad sample of staff, aligning well with the research's mono-quantitative design and the need for data-driven evaluation.

The method of data collection that was considered for the research on the influence Application of AI Image Detection for Hospital Waste Management in Asiri Hospital Private Limited within the Sri Lankan health sector was not selected without paying attention to different aspects including the nature of the research objectives, the characteristics of the study population as well as the ethical issues involved. There are alternative data collection techniques, however, several reasons justify underlying the use of a survey technique via Google Forms as the most suitable method to conduct the research.

Qualitative data collection methods like interviews or focus groups were not a suitable choice for these research due to the large and consist of a lot of the members' data information. The high degree of intricacy and diversity of the topic to be investigated enables a survey method to gather information quickly from a wide range of individuals at the Asiri Hospital in Kandy, Sri Lanka. This approach in the research will result in capturing different angles and views that will provide the researcher with a broad and profound understanding of the topic under investigation. In this regard, information-collection strategies that can be quantified like the observational studies or experimental models were rejected due to practical factors and ethical considerations. The observational studies demand allocation of a huge resource consisting of time and workforce to observe and record data in real time condition, which may not be possible because of the nature of the healthcare setting.

3.9.1. Data Collection and Analyze Tools

Application of AI image detection in hospital waste management at Asiri Hospital Private Limited, Google Forms was used as the primary platform for administering the structured questionnaire. This digital tool was selected for its ease of use, accessibility, and ability to efficiently collect and organize responses from a large number of participants across different hospital departments. Google Forms enabled the researchers to create a clean, user-friendly interface with various question types such as Likert scales, multiple-choice, and short-answer fields, aligning perfectly

with the study's mono-quantitative research design. It also facilitated quick distribution via email and internal communication channels, minimizing disruption to hospital workflows.

Real-time data collection and automatic response aggregation helped streamline the analysis process, allowing researchers to download data in formats compatible with statistical tools like Excel or SPSS. Moreover, the anonymity feature of Google Forms encouraged honest and unbiased feedback from participants, enhancing the reliability of the results. Overall, the use of Google Forms supported efficient, secure, and scalable data collection for evaluating the effectiveness and user acceptance of the AI waste detection system.

Google Forms can easily bring about the required data by using the Likert scale question, where participants are required to rank their response in a Likert scale or numeric scale form. To begin with, Google Forms, which is equipped with a user-friendly and intuitive interface, allows to create and disseminate surveys to a broad audience, including the hospital staff (medical professionals), patients, administrators and policy-makers in Asiri Hospital in Sri Lanka Using online survey tools allows researchers to make their surveys available across different devices and operating systems which helps participants respond to the survey at their own convenience (consequently participants will be able to increase the response rates which leads to a better representativeness of sampled population).

Not only does Google forms present an array of customization features whereby researchers can craft questions with Likert scale options such as agree, agree fairly, disagree and strongly disagree, but the forms also come with predefined emerging categories, classifications and structured choices for the analysts to choose. This flexibility enables researchers to capture detailed feedback along with the attitudes, perceptions, and preferences of hospital staff and stakeholders regarding the use of AI-based image detection in waste management systems. Additionally, tools like Google Forms offer built-in features for real-time visualization and analysis of survey data, simplifying the interpretation of responses and helping to identify key trends and patterns across different respondent groups. In summary, Google Forms serves as a versatile and efficient platform for collecting quantitative data, especially through Likert scale surveys, allowing researchers to understand how AI technologies are currently perceived and applied in the waste handling processes at Asiri Hospital Kandy.

3.10. Sampling framework

3.10.1 Population

We have decided to use the population of 120 individuals from the research place which is the Sri Lankan health care industry and in this case of study they are the Asiri Hospitals located at Kandy. On this side, these groups include medical professionals, patients, administrators, and policymakers, who all play an important role in Application of AI Image Detection for Hospital Waste Management in Asiri Hospital Private. Rather than the general people, selecting individuals from the research subject will result in the population which is specifically representative of the given context of the study. Thus, the study findings will be more relevant, authentic, and applicable to Sri Lankan health care industry. For one, the sampling population is made up of individuals who are diverse and representative of different standpoints, extent of experiences, and roles in healthcare. The population heterogeneity will result in research outcomes rich and inclusive, as showed by the varied points of view and concerns related to Application of AI Image Detection for Hospital Waste Management in Asiri Hospital Private Limited.

3.10.2. Sample Size

The research samples of 132 persons selected from Asiri Hospital in Kandy, Sri Lanka, is collected through stratified random sampling which ensures the representativeness and generalizability of the study results. The random sampling technique consists of the possibility of everyone in the population having the same likelihood of being involved in the sample, avoiding bias and increasing the probability of reaching a sample that resembles the characteristics of the general population. The sample size of 132 is determined using Morgan's table, which takes into account the population size of 200 individuals. According to Morgan's table, for a population size of 200, an adequate sample number for a 5% margin of error and a 95% confidence level is 132 people. This sample size ensures that the study has sufficient statistical power to detect meaningful differences and draw reliable conclusions about the influence of Application of AI Image Detection for Hospital Waste Management in Asiri Hospital Private Limited. The implementation of stratified random sampling in Asiri hospital can take place through the adoption of a systematic approach to select one or several samples from the hospital population. First of all a list of eligible staff members within the hospital which consists of the healthcare professionals, patients, administrators and the policy makers is generated.

Subsequently, the following sampling techniques can be utilized, simple random sampling or stratified random sampling, in order to randomly select the randomly selected participants from

this list of individuals, to ensure that all individuals have equal opportunity to become a part of the sample. The research implements a random sampling strategy to see that the selected sample size is representative of the community in question which is made up of individuals in different labor roles as well as occupational health professionals in the healthcare branches in Kandy, Sri Lanka. This method not only improves the study's reliability but also makes its findings more generalizable, allowing researchers to draw correct conclusions and recommend informed policies on the use of Application of AI Image Detection for Hospital Waste Management in Asiri Hospital Private Limited.

Department	Position	Population	Sample Size
Medical	Doctors	60	40
	Medical Equipment operators	20	13
	Nurse	40	27
	Patients	40	27
Administration	Hospital Administrators	20	13
IT department	IT specialist,	15	10
	Analysis	7	5
Other	policymakers	25	16
Total		***200***	***132***

Table 2 - Sample Size

Operationalization

Application of AI Image Detection for Hospital Waste Management in Asiri Hospital Private Limited.

Variable	**Indicators**	**Literature Review**	**Measurement (Likert Scale)**
Waste classification accuracy (percentage of correctly identified waste items).	Waste classification accuracy	Chowdhury, M.E.H., Rahman, T., Islam, M.R. and Khandakar, A., 2020.	**(1-5 Liker Scale)** 1 – Strongly disagree 2- Disagree 3 – Moderate 4 – Agree 5 – Strongly agree
	staff compliance rate	**Pittet et al. (2000)**,	
.	Consistency Across Shifts or Departments	Alsubaie et al. (2013)	
Reduction in waste misclassification incidents.	Total Volume of Waste Reduced	Smith, 2020	**(1-5 Liker Scale)** 1 – Strongly disagree 2- Disagree 3 – Moderate 4 – Agree 5 – Strongly agree
	Reduction in Misclassified Waste	Jones et al., 2019	
	Waste Sent to Landfill	Global Waste Index, 2021	

	Percentage of Recycled Materials	European Environment Agency, 2020	
	Cost Savings from Waste Management	Carter and Thomas, 2018	
Time taken for waste sorting and disposal	Average Time per Waste Item for Sorting	Brown and Green, 2021	**(1-5 Liker Scale)** 1 – Strongly disagree 2- Disagree 3 – Moderate 4 – Agree 5 – Strongly agree
	Total Time to Sort Waste per Shift	Smith et al., 2020	
Staff compliance rate with waste disposal protocols.	Percentage of Correctly Segregated Waste Items	Johnson, R. and Lee, S. (2019).	**(1-5 Liker Scale)** 1 – Strongly disagree 2- Disagree 3 – Moderate 4 – Agree 5 – Strongly agree
	Compliance Rate by Department/Unit	Nguyen, H. and Turner, G. (2020).	
	Number of Waste Sorting Errors Per Shift	Davis, F., Rogers, A. and Taylor, M. (2021).	

Table 3 - Operationalization

3.11.Reliability validity and Generalizability

Especially in research it is very vital to make sure the findings are as well reliable, valid and generalizable for the study to maintain its' a strong and credible nature. The reliability refers to whether an outcome of the experiment or a piece of data could be reproduced and this should be the same across the conditions, for example, different moments or environments, or even people from different communities (Nikolopoulou, 2023). It is significant to make sure that the way the

data is collected, for instance, through questionnaires, causes the same group of respondents to answer consistently under the similar environment. Employing approaches like pilot testing enable improved trustworthiness.

The concept of validity refers to the accuracy and appropriateness of the measurement tools in fully capturing the intended constructs or factors (Hassan, 2024). In this research, it is essential to evaluate whether the survey questions are scientifically aligned with all key aspects under investigation specifically the implementation of AI image detection in hospital waste management, staff awareness, operational efficiency, environmental impact, and safety compliance. Content validity can be ensured by involving a panel of subject matter experts who review the questionnaire to assess whether the questions are structured properly and reflect the core research objectives. Additionally, factor analysis may be applied to verify construct validity, confirming that the survey items effectively represent the theoretical framework and measure the intended dimensions related to AI adoption in waste management at Asiri Hospital Kandy.

By generalizability, it is meant the extent to which the results of your research can be utilised or extended spatially, beyond the sampling area of the study population (Nikolopoulou, 2023). In your, you target the ASIRI hospital situated in Kandy, Sri Lanka to execute on your research. In order to increase the generalization capacity of your results, you can carry out sampling types that secure the representativeness of the phase of healthcare professionals for those settings. Moreover, a methodological explanation of your research procedure, sampling arrangements, as well as your competitors will help to evaluate the suitability of the results by other researchers.

In order to have good reliability, validity, and generalizability in this research take strict considerations in design, data collection and reporting process carefully, and openly during all stages of the study. Through exposing of the various facets, it will reinforce your work's reliability and offer you the possibility to make valuable contributions in the healthcare analytics and management.

3.12. Roll of the researcher

In an attempt to evaluate the impact of Application of AI Image Detection for Hospital Waste Management in Asiri Hospital Private Limited the researcher is central to the success of the undertaking. The integrity, impartiality and ethics of the study are dependent on the researcher. The researcher is the principal creator and the effective implementer of the research process and, at the same time, an efficient overseer of all stages, from idea inception to knowledge sharing.

The researcher as an objective inquirer, who is sincere, unbiased and depends on conducting the research with honesty and safeguarding of rigor. Researchers should always be impartial in research work that they do they should remain objective without being influenced by other people's ideas or their own prejudices. The principles of objectivity and impartiality are observed, which are the basic conditions for the reliability of the research outcomes in the assurance of which the study results are free from undue influence or distortion. The researcher resembles a microscopic and a strategist who is very cautious while putting together the plan to sample effectively and collect data as accurately as possible. Adopting random sampling methods, administering different instruments such as the Google Forms are conducting the survey, the researcher has aiming to capture a broad perspective of the diversified perspectives and experience of the stakeholders at the asiri Hospital in Kandy. This inclusive approach not only adds up to the validity of the research findings, but also contributes to a more deep comprehension of the complex intricacies revolving around the Application of AI Image Detection for Hospital Waste Management in Asiri Hospital Private Limited.

The researcher plays the role of the ethical speciality and confidentiality deviser as well as the data gatherer. Ensuring informed consent is given, study participant privacy is protected and appropriate guidelines are adhered to, the researcher protects participants' rights and dignity. Furthermore, the author exemplifies the attitude to transparency and accountability by clearly saying how he reached certain conclusions in the study to all stakeholders including the health professionals, patients, administrators, and policymakers. To put it simply, the mission of the researcher in the above study is multifaceted, involving the role of an unbiased investigator, an attentive planner, an ethical custodian, and a transparent communicative. These roles must be executed with honesty and dedication to ensure that the research outcomes are legitimate and competitive and that they also efficiently contribute to the discourse on the significant issues of Application of AI Image Detection for Hospital Waste Management in Asiri Hospital Private Limited .

3.13. Ethical considerations

The implementation of AI image detection for hospital waste management at Asiri Hospital Kandy requires a thorough evaluation of several ethical considerations to ensure the technology is used responsibly. One of the foremost concerns is maintaining data privacy and confidentiality, particularly when handling images or videos that might inadvertently capture patient-related visuals or other sensitive information. Compliance with privacy regulations is essential to avoid

ethical breaches. Furthermore, obtaining informed consent from all staff involved in the waste handling process is crucial. These individuals should be fully aware of the AI system's functionality, purpose, and the manner in which it monitors and classifies waste, ensuring transparency and ethical integrity throughout the system's deployment.

Additionally, it is important to address potential biases in the AI system by ensuring that training data is diverse and representative of various waste categories to prevent unfair misclassification. The hospital must also ensure accountability in cases of AI errors in waste sorting, ensuring that human oversight is in place to correct any misclassifications and that responsibility is clearly defined. Ethical concerns related to employment must be addressed, ensuring that AI does not replace jobs but instead supports staff by improving efficiency and providing opportunities for skill development.
Furthermore, the environmental impact of the AI system itself should be considered, ensuring that it operates in an energy-efficient manner and does not contribute to electronic waste. Transparency and explainability are key, as the decision-making process of the AI system should be understandable to staff, allowing them to intervene when necessary. Lastly, continuous monitoring and evaluation of the system's performance are necessary to ensure that the AI system remains ethically sound and aligned with hospital policies and legal requirements. By addressing these ethical considerations, Asiri Hospital can implement AI technology in a responsible and effective manner, promoting efficiency while safeguarding privacy, fairness, and environmental sustainability.

SECTION 4 – PARCTICABILITY & IDENTIFICATION OF CONSTRAINS

4.1. Practicability

The practicability of applying AI image detection for hospital waste management at Asiri Hospital Private Limited is highly promising, yet requires careful planning and resource allocation. The hospital must ensure that the necessary infrastructure, including high-quality cameras, sensors, and computational resources, is in place to support the AI system's operation. The integration of AI technology into existing waste management processes must be seamless, with minimal disruption to daily operations.

Training staff to effectively use and maintain the AI system is crucial, as is providing ongoing support to troubleshoot any technical challenges that may arise. Moreover, the system must be scalable to accommodate the volume of waste generated in a hospital environment, with the ability

to process and classify various types of waste accurately and in real time. The AI solution must also be adaptable to different hospital settings and waste management protocols, ensuring it works across diverse departments with varying waste types.

Cost considerations are another important aspect, as implementing AI image detection requires an initial investment in technology and ongoing maintenance, which must be balanced with potential savings from improved waste sorting and disposal efficiency. Additionally, the system must comply with relevant health and safety regulations, ensuring that it does not compromise the safety of staff or patients. Overall, while the adoption of AI in hospital waste management is highly feasible, its successful implementation depends on strategic planning, proper resource allocation, and addressing potential operational and financial challenges.

The clearly practical approach of the study is enabled by the use of Google Forms as the tool for data collection because it offers an accessible and user-friendly option for survey administration. Google Forms will help to get the surveys created and disseminated to the participants within Asiri Hospital Kandy was chosen for this study due to its accessibility and relevance as a leading healthcare facility in Sri Lanka. Using a survey strategy via Google Forms offers a user-friendly interface and cross-platform compatibility, allowing participants such as hospital staff and waste management personnel to respond at their convenience. This flexibility helps improve response rates and ensures a more representative sample. The platform enables quick and cost-effective collection of qualitative and quantitative data, which is ideal given the typical resource and logistical constraints associated with research. By employing structured questionnaires using Likert scale responses, researchers can capture detailed insights into staff perceptions, experiences, and attitudes regarding the use of AI image detection for waste management. This approach simplifies the data collection process, minimizing the burden on both participants and the research team.

While the questionnaire approach using Google Forms is more manageable than the other options in terms of data management and analysis, it still takes a good time to analyse the gathered information. This platform has in-built tools for real-time visualization and analysis of survey results enabling researchers to measure both response rates and track any patterns and trends and create actionable insights. This unified method of data handling and processing, on the other hand, increases data analysis efficiency and accuracy of the research process, thus allowing the researchers to extract valuable conclusions and suggestions from the data. The use of survey approach proves cooperation and communication to be the most crucial factor for researchers,

participants and stakeholders involved in the whole research process. The platform provides for sharing links for surveys in a smooth fashion, joint work on survey design and implementation, as well as providing the research findings to the appropriate audience. This collaborative facet helps to realistically shape the research by promoting transparency, accountability, and commitment from all parties, which then improves the research results' relevance and applicability in providing the basis for health practices and policies in Sri Lanka.

The Google Forms approach adopted for survey purposes exhibits tremendous practicality in various aspects including the administration of surveys, the efficiency of data collection, data management, analysis, and collaboration among stakeholders. By using these tangible advantages, the researchers can comprehensively examine how Application of AI Image Detection for Hospital Waste Management affect in Asiri Hospital Private Limited.

4.2. Identification of constraints

The implementation of AI image detection for hospital waste management at Asiri Hospital Private Limited faces several key constraints that must be addressed to ensure success. First, infrastructure limitations including the availability and placement of high-resolution cameras, reliable network connectivity, and sufficient edge-computing capacity can impact the system’s ability to capture and process images in real time. Second, data constraints such as the need for large, diverse, and accurately labeled training datasets may delay model development and reduce classification accuracy if insufficient or biased data are available.

Third, budgetary constraints encompass both the upfront investment in hardware, software, and staff training, as well as ongoing maintenance and update costs, which must be balanced against expected efficiency gains. Fourth, integration constraints the challenge of seamlessly embedding the AI solution into existing waste management workflows, IT systems, and regulatory reporting processes can create operational friction and require tailored software interfaces. Fifth, regulatory and compliance constraints demand that the system comply with healthcare privacy regulations and environmental waste-disposal standards, potentially limiting camera placement or data retention practices.

Sixth, human factors constraints, including staff resistance to new technology, learning curves, and the need for continuous training and support, may hinder user adoption and consistent use. Finally, technical constraints such as varying lighting conditions in disposal areas, occlusion of waste items, and the potential for algorithmic errors pose ongoing challenges that require robust model retraining and human-in-the-loop oversight to mitigate. Addressing these constraints

through careful planning, stakeholder engagement, and iterative refinement will be critical to the effective deployment of AI-driven waste management at Asiri Hospital.

GANT CHART

GANT CHART

Task	Month 1	Month 2	Month 3	Month 4
Literature review				
Data collection				
Model development				
Testing and deployment				
Analyzing and report writing				
Final review				

Figure 3 gant chart

CONCLUSION

The implementation of AI image detection for hospital waste management at Asiri Hospital Private Limited represents a significant advancement in ensuring safe, efficient, and compliant disposal of medical waste. With the increasing amount of medical waste generated worldwide, the use of AI can help healthcare systems to streamline their waste management processes, reduce costs, and improve sustainability. By leveraging deep learning–based computer vision to accurately classify waste in real time, the system reduces human error, enhances staff adherence to segregation protocols, and optimizes operational workflows.

AI technologies such as image detection can significantly enhance hospital waste management processes by improving the accuracy of waste classification, optimizing segregation, and minimizing the risk of hazardous disposal errors. At Asiri Hospital in Kandy, the implementation of AI image detection systems presents an opportunity to streamline waste handling, boost recycling efforts, and reduce environmental impact. Nevertheless, challenges such as data privacy, system integration, and the need for staff training must be carefully addressed. Additionally, the success of AI deployment depends on the hospital's readiness in terms of infrastructure and its ability to manage change among personnel. Despite these barriers, the potential advantages such as increased operational efficiency and improved compliance with healthcare waste regulations make the adoption of AI-driven waste management solutions both relevant and necessary. With

thoughtful planning, ongoing training, and continual system optimization, these challenges can be effectively managed.

By implementing the recommendations discussed in this study, healthcare systems can overcome the challenges and risks associated with AI implementation and leverage the full potential of AI to improve waste management practices, reduce costs, and increase sustainability. As such, AI represents an exciting opportunity for the healthcare industry to transform the way we manage clinical waste and move towards a more sustainable future.

Ethically grounded and pragmatically designed, the AI solution not only supports Asiri Hospital's environmental sustainability goals and regulatory obligations but also lays the groundwork for scalable, data-driven waste management practices that can be extended to other healthcare facilities. Ultimately, this initiative underscores the transformative potential of AI in fostering safer, greener, and more cost-effective hospital operations.

References

1. Abdullah, A., & Abdullah, S. (2021). AI-based Image Classification in Waste Segregation: A Study in Healthcare Waste Management. Journal of Environmental Health, 83(4), 112-119.
2. AI for Healthcare (https://www.aihealthcare.com)
3. Cheng, Y., & Li, Q. (2018). Machine Learning and AI for Environmental Health and Waste Management. Elsevier.
4. Hussain, Z., & Khan, M. (2020). *Implementing AI for Waste Management in Healthcare Facilities: A Case Study of Hospital Waste*. Journal of Sustainable Healthcare Practices, 15(3), 42-49.
5. Jiang, Y., & Yang, M. (2020). Artificial Intelligence in Healthcare: The Revolutionizing Role of AI in Medical Diagnostics and Waste Management. Springer.
6. Lee, Y., & Lee, S. (2022). AI and IoT Integration for Smart Waste Management in Healthcare Systems. International Journal of AI & Data Science, 19(2), 73-89.
7. Rajendran, S., & Suresh, S. (2019). AI in Waste Management: A Healthcare Perspective. Wiley-IEEE Press.
8. Singh, R., & Sharma, S. (2019). AI Technologies for Efficient Waste Segregation in Hospitals. Proceedings of the International Symposium on Environmental Engineering and Waste Management, 85-93.

9. Sri Lanka Ministry of Health (2017). Guidelines for Waste Management in Healthcare Facilities in Sri Lanka.
10. Jiang, Y., & Yang, M. (2020). Artificial Intelligence in Healthcare: The Revolutionizing Role of AI in Medical Diagnostics and Waste Management. Springer.
11. Rajendran, S., & Suresh, S. (2019). AI in Waste Management: A Healthcare Perspective. Wiley-IEEE Press.
12. Cheng, Y., & Li, Q. (2018). Machine Learning and AI for Environmental Health and Waste Management. Elsevier.
13. Hernandez, F., & Wang, L. (2021). AI in Healthcare Waste Management: Real-Time Image Classification for Hazardous Waste Identification. Proceedings of the International Conference on AI in Healthcare, 102-108.
14. Singh, R., & Sharma, S. (2019). AI Technologies for Efficient Waste Segregation in Hospitals. Proceedings of the International Symposium on Environmental Engineering and Waste Management, 85-93.
15. World Health Organization (WHO) (2018). Health Care Waste Management: A Handbook for Healthcare Providers.
16. Sri Lanka Ministry of Health (2017). Guidelines for Waste Management in Healthcare Facilities in Sri Lanka.
17. Waste Management World (https://www.waste-management-world.com)
18. IBM Watson Health (https://www.ibm.com/watson-health)
19. al., K. e., 2022. *IoT Integration:*. [Online]
20. al., L. e., 2019. *Predictive Analytics.* [Online]
    [Accessed 28 04 2025].
21. al., P. e., 2022. ai in healthcare management. [Online]
    [Accessed 03 05 2025].
22. al, Z. e., 2020. *ai sorting.* [Online]
    Available at:
    https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=%E2%80%A2%09Hazardous+Waste+Management%3A+In+healthcare%2C+where+proper+disposal+of+hazardous+medical+waste+is+critical%2C+AI+can+detect+and+handle+infectious+or+dangerous+materials+using+sensors
    [Accessed 24 04 2025].
23. BLOG, B., 2023. *AI in waste management.* [Online]
    Available at: https://bvmglobal.org/blog/AI-to-solve-waste-problem

24. Gupta & Sharma, 2021. *Hazardous Waste Management:*. [Online]
Available at: https://scholar.google.com/scholar?hl=
[Accessed 24 04 2025].

25. Hillier, W., 2024. *CareerFoundry.* [Online]
Available at: https://careerfoundry.com/en/blog/data-analytics/data-analytics-tools/#microsoft-excel

26. Learn, S., 2023. *Simplilearn.com.*. [Online]
Available at: https://www.simplilearn.com/what-is-data-collection-article
[Accessed 24 04 2025].

27. Thompson, W. &., 2023. *future direction.* [Online]
[Accessed 02 04 2025].

28. Alamgeer, Z., 2023. *theinnovidea.* [Online]
Available at: https://theinnovidea.com/time-horizon-in-research-onion/

29. Ben-Assuli, A, Z., D, S. & A, I., 2016. Cost-effectiveness evaluation of EHR: Simulation of an abdominal aorticaneurysm in the emergency department.

30. Bethencourt, J., Sahai, A. & Waters, B., 2007. Ciphertext-policy attribute-based encryption. *IEEE Symposium on Security and Privacy.*

31. Govindaraj, R., 2014. HEALTH CARE IN SRI LANKA. *What Can the Private Health Sector Offer?.*

32. Gupta, R., P, K. & N, D., 2019. *Sharing Organizational Data Outside Its Domain Using ABE in Cloud Environment.*. Singapore, International Conference on Advanced Computing Networking and Informatics 2019.

33. Nikolopoulou, K., 2023. *scribbr.* [Online]
Available at: https://www.scribbr.com/research-bias/generalizability/ [