



مجلة جامعة صحر
للأعمال المستدامة
Sohar University Journal
of Sustainable Business



جامعة صحر
Sohar University

e-ISSN: 3007-5572 | Volume 1, Issue 1 January 2025

مجلة جامعة صحر للأعمال المستدامة
Sohar University Journal of Sustainable Business
(SUJSB)



Vice Chancellor

Dr. Hamdan Sulaiman Al Fazari

VC Foreword

By the grace of Almighty Allah, with great delight we are pleased to announce the issue of Sohar University Journal of Sustainable Business (SUJSB). This is in par with a momentous occasion that befalls our 53rd National Day - a day of great pride. The establishment of this journal came in perfect coincidence with Oman Vision 2040, which has emphasized research and innovation development, connecting higher education and research with the labor market, using an approach of knowledge economy to enable full intellectual, technological, and economic capabilities, cultivating creative individuals who are proud of their identity and enjoy sustainable prosperity.

Sohar University Journal of Sustainable Business represents the first-ever journal to be published from the faculty of business at the University. In full commitment and adherence to the United Nations SDGs, this journal shall, therefore, focus on publishing various studies that will encompass sustainability into business and management practices.

It has been a long-standing strategic goal of establishing peer reviewed academic journals at Sohar University. This will be an important step toward making our institution more competitive in worldwide university rankings, particularly in respect to its contributions to highly impactful research. To achieve this goal, the university has invested significant resources and has cooperated with active working groups that are committed and dedicated. This academic achievement will enable Sohar University to be ranked among the leading Omani public and private universities, as well as being listed among pioneering Arab and global institutions.

At the time of planning this journal, and subsequent publications, the university planned for the journal and subsequent publications to be of international quality and indexed in reputable international databases. As a driver of quality and scientifically valid, it aspires to place itself in the Omani research landscape. It aims to be a role model of the quality and evidence-based research in the Omani research scene. It is to create a well-supported research environment to promote research excellence and knowledge transfer.

This ambitious vision is rooted in the continued support of the Ministry of Higher Education, Research and Innovation, on the committed academic faculty, and on an esteemed editorial board of international repute - composed of well-known international scholars from various disciplines. Our extensive highly qualified administrative and technical staff is committed to delivering this project with the greatest professionalism.

We pray for success in this academic endeavor and for this new venture in research and publishing too. We invite all researchers from and outside of Oman to share in this journal and help build its reputation. May Allah grant us success.

Editorial Team

Editor-in-Chief

Dr. Khalid Al. Qatiti

Managing Editors

Prof. Dr. Nur Naha Abu Mansor

Assoc. Prof. Dr. Mumtaz Ali Memon

Secretary

Ms. Iman Sulaiman Al. Maktoumi

Members of Editorial Board

Assoc. Prof. Dr. Imran Hameed

Assoc. Prof. Dr. Usama Al Mulali

Dr. Jeremy Philip Brown

Dr. Syed Aqib Jalil

Dr. Abdulrazak Al-Mashhadani

International Advisory Board

Prof. Dr. Carol Hooi, Ritsumeikan Asia Pacific University, Japan

Prof. Dr. Aini Aman, Universiti Kebangsaan Malaysia, Malaysia

Prof. Dr. Khurram Shahzad, Riphah International University, Pakistan

Prof. Dr. Riyad Eid, United Arab Emirates University, UAE

Prof. Dr. Dheeraj Sharma, IIM University, India

Assoc. Prof. Dr. Nuttawuth Muenjohn, University of Bradford, UK

Assoc. Prof. Dr. Abdul Karim Khan, United Arab Emirates University, UAE

Assoc. Prof. Dr. Jun-Hwa Cheah, University of East Anglia, UK

1. Journal Vision

To be a global platform connecting academia and business to drive sustainable business practices.

2. Journal Mission

Sohar University Journal of Sustainable Business fosters collaboration between scholars and practitioners to address real-world business challenges through rigorous research and diverse perspectives, enriching both academic knowledge and practical solutions.

3. Journal Objectives

Sohar University Journal of Sustainable Business aims to become a central forum for academics, researchers, and business professionals. It intends to bridge the gap between scholarly research and the practical aspects of sustainable business, fostering an exchange that enriches both the academic world and the business community.

4. Publication Themes/Focus Areas

With a strong commitment to the United Nations' Sustainable Development Goals (SDGs), SUJSB publishes research that integrates sustainability into business and management practices. This ensures that the content published in SUJSB contributes effectively to the global effort for sustainable development.

1. *Sustainable Strategic Management (SDG-8, SDG-12)*: Insights into sustainable corporate strategies, competitive analysis, and strategic planning for environmental and social responsibility.
2. *Sustainable HRM & Organizational Behavior (SDG-5, SDG-8)*: Research on integrating sustainability into human resource management and organizational behavior, promoting sustainable culture and practices within organizations.

3. *Green Marketing and Sustainable Consumer Behavior (SDG-12, SDG-13)*: Findings on the impact of sustainability in marketing and consumer responses to sustainable products.
4. *Finance and Accounting for Sustainability (SDG-17, SDG-13)*: Articles exploring green finance, ethical investing, and sustainability reporting.
5. *Sustainable MIS (SDG-9, SDG-12)*: Papers on sustainable data analytics and the impact of technology on eco-friendly business decisions.
6. *Sustainable Operations and Supply Chain Management (SDG-12, SDG-13)*: Research on optimizing operations and supply chains for minimal environmental impact and enhanced equity.
7. *Entrepreneurship and Innovation for Sustainability (SDG-11, SDG-9)*: Articles on green startups and sustainable business models.
8. *Ethics and Governance in Sustainable Business (SDG-16, SDG-17)*: Work on sustainable corporate governance and ethics, including ethical decision-making and stakeholder engagement.
9. *Business Technology for Sustainability (SDG-7, SDG-9)*: Analyses of how emerging technologies can address sustainability challenges and enhance business value.
10. *Regional Sustainability Case Studies (SDG-11, SDG-17)*: Case studies from Oman and the Gulf region, providing regional insights into global sustainability discussions.
11. *Sustainable Economics (SDG-8, SDG-10)*: Research on economic policies and practices that promote sustainable development, inclusive growth, and equitable economic systems.

5. Publication/Editorial Policies & Procedures

Peer Review Process

SUJSB adheres to rigorous procedures for evaluating the manuscripts it receives. Central to this process is the implementation of a double-blind peer review for every research publication. In this review system, both reviewers and authors remain anonymized to ensure impartiality and fairness, preventing any bias stemming from recognition or personal connections.

Once feedback is received from at least two reviewers, the managing editor notifies the authors, prompting them to make the necessary revisions. The Editorial Team then

evaluates how well the authors have incorporated the feedback into the revised manuscripts. If the revisions are deemed unsatisfactory, the authors are asked to make further changes and resubmit their work until all reviewers are satisfied. The Editor-in-Chief makes the final decision.

Publication Process

The time from manuscript submission to acceptance for publication in SUJSB typically ranges from 8 to 12 weeks. However, this timeframe can vary based on factors such as the author's responsiveness, reviewer availability, and the number of review rounds required. Accepted papers usually undergo an average of two revisions. Authors are notified when the digital versions of their approved papers are published on the journal's website. Each edition of SUJSB is initially released online and is freely accessible to all.

Publication Ethics (for Editors)

- The SUJSB editorial team has the authority to either accept or reject manuscripts that are submitted to the journal.
- The editors must exert their utmost efforts to uphold the integrity of the journal.
- The editing staff must give priority to integrity and timeliness in their work.
- It is the editors' responsibility to guarantee that papers are assigned to trustworthy reviewers who possess the relevant expertise and who will provide prompt assessment of manuscripts.
- The editors are to check for any potential conflicts of interest between authors and reviewers and guarantee that the review process is fair.
- Evaluations will be conducted entirely on the manuscript's content, regardless of the authors' background, ethnicity, religion, politics, socio-economic status, or institutional affiliations.
- The editors are required to reveal any possible conflicts of interest pertaining to manuscripts submitted to the SUJSB.
- All information and communication regarding submitted manuscripts will be treated as confidential and will only be disclosed to authors and reviewers.
- Editors are prohibited from utilizing unpublished data for personal benefit or research purposes.

- The editorial team is responsible for dealing with any misconduct in the publication process and taking appropriate action.
- The editorial team will provide regular information to authors regarding the review and publication processes.

Ethical Considerations for Reviewers

- Reviewers are responsible for aiding the editorial team in determining whether to accept or reject a submission.
- Reviewers who are unable to review the paper within the given timeframe should notify the editor immediately.
- Reviewers should refuse to assess papers that they consider unrelated to their research interests or outside the scope of their competence.
- Manuscripts submitted for review must be regarded as confidential materials and should not be shared for any reason. The Reviewers are required to report any ethical concerns to the editors.
- The Reviews should be impartial, justified – supported by evidence, and aimed at enhancing the quality of the manuscript content.
- Reviewers should promptly disclose any potential conflict of interest upon receiving a review request.

6. Guidelines for Authors

Submission Process:

- Authors must submit manuscripts electronically via the SUJSB submission portal.
- If you encounter issues with the online portal, submissions may be sent directly to sujbs@su.edu.om in MS Word format.
- Submissions must be original, unpublished, and not under consideration for publication elsewhere.

Preparation of Manuscripts:

- Manuscripts should be prepared in Microsoft Word, formatted in A4 size, with standard margins, using 12-point Times New Roman font and single line spacing.
- The total length of the manuscript should not exceed 10,000 words, including all components such as text, tables, figures, footnotes, and appendices.
- All submissions must be in English. Authors are responsible for the linguistic and grammatical quality of their submissions.
- Use a maximum of three levels of boldfaced headings for organization. The body text should be in normal font.
- All tables and figures must be numbered consecutively and include appropriate captions. High-resolution images are required, and visual aids should fit within the specified margins. Do not submit Tables and Figures separately. If any table or figure is derived from previously published resources, authors must obtain and provide proof of permission to use them in their manuscript. This ensures compliance with copyright laws and ethical publishing standards.

Manuscript Structure:

- *Title Page:* This page should include the paper's title, the names of the authors (excluding academic titles such as Dr. or Prof.), their affiliations, and email addresses. Clearly indicate the corresponding author to ensure proper communication during the review process.
- *Abstract:* Submit an abstract of no more than 200-250 words along with 4-6 keywords that accurately reflect the paper's content. The abstract should explicitly and briefly explain the purpose of the study, the design/methods used, the results obtained, and the originality (novelty/contributions) of the work.
- *Main Text:* Organize the main text with an introductory section, followed by the main body divided into sections as necessary. Conclude with a section titled "Conclusions." Use a clear and concise writing style to facilitate readability. Ensure that the main document does not contain any identifiable information about the authors or their institutions to maintain the integrity of the double-blind review process.

- *Implications for Sustainable Business Practices:* Authors are advised to include a section titled "Implications for Sustainable Practices" dedicated to explaining the implications drawn from the study's findings that help managers ensure sustainable business practices.
- *Font and Spacing:* The entire manuscript should be typed in 12-point Times New Roman font, black color, and should be single-spaced to ensure clarity and a compact presentation.
- *References:* Adhere strictly to the APA 7th edition format for all references and in-text citations. Ensure that all references cited in the text are listed at the end of the document, maintaining comprehensive and accurate citation practices.

7. Author Responsibilities and Ethical Procedures

- Authors are required to verify that the submission to SUJSB is an original piece of work.
- Authors must state any conflict of interest at the time of submitting the manuscript.
- Authors must explicitly disclose the funding agencies involved and any potential impact they may have on the research.
- Prior to carrying out any study, authors must obtain informed consent from all participants/respondents.
- Authors should ensure that no information is disclosed that infringes upon the privacy of the respondents.
- Authors should use inclusive language that respects diversity and avoids excluding any segment of society.
- The corresponding author has the duty of ensuring that all authors have reviewed and endorsed the final version of the manuscript and have given their agreement for its submission to SUJSB.
- It is anticipated that all authors who have been informed to SUJSB during the submission process have reached an agreement over the list and sequence of authors.
- The authors bear the responsibility for the content they submit to SUJSB, and all author(s) (if there are numerous) shall be held liable for any misconduct.

- Authors are required to inform the editors if they discover any substantial errors in their works.
- The manuscripts submitted to SUJSB must not be published elsewhere or be under consideration for publication in any other academic platform simultaneously.
- Publications that are based on or derived from any previously published presentation, lecture, or academic thesis can be submitted, provided that a proper recognition of prior publication in any of the aforementioned forms is included.
- It is expected that the authors will acknowledge and cite the relevant sources of information. Prior consent should be obtained, if necessary, before citing ideas or words that are not the original work of the writers.

Table of Content

S. No.	Title	Pages
1.	SUSTAINABLE HUMAN RESOURCE MANAGEMENT, JOB CRAFTING, AND EMPLOYEE EXPERIENCE: A CONCEPTUAL MODEL <i>Hira Jehanzeb</i>	1-14
2.	PSYCHOLOGICAL AND ORGANIZATIONAL RESILIENCE: KEYS TO LIFE SATISFACTION IN THE SERVICE SECTOR <i>Ayoub Sulaiman Mohammed Al Kindy</i>	15-26
3.	FACTORS IN DETERMINING INFORMATION SYSTEMS DEVELOPMENT METHODOLOGIES: A SYSTEMATIC LITERATURE REVIEW <i>Yahya Ateik Al-Sagheer Saeed , Zahidah Binti Zulkifli, Sumaia Binti Shikh Nasir and Wani Bilal Ahmed</i>	27-41
4.	AGILE METHODOLOGIES FOR PROJECT SUCCESS: EXPLORING THE ROLE OF INNOVATION AND MANAGEMENT SUPPORT <i>Waseem Haider, Noor Ahmad and Naseebullah</i>	42-56
5.	INTELLIGENT DATA SYSTEMS FOR SUSTAINABLE PREVENTION AND MANAGEMENT OF G6PD DEFICIENCY: A MARKOV CHAIN MODEL APPROACH <i>Divya Rani</i>	57-71
6.	A COMPREHENSIVE ANALYSIS OF BARRIERS TO AUGMENTED REALITY IMPLEMENTATION IN SUSTAINABLE INVENTORY MANAGEMENT <i>Zainab Asim and Syed Mohd Muneeb</i>	72-90

SUSTAINABLE HUMAN RESOURCE MANAGEMENT, JOB CRAFTING, AND EMPLOYEE EXPERIENCE: A CONCEPTUAL MODEL

Hira Jehanzeb

NUST Business School, National University of Sciences and Technology, Islamabad, Pakistan

ABSTRACT

The past decade has witnessed a surge of interest in sustainable human resource management from both academics and practitioners. However, research on the interplay between sustainable human resource management, job crafting, and employee experience remains scarce, with little to no existing studies. This study aims to bridge this gap by conceptualizing the interrelationships between these three concepts and proposing a research model. A comprehensive literature review was conducted on current research in sustainable human resource management, job crafting, and employee experience. The proposed model integrates sustainable human resource management, emphasizing its focus on long-term ecological, financial, and social gains. Job crafting is positioned as a mediating variable between sustainable human resource management (independent variable) and employee experience (dependent variable). This model offers a holistic understanding of how sustainable human resource management can facilitate employee job crafting, ultimately leading to an improved employee experience. This study contributes to the existing literature by introducing a novel model that integrates these three crucial aspects of the modern workplace, paving the way for future validation.

Keywords: Sustainable HRM, job crafting, employee experience, stakeholder theory

Paper Type: Conceptual paper

INTRODUCTION

The concept of employee experience has become a critical determinant in shaping organizational culture and promoting overall business success. Employee experience encapsulates the journey of an employee within a firm, from encountering the experiences of recruitment to departure (Batat, 2022; Yohn, 2018). It is a firm-wide initiative which emphasizes that employees are healthy, engaged, and productive (Bersin, 2021; Pillai et al., 2024). Notably, it is a people-centric management philosophy that focuses on factors that significantly influence employees' behaviors (Plaskoff, 2017). Overall, the employee experience is the sum of the

interactions an employee has with an organization, which influences their overall image of the organization.

According to a recent Withe report, a staggering 72% of candidates have reported that their decision to accept the job is dependent on the overall interview process (Withe Team, 2024). Additionally, it outlines that 60% of candidates have reported having poor experiences, while 49% have turned down job offers as a result of negative experiences. Likewise, another survey highlighted that 69% of employees are more inclined to remain with the firm for three years if they have a great onboarding experience (Click Boarding, 2021). Following the onboarding process, continuous support is pivotal, as 68% of employees would consider leaving if they did not feel supported by senior staff (PerformYard, 2024). Moreover, 50% reported that their jobs have an undesirable impact on their mental health (Agovino, 2024). These statistics present different types of experiences an employee has within an organization. Hence, it can be inferred that an overall good experience is essential for employees, as that determines the attraction and retention of top talent, makes a convincing case for having a fine onboarding system, and emphasizes fostering a strong supervisory relationship while simultaneously highlighting that a poorly designed job can have detrimental psychological impacts. Therefore, a positive employee experience is essential as it not only mitigates turnover (Click Boarding, 2021) but also enhances engagement and attracts top talent (PerformYard, 2024), making it a key focus area for any firm aiming to succeed in the current dynamic market.

The role of job crafting can be instrumental in creating a positive employee experience, as it is a self-initiated behavior that can help the employees establish boundaries and create a work environment that is more suited to their skills, abilities, and preferences (Kim & Beehr, 2018; Park & Park, 2023). Job crafting is a proactive behavior focused on effectively aligning the job with the employees' personal characteristics, as designing jobs that are tailored to the entire workforce is challenging for the managers (Lazazzara et al., 2020). Numerous researchers have argued that job crafting has positive outcomes such as meaningfulness in work, engagement with the tasks, and improved performance (Bruning and Campion, 2018; Slemp and Vella-Brodrick, 2014; Tims and Bakker, 2010; Tims et al. 2022). However, the question remains: What encourages employees to engage in proactive behaviors like job crafting?

Sustainable human resource management can serve as a key driver to foster job crafting. Sustainable human resource management is considered a broad concept, sometimes identified as the triple bottom line (Piwowar-Sulej, 2024). It further encapsulates sub-concepts such as green HRM, socially responsible HRM, and common good HRM (Piwowar-Sulej, 2024). Sustainable human resource management considers employees as a valuable resource for the organization, while carefully considering their needs, preferences, and perspectives (Sypniewska et al., 2023). Its initiatives are geared towards increasing the firm's performance by fostering long-term relationships with the workforce (Sypniewska et al., 2023). Deloitte's recent survey highlighted that, organizations focusing on the human sustainability yielded a 2.2% higher five-year return on equity, produced 50% less carbon dioxide per dollar of revenue, and were over twice as likely to provide a family sustaining living wage (Janaite, 2024).

Despite the extensive studies on sustainable human resource management, research on whether and how sustainable human resource management can influence job crafting and employee

experience remains unexplored. The purpose of this paper is to analyze contemporary research on sustainable human resource management, job crafting, and employee experience and offer a research model for future research directions. Thus, the present study contributes to the existing literature by addressing several gaps. First, this research is concerned with sustainable human resource management and its relationship to job crafting. Hence, this research proposes that sustainable human resource management has a direct impact on job crafting. Previous research has focused on sustainable human resource management and its association to career growth (Cheng et al., 2024), employee resilience (Lu et al., 2023), work engagement and perceived employability (Lulewicz-Sas et al., 2022). Little to no research has been conducted thus far to determine whether sustainable human resource management influences job crafting. Thus, this research fills this gap by conceptualizing the relationship between sustainable human resource management and job crafting.

Second, this paper is concerned with job crafting and its direct impact on employee experience. Recent literature has focused on studying job crafting in relation to detachment (Sanz-Vergel et al., 2024), applicant attraction (Schüler et al., 2023), and artificial intelligence (Li et al., 2024). There is an evident gap between job crafting and employee experience. Therefore, this paper proposes a model for future researchers to fill that gap.

Third, this paper proposes that job crafting mediates the relationship between sustainable human resource management and employee experience. Despite the literature available on sustainable human resource management (see Cheng et al., 2024; Lulewicz-Sas et al., 2022; Lu et al., 2023) and employee experience (see Malik et al., 2023; Pillai et al., 2024), studies on the mediating role of job crafting are almost absent. The majority of the available literature on employee experience is focused on conceptualizing the concept and understanding its dimensions (Batat, 2022; Panneerselvam & Balaraman, 2022; Plaskoff, 2017; Joshi et al., 2024). The present paper is among the first to conceptualize the mediating role of job crafting between sustainable human resource management and employee experience.

Lastly, this paper is grounded in the stakeholder theory. Recent studies on sustainable human resource management have emphasized on Maslow's hierarchy of needs theory and resource-based view (Huang et al., 2024), JD-R theory (Lu et al., 2023), social exchange theory (Papademetriou et al., 2023), and person-fit theory (Sypniewska et al., 2023). Previous studies on job crafting are underpinned in transactional theory of stress and coping (Cheng et al., 2023), JD-R theory (Schüler et al., 2023; Li et al., 2023), and conservation of resource theory (Harju et al., 2021). The literature available on employee experience is still in its initial stages and mostly emphasizes on conceptualizing the variable (Batat, 2022; Panneerselvam & Balaraman, 2022; Plaskoff, 2017; Joshi et al., 2024). Evidently, the recent literature is scarce in using stakeholder theory as the foundational basis. Therefore, the current study fills the gap by proposing stakeholder theory as the underlying theoretical framework.

This study is structured as follows: First, we begin with the conceptualization of sustainable human resource management, job crafting, and employee experience. Second, we develop a set of propositions and a research model that can be validated by future research scholars. Finally, we offer future recommendations.

LITERATURE REVIEW

Sustainable Human Resource Management

The research on sustainable human resource management is still in its infancy. In the past 10 years, sustainable human resource management has been a subject of interest for academics and practitioners in the field of HRM which is due to the expected advantages for both organizations and other stakeholders such as employees, consumers and the external environment (Lu et al., 2023).

The earliest description of sustainable human resource management focuses on the actions firms must undertake within their surroundings to attract highly qualified professionals in the future (Müller-Christ and Remer, 1999; Qamar et al., 2023). Later, sustainable human resource management has been defined as implementing long-term strategies which are socially responsible and economically effective in the process of recruiting, developing, retaining, and dis-employing of employees (Zaugg et al., 2001). Meanwhile, as per Gollan (2005) sustainable human resource management refers to a firm's ability to generate value and as an outcome have the capability to renew value and replenish wealth through the execution of human resource policies and practices. At the same time, Ehnert (2005) defined sustainable human resource management as "value of human resources is recognized as being more than immediate financial usefulness".

Recently, others have added to the discourse by associating the notion of sustainability to HRM. For instance, Wikhamn (2019) described sustainable human resource management as dealing with soft issues such as emphasis on the employee well-being, decent work environment, and development opportunities. Alternatively, some scholars have focused on a holistic and future oriented approach to HRM which prioritizes sustainability beyond profit maximization by focusing on the societal, environmental, and organizational dimensions (Qamar et al., 2023). However, the current conceptual paper follows the definition of Ehnert et al. (2016) - "Adoption of HRM strategies and practices that enable the achievement of financial, social, and ecological goals, with an impact inside and outside of the organization and over a long-term time horizon while controlling for unintended side effects and negative feedback" (p.90).

Job Crafting

Currently, while numerous operationalization of job crafting exist, the most prevalent approaches were proposed by Wrzesniewski and Dutton (2001) and Tims et al. (2012), namely role-based approach and resource based approach, respectively. Wrzesniewski and Dutton (2001) identified three types of job crafting. First, task crafting has been described as changes in the job tasks by altering amount, scope, or type. Second, relational crafting is explained as altering the social interactions at the workplace. Third, cognitive crafting is referred to as changing the way an individual perceives the job. In contrast, Tims et al. (2012) combined job crafting with the JD-R theory, defining four dimensions, which are (1) increasing structural job resources, (2) increasing social job resources, (3) increasing challenging job demands, and d) decreasing hindering job demands.

However, recent studies have made an attempt to integrate the two approaches and have proposed that there is a higher-order job crafting orientation, referred to as the approach and avoidance crafting (Bruning and Campion, 2018; Zhang and Parker, 2019; Tims et al., 2022). The former has been described as effortful actions through which the individuals try to gain favorable results while the latter has been explained as actions to avoid undesirable outcomes (Zhang & Parker, 2019; Tims et al., 2022). This is not to say that job crafting is about redesigning the job in its entirety but about altering certain components of the job within the parameters of the particular job tasks (Berg & Dutton, 2008; Tims et al., 2012). The present paper follows Wrzesniewski and Dutton (2001) for their definition on job crafting which has been referred to as "the physical and cognitive changes individuals make in the task or relational boundaries of their work" (p. 179).

Employee Experience

Employee experience was introduced in recent years and can be traced back to the late 2010s (Batat, 2022). Though the term employee experience was established by Abhari et al. (2008), its conceptualization was put forth by Jacob Morgan. He described it as "the combination of an organization's cultural, physical and technological environments that enables, empowers and enhances employee's overall evaluation of their workplace, about the positiveness of such workplaces" (Morgan, 2017; Panneerselvam & Balaraman, 2022, p. 202). Following Morgan's definition, other authors in the field have recently examined the concept and have offered several definitions. For instance, employee experience has been explained by Dery et al. (2018) as those work intricacies and behavioral norms about collaboration, creativity, and empowerment that have the potential to enable, empower and engage employees throughout the employment journey.

The recent definitions can be categorized into three distinct perspectives, namely, holistic, interactionism, and adjunction-based perspectives. First, the holistic aspect of employee experience has been described as how several personal and organizational factors influence the comprehensive and integrative journey of the employee's entire life experienced, impacting it positively or negatively (Batat, 2022). Additionally, both external and internal factors influence the experiences (see Itam & Ghosh, 2020; Plaskoff, 2017). Second, the aspect of interactionism has been referred to as the situations where the employees experience several kinds of interactions concurrently, comprising those that are organizational, social, and private (Abhari et al., 2008; Morgan, 2017). Third, the adjunction-based perspective describes the employees' experiences as the accumulation of perceptions acquired from the first interaction with organization and its actors to the last interaction (Yohn, 2018; Maylett and Wride, 2017). The present paper refers to Batat (2022) definition of employee experience which accounts for the three perspectives. Table 1 summarizes operational definitions of the constructs.

THEORETICAL BACKGROUND AND MODEL DEVELOPMENT

Stakeholder theory

A stakeholder is "any individual or group who can affect or is affected by actions, decisions, policies, practices or goals of an organization" (Freeman 1984, p. 25; Järlström et al., 2018). Stakeholder theory characterizes business models as frameworks that benefits customers, employees, suppliers, financiers, and communities, illustrating how improving the situation of one group favorably enhances the situation of others (Greenwood & Freeman, 2011). The theory further argues that the purpose, principles, and the organization's societal relationships should be a collaborative effort, with employees at the center of the equation (Greenwood & Freeman, 2011).

From the perspective of this study, sustainable human resource management and stakeholder theory converge in their responsibility to accomplish financial, ecological, and social objectives that affects both internal and external stakeholders. For instance, offering the employees tailored training for future needs of the organization can equip them with the confidence needed to take initiatives in their job roles leading to proactive behaviors such as job crafting. Once the workforce adapts to their roles which aligns with both personal needs and preferences, they experience increased job satisfaction, engagement, and overall well-being, which can contribute to an enhanced employee experience. Hence, stakeholder theory illustrates how sustainable human resource management favorably impacts employee experience through initiatives that are consistent with stakeholder interests, thereby cultivating a holistic organizational impact.

Table 1: Definitions

Variable	Definition
Sustainable human resource management	Adoption of HRM strategies and practices that enable the achievement of financial, social, and ecological goals, with an impact inside and outside of the organization and over a long-term time horizon while controlling for unintended side effects and negative feedback (Ehnert et al., 2016; p.90).
Job Crafting	The physical and cognitive changes individuals make in the task or relational boundaries of their work (Wrzesniewski & Dutton , 2001; p. 179).
Employee Experience	Employees' subjective and evolving perceptions of their cognitive, behavioral and emotional state, along with their social interactions among the employing organization and its related social actors, whether they are internal (e.g., coworkers and managers) or external (e.g., suppliers and clients). These perceptions are derived from numerous encounters affecting the well-being of employees and their perceived value throughout their experiential journeys within organizations (Batat, 2022; p. 996).

Sustainable Human Resource Management and Job Crafting

Sustainable human resource management is defined as "Adoption of HRM strategies and practices that enable the achievement of financial, social, and ecological goals, with an impact inside and outside of the organization and over a long-term time horizon while controlling for unintended side effects and negative feedback" (Ehnert et al., 2016, p.90). The concept of sustainable human resource management consists of sub-concepts such as green HRM, socially responsible HRM, and common good HRM (Piwowar-Sulej, 2024). Even though there is lack of evidence on a direct relationship between sustainable human resource management and job crafting, Luu et al. (2021) revealed a positive impact of socially responsible HRM practices on job crafting. Additionally, green HRM practices, too, have a significant impact on green crafting, as the author re-operationalized the concept of job crafting relevant to their study (Luu, 2019). Furthermore, other HR practices such as commitment HR practices (Hu et al., 2020), discretionary HR practices (Luu, 2020; Ekmekcioglu & Nabawanuka, 2023) are often positively associated with job crafting. From the perspective of stakeholder theory, sustainable human resource management has the potential to influence job crafting by focusing on the needs and interests of all stakeholders, especially employees. This cultivates an encouraging environment for the workforce to proactively modify their job roles, strengthening the job crafting behaviors. Hence, it is proposed that:

P1: Sustainable human resource management will positively impact job crafting.

Job Crafting and Employee Experience

Employee experience has been defined as "employee's holistic perceptions of the relationship with his/her employing organization derived from all the encounters at touch points along the employee's journey" (Plaskoff, 2017, p. 137; Yadav & Vihari, 2023). Employee experience is a complex and diverse concept that consists of various aspects such as job satisfaction, work-life balance, organizational culture, leadership, and career development (Contreras-Cruz et al., 2023; Malik et al., 2023; Basar, 2024). Previous studies have found that job crafting improves work-life balance (Slowiak & DeLongchamp, 2022) and job satisfaction (Zito et al., 2019), which can enhance the experiences of employees within an organization. Additionally, in a study by Lichtenthaler & Fischbach (2018), it was found that employee-oriented leadership styles can improve job crafting. This can result in an enhanced employee experience. Moreover, it was also found that two dimensions of job crafting i.e. task crafting and cognitive crafting had a positive impact on the career attitudes and commitment which ultimately led to career success (Yoon et al., 2019). This, too, may have a positive impact on employee experience. From the perspective of stakeholder theory, the objectives of the firm should be consistent with the well-being of the stakeholders (employees) which will encourage them to take initiatives by modifying their roles such that it creates a value and an enriching employee experience. Thus, we propose that:

P2: Job crafting will positively impact employee experience.

Job Crafting as Mediator

Job crafting is essentially shaping one's jobs so that tasks and social interactions are more fitted to the employee's requirements, abilities, and preferences (Wrzesniewski & Dutton, 2001). Job crafting helps in improving the person-job fit, revise meaning of the job, and make alterations to the work identity (Niessen et al., 2016). It can act as a mediator between sustainable human resource management and employee experience by allowing the workforce to customize their job roles consistent with sustainable human resource management which will enable them to leverage their strengths creating a better employee experience. Past research suggests that job crafting can be enhanced with the green HRM practices (Luu, 2019) and socially responsible HRM practices (Luu et al., 2021), which are types of sustainable human resource management. Additionally, job crafting can improve job satisfaction (Zito et al., 2019), career success (Yoon et al., 2019) and work-life balance (Slowiak & DeLongchamp, 2022). Furthermore, sustainable human resource management grounded in stakeholder theory, helps in understanding that both the paradigms focus on benefitting the stakeholder interests which can drive employees to take initiatives in better defining their job roles, thereby improving their overall experience. Therefore, we propose that:

P3: Job crafting will mediate the relationship between sustainable human resource management and employee experience.

Figure 1 illustrates the conceptual model of the study. The dotted lines represent the indirect relationship between sustainable human resource management and employee experience via job crafting.

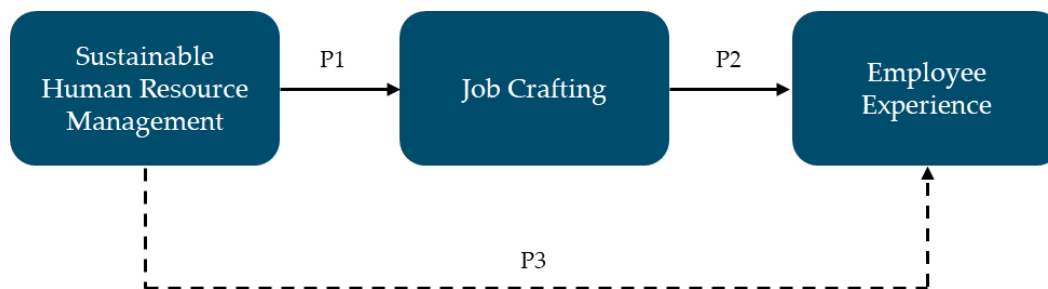


Figure 1: Conceptual Model

RECOMMENDATIONS FOR FUTURE RESEARCH

Several avenues can be explored to further advance the sustainable human resource management domain. First, empirical studies are required to validate the proposed research model in this study. It is recommended that future research scholars conduct longitudinal studies to analyze how sustainable human resource management impacts job crafting over a period of time. Also, how these proactive behaviors as a result of job crafting could impact the overall experience of an employee. Second, it is advised that researchers examine the role of individual sustainable human resource management practices such as responsible talent

management practices (Qamar et al., 2023) or flexible work arrangements, in facilitating job crafting. This can help achieve the most effective sustainable human resource management strategy which encourages proactive behavior. Doing so, may also help in identifying the practices which can help enhance the overall employee experience.

Third, it is recommended that researchers conduct comparative studies in multiple industries which can offer insightful observations into the generalizability of the proposed model. This will also help in understanding how sustainable human resource management and attitudes towards job crafting differ across different organizational settings. The findings can be used to tailor the sustainable human resource management strategies to specific contexts to help facilitate job crafting and simultaneously improve the employee experience. Fourth, it is suggested that future researchers utilize other theoretical frameworks to explain the model such as positive organizational scholarship, self-efficacy theory (Qamar et al., 2023), and psychological contract theory. These theories can offer various perspectives on how sustainable human resource management impacts employee experience with the mediation of job crafting while also strengthening the theoretical robustness.

Fifth, it is advised that scholars study the model with other mediators such as organizational commitment and psychological empowerment (Lu et al., 2023). Mediators such as employee well-being, employee resilience, and organizational learning can also be considered. This will offer a deeper understanding of the mechanisms which can explain how sustainable human resource management impacts employee experience. Additionally, testing the model with various mediators can help with formulating better practical interventions to enhance employee experience.

Finally, it is suggested that future studies analyze the potential moderating variables such as human capital (Li et al., 2023) and authentic leadership (Qamar et al., 2023). Moderating variables such as organizational culture and leadership styles can also be considered to better understand the various aspects and its impact on the research model. By addressing these recommendations, future research can offer a more in-depth understanding of how sustainable human resource management cultivate job crafting and improve employee experience, thereby contributing to the development of more effective sustainable human resource management strategies.

REFERENCES

- Agovino, T. (2024). Mental Health, HR and the Workplace. In *Society for Human Resource Management*, available at: <https://www.shrm.org/topics-tools/news/all-things-work/mental-health--hr-and-the-workplace> (accessed June 1, 2024).
- Batat, W. (2022). The employee experience (EMX) framework for well-being: an agenda for the future. *Employee Relations: The International Journal*, 44(5), 993-1013.
- Basar, D. (2024). The Relationship Between Employee Experience and Employee Engagement with The Moderating Role of Positive Affect in Finance Sector. *Borsa Istanbul Review*, 1-8.

- Berg, J. M., & Dutton, J. E. (2008). Crafting a fulfilling job: Bringing passion into work. *Ann Arbor, MI: University of Michigan, Ross School of Business*, 1-8.
- Bersin, J. (2021), "The crusade for employee experience: how did we get here?", available at: <https://joshbersin.com/2021/01/the-crusade-for-employee-experience-how-did-we-get-here/> (accessed 30 May 2024).
- Bruning, P. F., & Campion, M. A. (2018). A role–resource approach–avoidance model of job crafting: A multimethod integration and extension of job crafting theory. *Academy of Management Journal*, 61(2), 499-522.
- Cheng, B., Lin, H., & Kong, Y. (2023). Challenge or hindrance? How and when organizational artificial intelligence adoption influences employee job crafting. *Journal of Business Research*, 164, 1-10.
- Click Boarding (2021). *18 Jaw-Dropping Onboarding Stats You Need to Know*, available at: <https://www.clickboarding.com/18-jaw-dropping-onboarding-stats-you-need-to-know/> (accessed June 1, 2024).
- Contreras-Cruz, A., Kirbac, A., Dennett, C., & Daim, T. U. (2023). Human-centered design as a tool to improve employee experience: The case of a US plant-based food manufacturer. *Technology in society*, 73, 1-16.
- Dery, K., Van Der Meulen, N., & Sebastian, I. (2018). Employee experience: Enabling your future workforce strategy. *MIT Sloan Center for Information Systems Research*, 18(9), 1-4.
- Ehnert, I. (2009). Sustainability and human resource management: reasoning and applications on corporate websites. *European Journal of International Management*, 3(4), 419-438.
- Ehnert, I., Parsa, S., Roper, I., Wagner, M., & Muller-Camen, M. (2016). Reporting on sustainability and HRM: A comparative study of sustainability reporting practices by the world's largest companies. *The International Journal of Human Resource Management*, 27(1), 88-108.
- Ekmekcioglu, E. B., & Nabawanuka, H. (2023). How discretionary HR practices influence employee job satisfaction: the mediating role of job crafting. *Employee Relations: The International Journal*, 45(3), 776-793.
- Freeman, R. E. (1984). *Strategic management: A stakeholder approach*. Boston: Pitman.
- Gollan, P. J. (2005). High involvement management and human resource sustainability: The challenges and opportunities. *Asia Pacific Journal of Human Resources*, 43(1), 18-33.
- García-Cruz, J., Rincon-Roldan, F., & Pasamar, S. (2024). When the stars align: The effect of institutional pressures on sustainable human resource management through organizational engagement. *European Management Journal*, 1-11.
- Greenwood, M., & Freeman, R. E. (2011). Ethics and HRM: The contribution of stakeholder theory. *Business & Professional Ethics Journal*, 30(3/4), 269-292.
- Harju, L. K., Kaltainen, J., & Hakanen, J. J. (2021). The double-edged sword of job crafting: The effects of job crafting on changes in job demands and employee well-being. *Human Resource Management*, 60(6), 953-968.
- Hu, B., McCune Stein, A., & Mao, Y. (2020). How control and commitment HR practices influence employee job crafting. *Journal of Managerial Psychology*, 35(5), 361-374.

- Huang, M., Law, K. M., & Ouyang, Z. (2024). Sustainable human resource management practices and corporate sustainable supply chain: the moderating role of firm technology orientation. *Enterprise Information Systems*, 18(6), 751-770.
- Itam, U., & Ghosh, N. (2020). Employee experience management: A new paradigm shift in HR thinking. *International Journal of Human Capital and Information Technology Professionals (IJHCITP)*, 11(2), 39-49.
- Janaite, K. (2024). *When people thrive, business thrives*. Deloitte, available at: <https://www.deloitte.com/lv/en/about/press-room/deloitte-2024-global-human-capital-trends.html> (accessed May 31, 2024).
- Järlström, M., Saru, E., & Vanhala, S. (2018). Sustainable human resource management with salience of stakeholders: A top management perspective. *Journal of Business Ethics*, 152, 703-724.
- Joshi, A., Sekar, S., & Das, S. (2024). Decoding employee experiences during pandemic through online employee reviews: insights to organizations. *Personnel Review*, 53(1), 288-313.
- Kim, M., & Beehr, T. A. (2018). Can empowering leaders affect subordinates' well-being and careers because they encourage subordinates' job crafting behaviors?. *Journal of Leadership & Organizational Studies*, 25(2), 184-196.
- Lazazzara, A., Tims, M., & De Gennaro, D. (2020). The process of reinventing a job: A meta-synthesis of qualitative job crafting research. *Journal of Vocational Behavior*, 116, 1-18.
- Li, J., Yang, H., Weng, Q., & Zhu, L. (2023). How different forms of job crafting relate to job satisfaction: The role of person-job fit and age. *Current Psychology*, 42(13), 11155-11169.
- Li, W., Abdalla, A. A., Mohammad, T., Khassawneh, O., & Parveen, M. (2023). Towards examining the link between green hrm practices and employee green in-role behavior: spiritual leadership as a moderator. *Psychology Research and Behavior Management*, 17, 383-396.
- Li, W., Qin, X., Yam, K. C., Deng, H., Chen, C., Dong, X., ... & Tang, W. (2024). Embracing artificial intelligence (AI) with job crafting: Exploring trickle-down effect and employees' outcomes. *Tourism Management*, 104, 1-18.
- Lichtenthaler, P. W., & Fischbach, A. (2018). Leadership, job crafting, and employee health and performance. *Leadership & Organization Development Journal*, 39(5), 620-632.
- Lopez-Cabrales, A., & Valle-Cabrera, R. (2020). Sustainable HRM strategies and employment relationships as drivers of the triple bottom line. *Human resource management review*, 30(3), 1-11.
- Lu, Y., Zhang, M. M., Yang, M. M., & Wang, Y. (2023). Sustainable human resource management practices, employee resilience, and employee outcomes: Toward common good values. *Human Resource Management*, 62(3), 331-353.
- Lulewicz-Sas, A., Kinowska, H., & Fryczyńska, M. (2022). How sustainable human resource management affects work engagement and perceived employability. *Economics & Sociology*, 15(4), 63-79.
- Luu, T. T. (2019). Green human resource practices and organizational citizenship behavior for the environment: the roles of collective green crafting and environmentally specific servant leadership. *Journal of Sustainable Tourism*, 27(8), 1167-1196.

- Luu, T. T. (2020). Discretionary HR practices and employee well-being: The roles of job crafting and abusive supervision. *Personnel Review*, 49(1), 43-66.
- Luu, T. T., Vu, T. N., Rowley, C., & Luong, T. P. N. (2022). Nurturing mutual gains in the public sector: the roles of socially responsible human resource practices, employee use of normative public values, and job crafting. *Public Management Review*, 24(7), 1124-1154.
- Malik, A., Budhwar, P., Mohan, H., & NR, S. (2023). Employee experience—the missing link for engaging employees: Insights from an MNE's AI-based HR ecosystem. *Human Resource Management*, 62(1), 97-115.
- Maylett, T., & Wride, M. (2017). *The employee experience: How to attract talent, retain top performers, and drive results*. John Wiley & Sons.
- Morgan, J. (2017). *The employee experience advantage: How to win the war for talent by giving employees the workspaces they want, the tools they need, and a culture they can celebrate*. John Wiley & Sons.
- Niessen, C., Weseler, D., & Kostova, P. (2016). When and why do individuals craft their jobs? The role of individual motivation and work characteristics for job crafting. *Human relations*, 69(6), 1287-1313.
- Papademetriou, C., Anastasiadou, S., & Papalexandris, S. (2023). The effect of sustainable human resource management practices on customer satisfaction, service quality, and institutional performance in hotel businesses. *Sustainability*, 15(10), 1-24.
- Panneerselvam, S., & Balaraman, K. (2022). Employee experience: the new employee value proposition. *Strategic HR Review*, 21(6), 201-207.
- Park, S., & Park, S. (2023). Contextual antecedents of job crafting: review and future research agenda. *European Journal of Training and Development*, 47(1/2), 141-165.
- PerformYard (2024). 70 Pivotal HR Statistics for 2024, available at: <https://www.performyard.com/articles/hr-statistics#9-employee-engagement-statistics> (accessed June 1, 2024).
- Pillai, R., Ghanghorkar, Y., Sivathanu, B., Algharabat, R., & Rana, N. P. (2024). Adoption of artificial intelligence (AI) based employee experience (EEX) chatbots. *Information Technology & People*, 37(1), 449-478.
- Piwowar-Sulej, K. (2024). Sustainable human resource management: a mixed-method analysis of the research field focusing on the visegrad countries. *Central European Management Journal*, 1-15.
- Plaskoff, J. (2017). Employee experience: the new human resource management approach. *Strategic HR Review*, 16(3), 136-141.
- Qamar, F., Afshan, G., & Rana, S. A. (2023). Sustainable HRM and well-being: systematic review and future research agenda. *Management Review Quarterly*, 1-51.
- Sanz-Vergel, A. I., Nielsen, K., Rodríguez-Muñoz, A., & Antino, M. (2024). What happens at work does not always stay at work: daily job crafting and detachment among colleagues. *Applied Psychology*, 73(2), 776-800.
- Schüler, J., Franzke, S., Boehnlein, P., & Baum, M. (2023). Do job crafting opportunities help to win talent? Disentangling and contextualizing the effects of job crafting opportunities on applicant attraction. *Journal of Organizational Behavior*, 44(5), 776-801.

- Slemp, G. R., & Vella-Brodrick, D. A. (2014). Optimising employee mental health: The relationship between intrinsic need satisfaction, job crafting, and employee well-being. *Journal of Happiness Studies*, 15, 957-977.
- Slowiak, J. M., & DeLongchamp, A. C. (2022). Self-care strategies and job-crafting practices among behavior analysts: Do they predict perceptions of work-life balance, work engagement, and burnout?. *Behavior Analysis in Practice*, 15(2), 414-432.
- Sypniewska, B., Baran, M., & Kłos, M. (2023). Work engagement and employee satisfaction in the practice of sustainable human resource management-based on the study of Polish employees. *International Entrepreneurship and Management Journal*, 19(3), 1069-1100.
- Tims, M., & Bakker, A. B. (2010). Job crafting: Towards a new model of individual job redesign. *SA Journal of Industrial Psychology*, 36(2), 1-9.
- Tims, M., Bakker, A. B., & Derks, D. (2012). Development and validation of the job crafting scale. *Journal of vocational behavior*, 80(1), 173-186.
- Tims, M., Twemlow, M., & Fong, C. Y. M. (2022). A state-of-the-art overview of job-crafting research: current trends and future research directions. *Career Development International*, 27(1), 54-78.
- Westerman, J. W., Rao, M. B., Vanka, S., & Gupta, M. (2020). Sustainable human resource management and the triple bottom line: Multi-stakeholder strategies, concepts, and engagement. *Human Resource Management Review*, 30(3), 1-4.
- Wikhamn, W. (2019). Innovation, sustainable HRM and customer satisfaction. *International Journal of Hospitality Management*, 76, 102-110.
- Withe Team. (2024). 50+ Candidate Experience Statistics [2024]. Withe, available at: <https://withe.co/blog/candidate-experience-statistics> (accessed June 1, 2024).
- Wrzesniewski, A., & Dutton, J. E. (2001). Crafting a job: Revisioning employees as active crafters of their work. *Academy of management review*, 26(2), 179-201.
- Yadav, M., & Vihari, N. S. (2023). Employee experience: construct clarification, conceptualization and validation of a new scale. *FIIB Business Review*, 12(3), 328-342.
- Yohn, D.L. (2018), "2018 will be the year of employee experience", available at: <https://www.forbes.com/sites/denisejohn/2018/01/02/2018-will-be-the-year-of-employee-experience/#1d4fd2831c8f> (accessed 29 May 2024).
- Yoon, K. H., Kim, B. Y., & Eom, J. G. (2019). The effects of job crafting on career success of multinational corporations' employees. *Journal of Asian Finance, Economics and Business*, 6(4), 213-225.
- Zaugg, R. J., Blum, A., & Thom, N. (2001). Sustainability in human resource management. *Evaluation Report. Survey in European Companies and Institutions. Arbeitsbericht des Instituts für Organisation und Personal der Universität Bern und des eidgenössischen Personalamtes*, 1(1), 1-31.
- Zhang, F., & Parker, S. K. (2019). Reorienting job crafting research: A hierarchical structure of job crafting concepts and integrative review. *Journal of organizational behavior*, 40(2), 126-146.
- Zito, M., Colombo, L., Borgogni, L., Callea, A., Cenciotti, R., Ingusci, E., & Cortese, C. G. (2019). The nature of job crafting: Positive and negative relations with job satisfaction and work-family conflict. *International journal of environmental research and public health*, 16(7), 1-12.

***CORRESPONDING AUTHOR**

Hira Jehanzeb can be contacted at: *hirajehan17@gmail.com*

CITATION

Jehanzeb, H. (2025). Sustainable human resource management, job crafting, and employee experience: A conceptual model. *Sohar University Journal of Sustainable Business*, 1(1). 1-14.

PSYCHOLOGICAL AND ORGANIZATIONAL RESILIENCE: KEYS TO LIFE SATISFACTION IN THE SERVICE SECTOR

Ayoub Sulaiman Mohammed Al Kindy

Majis Industrial Services, Falaj Al Qabail, Sultanate of Oman

ABSTRACT

By employing the Conservation of Resources (COR) theory, this study aims to examine the impact of employees' psychological, adaptive and planned resilience on their life satisfaction. Data were collected from employees in hotels, hospitals, and other service sectors during the COVID-19 crisis. The data were analyzed using SPSS. The findings indicate that employees' adaptive and planned resilience positively correlate with their life satisfaction. In contrast, psychological resilience negatively impacts life satisfaction, which is inconsistent with previous studies. This research provides decision-makers with a clearer understanding of the factors affecting life satisfaction. Additionally, the study offers contextual contributions by uniquely collecting data from Oman during the COVID-19 crisis.

Keywords: Psychological resilience; life satisfaction; conservation of resources theory

Paper Type: Research paper

INTRODUCTION

Life satisfaction measures the quality of life, which can be used to measure mood, relationship objectives accomplished, self-concepts, and life-coping capacity during crises like the COVID-19 pandemic (Schmid, Christmann, Oehrlein, Stein, & Thönnissen, 2024). In Oman, COVID-19 first surfaced on February 24 2020. Its probability of effect is created for the psychological, social, economic and financial impact on the public in Oman (Ministry of Health, 2020; Times of Oman, 2020), including life satisfaction. The economy of Oman is mainly based on oil and gas, and some progress is being made in the services sector. Before the global COVID-19 outbreak, Oman had 3.1% unemployed people out of its 4.8 million population, with a US\$203.959 billion GDP (PPP) and 2.1% annual economic growth (Economic Freedom Index, 2020). The citizens of Oman have a moderate per capita income of US\$18,000, with a tolerated 0.9% inflationary impact. To minimize the health hazards of COVID-19, the government of Oman gradually reduced public activities since January 2020, which led to a complete lockdown in mid-March 2020 and affected life satisfaction for the employees working remotely. Based on complete socioeconomic isolation,

the medical advisors and financial analysts indicate long-term economic and psychological challenges for the community.

This COVID-19 crisis has become visible through their lifestyle and how they deal with others (Torales, et al., 2024). It also indicates how they continue to work, as it has become in all these matters that they are not satisfied with them. This belief is untrue because individuals should not think about it or act in an unhealthy way about how to deal with all the changes that may occur to them. All individuals must be able to adapt to all the changes that occur due to disease. Additionally, it is necessary that they feel satisfied with all the things that happen to them in life and adapt to all these changes to continue their life well and not face many difficulties in life. The post-COVID-19 period has brought various challenges to Oman's government regarding its citizens' sustainable mental and financial health. So, our research addressed a fundamental research question, i.e. What is the effect of psychological and organizational resilience on the life satisfaction of health sector employees? Therefore, it was essential to understand the learning psychological resilience policy and employee resilience and its effect on total resilience. This study focuses on studying the resilience of employees, organizations, and physicians in hospitals, hotels, and other service sectors, as well as assessing the relationship between psychological resilience and resilience among employees and the organizational resilience of small business owners after exposure to any crisis like COVID-19.

Studies investigating how psychological and organizational resilience concerning life satisfaction during the COVID-19 pandemic have identified many significant areas that need more investigation (Baldwin & Tomiura, 2020; Zakeri et al., 2021). Contextual research is necessary to comprehend the progression of resilience and life satisfaction during various pandemic stages. Furthermore, further investigation is required to study multiple groups, including different cultural settings and demographic variations, e.g. hotels and hospitals, to understand resilience's distinct patterns (Masten, 2002; Torales, et al., 2024). Finally, it is essential to inquire into the particular difficulties and elements contributing to life satisfaction where remote work settings were not possible during the pandemic (Prayag, Spector, Orchiston, & Chowdhury, 2019). By addressing these gaps, we may improve our understanding of resilience and use that knowledge to develop specific therapies.

This study aims to integrate the psychological and social science domains to illuminate the repercussions of a pandemic beyond its toll on the health and economic lives of Omani citizens. This study has extended the research on COVID-19 beyond its medical impacts on patients to a psychological trauma that the masses face immediately after the lockdown period. Finally, the government of Oman can educate the business community on continuing their business through safe ways, i.e. shifting to online delivery to save their weakly diversified economy.

In line with a contemporary global health crisis and the Omani vision of 2040, this research contributes to strategic goals related to the Omani economy. This study aims to test the effect of psychological and organizational resilience on life satisfaction. The explicit research question is how psychological, organizational and employee resilience impacts the life satisfaction of employees after the COVID-19 crisis.

LITERATURE REVIEW

By employing the Conservation of Resources (COR) theory (Hobfoll, 1989), this study has linked psychological and organizational resilience and life satisfaction. Many effects resulted from COVID-19, and the effects were not limited to the physical aspect but extended to include the psychological side of individuals (Hellewell et al., 2020). Many individuals have been greatly disturbed by the conditions that the world has been subjected to, which caused the spread of coronavirus, as we find that many of them no longer consider that there is value in life. Many of them have become exaggeratedly afraid. Some have become uninterested in all the advice and instructions on adhering to the guidelines for preventing this disease, as they are no longer satisfied with life. If a person cannot adapt to all the changes, he may become dissatisfied with life (Torales, et al., 2024). If the person becomes dissatisfied with life, he faces many problems and becomes vulnerable to many diseases associated with depression and anxiety. Therefore, the most successful method to continue living well is the ability to adapt and cope well with the disease. So that one can become satisfied with life. As is inevitable, many individuals still fear this disease even if it is eliminated. It is known that the psychological effects last for more extended periods than the physical effects. The body can recover quickly from disease if treatment is available, but what happens if a person is exposed to a mental illness?

One of the distinguishing features of COVID-19 is its highly contagious nature and fast transmission through human contact. That makes social isolation and economic lockdown its first line of prevention measures (Hellewell et al., 2020), which may reduce the spread of infection but have significant psychological and financial outcomes (Hellewell et al., 2020). This social isolation aspect of COVID-19 may result in the deteriorated psychological state of Omani citizens when confined in their houses and unable to maintain regular contact with their family, acquaintances, employers or business stakeholders. Humans have an innate need to belong, and a social cut-off leads to adverse psychological impacts (Momtaz, Hamid, Ibrahim, Yahaya, & Chai, 2011). Behavioural science literature advocates that Pandemic related isolation can have far-reaching implications for the psychological well-being of individuals (Van Bavel et al., 2020). Well-being includes positive emotions, happiness, and life satisfaction that can be lowered due to social detachment due to a pandemic (Mellor, Stokes, Firth, Hayashi, & Cummins, 2008). Positive emotions and life satisfaction are how an individual evaluates his life in terms of satisfaction and happiness (Carruthers & Hood, 2004).

The second isolation aspect is the economic lockdown and a significant decline in business operations. Apart from being psychologically stressful, this has important implications for the financial well-being of a business's owners and employees (Baldwin & Tomiura, 2020). COVID-19 has been deemed a significant source of the global financial crisis because it has halted all trade movements and business operations (McKibbin & Fernando, 2020). The loss of profits for business owners and income for part-time workers may impact their purchasing power, financial stress, and ability to afford living expenses, which are reflected in downhill economic well-being (Prawitz et al., 2006).

Resilience refers to a class of phenomena characterized by good outcomes despite serious threats to adaptation or development. The research on resilience aims to understand and evaluate the

processes that account for these positive outcomes. Resilience is a contextual and inferential concept that necessitates two types of judgments. (Masten., 2002). The first judgment addresses the threat side of the inference. Individuals are not considered resilient if there has never been a significant threat to their development; there must be current or past hazards judged to have the potential to derail normative development. In other words, there must be a demonstrable risk. In many cases, risks are actuarially based predictors of undesirable outcomes drawn from evidence that this status or condition is statistically associated with a higher probability of a "bad" outcome in the future (Kraemer et al., 1997). Many risk factors, ranging from status variables such as a biological child of a parent with schizophrenia or low socioeconomic status to direct measures of exposure to maltreatment or violence, are well-established statistical predictors of subsequent developmental problems, either specific problems or a broad spectrum of difficulties (Torales, et al., 2024).

HYPOTHESIS DEVELOPMENT

As per Prayag et al. (2019), flexibility is one of the essential positive resources that employees can use to solve many problems. Employee resilience is an emerging field in psychology and organizational behaviour. If you can use it well, you will find many positive results where psychological and employee resilience must facilitate the use of resources and better adapt to life satisfaction (Hobfoll, 1989). At the same time, it is known that employees' resilience at work can help them to respond in the face of all tasks and prosper in the future. Life satisfaction can be enhanced by providing better social support and focusing on better human resource development (Zakeri et al., 2021). This result can be accomplished by focusing on the behaviour of the participants' managers. Thus, the following hypothesis is proposed.

H1: Employee resilience positively affects employees' life satisfaction

Prayag et al. (2019) claim that the psychological resilience of human beings is required for life satisfaction. For instance, we can assume that if, during the pressure of job losses during COVID-19, the employee demonstrates more psychological resilience, s/he will be more satisfied with life and perform in the future workplace. There are two schools of thought related to psychological resilience. The first clarifies that psychological flexibility is the ability that allows individuals to deal with various difficulties and adapt to them. The second means that flexibility is a dynamic process that results from the disorders that must be performed in reintegrating it again, as both showed that flexibility could be developed and managed (Torales, et al., 2024). Yuko Neboda, a psychotherapist and spokesperson for the UK Psychotherapy Council, added that many people who suffer from fear and anxiety are less satisfied with life; in contrast, psychologically strong people are more satisfied with life (Maddy, 2020; Saleem et al., 2023). Thus, the following hypothesis is postulated.

H2: Psychological resilience positively affects employees' life satisfaction

Prayag et al. (2019) indicate that the organization's resilience is the ability to respond to all the changes and developments that may occur and benefit from them so that the organization continues to survive better. According to Hobfoll (1989), a firm that allocates more resources enhances the life satisfaction of its employees. This organizational resilience was developed among those firms during a crisis like COVID 19 when the firms adopted technology to allow employees to work remotely to enhance their life satisfaction (Beuren, dos Santos, & Theiss, 2022). Thus, we proposed the following hypothesis.

H3: Organizational resilience positively affects employees' life satisfaction

Figure 1 indicates the linkage between the independent and the dependent variables:

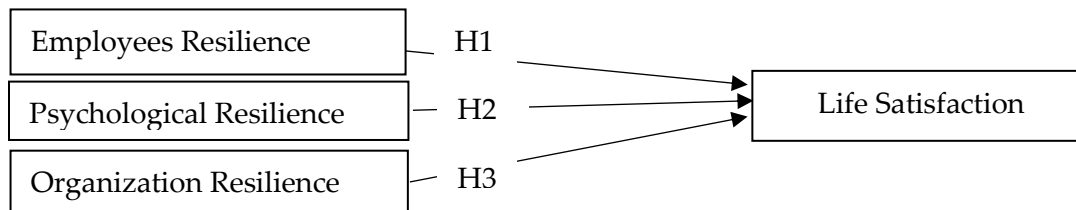


Figure 1: Theoretical Framework

METHODS

This study has used a quantitative method to collect and analyze data. This approach uses a simple random sampling method, where 250 employees are targeted with the customized and Arabic-translated questionnaire. For this purpose, the scales for the study variables are to be adapted to match the COVID-19 theme. The sample is proportionally drawn from all the service sector cities of Sohar to ensure an accurate representation of the population in Sohar. A total of 128 samples were used for the final data analysis. The study uses the SPSS- Process macro to test direct and moderating hypotheses.

Demographic Information

We conducted descriptive analysis, including Demographic Information concerning Nationality, Gender, Age, Qualification, Years of experience, Monthly Salary and the Service Sector of the 128 respondents (see Figure 2). Around 80% were Omani employees, and 20% were non-Omani employees. 58% of the participants were male, and 42% were female employees. The range of age of the participants was 26% their age was between 20 – 30 years old, 44% their age was between 30 – 40 years old, 23% their age was between 40 – 50 years old, and 7% their age was between 50 – 60 years old. The qualification of education of the participants was 20% with a diploma, or 49%-degree holder, 22% with a master's degree and 9% having other qualifications. The participants' years of experience represent 23% having experience between 1 – 5 years, 16% having experience

between 6 – 10 years, and 61% having experience of more than ten years. In addition, 16% of the participants had a monthly salary of less than 500 OMR, 14% had a salary range between 501 900 OMR, and 70 % had a monthly salary of more than 901 OMR. 19% represent the hospital sector, 13% represent the hotel sector, and 68% represent another services sector. Table 1, they were having the details of this Demographic Information.

Table 1: Demographics (N = 128)

Description	Details	Number of Participants
Nationality (الجنسية)	Omani (عماني)	102
	Non-Omani (غير عماني)	26
Gender (الجنس)	Male (ذكر)	74
	Female (أنثى)	54
Age (العمر)	20-30	34
	30-40	56
	40-50	29
	50-60	9
	Diploma (دبلوم)	25
Qualification (المؤهل العلمي)	Degree (بكالوريوس)	63
	Master (ماجستير)	29
	Others (أخرى)	11
	1-5 years	29
Years of experiences سنوات الخبرة	6-10 years	21
	more than ten years	78
	Less than 500 OMR أقل من	20
Monthly Salary الراتب الشهري	501 – 900 OMR	18
	Above 901 OMR أكثر من	90
	Hospital المستشفيات	24
Service Sector (select one) القطاع الخدمي	Hotel الفنادق	17
	Other Service Sector قطاعات أخرى	87

Measurement of Constructs

Psychological Resilience: This construct was measured using a four-item scale. The measure was adopted from the Study by Prayag et al. (2019). The sample items include "I tend to bounce back quickly after hard times" and "It is hard for me to snap back when something bad happens".

Organizational Resilience: This construct was measured using a ten (10) items scale. This scale consists of two sub-scales of five items, each, i.e. planned resilience and adopted resilience. The study of Prayag et al. (2019) also adopted the measure. The sample items include "Given how others depend on us, the way we plan for the unexpected is appropriate" and "If key people were unavailable, there are always others who could fill their role".

Employees' Resilience: This construct was measured using seven seven-item scale. The measure was adopted from the Study by Prayag et al. (2019). The sample items include "I successfully manage a high workload for long periods " and "I re-evaluate my performance and continually improve how I do my work".

Life Satisfaction: This construct was measured using an items scale. The measure was adopted from the Study by Prayag et al. (2019). The sample items include "In most ways, my life is close to my ideal" and "So far, I have gotten the important things I want ".

Reliability Analysis

The reliability analysis used Cronbach's Alpha to calculate each item's reliability. The 0.70 (70%) was selected as the minimum reliable value. Table 2 below shows the details of the constructs with Cronbach's Alpha values.

Table 2: Reliability Analysis

Constructs	Number of Items	Number of deleted items	Cronbach's Alpha
Life Satisfaction	5	0	0.892
Employees Resilience	6	0	0.876
Psychological resilience	4	1	0.909
Adaptive Resilience	5	0	0.866
Planned Resilience	5	0	0.929

Note: range of reliability is between 0.866 and 0.929

The life satisfaction scale consists of 5 items. The scale was adapted from the Study of Prayag et al. (2019). The Cronbach's Alpha of the scale is 0.892, which is above 0.7, so this scale is reliable for further analysis. Employee's resilience scale consists of 6 items. The scale was adapted from the Study of Prayag et al. (2019). The Cronbach's Alpha of the scale is 0.876, which is above 0.7, so this scale is reliable for further analysis. The psychological resilience scale consists of 5 items. The scale was adapted from the Study of Prayag et al. (2019). The Cronbach's Alpha of the scale is 0.556, which is less than 0.7, so in this case, we checked and removed the unreliable item (one item), and the Cronbach's Alpha is now 0.909, so this scale is reliable for further analysis. The adaptive resilience scale consists of 5 items. The scale was adapted from the Study of Prayag et al. (2019). The Cronbach's Alpha of the scale is 0.866, which is above 0.7, so this scale is reliable for further analysis. Finally, the planned resilience scale consists of 5 items. The scale was adapted from the Study of Prayag et al. (2019). The Cronbach's Alpha of the scale is 0.929, which is above 0.7, so this scale is reliable for further analysis.

DATA ANALYSIS AND RESULTS

In this part, we analyzed the data gathered using the questionnaire and responses from 128 participants. Then, we evaluated the responses and analyzed the findings and the results. It is

also worth mentioning that this questionnaire has been translated into Arabic, mainly to gain the respect of participants who do not speak or read English.

The questionnaire has five (5) sections besides the Demographic Information. The first section has taken the feedback and responses about Life Satisfaction. The second section talks about employee resilience. The third one has taken the participant's views about Psychological Resilience. The fourth section discusses Adaptive Resilience, and the fifth section discusses Planned Resilience.

Correlations and Regression Analysis

Table 3 below indicates the correlation analysis and describes the relationship between each independent variable with the dependent variable:

Table 3: Correlations Analysis

Constructs	Mean	SD	1	2	3	4	5
1. Life Satisfaction	3.26	0.9	1				
2. Employee Resilience	3.96	0.7	0.585**	1			
3. Psychological Resilience	3.17	1	-0.26**	-0.28**	1		
4. Adaptive Resilience	3.26	0.9	0.60**	0.72**	-0.19*	1	
5. Planned Resilience	3.52	0.9	0.55**	0.64**	-0.04	0.84**	1

** Correlation is significant at the 0.01 level (2 – tailed).

*Correlation is significant at the 0.05 level (2 – tailed).

Correlation Analysis demonstrates that the relationship between employee resilience and life satisfaction ($r=0.585$; $p<0.01$), the relationship between psychological resilience and life satisfaction ($r= -0.261$; $p<0.01$), the relationship between adaptive resilience and life satisfaction ($r= 0.604$; $p<0.01$) and the relationship between planned resilience and life satisfaction ($r= 0.552$; $p<0.01$).

Results show that 43.2% variation is explained in life satisfaction by four independent variables (Employee Resilience, Psychological Resilience, Adaptive Resilience and Planned Resilience). Based on table 4 below which indicate the direct and indirect effects of life satisfaction. We accept our first hypothesis, "employee resilience" impacts "life Satisfaction" during COVID-19 in hotels and hospitals sectors ($\beta=0.258$; $p <0.05$; $t= 2.556$, $\text{sig} = 0.012$). There is evidence of a linear relationship between employee resilience and life satisfaction. Based on the analysis and the results from this research, employee resilience positively affects life satisfaction. The second hypothesis is rejected, "psychological resilience" impacts "life Satisfaction" during COVID-19 at hotels and hospitals sectors ($\beta= -0.138$; $p <0.05$; $t= -1.881$, $\text{sig} = 0.62$). There is no evidence of a linear relationship between psychological resilience and life satisfaction. Unfortunately, based on the analysis and the results from this research, psychological resilience has negatively affected life satisfaction. We also reject the third hypothesis, "adaptive resilience" impacts "life Satisfaction" during COVID-19 at hotels and hospitals sectors ($\beta=0.239$; $p <0.05$; $t= 1.707$, $\text{sig} = 0.09$). There is no evidence of a linear relationship between adaptive resilience and life satisfaction. Based on the

analysis and the results from this research, adaptive resilience negatively affects life satisfaction. The fourth and last hypothesis was rejected, "planned resilience" impacts "life Satisfaction" during COVID-19 at hotels and hospitals sectors ($\beta=0.182$; $p < 0.05$; $t = 1.413$, $\text{sig} = 0.16$). There is no evidence of a linear relationship between planned resilience and life satisfaction. However, the outcomes of this research and the results show that planned resilience also positively affects life satisfaction.

Table 4: Regression Analysis

Independent Variables	Std. Error	Beta	t	Sig.
1. Employee Resilience	0.135	0.258	2.556	0.012
2. Psychological Resilience	0.067	-0.138	-1.881	0.062
3. Adaptive Resilience	0.139	0.239	1.707	0.090
4. Planned Resilience	0.135	0.182	1.413	0.160

Note: * $p < .05$; ** $p < .01$; *** $p < .001$ (significance levels). The number of cases is 128. Employees Resilience (ER); Psychological Resilience (PR); Adaptive Resilience (AR); Planned Resilience (PLR).

Here we have discussed the data gathered using the questionnaire and responses received from 128 participants. The data has been analyzed and evaluated using the SPSS tool. This part goes through the findings of the research study, the study's implications for both management and the employees, the research limitations, the future research, and the conclusion.

DISCUSSION AND IMPLICATIONS

At this stage, there are insufficient studies on the relationship and linkage between the different types of resilience (employee resilience, psychological resilience, adaptive resilience and planned resilience) with life satisfaction. Yet, these linkages and relationships are essential and critical to recovering social activities after any disturbance (Hall et al., 2018; Prayag et al., 2019). Regarding the first hypothesis, the findings and results are consistent with the previous study (Prayag et al., 2019), while the findings and results of psychological resilience and organization resilience (both adaptive and planned resilience) are unrelated to life satisfaction or inconsistent with the previous studies (Prayag, et al., 2019; Tamarit, et al., 2023). The reason for this inconsistency of organizational resilience (adaptive and planned resilience) could be that the organizational culture in the Middle East could be different from that of Western countries. Another reason could also be religion, where the Middle East needs to follow certain rules and regulations which may differ from Western countries. Finally, the third reason could be the collective nature of society.

Implications

The findings of this research study indicate that employee resilience, adaptive resilience, and planned resilience have a positive impact life satisfaction among hotels, hospitals, and other service sector employees. Psychological resilience, however, has shown unexpected results, showing a negative impact on employees' life satisfaction.

This research benefits the Ministry of Health and hospital staff by providing a clear plan for health facilities post-crisis, preparing them for future challenges of similar epidemics like COVID-19. It also offers decision-makers a better understanding of the factors affecting life satisfaction, enabling them to improve and develop a well-structured approach for handling unexpected crises and emergencies. The results directly impact employees in hotels, hospitals, and other service sectors by ensuring their motivation remains positive and their performance sustainable.

CONCLUSION

This research study has clarified the relationship and role of different types of resilience (employee, psychological, adaptive, and planned resilience) with life satisfaction. The finding indicates that the organization has to invest in organizational resilience, adaptive resilience, and planned resilience to enhance the employees' overall resilience and life satisfaction. An organization that supports preparing plans and processes to deal with any unexpected emergencies and crises and clear priorities on their employees' needs during these challenging times can be more resilient and survive any problematic situations. Finally, the Ministry of Health and the government of Oman can share the results and enhance the business community's improvement to continue their business through better and safer ways, i.e. shifting from normal and traditional modes to innovative and online services to save their growing diversified economy.

Limitations and future research

This research study has a few limitations. Geographical location is considered to be the most important limitation of this study. The sample taken to participate in this research study was mainly from Suhar city in Al-Batinah North. Hence, this research study might not be similar and linked to employees outside Suhar City. Another limitation could be that the factors used in this research study (employee, psychological, adaptive, and planned resilience) were selected based on previous studies related to different sectors like tourism. We may consider some other factors as well in future research.

Additionally, this research study depended only on one method to gather the information and data required to link life satisfaction and other resiliencies (employee resilience, psychological resilience, adaptive resilience, and planned resilience), which is the questionnaire. In future research, we may consider having mixed-method or multiple-method cases. Having mixed methods can enable the researcher to validate each factor's effect on life satisfaction deeply. Finally, as the Pandemic of COVID 19 is still new to the world, research and studies on the same topic are rare and limited in Oman and globally. These study limitations can offer opportunities for future research on the same issues and factors.

ACKNOWLEDGEMENT

Author thanks the Ministry of Higher Education, Research, and Innovation (MOHERI) for the support provided by grant SU/BFP/GRG/2020/03.

REFERENCES

- Baldwin, R., & Tomiura, E. (2020). Thinking ahead about the trade impact of COVID-19. *Economics in the Time of COVID-19*, 59.
- Beuren, I. M., dos Santos, V., & Theiss, V. (2022). Organizational resilience, job satisfaction and business performance. *International Journal of Productivity and Performance Management*, 71(6), 2262-2279.
- Cao, W., Fang, Z., Hou, G., Han, M., Xu, X., Dong, J., & Zheng, J. (2020). The psychological impact of the COVID-19 epidemic on college students in China. *Psychiatry Research*, 287, <https://doi.org/10.1016/j.psychres.2020.112934>
- Carruthers, C. P., & Hood, C. D. (2004). The power of the positive: Leisure and well-being. *Therapeutic Recreation Journal*, 38(2), 225.
- Frobies (2020), Can Coronavirus and Oil Price War Crisis Take Union Pacific Stock Below \$100? Available at <https://www.forbes.com/sites/greatspeculations/2020/04/21/can-coronavirus-and-oil-price-war-crisis-take-union-pacific-stock-below-100/#227244ca2882>
- Hellewell, J., Abbott, S., Gemma, A., Bosse, N. I., Jarvis, C. I., Russell, T. W., ... & Flasche, S. (2020). Feasibility of controlling COVID-19 outbreaks by isolation of cases and contacts. *The Lancet Global Health*. [https://doi.org/10.1016/S2214-109X\(20\)30074-7](https://doi.org/10.1016/S2214-109X(20)30074-7)
- Hobfoll, S. E. (1989). Conservation of Resources: A New Attempt at Conceptualizing Stress. *American Psychologist*, 44(3), 513-524.
- Kraemer, H. C., Kazdin, A. E., Offord, D. R., Kessler, R. C., Jensen, P. S., & Kupfer, D. J. (1997). Coming to terms with the terms of risk. *Archives of general psychiatry*, 54(4), 337-343.
- Masten, A. S. (2001). Ordinary magic: Resilience processes in development. *American psychologist*, 56(3), 227.
- Masten, A. S. (2002). Resilience comes of age. In *resilience and development* (pp. 281-296). Springer, Boston, MA.
- McKibbin, W. J., & Fernando, R. (2020). The global macroeconomic impacts of COVID-19: Seven scenarios. *Centre for Applied Macroeconomic Analysis: working paper*, Available at http://www.sensiblepolicy.com/download/2020/2020WorkingPapers/2020_19_CAMA_COVID19_mckibbin_fernando_0.pdf last accessed on May 12, 2020.
- Mellor, D., Hayashi, Y., Firth, L., Stokes, M., Chambers, S., & Cummins, R. (2008). Volunteering and well-being: Do self-esteem, optimism, and perceived control mediate the relationship? *Journal of Social Service Research*, 34(4), 61-70.
- Momtaz, Y., Hamid, T. A., Ibrahim, R., Yahaya, N., & Tyng Chai, S. (2011). Moderating effect of religiosity on the relationship between social isolation and psychological well-being. *Mental Health, Religion & Culture*, 14(2), 141-156.

- Oman Times (2020), Crude Oil Production Falls by 1.26 Percent in Jan. 2020 in the Sultanate, available at: <https://omannews.gov.om/NewsDescription/ArtMID/392/ArticleID/8339/Crude-Oil-Production-Falls-by-126-Percent-in-Jan-2020-in-the-Sultanate>
- Prayag, G., Spector, S., Orchiston, C., & Chowdhury, M. (2019). Psychological resilience, organizational resilience and life satisfaction in tourism firms: Insights from the Canterbury earthquakes. *Current Issues in Tourism*, 23(10), 1216-1233.
- Savage, Maddy. (2020, October 29). *WORKLIFE*. Retrieved November 16, 2020, from Coronavirus: The possible long-term mental health impacts: <https://www.bbc.com/worklife/article/20201021-coronavirus-the-possible-long-term-mental-health-impacts>
- Saleem, I., Hoque, S. M. S., Tashfeen, R., & Weller, M. (2023). The interplay of AI adoption, IoT edge, and adaptive resilience to explain digital innovation: evidence from German family-Owned SMEs. *Journal of Theoretical and Applied Electronic Commerce Research*, 18(3), 1419-1430.
- Schmid, L., Christmann, P., Oehrlein, A. S., Stein, A., & Thönnissen, C. (2024). Life satisfaction during the second lockdown of the COVID-19 pandemic in Germany: the effects of local restrictions and respondents' perceptions about the pandemic. *Applied Research in Quality of Life*, 19(2), 445-467.
- Tamarit, A., De la Barrera, U., Schoeps, K., Castro-Calvo, J., & Montoya-Castilla, I. (2023). Analyzing the role of resilience and life satisfaction as mediators of the impact of COVID-19 worries on mental health. *Journal of Community Psychology*, 51(1), 234-250.
- Torales, J., Barrios, I., Melgarejo, O., Ruiz Díaz, N., O'Higgins, M., Navarro, R., ... & Ventriglio, A. (2024). Hope, resilience and subjective happiness among general population of Paraguay in the post COVID-19 pandemic. *International Journal of Social Psychiatry*, 70(3), 489-497.
- Zakeri, M. A., Hossini Rafsanjanipoor, S. M., Zakeri, M., & Dehghan, M. (2021). The relationship between frontline nurses' psychosocial status, satisfaction with life and resilience during the prevalence of COVID-19 disease. *Nursing open*, 8(4), 1829-1839.

*CORRESPONDING AUTHOR

Ayoub Sulaiman Mohammed Al Kindy can be contacted at: ayoub@miscoman.com

CITATION

Al Kindy, A. S. M., (2025). Psychological and organizational resilience: Keys to life satisfaction in the service sector. *Sohar University Journal of Sustainable Business*, 1(1). 1-13.

FACTORS IN DETERMINING INFORMATION SYSTEMS DEVELOPMENT METHODOLOGIES: A SYSTEMATIC LITERATURE REVIEW

**Yahya Ateik Al-Sagheer Saeed¹, Zahidah Binti Zulkifli^{1*}, Sumaia Binti Shikh Nasir¹
and Wani Bilal Ahmed¹**

*¹Kulliyah of Information and Communication Technology, International Islamic University
Malaysia, Kuala Lumpur, Malaysia*

ABSTRACT

Choosing the appropriate Software Development Life Cycle (SDLC) methodology is a complex task for many firms and software engineers. The challenge arises not only from a lack of understanding of the criteria needed to select a methodology that adds value to the firm but also from a limited recognition that a methodology can be applicable across multiple life cycle models. This study aims to identify the critical factors influencing the choice of Information Systems (IS) methodologies for development projects. To address this, we conducted a systematic literature review (SLR), adapting a mapping study process from existing guidelines to categorize and structure the research evidence published in the field of IS methodologies. Our synthesis of 36 relevant papers identified four key factors influencing the selection of IS development methodologies: (1) Security, (2) Quality, (3) Communication, and (4) Test Cases. These findings provide a valuable framework for selecting appropriate IS development methodologies, focusing on factors that can serve as benchmarks for making informed choices. Furthermore, the ongoing digital transformation, accelerated by the 2020 pandemic, has underscored the urgency of integrating robust IS methodologies, particularly in the context of higher education institutions, which have swiftly shifted towards online learning and digital student services.

Keywords: Information System Development, Systematic literature review

Paper Type: Research paper

INTRODUCTION

The reliance on information systems has surged over the past decades, driven by advancements in computing and communication technologies. (Liu, 2021) This sector's growing significance has prompted continuous enhancements in system development methods and techniques.

(Nikolaieva, n.d.) are employed to streamline system development in alignment with project requirements. (Alsaqqa, 2020). However, the process of choosing the most suitable methodology can be complex and requires careful consideration of multiple factors to make an informed decision. This study aims to identify the key factors influencing the selection of information systems development methodologies for project execution. (Barbara Kitchenham, Stuart M. Charters, 2007).

BACKGROUND OF THE STUDY

Information system development methodologies vary significantly between large-scale projects that require precise tracking of each development stage and small to medium-sized projects that focus primarily on critical development phases. The rise of agile software development has brought attention to lightweight methodologies that are tailored to specific types of projects and organizations involved in information system development. Despite this, numerous factors can contribute to the failure of information systems, whether these factors act in combination or individually (Gunawardhana & Perera, 2015). A major contributing factor to these failures is a lack of understanding, which can create significant problems and ongoing obstacles in information system development projects (Hart & Warne, 2007). Uwadia et al. (2006) reported that up to 25% of large systems development projects were canceled, 60% encountered cost overruns, 75% faced quality issues, and less than 1% of projects were completed on schedule.

The challenge lies in selecting an information system development methodology that aligns with the specific needs of the development firm and the nature of its projects. Firms often lack the necessary knowledge and experience to effectively evaluate and choose from the various available methodologies. Frequently, decisions are based on the recommendations of consulting firms that may promote their proprietary methodologies, leading to the selection of methodologies that are only partially suitable. This approach is a critical factor in the low adoption rates of information system development methodologies among development firms. For instance, it has been found that 60% of firms do not utilize any specific development methodology, and only 6% adhere strictly to a chosen methodology. This highlights a significant gap in the effective application of development methodologies, which can undermine project success and organizational efficiency.

METHODS

A systematic literature review (SLR) is a method of inquiry that meticulously evaluates all existing research evidence to provide reliable answers to specific research questions or issues (Salleh, 2011). The primary aim of an SLR is to produce a scientific synthesis of the evidence within a given area (Salleh, 2011). Unlike traditional narrative reviews, an SLR delves deeper into the literature to retrieve and analyze fact-based evidence. Since the 1990s, this method has gained popularity as a research methodology, particularly in medical research, where several well-established standards have been developed to support its application (Babar, 2009). The present study's SLR is structured around three main phases: planning, conducting, and reporting the

review. Our approach adheres to the guidelines well-established in the existing literature (Barbara et al., 2007; Vale, 2017).

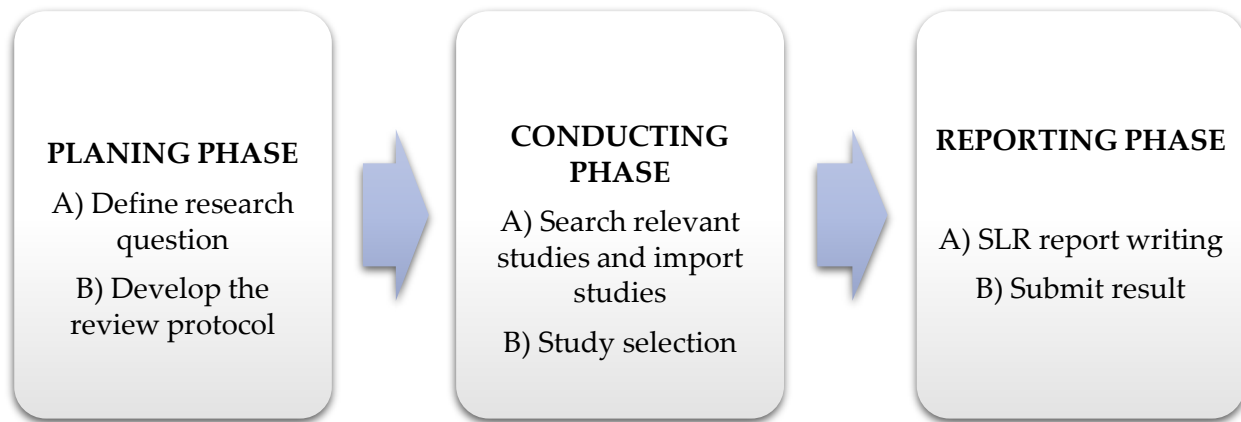


Figure 1: Mapping study process

Planning phase

The planning review is the initial phase of a systematic literature review (SLR), focusing on defining the mapping study protocol, which outlines the systematic activities for gathering and collecting information (Vale, 2017). The starting point of the SLR is to identify and formulate the research question, which is then documented in the review protocol.

Research Questions

The primary objective of formulating the research question is to guide the identification of relevant literature, determine the data to be extracted from selected studies, and establish the parameters for evaluation. This systematic literature review (SLR) specifically aims to identify the key factors for selecting appropriate Information System development methodologies. Consequently, this study focuses on systematically analyzing previous research contributions on Information Systems Methodologies published between 2017 and 2021.

RQ: What are the factors when choosing Information Systems Methodologies for Information system development projects?

Develop the Review protocol

After formulating the research question for the systematic literature review (SLR), the PICOC criteria were applied to further refine it. The PICOC framework—Population, Intervention, Comparison, Outcome, and Context—was used to break down the research question into distinct elements, which were then separated by commas. This approach enables the terms to be saved separately as keywords, facilitating the design of an effective search string for the literature review.

Table 1. Summary of PICOC

Population	Information Systems Development
Intervention	Methodologies
Comparison	N/A
Outcome	Factors
Context	Information system development projects

Table 2. Keywords and Synonyms

Keyword	Synonyms	Related to
Factors	Characteristics Considerations Criteria Specifications	Outcome
Information Systems Development	Application Development Software Development Systems Development	Population
Methodologies	Method Methodology Techniques	Intervention
N/A		Outcome

To derive effective search terms for a study, one should follow a systematic process. First, it is essential to formulate the research question using the PICOC framework, which includes defining the Population, Intervention, Comparison, Outcome, and Context related to the study. This framework helps in structuring a clear and focused research question. Next, identify the key terms from this research question that will serve as the foundation for designing the search string. Following this, list synonyms and alternative terms for each keyword to ensure comprehensive coverage of the topic. This step is crucial for capturing all relevant literature, even if different terminology is used. Once the synonyms and alternative terms are identified, they should be combined using the Boolean operator "OR." This operator connects all possible variations of each keyword, such as "Information Systems" OR "IS," expanding the search to include all relevant documents. Finally, the main keywords and their synonyms should be linked using the Boolean operator "AND." This ensures that the search string incorporates all major aspects of the research question, for example, "Information Systems" AND "Development Methodologies," thereby focusing the search results on studies that address the complete scope of the research inquiry.

Conducting Phase

Searching relevant studies: According to Kitchenham and Charters (2007) a systematic literature review (SLR) requires an exhaustive and in-depth process to identify all relevant previous studies comprehensively. This meticulous approach ensures that the research questions (RQs) are thoroughly addressed. In this section, we describe the review strategies designed to retrieve relevant studies systematically. For the automatic search process, we used a carefully constructed search string with appropriate search terms.

("Information Systems Development" OR "Application Development" OR "Software Development" OR "Systems Development") AND ("Methodologies" OR "Method" OR "Methodology" OR "Techniques") AND ("N/A") AND ("Factors" OR "Characteristics" OR "Considerations" OR "Criteria" OR "Specifications")

This study utilized three prominent digital libraries—Scopus, IEEE Digital Library, and ProQuest—to identify relevant research in the field of criteria for selecting information systems development methodologies. Specific combinations of keywords were generated and searched across these databases. These platforms were selected for their established reputations as multidisciplinary study repositories, encompassing a wide range of peer-reviewed journals and maintaining up-to-date content. Table 3 below presents the imported studies.

Table 3: Imported studies

Database	Number of Imported studies
Scopus	128
IEEE Digital Library	58
ProQuest	77

Selection Strategy : To address the research question of this study and identify relevant primary studies on criteria for selecting information system development methodologies, a systematic selection process was employed. This process includes both inclusion and exclusion criteria tailored to the research question.

The researcher established specific selection criteria to ensure the relevance and quality of the papers included in the study. The inclusion criteria mandate that papers must be within the fields of computer science and software design. Additionally, the papers must originate from conferences, journals, dissertations, or theses to ensure academic rigor and credibility. Only open-access papers are considered to facilitate unrestricted availability. Moreover, the selected papers must be published between 2017 and 2021 to ensure the research is current and reflects recent advancements in the field.

Conversely, the exclusion criteria specify that any papers not written in English are to be omitted from the study. This language restriction ensures that the researcher can accurately interpret and analyze the content without language barriers.

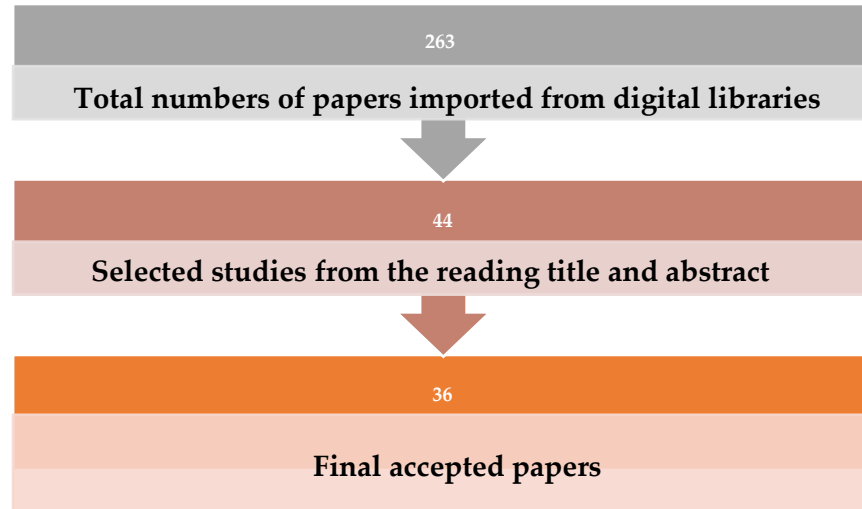


Figure 2: paper selection process

Figure 2 illustrates the paper selection process employed in this study. Content-level filtration involved applying inclusion and exclusion criteria to include papers from the fields of computer science and software design, sourced from conferences, journals, dissertations, and theses. Additionally, papers with open access published between 2017 and 2021 were considered, while non-English papers were excluded. Initially, 263 papers were imported from digital libraries. After reviewing titles and abstracts, 44 papers met the criteria. Upon further scrutiny, 8 duplicate papers were identified, resulting in a final selection of 36 papers.

Reporting phase

SLR results: This section synthesizes the evidence by analyzing the extracted data from the literature search results. The systematic literature review (SLR) identified key factors that significantly influence Information System Development Methodologies. Table 5 presents a comprehensive list of these influential factors.

RQ: *What are the factors when choosing Information Systems Methodologies for Information system development projects?*

Table 4: List of Factors

No.	Factors	Studies	Total studies
1	Security	S2, I8, P2, P4, P6, P8, P12	7
2	Quality	I2, I3, I10, P9	4
3	Communication	S4, I13, I15	3
4	Test cases	S1, S6, S7	3

The study revealed consensus among authors that security has the most significant impact on the selection of system methodologies. Specifically, "Security" was identified as the most frequently studied factor influencing methodology selection (mentioned in 7 papers), followed by "Quality"

(discussed in 4 papers), "Communication" (mentioned in 3 papers), and "Test Cases" (also covered in 3 papers). Table 6 provides definitions for each of these factors.

Table 5: Factors Definitions

No.	Factors	Definition
F1	Security	To identify, mitigate, and avoid security threats to software and data assets
F2	Quality	Describes the customer satisfaction as well as development organization. While determining the customer satisfaction, a triangle that consists of the time, budget, and customer expectation requirements is considered. Thus, from an organizational viewpoint, another triangle of workflow, goodwill, and business is considered.
F3	Communication	The act of transmitting information between individuals
F4	Test cases	Test scenario measuring functionality across a set of actions or conditions to verify the expected result.

List of selected papers: As part of the study selection process, a total of 263 papers were initially imported from digital libraries. Of these, 255 papers proceeded to the data extraction phase. During this phase, the inclusion and exclusion criteria were applied to refine the selection. Specifically, papers not written in English and those unrelated to System Development Methodologies (SDM) were excluded. This rigorous filtering process resulted in 36 studies being accepted for final analysis. The complete list of all included papers is provided as an appendix.

DISCUSSION

The purpose of this systematic literature review (SLR) was to identify SDLC being practiced despite the fact that there are lot of software development models available, from the SLR we found out the most essential ones, such as Waterfall and Agile methodologies. Until date, the waterfall approach has been the most often utilized in software development. According to many in the software industry, the waterfall model has been the dominant in past and is being still practiced. However, the Agile techniques are developing and making firms switch from the old waterfall model to agile methods. Projects that need a high level of usability tend to employ conventional approaches in the early stages since the client specifies these needs. As a result, all new initiatives are based on the needs of usability. Even said, conventional software development techniques are not best suited for today's fast changing environment, which excludes the possibility of using agile approaches. However, there are certain issues with integrating Agile methodologies and usability at the same time.

The result of the SLR shows that most of the researchers focused Security, Quality Assurance, developing different frameworks and Study shows most of them likely to use Agile Methodology. In fact, Agile methodologies and usability have more in common than you may think. They both

follow the cyclic development approach and user centric design, and they both place a strong emphasis on team co-ordination and communication. Despite the fact that they have a shared goal, there are numerous areas of disagreement and disagreement that might impede the progress of the project. Agile techniques thrive on achieving continuous engagement between developers and customers in order to generate excellent software, while Usability methods thrive on achieving continuous interaction between developers and users in order to develop good software. Consequently, an agile technique might overlook numerous chances for end-users if customers lack a clear grasp of the end-users. Following the introduction of agile methodologies, the process becomes straightforward and quick to implement by identifying and correcting design problems immediately following implementation. Agility is a way of working where changes are made often. There are a variety of questions and design problems from different departments that the developers must address before the process can go forwards successfully. The developers and usability testers collaborate to identify the appropriate level of test coverage for the application. Agile techniques may be successfully used for projects that are currently being done using conventional methods.

"Software Requirements Specification" is used in the classic waterfall paradigm (SRS). As soon as the SRS is implemented by the designers, they may begin working on new projects. As a result, client feedback and interactions are completely ignored, resulting in substantial losses if the project fails. Their job is to design based on user needs. Waterfall is a "over the fence" strategy. A system where the user expresses their needs and receives the product in a timely manner. Customers have a hard time defining software needs if they don't know how things have changed and progressed. The client is at the core of the agile development approach, while with agile methods the customer may add additional requirements throughout the development process. Throughout the whole development process, the clients are accessible.

CONCLUSION

In this paper, we perform a systematic literature review on the different Software Development Life Cycles, as a result of this SLR, new ideas about software development and usability might be generated. It is based on Barbara Kitchenham's systematic literature review technique. A successful project can be seen from the findings and discussion of this research, which shows that agile development methodologies are being used with usability. The product's price may even be reduced via the use of cutting-edge usability approaches like "Discount Usability."

Because of a set of standards that assist in incorporating usability into agile techniques, agile methods have been shown to favourably contribute to the usability of a product. In this paper, it is advocated for a combined strategy in which agile methodologies and usability engineering may be applied with the greatest amount of correlation possible.

REFERENCES

- Abrar, M. F., Khan, M. S., Ali, S., Ali, U., Majeed, M. F., Ali, A., Amin, B., & Rasheed, N. (2019). Motivators for large-scale agile adoption from management perspective: A systematic literature review. *IEEE Access*.
- Aizaz, F., Khan, S. U. R., Khan, J. A., Inayat-Ur-Rehman, & Akhunzada, A. (2021). An empirical investigation of factors causing scope creep in agile global software development context: A conceptual model for project managers. *IEEE Access*.
- Akbar, M. A., Sang, J., Khan, A. A., Amin, F.-E., Nasrullah, Hussain, S., Sohail, M. K., Xiang, H., & Cai, B. (2018). Statistical analysis of the effects of heavyweight and lightweight methodologies on the six-pointed star model. *IEEE Access*.
- Akbar, M. A., Sang, J., Khan, A. A., Fazal-E-Amin, Nasrullah, Shafiq, M., Hussain, S., Hu, H., Elahi, M., & Xiang, H. (2018). Improving the quality of software development process by introducing a new methodology–AZ-Model. *IEEE Access*.
- Alzoubi, Y. I., & Gill, A. Q. (2020). An empirical investigation of geographically distributed agile development: The agile enterprise architecture is a communication enabler. *IEEE Access*.
- Arrey, D. A. (2019). Exploring the integration of security into software development life cycle (SDLC) methodology (Order No. 13428588). Available from ProQuest One Academic; SciTech Premium Collection. (2191192923).
- Aslam, W., & Ijaz, F. (2018). A quantitative framework for task allocation in distributed agile software development. *IEEE Access*.
- Babar, M. Z. (2009). Systematic literature reviews in software engineering: Preliminary results from interviews with researchers. In 3rd International Symposium on Empirical Software Engineering and Measurement (pp. 346-355).
- Bajaj, A., & Sangwan, O. P. (2019). A systematic literature review of test case prioritization using genetic algorithms. *IEEE Access*.
- Kitchenham, B., & Charters, S. M. (2007). Guidelines for performing systematic literature reviews in software engineering. Keele University and Durham University Joint Report.
- Campbell, J. (2019). Exploring The Strategies Software Developers Need to Maintain Security Requirements During Agile Development Processes. Doctoral dissertation. Colorado Technical University.
- Cvetkovic, N., Morača, S., Jovanović, M., Medojević, M., & Lalić, B. (2017). Enhancing the agility and performances of a project with lean manufacturing practices. In *Annals of DAAAM and Proceedings of the International DAAAM Symposium* (pp. 661-670). Danube Adria Association for Automation and Manufacturing, DAAAM.
- Dar, H., Lali, M. I., Ashraf, H., Ramzan, M., Amjad, T., & Shahzad, B. (2018). A systematic study on software requirements elicitation techniques and its challenges in mobile application development. *IEEE Access*.
- De Silva, I. J. (2019). A Framework to Evaluate Candidate Agile Software Development Processes. Doctoral dissertation. University of Minnesota.
- Gunawardhana, D. N. T., & Perera, C. (2015). Classification of failure factors in information systems. *International Journal for Innovation Education and Research*, 3(11).

- Fasano, J. W. (2020). Agile Software Development Practices for Customer Service and Support Doctoral dissertation. Capella University.
- Fernández-Diego, M., Méndez, E. R., González-Ladrón-De-Guevara, F., Abrahão, S., & Insfran, E. (2020). An update on effort estimation in agile software development: A systematic literature review. *IEEE Access*.
- Horton, S. (2020). Are software security issues a result of flaws in software development methodologies?(Order No. 27962083). Available from ProQuest One Academic. (2405158801).
- Johnston, R. A. (2018). A multivariate Bayesian approach to modeling vulnerability discovery in the software security lifecycle. The George Washington University.
- Jose, C. R. (2020). Exploring security process improvements for integrating security tools within a software application development methodology. [Unpublished dissertation or thesis].
- Khan, R. A., Khan, S. U., Khan, H. U., & Ilyas, M. (2021). Systematic mapping study on security approaches in secure software engineering. *IEEE Access*.
- Khatibsyarbini, M., Isa, M. A., Jawawi, D. N. A., & Hamed, H. N. A., & Mohamed Suffian, M. D. (2019). Test case prioritization using firefly algorithm for software testing. *IEEE Access*.
- Kipreos, M. (2019). The impact of leadership style on the adoption of agile software development: A correlational study. [Unpublished dissertation or thesis].
- Kochhar, P. S., Xia, X., & Lo, D. (2019). Practitioners' views on good software testing practices. In *Proceedings - 2019 IEEE/ACM 41st International Conference on Software Engineering: Software Engineering in Practice, ICSE-SEIP 2019* (pp. 61-70). Institute of Electrical and Electronics Engineers Inc.
- Liu, S. (2021, October 22). Information technology (IT) spending on enterprise software worldwide. Retrieved from Statista: <https://www.statista.com/statistics/203428/total-enterprise-software-revenue-forecast/>
- Lunesu, M. I., Tonelli, R., Marchesi, L., & Marchesi, M. (2021). Assessing the risk of software development in agile methodologies using simulation. *IEEE Access*.
- Pawaskar, S. (2014). Maximizing the Performance of Agile Teams for IoT Development. Retrieved from Bepress [works.bepress.com]
- Nikolaieva, A. (n.d.). 8 best software development methodologies. Retrieved from Uptech: <https://www.uptech.team/blog/software-development-methodologies>
- Patel, S. (2021). Dynamic modeling of the effectiveness of software development methods on DoD programs (Order No. 28716962). Available from ProQuest Central; ProQuest One Academic; Publicly Available Content Database. (2572595494).
- Rindell, K., Ruohonen, J., Holvitie, J., Hyrynsalmi, S., & Leppänen, V. (2021). Security in agile software development: A practitioner survey. *Information and Software Technology*.
- Salleh, N. M. (2011). Empirical studies of pair programming for CS/SE teaching in higher education: A systematic literature review. *IEEE Transactions on Software Engineering*, 37(4), 509–525.
- Alsaqqa, S., Sawalha, S., & Abdel-Nabi, H. (2020). Agile software development: Methodologies and trends. *International Journal of Interactive Mobile Technologies (ijIM)*, 14(25).

- Sami, M. (2012, March 21). Choosing the right software development life cycle model. Retrieved from Melsatar: <https://melsatar.blog/2012/03/21/choosing-the-right-software-development-life-cycle-model/>
- Santolucito, M. (2020). A Modular Synthesis Framework for Software Deployment, Design, and Implementation. Doctoral dissertation. Yale University.
- Saraiva, R., Medeiros, A., Perkusich, M., Valadares, D., Gorgônio, K. C., Perkusich, A., & Almeida, H. (2020). A Bayesian networks-based method to analyze the validity of the data of software measurement programs. IEEE Access.
- Sarwar, A., Hafeez, Y., Hussain, S., & Yang, S. (2020). Towards taxonomical-based situational model to improve the quality of agile distributed teams. IEEE Access.
- Taaibosch, S. (2017). Factors influencing the transition to Agile software development M.Com Thesis. University of Johannesburg.
- Tran, H. K. V., Unterkalmsteiner, M., Börstler, J., & Ali, N. B. (2021). Assessing test artifact quality – A tertiary study. Information and Software Technology.
- Tunio, M. Z., Luo, H., Cong, W., Fang, Z., Gilal, A. R., Abro, A., & Shao, W. (2017). Impact of personality on task selection in crowdsourcing software development: A sorting approach. IEEE Access.
- Uwadia, C. O., Ifinedo, P. E., Nwamarah, G. M., Eseyin, E. G., & Sawyerr, A. (2006). HEof management information systems for Nigerian universities. Information Technology for Development, 12(2), 91-111.
- Vale, T. D. (2017). Software product lines traceability: A systematic mapping study. Information and Software Technology, 84, 1–18.
- Van Wyk, L. (2018). A framework to measure the value of agile software projects. M.Com Thesis. University of Johannesburg.
- Venkatesh, V., Thong, J. Y. L., Chan, F. K. Y., Hoehle, H., & Spohrer, K. (2020). How agile software development methods reduce work exhaustion: Insights on role perceptions and organizational skills. Information Systems Journal.
- Wang, J., Wang, Z., & Li, J. (2018). A recommendation method for social collaboration tasks based on personal social preferences. IEEE Access.
- Younas, M., Jawawi, D. N. A., Mahmood, A. K., Ahmad, M. N., Sarwar, M. U., & Idris, M. Y. (2020). Agile software development using cloud computing: A case study. IEEE Access.
- Yu, D., Zhou, Z., & Wang, Y. (2020). Crowdsourcing software task assignment method for collaborative development. IEEE Access.

***CORRESPONDING AUTHOR**

Yahya Ateik Al-Sagheer Saeed can be contacted at: yahya.ateik@live.iium.edu.my

CITATION

Saeed, Y. A. A., Zulkifli, Z. B., Nasir, S. B. S., Ahmed, W. B. (2025). Factors in determining information systems development methodologies; A systematic literature review. *Sohar University Journal of Sustainable Business*, 1(1). 1-16.

Appendix: List of Papers

Code	Papers	Factors
S1	Assessing test artifact quality—A tertiary study	Central artifacts in software testing (Tran et al., 2021)
S2	Security in agile software development: A practitioner survey	Security Engineering Security design (Rindell et al., 2021)
S3	How agile software development methods reduce work exhaustion: Insights on role perceptions and organizational skills	Unambiguous role perceptions and thereby (Venkatesh et al., 2020)
S4	An Empirical Investigation of Geographically Distributed Agile Development: The Agile Enterprise Architecture is a Communication Enabler	Active communication efficiency communication effectiveness (Alzoubi and Gill, 2020)
S5	Agile Software Development Using Cloud Computing: A Case Study	Agile Development and Cloud Computing (ADCC) framework (Younas et al., 2020)
S6	Practitioners' Views on Good Software Testing Practices	Test cases (Kochhar et al., 2019)
S7	Test Case Prioritization Using Firefly Algorithm for Software Testing	Automated test case classification automated prioritization of system test cases (Khatibsyarbini et al., 2019)
S8	Enhancing the agility and performances of a project with lean manufacturing practices	Lean Kanban manufacturing principles (Cvetkovic et al., 2017)
I1	Statistical Analysis of the Effects of Heavyweight and Lightweight Methodologies on the Six-Pointed Star Model	Lightweight methodologies for small-scale projects, heavyweight methodologies for medium and large-scale projects (Akbar et al., 2018)
I2	Improving the Quality of Software Development Process by Introducing a New Methodology—AZ-Model	Quality (Akbar et al., 2018)
I3	A Systematic Study on Software Requirements Elicitation Techniques and its Challenges in Mobile Application Development	Quality assessment criteria, time and cost factors, resource effectiveness, domain understanding, applicability (Dar et al., 2018)
I4	Motivators for Large-Scale Agile Adoption From Management Perspective: A Systematic Literature Review	Quick delivery of software products with minimal cost and user satisfaction (Akbar et al., 2019)

I5	An Update on Effort Estimation in Agile Software Development: A Systematic Literature Review	Team and project factors (Fernández-Diego et al., 2020)
I6	Assessing the Risk of Software Development in Agile Methodologies Using Simulation	Risk factors (Lunesu et al., 2021)
I7	An Empirical Investigation of Factors Causing Scope Creep in Agile Global Software Development Context: A Conceptual Model for Project Managers	Ability to manage and control the change elements (Aizaz et al., 2021)
I8	Systematic Mapping Study on Security Approaches in Secure Software Engineering	Software security measures (Khan et al., 2021)
I9	A Bayesian Networks-Based Method to Analyze the Validity of the Data of Software Measurement Programs	Trustworthiness (Saraiva et al., 2020)
I10	A Systematic Literature Review of Test Case Prioritization Using Genetic Algorithms	Quality and reliability (Bajaj et al., 2019)
I11	A Quantitative Framework for Task Allocation in Distributed Agile Software Development	Task allocation to team members (Aslam et al., 2018)
I12	Impact of Personality on Task Selection in Crowdsourcing Software Development: A Sorting Approach	Personality on task selection (Tunio et al., 2017)
I13	Crowdsourcing Software Task Assignment Method for Collaborative Development	Developer collaboration (Yu et al., 2020)
I14	Towards Taxonomical-Based Situational Model to Improve the Quality of Agile Distributed Teams	Situational factors (Sarwar et al., 2020)
I15	A Recommendation Method for Social Collaboration Tasks Based on Personal Social Preferences	Social-collaboration tasks (Wang et al., 2018)
P1	Agile Software Development Practices for Customer Service and Support	Agile software development practices (Fasano & John, 2020)
P2	Are Software Security Issues a Result of Flaws in Software Development Methodologies?	Software Security (Horton & Sandra, 2020)

P3	A Framework to Measure the Value of Agile Software Projects	Agile software development practices (Van Wyk & Louis, 2018)
P4	Exploring The Strategies Software Developers Need to Maintain Security Requirements During Agile Development Processes	Software Security (Campbell & John, 2019)
P5	A Modular Synthesis Framework for Software Deployment, Design, and Implementation	Framework Development (Santolucito & Mark, 2020)
P6	A Multivariate Bayesian Approach to Modeling Vulnerability Discovery in the Software Security Lifecycle	Software Security (Johnston et al., 2018)
P7	Dynamic Modeling of the Effectiveness of Software Development Methods on DoD Programs	Evaluating Different Software methodologies for DoD programs (Patel & Shirali, 2021)
P8	Exploring Security Process Improvements for Integrating Security Tools within a Software Application Development Methodology	Software Security (Jose & Crispin, 2020)
P9	Factors Influencing the Transition to Agile Software Development	Software Quality (Taaibosch & Shari, 2017)
P10	The Impact of Leadership Style on the Adoption of Agile Software Development: A Correlational Study	Evaluating Different Software methodologies (Kipreos & Mike, 2019)
P11	A Framework to Evaluate Candidate Agile Software Development Processes	Project Cost and Risk (De Silva & Ian, 2019)
P12	Exploring the Integration of Security into Software Development Life Cycle (SDLC) Methodology	Software Security (Arrey et al., 2019)
P13	Maximizing the Performance of Agile Teams for IoT Development	Agile and IOT development (Moedt & Wouter, 2019)

AGILE METHODOLOGIES FOR PROJECT SUCCESS: EXPLORING THE ROLE OF INNOVATION AND MANAGEMENT SUPPORT

Waseem Haider^{1*}, Noor Ahmad^{2*} and Naseebullah²

¹Faculty of Management, University Teknologi Malaysia, Johor, Malaysia.

²University College of Zhob, Balochistan University of Information Technology, Engineering and Management Sciences (BUITEMS), Quetta, Pakistan

ABSTRACT

This study explores the role of Agile methodologies in achieving a higher project success rate. Additionally, we sought to determine the extent to which management support influences the effectiveness of Agile techniques in project success. Moreover, our study looks into the influence of project innovation on project success and explores strategies to enhance its effect. Using a qualitative approach, data were collected from Agile administrators working in various project-based organizations. A total of 15 organizations across Pakistan participated in this study. Our research demonstrates that Agile methodologies promote innovation, which in turn enhances the success of projects. Our results revealed that the Agile methodology is a major contributor to project success and prioritizes finding early solutions to problems. We emphasize the vital importance of project innovation and management support in raising a project's overall success. The findings of this study provide valuable implications for practitioners and recommend several new insights for theory development.

Keywords: Project success, agile methodology, management support, innovation, qualitative

Paper Type: Research paper

INTRODUCTION

Organizations are adopting Agile techniques as a strategic approach to improve project success in today's dynamic and competitive business climate. Agile methods deviate from traditional, rigid approaches by prioritizing flexibility, adaptability, and response to changing requirements (Cockburn and Highsmith 2001, Gislén 2016). Agile approaches facilitate the iterative and incremental delivery of value, allowing teams to provide products or services that effectively address changing customer needs and market expectations. Agile approaches not only enable efficient project execution but also cultivate a culture of creativity within enterprises. In Agile, innovation encompasses not only technological developments but also new management

techniques and operational approaches that have a substantial impact on project outcomes (Bindrees et al., 2014). Agile frameworks foster a mentality of experimentation, swift validation of concepts, and rapid adjustment to market realities, so bolstering an organization's capacity to remain competitive and fulfil customer expectations.

A key factor in effectively implementing Agile techniques is strong managerial support. Leadership is crucial in establishing a climate conducive to the successful implementation of Agile concepts. Efficient managerial assistance guarantees that teams are given authority, communication channels are kept accessible, and stakeholders are actively involved in decision-making procedures (Highsmith and Cockburn 2001). This conducive atmosphere ensures that project objectives are in line with the overall goals of the firm, making it easier to implement and maintain Agile processes. This study article seeks to investigate the interconnections of Agile techniques, innovation, and managerial support to enhance project success. This study aims to discover the crucial success elements and best practices linked to Agile project management by analysing case studies and empirical research. This research provides useful insights to both theory and practice by analysing how firms utilize Agile frameworks to improve innovation capabilities and create exceptional project results.

Agile methodologies have become prominent because they are capable of providing concrete advantages in project management. Agile approaches, in contrast to traditional waterfall methods, advocate for an iterative and collaborative approach to project execution rather than a linear and sequential one (Mahnica & Drnovsek 2005). Agile approaches, such as Scrum and Kanban, prioritize ongoing improvement, collaborative cooperation, and customer involvement across the whole project lifecycle. An essential benefit of Agile techniques is their capacity to effectively adapt to change. Agile teams are more capable of adapting and adjusting their approach in real-time in the current unpredictable business climate, where market conditions and client preferences can change rapidly (Serrador & Pinto 2015). This adaptability not only mitigates potential project hazards but also improves the overall excellence of outcomes by enabling teams to integrate feedback and make necessary adjustments.

Moreover, Agile approaches facilitate openness and clarity throughout projects. Agile teams establish effective communication channels and keep all stakeholders informed about project progress and difficulties through activities including daily stand-up meetings, sprint reviews, and retrospectives (Heimicke et al., 2019). Transparency promotes trust and collaboration within teams, allowing them to work together harmoniously towards shared project objectives. In Agile techniques, innovation plays a fundamental role by fostering ongoing improvement and the generation of value. Agile frameworks promote the exploration of novel ideas, technologies, and processes in order to discover inventive solutions that fulfil client requirements (Serrador & Pinto, 2015). Agile enables teams to foster innovation by granting them the autonomy to swiftly explore and execute ideas, in contrast to conventional approaches that may hinder creativity with inflexible procedures and extensive paperwork. Furthermore, Agile techniques promote a culture of acquiring knowledge and adjusting accordingly. Agile teams, by accepting change as an inherent aspect of the development process, are more likely to actively pursue creative solutions and adopt new technologies that can improve project results

(Sharma et al., 2012). By adopting a proactive approach to innovation, firms may maintain a competitive edge and take advantage of emerging market opportunities.

Effective management support is crucial for the successful integration and execution of Agile techniques within enterprises. Leaders have a vital responsibility in establishing a setting that is conducive to the growth of Agile principles. This involves nurturing a culture that promotes cooperation, trust, and ongoing enhancement (Kuchel et al., 2022). Management support guarantees that Agile teams have the necessary resources, advice, and authority to continually provide value to stakeholders. Furthermore, the backing of management aids in the synchronization of project goals with the objectives of the business. Leaders facilitate Agile teams' ability to concentrate on delivering outputs that contribute to the overall performance of the firm by establishing distinct priorities and offering strategic guidance (Pichler 2006). This alignment guarantees that Agile projects are in sync with the business plan and actively contribute to the organization's long-term growth and sustainability.

Agile methodologies, innovation, and management support are essential elements for achieving project success in the current competitive corporate landscape. By adopting Agile principles, organizations can improve their capacity to adapt to change, cultivate a culture of creativity, and efficiently provide value to consumers. Efficient managerial assistance is crucial for establishing a conducive atmosphere that fosters the successful implementation of Agile methodologies, guaranteeing that teams are empowered and in sync with the objectives of the firm.

Organizations can achieve sustainable success and competitive advantage in the marketplace by comprehending the interaction between Agile techniques, innovation, and management support. Agile project management has had fast growth in popularity within the software industry in the last twenty years (Begel & Nagappan, 2007; Dingsøyr et al., 2012; Moe et al., 2010). Originally introduced as a substitute for conventional, specification-based approaches like waterfall, agile techniques - which encompass the fundamental ideals and concepts of agile software development - have quickly gained widespread acceptance in software businesses globally (Stavru, 2014). Their widespread adoption is often credited to their capacity to adapt to quickly evolving corporate needs, technologies, and market circumstances (Augustine et al., 2005).

Agile methodologies prioritize the significance of a cooperative and human-centered approach to software development (Fowler & Highsmith, 2000). As a result, agile methodologies brought about various modifications in the roles and practices of traditional software development. The primary responsibility of the manager or scrum master in agile projects is to exhibit adaptable leadership (Augustine, 2005), support the process, eliminate obstacles, and inspire their teams (Chau & Maurer, 2003). This contrasts with the conventional function of a manager, which involves adopting a command-and-control style of management (Nerur et al., 2005).

The rest of the sections of the article are arranged as; section two covers relevant literature review, sections three illustrates research procedure, section four covers interviews and results, section five explain the discussion and section 6 concludes the article.

LITERATURE REVIEW

Agile methodologies and project success

Various parameters are used to evaluate the efficacy of information technology (IT) initiatives (Jennex 2006). Nevertheless, the challenges of achieving satisfactory success rates for these programs persist. It has been noted that thirty years of research on software-related projects have elapsed; however, the agile software progress procedure has emerged as a central, decisive, and leading procedure that is currently in use and has demonstrated its effectiveness in achieving project excellence. The software development industry is regarded as a critical component in achieving the project's objectives due to the influence of the agile approach. In the current dynamic business environment, it is becoming increasingly apparent to numerous organizations that the traditional methods are not as effective in ensuring that customers receive what customers desire. The majority of initiatives fail to achieve their intended level of success due to the fact that the final product is not as appealing as anticipated (Vijayasathiy & Turk 2012). Consequently, the relationship between the company and the consumer does not flourish; rather, it deteriorates. This scenario is not conducive to the success of any progressive organization, as customer satisfaction is the primary means of increasing productivity in the business sector (Conforto et al., 2014).

The agile approach is straightforward to implement, as it necessitates that the organization establish a work environment in which employees perceive their responsibility to become productive. There is a spotless environment in which to work and contribute ideas to the ongoing endeavor. Agile also allows the organization to engage in regular, face-to-face interactions with clients to ascertain their expectations regarding the project. The organization then endeavors to meet those expectations through regular iterations and working within the project's scope (Hoda et al., 2012).

Project innovation and project success

The conventional project management methodologies are insufficiently modernized to accommodate the reduced product life cycles and the continuous, rapid changes in requirements. The Agile project management approach, which is iterative and adoptive, is employed to resolve these changes. As the market for creativity continues to evolve in tandem with the accelerated advancement of technology, Agile is most frequently implemented in software enhancement businesses (Chin et al., 2012).

The Agile methodology employs innovative engineering techniques that prioritize software design from a human perspective. Agile aims to provide high-quality products at a rapid pace and to create satisfied consumers. For the past thirty years, the primary focus of research has been on the identification of software development variables that influence the project's objectives. In the realm of software development, the agile methodology has recently gained significant traction in its own research field (Alam et al., 2016).

An accelerated demand for the adaptability and use of agile methodologies has resulted from the dynamic developments in the information technology industry. In these environments and trends, organizations that implement agile procedures tend to enhance the objectivity of their initiatives (Rasnacis & Berzisa 2017).

Role of project innovation in agile project management

The software design industry has undergone a fundamental reevaluation of its strategies for improving its competitive edge. Organizations can engage with their consumers continuously to enhance their products and processes through the implementation of an agile approach (Waja et al., 2021). The agile project management method is a novel procedure, and a more effective solution is being devised using a creative, modern approach. The 21st-century project administration methodology known as Agile is frequently advocated. Employees are more adept at executing intricate tasks over brief periods than over extended periods (Rahul et al. 2023). By establishing a consistent pattern and repeating these brief intervals, the effectiveness is further enhanced. It is challenging to monitor progress or respond to changes over extended periods of time, as traditional project management operates in phases that last for several weeks or months. In addition, it necessitates time to accumulate new information and respond promptly to mitigate scheduling complications (Omonije, 2024). A change in the context in which software projects are managed to accomplish creative solutions is referred to as project progress. Project innovation is the process of fostering creativity within the project and also identifying the advancements for a new project based on previous experience (Sandstø & Reme-Ness, 2021).

Role of Management Support

Management support is a key factor that substantially impacts project outcomes in the context of agile project management. An analysis carried out among IT specialists in Pakistan highlights the crucial part that management support plays in the successful implementation of agile concepts and the ensuing success of projects. In the context of agile project management, the degree of assistance offered by management plays a major role in a project's success (Conforto and Amaral 2016). In a recent investigation, the majority of the contributors reported that their management teams provided significant encouragement for them to implement and support agile methodologies. Frequently, this assistance was provided through recurrent training sessions and seminars, which fostered a more adaptable environment and increased the level of innovation among employees. However, the survey also identified numerous issues with the assistance provided by management. These challenges encompassed the necessity of reporting frequently, the challenge of adjusting project costs and personnel, the inability of managers to comprehend the application of new techniques, and the necessity of monitoring multiple systems for changes. The study discovered that more productive efforts were the result of higher-quality commodities and more support from management, despite these restrictions. According to participants, administrators who implement agile methodologies significantly enhance project outcomes. The study also emphasized the importance of enhanced

communication and information sharing among project teams, co-managers, and administrators to expedite the development of new software. Completion of projects may be significantly more successful and creative when agile methodologies are implemented in conjunction with strong management support (Dorairaj et al., 2013).

Strong management support combined with agile approaches may lead to more creativity and project success (Conforto, Amaral et al. 2016). The results of this research indicate that senior management support is essential for cultivating a positive and innovative culture, which improves project success. Stated differently, it is imperative. The research suggests that enhancing team member and management communication might aid in closing the knowledge gap. Regular scheduling of meetings, training sessions, and workshops is necessary to ensure that all participants are informed on the latest agile practices and project developments. More creative and successful project outputs result from enhanced team dynamics and individual abilities in a dynamic learning environment.

To fully realise the potential of agile project management, it is necessary to establish a robust management team and enhance communication. A company's project success rate may increase because of an actively engaged management team and a concentration on open communication (Crowder and Friess 2015). The creative and growth-oriented initiatives of this partnership are rewarded with improved project outcomes and long-term organisational success. Additionally, it facilitates the efficient implementation of agile concepts. Management support is essential for the regulation of agile project management. The successful implementation of agile concepts necessitates the unwavering support of senior management. Innovation and excellence are promoted by the active participation and complete support of management in the agile process (Siakas and Siakas 2007).

In a supportive environment, the utilisation of agile methodologies is enhanced, leading to increased productivity and creativity among teams. Lastly, initiatives that are supported by a strong management team are more likely to be successful and completed to a high standard. Project management initiatives that receive the full support of senior management are more likely to establish a long-term environment that is conducive to innovation and development (Turner & Müller 2005). Figure 1 presents the flow chart of the study.

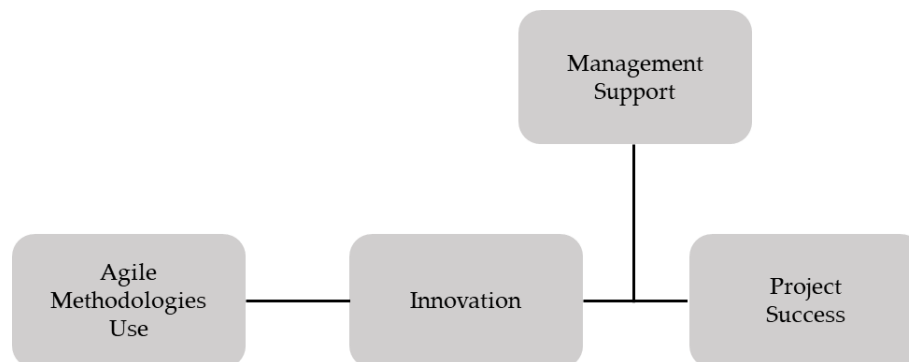


Figure 1: Study Flow Chart

METHODS

Scientific perspective and approach

The theoretical perspective of this paper is centered on positivism. Positivism is the dominant research paradigm in IB (Bonache & Festing 2020). Positivism posits that phenomena are understood through models, which constitute true explanations that are independent of the observer. Models include variables connected by generalizable causal mechanisms that can be measured empirically (Edmondson & McManus 2007).

Moreover, this paper employs a deductive approach, which entails the development of a theory and the development of a plan to evaluate the theory. The entire investigation is centered on theory in accordance with this methodology. The objective is to identify the prevalent PM practices in Pakistan. The objective is to evaluate the validity of contemporary agile management theory and to evaluate its practical application.

Research method

This research employs a qualitative research design, aiming to explore personal experiences and case studies to derive in-depth insights into the research problem. The study was conducted across various settings pertinent to the participants' experiences, incorporating individuals from diverse backgrounds. Participants were selected using purposive sampling to ensure a comprehensive range of perspectives. Data collection was executed through open-ended questionnaires, meticulously designed to elicit detailed responses and capture the subtleties of participants' experiences. These questionnaires were disseminated both in-person and electronically, with participants allotted sufficient time to respond. Follow-up questions were posed when clarification was required. Ethical considerations were rigorously observed, including obtaining informed consent from all participants and ensuring the confidentiality of their responses throughout the research process.

The qualitative data obtained from the questionnaires were subjected to thematic analysis, facilitating the identification of common themes, patterns, and insights from the participants' responses. NVivo software was employed to assist in the organization and coding of qualitative data, enhancing the efficiency and accuracy of the analysis process. To ensure the validity and reliability of the findings, data triangulation was utilized, and multiple coders were engaged to cross-verify the identified themes. Acknowledging potential limitations, the subjective nature of qualitative data may introduce bias. However, the implementation of rigorous data triangulation and the use of multiple coders were strategies employed to mitigate these limitations. In conclusion, the qualitative approach adopted in this study provides a robust framework for exploring personal experiences and case studies, ensuring that the findings are rich, detailed, and insightful.

Sampling and data collection

Sampling is a method that entails the selection of a restricted number of suitable candidates from a population cohort (Rahi 2017). The selection population consists of all organizations in Pakistan's IT sector that implement agile project management. All of the principal employees and administrators of these organizations are included in the community. These contacts are actively pursued and identified through personal and professional relationships. The candidates who were selected for the position were expected to have a plethora of experience in the field of information technology. Consequently, their viewpoint will be more relevant to our subject matter.

As the IT sector is characterized by limited resources, data was collected from 15 software companies in Pakistan to attain this objective. These organizations have been operating in this sector for an extended period and are exclusively software-based. Negotiations were conducted with individuals holding managerial positions in their respective departments. Each respondent cooperated to the extent that agreed to respond to the inquiries in writing, as they are currently experiencing a challenging situation and have a full schedule. Initially, outreach was made to 15 companies in Islamabad and Rawalpindi to gather a comprehensive amount of data to achieve more precise results. However, only ten organizations responded to the inquiries. The selection of these modest to medium-sized firms in Punjab, Pakistan, was influenced by personal and professional networks. Qualitative data was collected using one-on-one semi-structured interviews. A thorough evaluation of the transcriptions was conducted with the interviewees to minimize the probability of translation errors. Verified accord with the transcripts, thereby guaranteeing the precision of the findings

Scientific Credibility

A criterion known as validity evaluates whether the questions are aligned with objectives of the study. The degree to which a test regularly yields similar findings when administered under controlled circumstances is known as reliability, whereas the relevance and appropriateness of the testing are the focus of validity. A rigorous strategy was put into place to guarantee the quality and dependability of the interview. We followed the requirements, which required an introduction focused on research to be included at the beginning of the survey. It was acceptable for respondents to say no to participation. The person asking the questions uses an agile approach to project management.

RESULTS

Fifteen executives who are employed by IT companies in Pakistan were interviewed. Certain project administrators possessed a fundamental and comprehensive understanding of the project's proper execution. Initially, the audience was asked about their demographic origins and personal details. Inquiries about the participants' age, gender, income, education, job position, phone number, and email address were made. Our initial inquiry was regarding the

implementation of agile methodologies within organizations. When asked about using agile methods in organizations, thirteen out of fifteen said yes.

Subsequently, participants were questioned regarding the challenges confronted during the transition from conventional methodologies to agile methodologies. The objective was to ascertain the obstacles that impede organizations from incorporating agile methodologies into their projects, as well as to gain a deeper understanding of Pakistan's business trends and market conditions. The transition from traditional to agile approach was not particularly challenging, according to the majority of respondents, as the objective of excellence outweighed any minor obstacles. Nevertheless, a few participants noted that organizational culture and staff mindset posed obstacles to complete integration of agile practices by management. Noting that personnel accustomed to conventional procedures needed additional time and effort to adapt to changes in the process. Consequently, participants were questioned regarding the challenges encountered when employing or implementing agile methodologies. Additionally, the objective of this investigation was to align with current business trends in Pakistan.

The following issues have been noted by respondents. Both the management and the employee need to put in more time and effort.

- Agile planning altered the planning process by requiring iteration at every step of development.
- Managing time effectively is important to achieve deadlines.
- Specialized training is necessary for both management and staff.
- Another problem is ignorance.
- Workers were reluctant to stand every day during progress sessions.
- Constant scope changes can result in cost overruns.

If using agile methodologies contributed to the success of their company's project, the respondents were questioned about it. Evaluating the effects of applying agile methods in their projects was the aim. Surprisingly, nine out of ten respondents said that introducing agile into their company enhanced project success and enhanced product quality. One person did, however, offer a balanced perspective, acknowledging both advantages and disadvantages. Agile performed better in some situations than others, even if it was beneficial in some.

To comprehend the trend of management proposing changes to products in organizations, participants were questioned about how frequently innovation occurs in their projects. A significant majority of respondents stated that their organization regularly engages in innovative activities. Every job undertaken presents new specifications or market trends, necessitating creative thinking and new ideas to keep up with shifting market conditions.

Afterwards, participants were asked regarding how new techniques and products affected tasks within their organizations. Nearly all interviewees emphasized the importance of making significant changes to processes and products to achieve previously unattainable success. This transformative approach, alongside increased profitability, also led to higher customer satisfaction. Some respondents highlighted the need for caution, emphasizing the thorough evaluation of every change before company-wide implementation. If deemed beneficial, changes are then implemented across the organization.

The degree of management support that the participants received for putting actual agile approaches into practice was questioned. The objective was to evaluate the project management organization's mindset and degree of adaptability while adhering to authentic agile methodologies. The majority of respondents indicated that management strongly encourages the adoption and observance of agile methods. The respondents highlighted management's proactive approach in fostering an agile work environment through regular organization of training sessions and seminars aimed at enhancing productivity among employees.

Participants were asked about the challenges encountered when collaborating with their supervisors to implement agile practices. The aim of the study was to identify the challenges that workers have when trying to implement agile methodologies as advised by their managers. Time commitments, a lack of familiarity with new techniques or features, the requirement for daily reporting, managing several vendors and systems for a single change, abrupt modifications to the project's scope, reassessing modifications to current systems, assessing the effects of changes on ongoing work, and modifying project expenses and efforts were among the primary concerns mentioned by the respondents. These challenges draw attention to the various obstacles that staff members face while trying to use agile methodologies successfully.

Lastly, interviewers were questioned to compare the agile project management approach's effectiveness to that of the conventional project management methodology. The responses from every participant were remarkably consistent, expressing a shared conviction that utilizing agile methodology outperforms the traditional approach in numerous aspects. While some stated that it decreased the chance of a project failing, others asserted that agile is better at achieving predetermined objectives. The emphasis among the respondents was on effective planning, carrying out, and implementing processes, which made each one easy to manage. Increased customer satisfaction shortened product release cycles, flexibility, transparent communication, and an emphasis on producing the right product were some of the advantages of agile project management that were highlighted. From a collective standpoint, it is evident, in conclusion, that agile processes are far more successful than conventional project management techniques.

Overall, the results indicate that project teams, co-managers, and supervisors need to communicate and share knowledge on software innovation more effectively. Moreover, the research argues that agile methodologies combined with managerial assistance can enhance project creativity, so making a major contribution to the project's overall success.

DISCUSSION

Our study provides significant insights into how agile approaches affect the success of projects, with a specific focus on project creativity and management support. The results of extensive study and analysis demonstrate that the use of agile approaches greatly improves project performance by promoting proactive problem-solving, continuous improvement, and increased customer satisfaction (Islam & Storer, 2020). The agile framework, known for its adaptability and iterative approach, fosters an atmosphere conducive to experimentation and creativity (Sandstø and Reme-Ness, 2021). Teams can respond quickly to changes and new challenges due

to their adaptability, which enables proactive problem-solving. Continuous improvement, a fundamental tenet of agile techniques, guarantees the ongoing development and enhancement of projects, resulting in improved performance outcomes (Al-Saqqa et al., 2020).

Innovation is recognized as a vital component in attaining exceptional project results. Projects that integrate pioneering methodologies are more prone to achieve success, as these methodologies foster original ideas and imaginative troubleshooting (Gumiński et al., 2023). The agile methodology's focus on iteration and feedback loops offers abundant chances for teams to test new ideas and improve their approaches based on immediate feedback (Yermolaieva, 2020). The iterative method described not only improves the quality of the products, but also increases team morale and client satisfaction (Lee & Xia, 2010). For instance, in the software development sector, the implementation of agile principles has demonstrated a decrease in development cycles and an enhancement in product quality through the facilitation of regular testing and modification (Wilson, 2020).

Additionally, the study emphasizes the significance of robust managerial backing for the effective application of agile practices. Projects that have strong support from management tend to have greater success rates because of their effective communication, efficient allocation of resources, and a supportive organizational culture (Miller, 2019). Management support is crucial in enabling the adoption of agile approaches by providing teams with the essential resources and direction needed to overcome the problems associated with this change (Baxter et al., 2022). Companies that have effectively implemented agile practices frequently attribute their success to robust leadership and precise communication (Nguyen & Hu, 2019).

Nevertheless, the shift from conventional procedures to agile approaches presents obstacles such as staff opposition and the requirement for further training and exertion (Villamizar et al., 2020). Staff resistance may arise because to a reluctance to modify current procedures or a lack of comprehension of agile principles. In order to surmount these challenges, firms need to allocate resources towards extensive training initiatives and foster a culture that actively embraces change and ongoing learning (Butler et al., 2020). Notwithstanding these difficulties, our research emphasizes the profound influence of agile approaches on project management. Organizations can get optimal outcomes and improve their overall project success rates by promoting innovation and ensuring robust managerial backing (Marek et al., 2021). The findings highlight the crucial significance of establishing a suitable environment for experimentation, innovation, and proactive problem-solving, all of which are fundamental elements of the agile framework. This change entails not just altering processes but also adopting a mindset that embraces flexibility and collaboration (Gunasekaran et al., 2019).

CONCLUSION

This study investigated the effectiveness of Agile techniques, specifically their capacity to resolve problems during initial consultations and project initiation. The Agile methodology has proven to be a highly effective approach due to its flexibility, iterative nature, and focus on stakeholder collaboration. The findings of this study emphasize the significance of project

innovation as a key mechanism in understanding the relationship between project performance and the implementation of Agile methodology. Agile approaches boost the innovative capacities of project teams by creating an environment that encourages experimentation and continuous development, resulting in better solutions. Moreover, this study found that managerial support is vital in improving the overall effectiveness of Agile methods and enhancing project performance. Efficient managerial assistance, encompassing transparent communication, allocation of resources, and the cultivation of a supportive culture, is imperative for the successful execution of Agile methodologies.

This work significantly enhances existing knowledge by contributing to the understanding of Agile techniques, which has been a neglected area until now. Prior studies have not extensively investigated the practical implementation of Agile techniques, particularly in the context of developing nations such as Pakistan. Thus, this research contributes substantially to existing knowledge by presenting empirical evidence on the significance of Agile methodologies in project-based enterprises in Pakistan.

The study has a few limitations. Time and resource constraints were significant obstacles in this research. Most data were collected from project establishments primarily in urban areas, which may limit the validity of the conclusions due to the absence of representation from other important cities across Pakistan. Future research should address this limitation by expanding the geographical scope to include a more diverse range of cities across Pakistan, ensuring a more representative sample.

The present study employs a qualitative approach, which, while valuable, has its limitations in terms of generalizability and statistical validation. Therefore, future studies should validate these findings using a quantitative approach to enhance the robustness and applicability of the results. Employing mixed-method approaches, such as combining quantitative surveys with qualitative case studies, could provide a more comprehensive understanding of the phenomena under study.

REFERENCES

- Al-Saqqa, S., et al. (2020). Agile software development: Methodologies and trends. *International Journal of Interactive Mobile Technologies (ijIM)*, 14, 246.
- Alam, S., Aziz, M. A., Bhatti, S. N., & Alam, S. (2016). Analysis of Requirement Engineering Techniques in Agile Development Method. *International Journal of Computer Science and Information Security*, 14(11), 889.
- Augustine, S. (2005). *Managing agile projects*. Prentice Hall PTR.
- Augustine, S., Payne, B., Sencindiver, F., & Woodcock, S. (2005). Agile project management: steering from the edges. *Communications of the ACM*, 48(12), 85-89.
- Baxter, A. L., et al. (2022). Collaborative experience between scientific software projects using agile Scrum development. *Software: Practice and Experience*, 52(10), 2077-2096.
- Begel, A., & Nagappan, N. (2007, September). Usage and perceptions of agile software development in an industrial context: An exploratory study. In *First International*

- Symposium on Empirical Software Engineering and Measurement (ESEM 2007)* (pp. 255-264). IEEE.
- Berente, N. (2020). Agile development as the root metaphor for strategy in digital innovation. In *Handbook of Digital Innovation* (pp. 83-96). Edward Elgar Publishing.
- Bindrees, M., et al. (2014). Re-evaluating media richness theory in software development settings. *Journal of Computer and Communications*, 2, 37-51.
- Bonache, J., & Festing, M. (2020). *Research paradigms in international human resource management: An epistemological systematisation of the field*. SAGE Publications Sage UK: London, England, 34, 99-123.
- Butler, C. W., et al. (2020). Managing software development projects for success: Aligning plan- and agility-based approaches to project complexity and project dynamism. *Project Management Journal*, 51(3), 262-277.
- Chau, T., & Maurer, F. (2003). Knowledge sharing in agile software teams. In *Lecture Notes in Computer Science* (Vol. 2890, pp. 100-112). Springer.
- Chin, C., et al. (2012). Project management methodologies: A comparative analysis. *Journal for the Advancement of Performance Information & Value*, 4, 4-19.
- Cockburn, A., & Highsmith, J. (2001). Agile software development: The people factor. *Computer*, 34(11), 131-133.
- Conforto, E., et al. (2014). Can agile project management be adopted by industries other than software development? *Project Management Journal*, 45, 21-34.
- Conforto, E. C., & Amaral, D. C. (2016). Agile project management and stage-gate model—A hybrid framework for technology-based companies. *Journal of Engineering and Technology Management*, 40, 1-14.
- Conforto, E. C., et al. (2016). The agility construct on project management theory. *International Journal of Project Management*, 34(4), 660-674.
- Crowder, J. A., & Friess, S. (2015). *Agile project management: Managing for success*. Springer.
- Dingsøyr, T., et al. (2012). A decade of agile methodologies: Towards explaining agile software development. *Journal of Systems and Software*, 85(6), 1213-1221.
- Dorairaj, S., et al. (2013). Agile software development with distributed teams: Senior management support. In *2013 IEEE 8th International Conference on Global Software Engineering* (pp. 63-67). IEEE.
- Edmondson, A., & McManus, S. (2007). Methodological fit in management field research. *Academy of Management Review*, 32(4), 1155-1179.
- Fowler, M., & Highsmith, J. (2001). The agile manifesto. *Software Development*, 9, 28-35.
- Gislen, M. (2016). *Achieving agile quality: An action research study (Master's thesis)*. Blekinge Institute of Technology, Karlskrona, Sweden.
- Gumiński, A., et al. (2023). Advantages and disadvantages of traditional and agile methods in software development projects: Case study. *Scientific Papers of Silesian University of Technology Organization and Management Series*, 2023, 1-12.
- Gunasekaran, A., et al. (2019). Agile manufacturing: An evolutionary review of practices. *International Journal of Production Research*, 57(15-16), 5154-5174.

- Heimicke, J., et al. (2019). Comparison of existing agile approaches in the context of mechatronic system development: Potentials and limits in implementation. *Proceedings of the Design Society: International Conference on Engineering Design*, 1, 2199-2208.
- Highsmith, J., & Cockburn, A. (2001). Agile software development: The business of innovation. *Computer*, 34(9), 120-127.
- Hoda, R., et al. (2012). Developing a grounded theory to explain the practices of self-organizing agile teams. *Empirical Software Engineering*, 17(6), 1-31.
- Islam, G., & Storer, T. (2020). A case study of agile software development for safety-critical systems projects. *Reliability Engineering & System Safety*, 200, 106954.
- Jaggars, D., & Jones, D. (2018). An agile planning and operations framework. *Performance Measurement and Metrics*, 19(2), 121-126.
- Jennex, M. (2006). A model of knowledge management success. *International Journal of Knowledge Management*, 2(3), 51-68.
- Kuchel, T., Neumann, M., Diebold, P., & Schön, E. M. (2022). *Key Challenges with Agile Culture--A Survey among Practitioners*. arXiv preprint arXiv:2212.07218.
- Lee, G., & Xia, W. (2010). Toward agile: An integrated analysis of quantitative and qualitative field data on software development agility. *Management Information Systems Quarterly*, 34(1), 87-114.
- Mahnic, V., & Drnovscek, S. (2005, June). Agile software project management with scrum. In *EUNIS 2005 Conference-Session papers and tutorial abstracts* (p. 6). sn.
- Marek, K., et al. (2021). The state of agile software development teams during the COVID-19 pandemic. In *International Conference on Lean and Agile Software Development* (pp. 123-134). Springer.
- Miller, G. J. (2019). Framework for project management in agile projects: A quantitative study. In *Conference on Advanced Information Technologies for Management* (pp. 45-58). Springer.
- Moe, N., et al. (2010). A teamwork model for understanding an agile team: A case study of a Scrum project. *Information & Software Technology*, 52(5), 480-491.
- Nerur, S., et al. (2005). Challenges of migrating to agile methodologies. *Communications of the ACM*, 48(5), 72-78.
- Nguyen, D., & Hu, E. (2019). *Agile Adoption in Public Agencies: A case study of the Swedish Tax agency* (Dissertation). Retrieved from <https://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-264224>
- Omonije, A. (2024). Agile methodology: A comprehensive impact on modern business operations. *International Journal of Science and Research (IJSR)*, 13, 45-56.
- Pichler, R. (2006). Agile estimating and planning by Mike Cohn. *Journal of Product Innovation Management*, 23(6), 588-589.
- Rahi, S. (2017). Research design and methods: A systematic review of research paradigms, sampling issues and instruments development. *International Journal of Economics & Management Sciences*, 6(2), 1-5.
- Rahul, N., et al. (2023). The impact of agile methods on software projects implementation and management. *American Journal of Industrial and Business Management*, 13, 183-194.
- Rasnacis, A., & Berzisa, S. (2017). Method for adaptation and implementation of agile project management methodology. *Procedia Computer Science*, 104, 43-50.

- Sandstør, R., & Reme-Ness, C. (2021). Agile practices and impacts on project success. *Journal of Engineering, Project, and Production Management*, 11, 255-262.
- Serrador, P., & Pinto, J. (2015). Does agile work? — A quantitative analysis of agile project success. *International Journal of Project Management*, 33(5), 1040-1051.
- Sharma, S., et al. (2012). Agile processes and methodologies: A conceptual study. *International Journal on Computer Science and Engineering*, 4(5), 24-30.
- Siakas, K. V., & Siakas, E. (2007). The agile professional culture: A source of agile quality. *Software Process: Improvement and Practice*, 12(6), 597-610.
- Smith, J. K., & Smith, L. F. (2001). Spending time on art. *Empirical Studies of the Arts*, 19(2), 229-236.
- Stavru, S. (2014). A critical examination of recent industrial surveys on agile method usage. *Journal of Systems and Software*, 94, 87-97.
- Turner, R., & Müller, R. (2005). The project manager's leadership style as a success factor on projects: A literature review. *Project Management Journal*, 36(2), 49-61.
- Vijayarathy, L., & Turk, D. (2012). Drivers of agile software development use: Dialectic interplay between benefits and hindrances. *Information and Software Technology*, 54(2), 137-148.
- Villamizar, H., et al. (2020). An efficient approach for reviewing security-related aspects in agile requirements specifications of web applications. *Requirements Engineering*, 25(4), 439-468.
- Waja, G., et al. (2021). Agile software development. *International Journal of Engineering Applied Sciences and Technology*, 5(1), 23-34.
- Wilson, A. (2020). Emotionally agile leadership amid COVID-19. *School Leadership Review*, 15(2), 1-12.
- Yermolaieva, S. (2020, November). Communication Challenges in Agile Teams from The Communication Theory Prospective. In *Proceedings of the 2020 European Symposium on Software Engineering* (pp. 88-95).

*CORRESPONDING AUTHORS

Waseem Haider can be contacted at: waseemhaider@graduate.utm.my

Noor Ahmed can be contacted at: noor.ahmed@buitms.edu.pk

CITATION

Haider, W., Ahmad, N., Naseebullah. (2025). Agile strategies for project success: Exploring innovation and management support. *Sohar University Journal of Sustainable Business*, 1(1). 1-18.

INTELLIGENT DATA SYSTEMS FOR SUSTAINABLE PREVENTION AND MANAGEMENT OF G6PD DEFICIENCY: A MARKOV CHAIN MODEL APPROACH

Divya Rani

Medanta Super Speciality Hospital, Jharkhand, India

ABSTRACT

Adopting sustainable healthcare practices is crucial for effectively managing genetic disorders. Despite significant advances in our understanding of the genome over the last decade, there are notable limitations in epidemiological and analytic approaches for investigating the effects of common chronic genetic diseases like Glucose-6-phosphate dehydrogenase (G6PD) deficiency in Oman. This study aims to use pedigree charting and Markov Chain Model analysis to determine the pattern of gene distribution for G6PD deficiency in the family trees of Omani nationals. It also identifies the pattern of gene distribution for G6PD deficiency by synchronizing medical data, including the genetic history of families, and applying Markov's model to find the family generation at which G6PD deficiency becomes normal homozygote and reaches an equilibrium state. Based on the analysis using the Markov Chain Model, it is observed that after a few generations, the population attains a normal homozygote state. However, this equilibrium is not consistent across all families. In some families, the generation becomes normal after 18 stages, while in others it becomes normal after 12 stages. Leveraging intelligent data systems can reduce long-term healthcare costs and improve population health, ultimately fostering economic sustainability in Oman.

Keywords: Markov Chain, G6DP, genetics, Anemia, Oman

Paper Type: Research paper

INTRODUCTION

Sustainable healthcare in Oman focuses on creating a resilient health system that meets current needs without compromising future generations. Emphasizing preventive care and public health initiatives helps reduce the burden on healthcare facilities. Technological advancements, like telemedicine and electronic health records, enhance efficiency and accessibility. Oman's population is distinguished by large family sizes, advanced maternal and paternal ages (Rajab et

al., 2013). As a result, the presence of gene-related defects, various genetic anomalies, and syndromes is extremely high in Oman's general population (Islam, 2012). In a new report, Oman's Ministry of Health revealed that citizens in the country inherit more than 300 diseases from their parents.(Al Mawali et al., 2022). The likelihood of a child developing a genetic disease such as G6PD is 3.5 to 4.7 per 1,000 live births, according to the report, that the Sultanate has a newborn birth defect or any of the genetic diseases at a rate of 5 to 7 percent, compared to a global average of 4.4 percent (Al-Sheryani et al., 2023). According to statistics, congenital disorders account for 37% of newborn deaths and premature births (Rajab et al., 2013). Genetic disorders account for 10% of neonatal mortality and 52% of mortality in older children (Al-Sheryani et al., 2023). The prevalence of these genetic disorders, comparable to rates in other Arab countries, is highly concerning.

Managing genetic diseases can be challenging, as treatments are often time-consuming and costly, and currently, no definitive cure exists. The patient must endure the trauma of taking medicine or receiving blood transmission for the rest of his or her life, or he or she must undergo organ transplantation. According to studies by Center of Arab Genomic studies, 10% of Omani nationals carry genes for sickle cell anemia, 3% carry mutations to genes with beta thalassemia and 45% has genes for alpha thalassemia (Al-Riyami & Ebrahim, 2003). Also, down syndrome is as common among 1 in every 350 live births.

The most common genetic disease being Glucose-6-phosphate dehydrogenase (G6PD) deficiency accounting for 12% in women and 28% among men. In total, a skyscraping percentage of around 60% of Omani nationals are carrying genes for genetic disorders or, suffering from different genetic anomalies (Al-Maawali, 2022)(Rajab et al., 2013). It is a significant challenge for the country because 60% of its 2.5 million-person at least have one type of genetic blood disorder deficiency exists in the population. (Sulaiman et al., 2001). Health officials emphasized because inter-tribal marriage is so common in Oman, premarital tests should be performed, which would result in a significant decrease in blood-related genetic disorders (Bruwer et al., 2022).

Many people have advocated for mandatory premarital tests in order to protect their children from inheriting genetic disorders like G6PD deficiency (Alangari et al., 2023). In general, no public health measures are aimed at avoiding congenital and genetic diseases, which are also constrained by cultural and legal constraints. Some countries have begun low-cost prevention programs, such as premarital carrier screening, for certain common genetic disorders G6PD deficiency. In this region, strategies for genetic disorder prevention should include the community genetics integration into primary care, education, and expansion of existing specialized genetic services. The goal of this research is to aware the Omani nationals about the G6PD (Glucose-6-phosphate dehydrogenase) deficiency and how to prevent them by finding the equilibrium state/normal state of their family generations by using Markov's Chain Model and also to highlight the use and simplicity of Markov chain modeling in the study of G6PD disorders. This study focuses on integrating advanced data systems and preventive measures to enhance public health. Leveraging technologies like intelligent data systems and Markov Chain models, Oman aims to identify and mitigate the risks associated with genetic disorders. This approach not only improves patient outcomes by enabling early diagnosis and tailored interventions but also reduces long-term healthcare costs. By promoting preventive care, efficient data

management, and community education, Oman advances toward a more sustainable and economically viable healthcare system, ensuring better health for future generations.

BACKGROUND OF THE STUDY

Oman was historically the main business port of the Arabian Gulf region. Because of its extensive trade activities, the Omani people have a diverse social and ethnic background. According to the survey, which was designed, carried out, and funded by the Sultanate of Oman's Ministry of Health, the statistics are very concerning.(Al-Riyami & Ebrahim, 2003). According to the Oman Hereditary Disorder Association (OHDA), 10% of the Omani population is genetically predisposed to at least one dangerous blood disorder.

According to a recent study conducted in the Sultanate of Oman, G6PD (Glucose-6-phosphate dehydrogenase) is very common in society. It is reported to occur 17.9% more frequently in children under the age of five (25 per cent with males and 10 per cent with females) (Rajab et al., 2013). Males were more than twice as likely as females to have G6PD deficiency in all regions of the Sultanate. Based on the rates listed above, it is possible to calculate that in the Sultanate as a whole, the statistics are as in table 1:

Table 1: Genotype traits in the Sultanate of Oman

#	Genetic Trait	Population Statistics
1	G6PD deficiency	Under 5 years of age = 44,733 children
2	Sickle cell trait	14,306
3	Sickle cell disease	474
4	Beta-thalassaemia trait	5393
5	Bets-thalassaemia major	175
6	Mean Hb level	Children under the age of five had 10.9 g/dl, males had 10.89 g/dl, and females had 10.99 g/dl.
7	Anemic	Under 5 years of age = ½ of the children
8	Mild anemia was predominant	46% (sixty-five percent of children aged 0 to or equal to one year)
9	Moderate	4%
10	Severe anemia	0.2%

Source: <https://ghdx.healthdata.org>

With these frightening statistics spreading throughout society, the Ministry of Health (<https://www.moh.gov.om>) is attempting to identify and eliminate the causes. Pre-marital screening appeared to be the prudent course of action in order to avoid having more blood-disease patients. Premarital screenings are recommended for couples to protect their future children from genetic health problems.

G6PD DEFICIENCY

G6PD deficiency is genetically transmitted from one or both parents to a child. G6PD (Glucose-6-phosphate dehydrogenase) deficiency is a hereditary condition that is inherited in an X-linked recessive manner marked by low G6PD enzyme levels. Arab countries have a high prevalence of genetic diseases, with a higher prevalence in Saudi Arabia (39.8 percent), Syria (30 percent), and Oman (29 percent) than in other Arab countries (Natarajan & Joseph, 2021). Only a few studies have been conducted in Arab countries to investigate the prevalence of G6PD mutations and their functional role in illness.

LITERATURE REVIEW

Comparing various genetic models has been an active area of research due to the multitude of models in use. Since the late 1980s, scholars have developed Markov chain models of genetic algorithms to enhance the understanding of these genetic models (Munkhammar & Widén, 2018). Most genetic algorithms can be represented as Markov chains over populations. This study reviews a well-established Markov chain model, examines the G6PD research report, and constructs new Markov chain models. A notable application of the Markov Chain Model was to study gene distribution in albinism, proposing that one parent must be a typical homozygote with selective pressures applied (Sun et al., 2023). It was concluded that after six generations, all individuals would be normal homozygotes, leading to the extinction of the albino gene in the population. Similarly, a discrete-time Markov chain model was employed to tackle the issue of infectious diseases, observing that hepatitis B became more infectious over time compared to tuberculosis and HIV despite the low initial infection probability.

Digital microfluidics (DMF) has also been utilized to quantitatively and kinetically evaluate G6PD activity. In a study involving 86 samples (Paxinou et al., 2021), DMF results were compared with two reference methods, achieving a reproducibility of 3.8% over 5 days across two operators and instruments (Cornel et al., 2024). Hidden Markov Models (HMMs) have been developed for various computational biology challenges, including multiple sequence alignment, homology detection, protein sequence categorization, and genome annotation (Sun et al., 2014). The principles, techniques, practices, and policies influencing European population genetic screening programs were examined from professional and scientific perspectives, aiming to raise awareness among healthcare professionals and policymakers (King et al., 2022). Methods included analyzing current professional regulations, regulatory frameworks, and relevant documents. HMMs have also been used to identify patterns in genomic sequences, assessing model performance by varying the number of states in the Markov model and using several performance indicators, utilizing publicly available genetic data (Grzymski et al., 2020).

A weighted Markov chain was introduced for predicting future incidence states, using standardized self-coefficients as weights based on infectious disease incidence properties, with the Markov chain Monte Carlo approach examining these characteristics to maximize long-term benefits. The applications of Markov chains have been highlighted, demonstrating their usefulness in applied mathematics. The main causes of G6PD deficiency have been identified as

the absence of a screening program, uncertainty regarding jaundice onset and progression, rapid increases in bilirubin levels, and early hospital discharge without proper monitoring of high-risk infants (Lacaze et al., 2022), advocating for screening programs and public health initiatives including education, surveillance, and training.

Studies on G6PD deficiency polymorphisms in neonatal hyperbilirubinemia among Egyptian neonates provided insights into the Mediterranean variant's prevalence in Egyptian infants (Luzzatto et al., 2020). Genetic/genomic test information characteristics, such as predictability, immutability, and uniqueness, are crucial for developing information security policies and addressing "genetic exceptionalism" concerns, aiding in the integration of genetic/genomic information into healthcare (Ong et al., 2017). Combining genotype and deep phenotype data from Electronic Health Records (EHRs) has been shown to accelerate genetic diagnoses, with EHR narratives automating phenotype-driven clinical exome or genome analysis, promoting broader adoption of genomic medicine. A recursive hierarchical extension of hidden Markov models, called Hierarchical Hidden Markov Models (HHMM), has been introduced, efficiently estimating model parameters from unlabeled data using an effective estimation method (Mesa et al., 2016). Mechanisms in electronic health records have been developed for requesting a pharmacogenomics panel either preemptively or in response to a specific drug indication. These studies underscore the diverse applications and advancements in using Markov chain models and related methodologies to study genetic patterns, disease incidences, and the integration of genomic data into healthcare.

MANAGEMENT AND PREVENTIONS OF G6PD DEFICIENCY

Many factors, such as genes, environment, and lifestyle, are shared by families. These factors, when considered together, can provide ideas to medical problems that may run in families. Healthcare personals can identify whether a person, another family member, or future generations are at a higher risk of developing a specific condition by observing disorder patterns in relatives. Children, siblings and sisters, parents, aunts and uncles, nieces and nephews, grandparents, and cousins are all included in a detailed record. A family medical history is a document that contains information about a person's and his or her close relatives' health (Khalifa et al., 2021; Yoon et al., 2002). A person's family history can also help predict the risk of rarer conditions caused by single gene mutations, such as G6PD deficiency (Hassan et al., 2014). A person who has no family history of an illness, on the other hand, may be predisposed to developing that ailment. Knowing one's family medical history enables them to take precautionary measures to lower their risk (Beutler, 1996). According to healthcare providers, people who have a medical condition that runs in their family may benefit from regular checkups or testing.

Proposed method

The method adopted in this study involves several crucial steps. Initially, health data is stored through digital devices, ensuring accurate and efficient data collection. Following this, the digital

data undergoes processing to prepare it for further analysis. The processed data is then analyzed to derive meaningful results from the digital information. Once the analysis is complete, the pedigree of the suspect is developed, which involves mapping out the genetic relationships and potential inheritance patterns within the family. Finally, Markov's model is applied to the suspected family data to identify and predict genetic patterns and potential disease risks, thus providing a comprehensive approach to understanding genetic influences within the family.

A person's future health cannot be predicted based on his or her family's medical history; it only provides risk information. At least three generations should be included in the history. Gather the following information in an electronic sheet for each person: gender, year of birth, ethnicity, medical health condition, conditions affecting one's mental health, including a history of substance abuse, pregnancy complications such as miscarriage, stillbirth, birth defects, and infertility, age at diagnosis for each condition, and lifestyle factors including diet, exercise, and tobacco use. For deceased relatives, include the age at the time of death as well as the cause of death.

Intelligent data integration and decision support throughout the patient journey

The quality and availability of the data heavily influences decision-making in today's digitalized healthcare environment. Smart data integration may significantly improve decision-making quality, particularly in healthcare, where clinical decision-makers confront various impediments and challenges throughout the patient journey. Gathering enough information from the patient's family history which is used to screen for disease risk and to guide treatment because making decisions is a time-consuming procedure that is difficult to complete just via dialogue between patients and their health care professionals.

The patient e-card stores personal and patient information. The card stores previous diseases that were chronic and/or significant with diagnosis dates, long-term medications with dosages, allergies with dates of diagnosis, vaccines with dates, and surgical procedures with dates of operation, clinic name, and summary information (Bianco et al., 2013). The card also contains information about the patient's most recent examination and prescriptions.

On the basis of the available intelligent data, digital Genetic health information system process the data and generate valid information regarding the G6PD suspect as per the flow chart in Figure 1. After analyzing the information by the health professionals, a pedigree of a suspect drawn to derive a final conclusion related to G6PD deficiency.

Pedigrees

Based on a Specific family's electronic medical history, a "pedigree" of a family tree will be generated, assisting medical professionals in determining the risk of G6PD disease. A pedigree (or family tree) is used to present family history in a clear manner, making it easier to identify abnormal inheritance patterns. A pedigree chart shows the phenotypes of a specific gene in family members and ancestors. It uses standardized symbols to represent family members and

relationships as in figure 2. A pedigree can be created much faster than information can be recorded about a patient's family history in writing, and it enables disease patterns to emerge as the pedigree is drawn (Lacy, 2012). Because family histories change all the time, the pedigree can be easily updated on future visits. Most of the time, three generations are enough to produce reliable results. Inquiries about names, birthdays, and clinically relevant data. Progeny, miscarriages, or unintended childlessness. Based on the availability of random electronic health records, a pedigree genetic analysis (for 5 generations) is done.

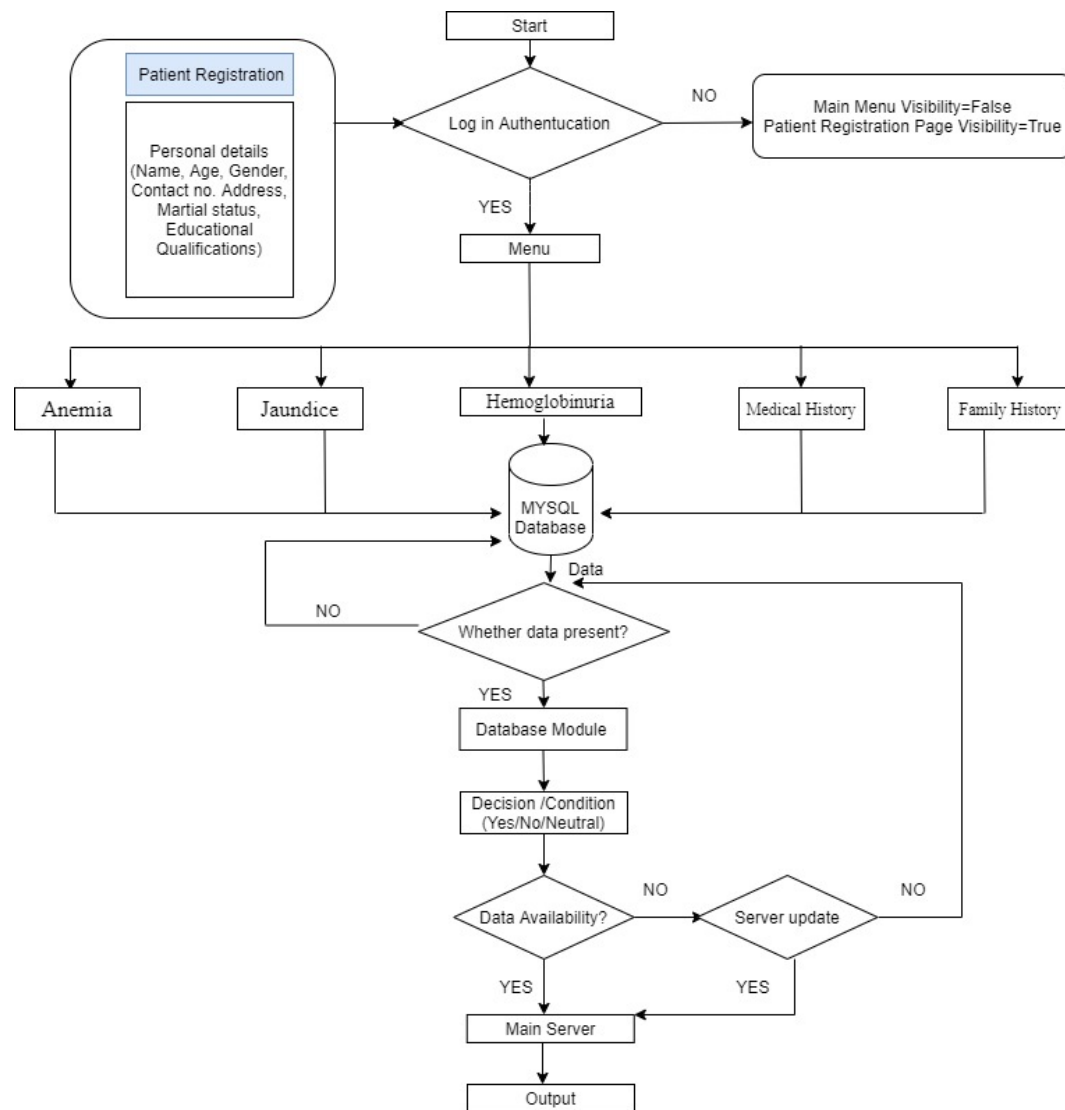


Figure 1: Process of digital information of G6PD deficiency suspects

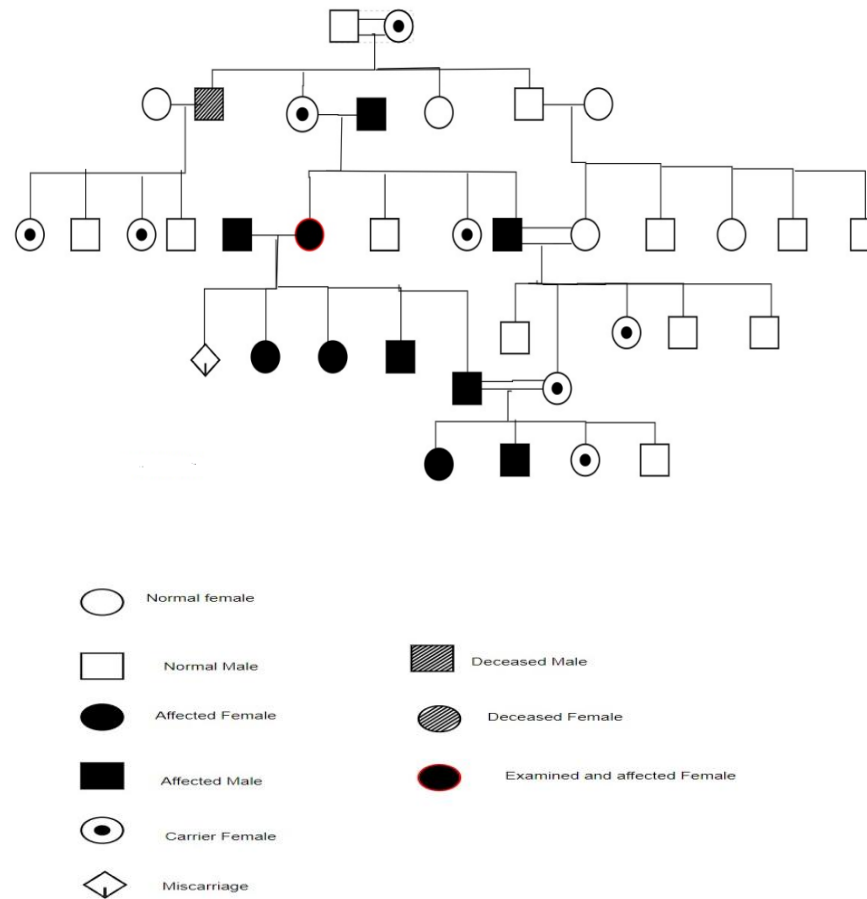


Figure 2: Family pedigree to determine inheritance pattern of the G6PD deficiency.

Pedigree chart helps doctors to analyze and assess the risk of G6PD deficiency. So as per the pedigree chart of the particular sample, analysis about G6PD deficiency are as:

The randomly examined female has consanguineous marriages in family with history of miscarriages, chronic anemia, jaundice and sclera confirmed diagnosis of G6PD deficiency in almost every generation.

The generational analysis of pedigree in consanguineous marriages reveals distinct patterns across five generations. In the first generation, there is a consanguineous marriage, which sets the stage for the genetic analysis of subsequent generations. The second generation includes one deceased male and one carrier female. In the third generation, there are carrier females and an affected female who has been examined. Moving to the fourth generation, both males and females are affected. Finally, in the fifth generation, as a result of continued consanguineous marriages, there is a probability of affected males and females as well as carrier females, as indicated by the pedigree chart. 25% of son=healthy.

50% of children=may get affected

25% of daughter=carrier.

By doing the test during the engagement period has been reported as one of the significant reasons for marriage continuation despite abnormal premarital screening and counseling results. As a result, more effort is required to test at an early stage.

Markov Chain Model

The pattern of gene distribution on G6PD is determined using a six-state Markov Chain Model. A Markov chain, also known as a Markov process, is a stochastic model that describes a series of potential events in which the probability of each occurrence is determined only by the state obtained in the preceding event. In simpler terms, it is a process for which future outcomes can be predicted only based on its current state, and, more significantly (Khalifa et al., 2021), such predictions are just as good as those that could be made knowing the process's whole history. A Markov chain model is one of the most important tools in stochastic processes (Pes & Dore, 2022). A "Transition Matrix" and an "Initial Distribution" are required for the formation of a Markov chain.

At time n , the transition matrix is the matrix $P(n) = (P_{ij}(n))$, which means that the $(i, j)^{th}$ element of $P(n)$ equals $P_{ij}(n)$. The transition matrix satisfies:

- (i) $P_{ij}(n) \geq 0 \quad \forall i, j$ (the entries are non-negative)
- (ii) $\sum_j P_{ij}(n) = 1 \quad \forall i$ (the rows sum to 1)

A stochastic matrix is any matrix that meets (i), (ii) above. As a result, the transition matrix is stochastic.

Let $(X_n)_{n \in \mathbb{N}_0}$ be a random variable sequence with values in S . In this case, n represents the time at which the state X_n happens. So, to finish the Markov chain, designate D_S as the collection of discrete distributions on S such that $D_S = \{P = (P_{ij})_{i,j \in S} : P_{ij} \geq 0, \sum_{j \in S} P_{ij} = 1\}$

In this case, the distribution as row vectors. So $P_0 = (P_{0i})_{i \in S} \in D_S$ the initial distribution of the chain $(X_n)_{n \in \mathbb{N}_0}$ if $P[X_0 = i] = P_{0i}, \forall \text{ states } i \in S$.

A discrete time the square transition matrix P . P_{ij} fully describes the Markov process, indicates that the likelihood of the system existing in state j at time $t = 0$ is implied by the probability of the system transitioning from state i to state $P_{ij}(0)$.

A probability state vector is a set of state probabilities that add up to one. A state is a mutually exclusive and exhaustive situation that a process can be in at any one time. If $P_{ij}(0) = 1$, then $P_{ij}(0) = 0$ for $i, j = 1, 2, 3$ and for i, j . The transition matrix is a set of conditional probabilities for changing states.

The following is the Markov's chain model for six transitions:

XX = Normal Female
 XX₁ = Carrier Female
 X₁X₁ = affected Female
 XY = Normal Male
 X₁Y = affected Male

Table 2: Genetic scenarios

Male Genes	Female Genes	XX	XX1	X1X1	XY	X1Y
X1	X1	X1X	X1X		X1Y	X1Y
X	X1	XX	X1X		XY	X1Y
X	X	XX	XX		XY	XY
Y	X	XY	XY		XY	XY
X1	XX1	XX1	X1X1		XY	X1Y
X1	X1X1	X1X1	X1X1		X1Y	X1Y
XY	XX1	0	0.5		0	0
XY	X1X1	0	0	0.25	0.25	0
XY	XX	0	0	1	1	0
X1Y	XX1	0	0.5	0	0	0.5
X1Y	X1X1	0.25	0.25	0	0	0.25
X1Y	XX	0.5	0	0	0	0.5

The table 2 illustrates the various genotypes of offspring based on different combinations of male and female genes, showing the possible outcomes when specific genes from parents combine. When the male genes are X1 and the female genes are X1, the offspring will have the genotypes X1X (affected female) and X1Y (affected male). For the combination of male X and female X1 genes, the offspring will have the genotypes XX (normal female), X1X (carrier female), XY (normal male), and X1Y (affected male). When both the male and female genes are X, the offspring will be XX (normal female) and XY (normal male) with a probability of 1. If the male genes are Y and the female genes are X, the offspring will be XY (normal male) with a probability of 1. When the male genes are X1 and the female genes are XX1, the offspring will be XX1 (carrier female), X1X1 (affected female), XY (normal male), and X1Y (affected male). If the male genes are X1 and the female genes are X1X1, the offspring will be X1X1 (affected female) and X1Y (affected male).

The probability distributions derived from these combinations, when a normal male (XY) and a carrier female (XX1) reproduce, there is a 50% probability of having carrier offspring (XX1, X1Y). When a normal male (XY) and an affected female (X1X1) reproduce, there is a 25% probability for each of the genotypes X1X1, X1Y, and 0% for normal. When both parents are normal (XX and XY), all offspring will be normal with a probability of 1. For an affected male (X1Y) and a carrier female (XX1), there is a 50% probability for each of the genotypes XX1, X1Y. When an affected male (X1Y) and an affected female (X1X1) reproduce, there is a 25% probability for each of the genotypes X1X1 and X1Y. Lastly, when an affected male (X1Y) and a normal female (XX) reproduce, there is a 50% probability of having affected offspring (X1Y) and a 50% probability of carrier offspring (XX1). This comprehensive table combines the genotypic outcomes and their probabilities, offering a clear view of the genetic inheritance patterns across different parental gene combinations.

Table 3: Probability of offspring genotype

Time	X ₁ X ₁	XX ₁	XX	XX	XX ₁	X ₁ X ₁
1	0.225	0.125	0.275	0.275	0.200	0.125
2	0.1125	0.1875	0.30635	0.30635	0.85625	0.1125
3	0.2703125	0.4234875	0.353225	0.353225	0.4141125	0.2701125
4	0.238584375	0.280140625	0.459096875	0.459096875	0.386012500	0.238584375
5	0.2157953125	0.44534175045	0.52913203125	0.52913203125	1.0264003125	0.2157953125
.....						
.....						
25	0	0.5	0	0	0	0

From the above table 3, it is observed that equilibrium is reached at 25th stage and it can be found as per the given formula $P_{(i)}^T = P_{(i-1)}^T P$. The above table shows that the traits of G6PD will no more be in existence after the generations. This is due to the fact that each probability state vector goes to [0,0,0,0,0,0]. This study demonstrates that after a few generations, the population obtained a typical homozygote, which is not fixed for each family. It will vary from family to family, in some family the generation become normal after 12 stages or in some family it will be normal after six stages.

Similarly, for all the six state genotypes or initial state probability vectors equilibrium can be attained by the given formula. As a result, the six state Markov's model predicts that in a few generations, everyone in the family tree will become normal.

DISCUSSION AND FINDINGS

The study aims to adopt sustainable healthcare practices to manage G6PD deficiency in Oman by using pedigree charting and the Markov Chain Model to determine gene distribution patterns in family trees. The methodology synchronizes all medical data, including genetic history, through individual Civil IDs, applying Markov's model to predict the generational equilibrium state of G6PD deficiency. G6PD deficiency, a common genetic disorder in Oman, is genetically transmitted and marked by low G6PD enzyme levels, leading to various health complications. The prevalence of genetic disorders, including G6PD deficiency, is notably high in Oman, with significant implications for public health. This underscores the importance of preventive measures and intelligent data integration in healthcare. The study highlights the use of Markov Chain models, which are stochastic models describing sequences of potential events based on their preceding states. These models help predict future outcomes and are crucial in epidemiological studies. By examining different genetic combinations and their probabilities, the study provides insights into the inheritance patterns of G6PD deficiency. The detailed analysis using the Markov Chain model involves various steps, including storing health data digitally, processing this data, analyzing the results, developing a pedigree chart, and applying the Markov model to the family data. This process helps in understanding how G6PD deficiency propagates through generations and at what point the population reaches a normal homozygote state, indicating the absence of the deficiency. The study also emphasizes the importance of family medical history in predicting health risks. Information such as gender, birth year, ethnicity,

medical conditions, mental health history, pregnancy complications, lifestyle factors, and causes of death in deceased relatives should be documented. This data, integrated into intelligent data systems, can significantly enhance decision-making quality in healthcare. Pedigree charts play a crucial role in this process, as they visually represent family histories and help identify abnormal inheritance patterns. The study presents generational analyses of pedigrees in consanguineous marriages, showing the progression of G6PD deficiency through different generations. This helps in assessing the risk and planning preventive measures. The Markov Chain model's six-state transition analysis provides a detailed understanding of genotype probabilities, demonstrating how different combinations of male and female genes affect offspring genotypes.

The model predicts that after several generations, the population will eventually reach an equilibrium state where G6PD deficiency is no longer present. The findings of this study have significant implications for public health in Oman. By leveraging intelligent data systems and Markov Chain models, the healthcare system can improve early diagnosis, tailor interventions, and reduce long-term healthcare costs. This approach aligns with broader goals of enhancing healthcare sustainability and improving population health. This study demonstrates the effectiveness of using Markov Chain models and intelligent data systems in managing genetic disorders like G6PD deficiency. The integration of advanced technologies and preventive measures can lead to better health outcomes, economic sustainability, and a more resilient healthcare system in Oman. The Markov Chain model proves to be a valuable tool in predicting and managing genetic disorders, offering a feasible approach for future epidemiological studies.

CONCLUSIONS

As the Human Genome research advances, and more genetic testing is made available, family electronic health history is becoming increasingly important to know about the generations. In the near future, the role of genetic and genomic data in public health will become increasingly important. It has the potential to reveal information (such as disease onset at a young age, close relationships between patients, multiple affected family members, a suspicious genetic history, or diseases with a known genetic basis) that can be used to identify patients who may benefit from real-time consultation with medical genetics or disease-specific medical or surgical specialists. This work might serve as an introduction to the rich literature on Markov chains and its possible uses in epidemiological modeling. While there are many alternatives, more complex approaches for describing illness dynamics, the Markov approach's simplicity is appropriate for determining preliminary quantities of interest in the study of disease dynamics. Leveraging Markov Chain models within intelligent data systems presents a viable strategy for enhancing the sustainable management of G6PD deficiency in Oman. This approach not only supports the immediate needs of public health but also contributes to long-term health sustainability, aligning with broader goals of reducing the burden of genetic disorders and improving overall population health. As a result, the Markov chain model is proposed as a feasible approach for calculating other key epidemiological variables of infectious illnesses and generalizing transition probabilities for future forecasts.

REFERENCES

- Al-Maawali, A. (2022). Oman Genome Project is the Future of Using Genomics as the Determinant of Health and Disease in the Society. In *Oman medical journal* (Vol. 37, Issue 6, p. e440). <https://doi.org/10.5001/omj.2022.107>
- Al-Riyami, A., & Ebrahim, G. J. (2003). Genetic Blood Disorders Survey in the Sultanate of Oman. *Journal of Tropical Pediatrics*, 49 Suppl 1, i1–20. <http://europepmc.org/abstract/MED/12934793>
- Al-Sheryani, A., Al-Gheithi, H., Al Moosawi, M., Al-Zadjali, S., Wali, Y., & Al-Khabori, M. (2023). Molecular Characterization of Glucose-6-phosphate Dehydrogenase Deficiency in Oman. *Oman Medical Journal*, 38(5), e552. <https://doi.org/10.5001/omj.2023.107>
- Al Mawali, A. H. N., Al Qasmi, A. M., Al Sabahi, S. M. S., Idikula, J., Elaty, M. A. A., Morsi, M., & Al Hinai, A. T. (2017). Oman Vision 2050 for Health Research: A Strategic Plan for the Future Based on the Past and Present Experience. *Oman Medical Journal*, 32(2), 86–96. <https://doi.org/10.5001/omj.2017.18>
- Alangari, A. S., El-Metwally, A. A., Alanazi, A., Al Khateeb, B. F., Al Kadri, H. M., Alshdoukhi, I. F., Aldubikhi, A. I., Alruwaili, M., & Alshahrani, A. (2023). Epidemiology of Glucose-6-Phosphate Dehydrogenase Deficiency in Arab Countries: Insights from a Systematic Review. In *Journal of Clinical Medicine* (Vol. 12, Issue 20). <https://doi.org/10.3390/jcm12206648>
- Beutler, E. (1996). G6PD: Population genetics and clinical manifestations. *Blood Reviews*, 10(1), 45–52. [https://doi.org/10.1016/S0268-960X\(96\)90019-3](https://doi.org/10.1016/S0268-960X(96)90019-3)
- Bianco, A. M., Marcuzzi, A., Zanin, V., Girardelli, M., Vuch, J., & Crovella, S. (2013). Database tools in genetic diseases research. *Genomics*, 101(2), 75–85. <https://doi.org/10.1016/J.YGENO.2012.11.001>
- Bruwer, Z., Al Ubaidani, S., Al Kharusi, K., Al Murshedi, F., Al-Maawali, A., Al Sayegh, A., Al Kindy, A., Al Riyami, N., Al Dughaiishi, T., Al Salmani, M., Al Hashmi, N., Al Shehhi, M., Al Fahdi, B., Al Amri, S., & Al-Thihli, K. (2022). Uptake of prenatal genetic diagnosis and termination of pregnancy by Omani Muslim families at risk of genetic disorders: experience over a 9-year period. *Journal of Community Genetics*, 13(3), 303–311. <https://doi.org/10.1007/s12687-022-00584-1>
- Cornel, M. C., van der Meij, K. R. M., van El, C. G., Rigter, T., & Henneman, L. (2024). Genetic Screening—Emerging Issues. In *Genes* (Vol. 15, Issue 5). <https://doi.org/10.3390/genes15050581>
- Grzymski, J., Elhanan, G., Morales-Rosado, J., Smith, E., Schlauch, K., Read, R., Rowan, C., Slotnick, N., Dabe, S., Metcalf, W., Lipp, B., Reed, H., Sharma, L., Levin, E., Kao, J., Rashkin, M., Bowes, J., Dunaway, K., Slonim, A., & Lu, J. (2020). Population genetic screening efficiently identifies carriers of autosomal dominant diseases. *Nature Medicine*, 26, 1–5. <https://doi.org/10.1038/s41591-020-0982-5>
- Hassan, K. S., Al-Riyami, A. Z., Al-Huneini, M., Al-Farsi, K., & Al-Khabori, M. (2014). Methemoglobinemia in an elderly patient with glucose-6-phosphate dehydrogenase deficiency: a case report. In *Oman medical journal* (Vol. 29, Issue 2, pp. 135–137). <https://doi.org/10.5001/omj.2014.33>
- ISLAM, M. M. (2012). THE PRACTICE OF CONSANGUINEOUS MARRIAGE IN OMAN: PREVALENCE, TRENDS AND DETERMINANTS. *Journal of Biosocial Science*, 44(5), 571–594.

- <https://doi.org/DOI: 10.1017/S0021932012000016>
- Khalifa, Y., Mandic, D., & Sejdić, E. (2021). A review of Hidden Markov models and Recurrent Neural Networks for event detection and localization in biomedical signals. *Information Fusion*, 69, 52–72. <https://doi.org/https://doi.org/10.1016/j.inffus.2020.11.008>
- King, K., Kaganovsky, J., & Shirts, B. (2022). eP493: Population genetic screening study participants intend to share test results with family members. *Genetics in Medicine*, 24(3, Supplement), S313–S314. <https://doi.org/https://doi.org/10.1016/j.gim.2022.01.525>
- Lacaze, P. A., Tiller, J., Winship, I., & Group, F. the D. N. A. S. I. (2022). Population DNA screening for medically actionable disease risk in adults. *Medical Journal of Australia*, 216(6), 278–280. <https://doi.org/https://doi.org/10.5694/mja2.51454>
- Lacy, R. C. (2012). Extending Pedigree Analysis for Uncertain Parentage and Diverse Breeding Systems. *Journal of Heredity*, 2012(2), 197–205. <https://doi.org/10.1093/jhered/esr135>
- Luzzatto, L., Ally, M., & Notaro, R. (2020). Glucose-6-phosphate dehydrogenase deficiency. *Blood*, 136(11), 1225–1240. <https://doi.org/https://doi.org/10.1182/blood.2019000944>
- Mesa, A., Basterrech, S., Guerberoff, G., & Alvarez-Valin, F. (2016). Hidden Markov models for gene sequence classification. *Pattern Analysis and Applications*, 19(3), 793–805. <https://doi.org/10.1007/s10044-015-0508-9>
- Munkhammar, J., & Widén, J. (2018). A Markov-chain probability distribution mixture approach to the clear-sky index. *Solar Energy*, 170. <https://doi.org/10.1016/j.solener.2018.05.055>
- Natarajan, J., & Joseph, M. A. (2021). Premarital screening for genetic blood disorders — an integrated review on the knowledge and attitudes of Middle Eastern university students. *Middle East Fertility Society Journal*, 26(1), 19. <https://doi.org/10.1186/s43043-021-00065-4>
- Ong, K. I. C., Kosugi, H., Thoeun, S., Araki, H., Thandar, M. M., Iwagami, M., Hongvanthong, B., Brey, P. T., Kano, S., & Jimba, M. (2017). Systematic review of the clinical manifestations of glucose-6-phosphate dehydrogenase deficiency in the Greater Mekong Subregion: implications for malaria elimination and beyond. *BMJ Global Health*, 2(3), e000415. <https://doi.org/10.1136/bmjgh-2017-000415>
- Paxinou, E., Kalles, D., Panagiotakopoulos, C. T., & Verykios, V. S. (2021). Analyzing Sequence Data with Markov Chain Models in Scientific Experiments. *SN Computer Science*, 2(5), 385. <https://doi.org/10.1007/s42979-021-00768-5>
- Pes, G. M., & Dore, M. P. (2022). Acquired Glucose-6-Phosphate Dehydrogenase Deficiency. *Journal of Clinical Medicine*, 11(22). <https://doi.org/10.3390/jcm11226689>
- Rajab, A., Al Rashdi, I., & Al Salmi, Q. (2013). Genetic services and testing in the Sultanate of Oman. Sultanate of Oman steps into modern genetics. *Journal of Community Genetics*, 4(3), 391–397. <https://doi.org/10.1007/s12687-013-0153-1>
- Sulaiman, A. J., Al-Riyami, A., Farid, S., & Ebrahim, G. (2001). Oman Family Health Survey 1995. *Journal of Tropical Pediatrics*, 47 Suppl 1, 1–33.
- Sun, J., Lindsay, B., & Rhodes, G. (2023). Markov chain composite likelihood and its application in genetic recombination model. *Journal of Statistical Computation and Simulation*, 94, 1–27. <https://doi.org/10.1080/00949655.2023.2288167>
- Sun, J., Palade, V., Wu, X., & Fang, W. (2014). Multiple Sequence Alignment with Hidden Markov Models Learned by Random Drift Particle Swarm Optimization. *IEEE/ACM Transactions on Computational Biology and Bioinformatics*, 11(1), 243–257.

<https://doi.org/10.1109/TCBB.2013.148>

Yoon, P. W., Scheuner, M. T., Peterson-Oehlke, K. L., Gwinn, M., Faucett, A., & Khoury, M. J. (2002). Can family history be used as a tool for public health and preventive medicine? *Genetics in Medicine*, 4(4), 304–310. <https://doi.org/10.1097/00125817-200207000-00009>

***CORRESPONDING AUTHOR**

Divya Rani can be contacted at: divyaraniryazan@gmail.com

CITATION

Rani, D. (2025). Intelligent Data Systems for Sustainable Prevention and Management of G6PD Deficiency in Oman: A Markov Chain Model Approach. *Sohar University Journal of Sustainable Business*, 1(1), 1-15.

A COMPREHENSIVE ANALYSIS OF BARRIERS TO AUGMENTED REALITY IMPLEMENTATION IN SUSTAINABLE INVENTORY MANAGEMENT

Zainab Asim^{1*} and Syed Mohd Muneeb¹

¹*Tecnologico de Monterrey, Escuela de Ingeniería y Ciencias, Mexico*

ABSTRACT

Using the Best-Worst Method, this study investigates the barriers to adopting Augmented Reality (AR) in inventory management to attain sustainability. Data were collected from 53 experts across various roles in the supply chain and AR technology, including Logistics Coordinators, Warehouse Managers, IT Managers, Operations Managers, and AR Technology Providers. The study identified and ranked significant barriers, with financial barriers emerging as the most critical. These include high initial capital expenditure and uncertain return on investment. Operational barriers, such as the complexity of operations and maintenance support, and technological barriers, including high implementation costs and rapid technological changes, were also notable. The findings highlight the need for strategic approaches to address these challenges. For instance, phased implementation and cost-sharing models can help mitigate financial risks. Detailed implementation roadmaps and robust support systems are essential to manage operational complexities. Additionally, continuous learning programs and stringent data security protocols are necessary to address technological barriers. This research provides valuable insights for managers aiming to integrate AR into inventory management, emphasizing the importance of addressing financial, operational, and technological challenges. By tackling these areas, organizations can fully harness the potential of AR technology in transforming inventory management processes, enhancing efficiency, accuracy, and sustainability in the supply chain.

Keywords: Augmented reality; inventory management; sustainable supply chain.

Paper Type: Research paper

INTRODUCTION

Augmented Reality (AR) has emerged as a transformative technology with the potential to revolutionize various industries, including supply chain management. In inventory management, AR offers innovative solutions that enhance efficiency, accuracy, and sustainability. By overlaying digital information onto the physical world, AR can streamline

inventory tracking, optimize warehouse operations, and improve decision-making processes (Rohani et al., 2022). Despite these advantages, the adoption of AR in inventory management has been limited. This research aims to identify and rank the barriers to implementing AR in inventory management using the Best-worst Method (BWM) technique. By understanding these barriers, we can provide insights to help overcome them and promote the sustainable integration of AR technology.

Inventory management is a critical component of supply chain operations, influencing a company's efficiency, cost-effectiveness, and customer satisfaction. Traditional inventory management systems often rely on manual processes or basic automation, which can be error-prone and inefficient. AR, with its ability to provide real-time visualization and data integration, presents a significant advancement over conventional methods (Zaman et al., 2023). It can reduce human errors, speed up inventory audits, and provide more accurate stock levels. Moreover, AR can enhance worker productivity by providing step-by-step instructions and reducing the time needed to locate items within warehouses. These improvements not only boost operational efficiency but also contribute to sustainability by optimizing resource use and reducing waste.

Despite the clear benefits, the adoption rate of AR in inventory management remains low. Several factors contribute to this slow uptake, including technological, organizational, financial, environmental, legal, and social barriers (Sharma, 2011). Technological barriers such as high implementation costs and lack of technical expertise can deter companies from investing in AR. Organizational resistance to change and lack of top management support can further impede adoption. Financial concerns about uncertain return on investment and ongoing maintenance costs also play a significant role. Environmental considerations, such as increased energy consumption and e-waste generation, raise sustainability concerns. Legal issues related to regulatory compliance and intellectual property rights add another layer of complexity. Social factors, including user acceptance and cultural barriers, further complicate the integration process.

Addressing these barriers is crucial for the broader adoption of AR in inventory management. The BWM provides a robust framework for identifying and ranking these barriers (Singh and Kumar, 2024). BWM involves selecting the most and least significant barriers and comparing all others against these extremes to derive a ranking. This method offers a systematic approach to prioritize the barriers based on their relative importance, providing valuable insights for decision-makers.

The first step in this research involves a comprehensive literature review and expert consultations to identify potential barriers to AR adoption. These barriers are then categorized into six broad categories: technological, organizational, financial, environmental, legal, and social. Each category encompasses several sub-categories, capturing the multifaceted challenges faced by organizations. For instance, under technological barriers, issues such as high implementation costs, lack of technical expertise, data security concerns, and compatibility issues are considered. Organizational barriers include resistance to change, lack of top management support, integration challenges, and training requirements. Financial barriers encompass high maintenance costs, uncertain Return-on-Investment (ROI), cost of training, and

initial capital expenditure. Environmental barriers focus on energy consumption, e-waste generation, carbon footprint, and resource efficiency. Legal barriers address regulatory compliance, intellectual property issues, data privacy regulations, and liability concerns. Social barriers include user acceptance, cultural barriers, ethical concerns, and the impact on employment.

Once the barriers are identified, the BWM technique is applied to rank them. This involves engaging experts to rate the significance of each barrier compared to the best and worst barriers identified in each category. The data collected from these ratings are then analyzed to calculate the weights of each barrier, resulting in a prioritized list. This ranking highlights the most critical barriers that need to be addressed to facilitate the adoption of AR in inventory management.

The findings of this research are expected to provide actionable insights for both practitioners and policymakers. By understanding the key barriers to AR adoption, organizations can develop targeted strategies to overcome them. For instance, addressing high implementation costs might involve exploring cost-sharing models or phased implementation approaches. Enhancing technical expertise could be achieved through specialized training programs and collaborations with technology providers. To overcome organizational resistance, change management initiatives and strong leadership support are essential. Financial concerns can be mitigated by conducting detailed cost-benefit analyses and securing funding for pilot projects. Addressing environmental barriers requires integrating AR solutions with sustainable practices, such as energy-efficient technologies and e-waste recycling programs. Legal barriers can be navigated by staying informed about regulatory developments and seeking legal counsel. Social barriers can be addressed through user-centered design, cultural sensitivity, and ethical considerations.

The adoption of AR in inventory management presents significant opportunities for enhancing efficiency and sustainability. However, numerous barriers hinder its widespread implementation. This research aims to systematically identify and rank these barriers using the BWM, providing a clear roadmap for organizations to overcome these challenges. By addressing these barriers, businesses can leverage AR technology to transform their inventory management processes, driving operational excellence and sustainability in the supply chain.

To provide a comprehensive understanding of the study, the remaining of this paper is organized as follows. Section 2 presents a thorough literature review, discussing the current state of AR in inventory management and identifying key barriers to its adoption. Section 3 details the research methodology, including the data collection process and the application of the BWM for analysis. Section 4 outlines the results, highlighting the identified barriers and their respective rankings. Section 5 provides a detailed discussion of the findings, comparing them with existing literature and discussing their implications. Finally, Section 6 concludes the paper by summarizing the key insights, suggesting practical recommendations for overcoming the identified barriers, and proposing directions for future research.

LITERATURE REVIEW

AR is increasingly recognized for its potential to revolutionize inventory management within supply chain operations (Attaran, 2020). AR enhances the physical world with digital information, offering significant benefits such as improved accuracy, increased efficiency, and enhanced sustainability (Masood and Egger, 2019). Despite these advantages, the adoption of AR in inventory management remains limited, primarily due to several barriers. This literature review explores the current state of AR in inventory management, identifies key barriers to its adoption, and discusses implications for future research and practice.

AR technology has evolved rapidly, driven by advancements in computing power, sensor technology, and data processing capabilities. In the context of inventory management, AR can significantly streamline operations by providing real-time, accurate data overlays, reducing human errors, speeding up inventory audits, and optimizing warehouse layouts. Research has shown that AR can improve picking accuracy and efficiency, enhance worker productivity, and facilitate better training through immersive experiences.

A systematic review by Akbari et al. (2022) highlights the maturity and current trends of AR in operations and supply chain management. Their study indicates a growing body of literature focused on the benefits of AR, particularly in manufacturing and logistics. However, they also note that AR's application in inventory management is still in its nascent stages, with limited empirical studies exploring its full potential.

Another study by Rejeb et al. (2020) explores the applications of AR in logistics and supply chain management. They identify key areas where AR can provide significant benefits, such as real-time tracking, improved visibility, and enhanced decision-making. Their findings suggest that while the technology holds promise, practical implementation is hampered by various challenges, including technical limitations and high costs.

Despite the promising potential of AR, several barriers impede its widespread adoption in inventory management. Technological barriers are among the most significant challenges (Masood and Egger, 2020). According to their findings, high implementation costs and the lack of technical expertise are primary concerns. Integrating AR systems with existing inventory management software can be complex and resource-intensive. Additionally, issues related to data security and privacy pose significant risks, as AR systems often rely on extensive data collection and processing.

Organizational barriers also play a crucial role. Resistance to change from employees and managers can hinder the adoption of new technologies. Furthermore, the lack of top management support and the need for significant training to ensure employees are proficient in using AR technology add to the complexity of implementation. A study by Chuah (2018) highlights how organizational inertia and the fear of change can be significant obstacles to adopting innovative technologies.

Financial barriers, such as uncertain ROI and high maintenance costs, are significant deterrents. Companies are often reluctant to invest in new technologies without clear evidence of financial benefits. The initial capital expenditure required to implement AR technology can also be

prohibitively high for many organizations. According to Tikwayo and Mathaba (2023), the financial risk associated with new technology investments is a considerable hurdle for many companies.

Environmental barriers include concerns about increased energy consumption and electronic waste generation. While AR can enhance operational efficiency, its implementation must be carefully managed to avoid offsetting sustainability benefits. Moreover, the potential increase in the carbon footprint due to the deployment of AR technology needs to be addressed. Stoltz et al. (2017) discuss the environmental impacts of new technologies and emphasize the need for sustainable implementation practices.

Legal barriers encompass regulatory compliance, intellectual property issues, data privacy regulations, and liability concerns. Navigating the complex regulatory landscape for AR technology can be time-consuming and costly. Intellectual property issues related to AR technologies and their applications can also pose significant challenges. Conroy (2017) explore the legal complexities associated with deploying AR in commercial settings and the regulatory hurdles that companies must overcome.

Social barriers, such as user acceptance, cultural differences, ethical concerns, and the impact on employment, further complicate AR adoption. Achieving widespread user acceptance and comfort with AR technology requires addressing cultural and ethical considerations. Additionally, concerns about job displacement due to automation need to be carefully managed. Martínez et al. (2014) highlight the social implications of adopting new technologies and the importance of addressing workforce concerns.

To systematically address these barriers, this study employs the BWM (Rezaei, 2015; Rezaei, 2016) to identify and rank the most significant obstacles. The BWM technique involves selecting the most and least critical barriers from a list and comparing all others against these extremes to derive a ranking. This approach provides a structured way to prioritize the barriers based on their relative importance, offering valuable insights for decision-makers.

The methodology for this study involves a comprehensive literature review and expert consultations to identify potential barriers to AR adoption. These barriers are then categorized into technological, organizational, financial, environmental, legal, and social factors. Experts rate the significance of each barrier, and the data collected from these ratings are analyzed using the BWM technique to calculate the weights of each barrier, resulting in a prioritized list.

The findings of this study have significant implications for both research and practice. Understanding the key barriers to AR adoption in inventory management can help organizations develop targeted strategies to overcome them. For instance, addressing high implementation costs might involve exploring cost-sharing models or phased implementation approaches. Enhancing technical expertise could be achieved through specialized training programs and collaborations with technology providers.

To overcome organizational resistance, change management initiatives and strong leadership support are essential. Financial concerns can be mitigated by conducting detailed cost-benefit analyses and securing funding for pilot projects. Addressing environmental barriers requires

integrating AR solutions with sustainable practices, such as energy-efficient technologies and e-waste recycling programs. Legal barriers can be navigated by staying informed about regulatory developments and seeking legal counsel. Social barriers can be addressed through user-centered design, cultural sensitivity, and ethical considerations.

Table 1: Detail of Categories and sub-categories of barriers identified in LR

Category	Sub-Category	Description	Sources
Technological	High Implementation Costs	The initial costs of purchasing and integrating AR technology can be prohibitively high.	Zhmud et al. (2021); Masood and Egger (2019)
	Lack of Technical Expertise	Insufficient technical knowledge and skills among staff to operate and maintain AR systems.	Osuna et al. (2019); Alqahtani and AlNajdi (2023)
	Data Security Concerns	Concerns about the security and privacy of data collected and used by AR systems.	Syed et al. (2022), Oke and Arowoia (2022)
	Compatibility Issues	Compatibility issues between AR hardware and existing inventory systems.	Martínez et al. (2014), Kumari and Polke (2020)
	Reliability and Performance	Concerns about the reliability and performance of AR systems in various operating conditions.	Palmarini et al. (2018), Schein and Rauschnabel (2021)
	Rapid Technological Changes	Rapid changes in AR technology can make it difficult to keep systems up-to-date.	Schein and Rauschnabel (2021), Mendoza-Ramírez et al. (2023)
	Resistance to Change	Employees and managers may resist adopting new technologies due to comfort with existing processes.	Schein and Rauschnabel (2021); Konopka et al. (2024)
Organizational	Lack of Top Management Support	Insufficient support from top management can hinder the implementation of AR technology.	de Macêdo Brito et al. (2024)
	Integration with Existing Systems	Difficulty in integrating AR systems with existing inventory management software and processes.	Berkemeier et al. (2019), Viljakainen (2020)
	Training Requirements	Significant training is required to ensure employees are proficient in using AR technology.	Thompson & Richards (2018), Zhang et al. (2019)
	Workforce	Variability in the ability of the	Schein and

	Adaptability	workforce to adapt to new AR technologies.	Rauschnabel (2021), Sidani et al. (2021)
	High Maintenance Costs	Ongoing maintenance and upgrade costs for AR systems can be substantial.	Oesterreich and Teuteberg(2017), Nassereddine et al. (2022)
Financial	Uncertain ROI	Uncertainty about the return on investment for AR technology can deter companies from adopting it.	Berman and Pollack (2021)
	Cost of Training	Financial burden associated with training employees to use AR technology effectively.	Zhmud et al. (2021), Oke and Arowoiya (2022)
	Initial Capital Expenditure	The significant upfront investment required to implement AR technology.	Oesterreich and Teuteberg(2017), Nassereddine et al. (2022)
	Energy Consumption	AR systems may increase energy consumption, offsetting some sustainability benefits.	Bekaroo et al. (2018), An et al. (2024)
Environmental	E-Waste Generation	The introduction of AR technology can lead to increased electronic waste.	Sureshkumar et al. (2023)
	Carbon Footprint	Lower carbon emissions resulting from reduced need for physical audits and transportation.	Isley et al. (2017), Shevchenko et al. (2021)
	Resource Efficiency	Improved utilization of storage space and reduction in overstock/understock situations.	Isley et al. (2017), Thiede et al. (2022)
	Regulatory Compliance	Navigating the regulatory landscape for AR technology can be complex and time-consuming.	Wassom (2014), Gromova et al. (2022)
Legal	Intellectual Property Issues	Issues related to the intellectual property of AR technologies and their applications.	Hallevy et al. (2018), Gromova et al. (2022)
	Data Privacy Regulations	Compliance with data privacy laws and regulations.	Gromova et al. (2022), Volkov (2023)
	Liability Concerns	Concerns regarding liability and insurance related to the use of AR technology.	Hallevy et al. (2018), Mostert (2020)
Social	User Acceptance	Achieving widespread user acceptance and comfort with AR	Wintersberger et al. (2018), Schein

		technology can be challenging.	and Rauschnabel (2021)
	Cultural Barriers	Cultural differences can affect the acceptance and use of AR technology in global supply chains.	Oke and Arowoiya (2022)
	Ethical Concerns	Ethical issues related to surveillance and privacy in using AR.	Schein and Rauschnabel (2021), Mendoza-Ramírez et al. (2023)
	Impact on Employment	Concerns about the impact of AR on employment and job displacement.	Billinghurst (2021)
Operational	Complexity of Operations	The complexity of implementing AR in diverse and dynamic inventory management environments.	Hall et al. (2015), Alqahtani and AlNajdi (2023)
	Supply Chain Disruptions	Potential disruptions in supply chain operations during the transition to AR.	Stoltz et al. (2017), Rejeb et al. (2020)
	Maintenance and Support	Challenges in maintaining and supporting AR systems in operational environments.	Osuna et al. (2019); Alqahtani and AlNajdi (2023)
	Scalability Issues	Difficulties in scaling AR solutions across different locations and operations.	Palmarini et al. (2018), Schein and Rauschnabel (2021)

METHODOLOGY

Data Collection and Expert Selection

The methodology of this study is structured to systematically identify and rank the barriers to adopting AR in inventory management using the BWM. For this study we have approached 75 experts following snowball sampling technique. The high technicality of our questionnaire was a restriction in having a large sample size. Out of 75, only 53 responses were having consistency index within the acceptable range (Rezaei, 2016). The experts approached in this study were from various fields including Logistics Coordinators, Warehouse Managers, IT Managers, Operations Managers, and AR Technology Providers. These experts provided a comprehensive understanding of the barriers faced in implementing AR technology in inventory management.

Best-worst Method (BWM) Overview

The BWM is a multi-criteria decision-making method that involves selecting the most important (best) and least important (worst) factors from a set of criteria and comparing all others against

these extremes to derive a ranking. This method provides a structured approach to prioritize barriers based on their relative importance, offering valuable insights for decision-makers.

Steps in Applying BWM

1. Selection of Factors:

Identify the factors influencing the adoption of AR in inventory management. These factors were categorized into six broad categories: technological, organizational, financial, environmental, legal, and social. Each category encompassed several sub-categories capturing the multifaceted challenges faced by organizations.

2. Determining Best and Worst Factors:

The decision-makers (DMs) selected the most important (best) and least important (worst) factors from among the identified set of factors $(F_1, F_2, \dots, F_n)$.

3. Pairwise Comparisons:

The DMs provided preference scores for all factors with respect to the best factor using a scale from 1 to 9, where 1 indicates equal importance and 9 indicates absolute importance of the best factor over the other factors. This resulted in the best-to-others vector (A_B) :

$$A_B = (a_{B1}, a_{B2}, \dots, a_{Bn})$$

Where a_{Bi} represents the preference score of the best factor over factor i .

Similarly, the DMs provided preference scores for all factors with respect to the worst factor, forming the others-to-worst vector (A_W) :

$$A_W = (a_{1W}, a_{2W}, \dots, a_{nW})$$

Where a_{1W} represents the preference score of factors i over the worst factor.

4. Determining Optimal Weights:

The optimal weight for the factors were determined by solving the following linear programming model:

$$\begin{aligned} & \text{MIN } \varepsilon \\ & \text{Subject to:} \\ & \omega_B - a_{Bi}\omega_i \leq \varepsilon, \quad \forall i = 1, 2, \dots, n \\ & \omega_i - a_{iW}\omega_W \leq \varepsilon, \quad \forall i = 1, 2, \dots, n \\ & \sum_{i=1}^n \omega_i = 1 \\ & \omega_i \geq 0 \end{aligned}$$

Where ω_B , ω_W , and ω_i are the optimal weights for the best, worst, and i -th factor respectively.

5. Aggregating Weights:

The aggregated weight ω_i^* for each factor was obtained using the geometric mean of the weights calculated for each DM:

$$\omega_i^* = \left(\prod_{k=1}^K \omega_{ik} \right)^{\frac{1}{K}}$$

Where ω_{ik} is the weight of factor i given by the k -th DM, and K is the total number of DMs.

6. Consistency Ratio Calculation:

The consistency ratio (CR) was calculated to measure the inconsistency in the pairwise comparisons. The CR is given by:

$$CR = \frac{\varepsilon^*}{\varepsilon_{max}}$$

where ε^* is the optimal value of the objective function and ε_{max} is the maximum possible value of ε . The CR ranges from 0 to 1, with values closer to 0 indicating more consistent judgments.

RESULT AND ANALYSIS

The results of this study are derived from an analysis using the BWM to evaluate the barriers to adopting AR in inventory management. The study gathered data from 53 respondents with varied expertise, including Logistics Coordinators, Warehouse Managers, IT Managers, Operations Managers, AR Technology Providers, and others (Table 2). This diverse group provided a comprehensive perspective on the challenges faced in implementing AR technology.

Table 2: Area of Expertise of Respondents

Area of expertise of respondents	Frequency
Logistics Coordinators	16
Warehouse Managers	12
IT Managers	5
Operations Managers	5
AR Technology Providers	3
Others	12
Total	53

The BWM analysis identified and ranked the barriers based on their significance. The analysis revealed that financial barriers were the most critical, followed by operational, technological, organizational, environmental, legal, and social barriers. Each barrier category was further broken down into sub-categories, which were weighted and ranked to provide a detailed understanding of the specific challenges within each category.

Table 3, represents how many respondents selected each category as the best or worst barrier to the adoption of AR in inventory management. This table provides insight into the perceived

significance of each barrier category from the respondents' viewpoints, highlighting the most critical areas that need to be addressed for successful AR implementation. For instance, 17 respondents identified financial barriers as the most critical, while 19 respondents identified legal barriers as the least significant. Technological barriers were identified as the best by 14 respondents and not considered the worst by any, indicating their high perceived importance but lower perceived difficulty compared to legal and social barriers.

Table 3: Selection of Best and Worst Categories by Respondents

Categories	Best	Worst
Technological	14	0
Organizational	7	8
Financial	17	2
Environmental	2	10
Legal	0	19
Social	0	12
Operational	13	2

The Weights for each category and sub-categories as well as their rankings as per significance is presented in Table 4. Higher weights reflect higher importance for the category or sub-category. The financial barriers emerged as the most significant, with an overall weight of 0.28531. Within this category, the sub-category of initial capital expenditure was identified as the most critical barrier, with a local weight of 0.29364 and a global weight of 0.083778, ranking first among all barriers. This finding underscores the substantial upfront investment required to implement AR technology, which can be prohibitive for many organizations. Uncertain ROI was also a significant financial barrier, ranking second overall with a global weight of 0.074312. High maintenance costs and the cost of training further contributed to the financial challenges, ranking fourth and fifth, respectively. These findings highlight the financial risks and ongoing costs associated with AR adoption, which can deter companies from investing in this technology.

Operational barriers were the second most significant category, with a weight of 0.20173. The complexity of operations was the most critical operational barrier, ranking third overall with a global weight of 0.065038. This barrier reflects the challenges in integrating AR into diverse and dynamic inventory management environments. Maintenance and support also emerged as a significant operational barrier, ranking seventh with a global weight of 0.055665. Supply chain disruptions and scalability issues were other notable operational barriers, emphasizing the potential disruptions and challenges in scaling AR solutions across different locations and operations.

Technological barriers were identified as the third most significant category, with a weight of 0.25084. High implementation costs were the most critical technological barrier within this category, ranking sixth overall with a global weight of 0.057896. This barrier highlights the substantial initial costs associated with purchasing and integrating AR technology. Rapid

technological changes were another significant technological barrier, ranking eighth with a global weight of 0.050256. This finding indicates the challenges in keeping AR systems up-to-date amidst rapid advancements in technology. Compatibility issues, lack of technical expertise, and concerns about data security and reliability were also significant technological barriers, reflecting the technical complexities and risks associated with AR implementation.

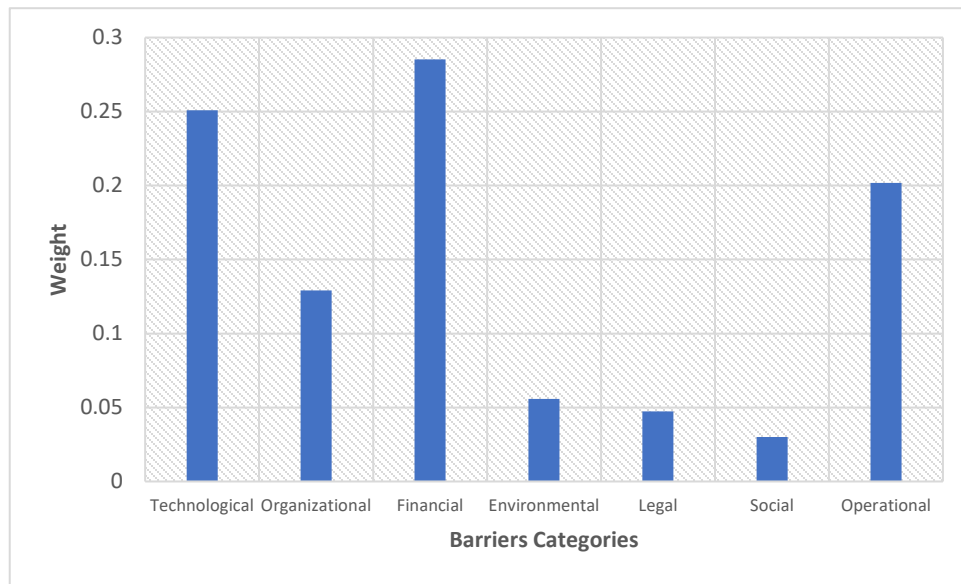


Figure 1: Relative weights for each barrier categories

Organizational barriers, with a weight of 0.12912, were the fourth most significant category. Workforce adaptability was the most critical organizational barrier, ranking twelfth overall with a global weight of 0.035369. This barrier underscores the variability in the ability of the workforce to adapt to new AR technologies. Integration with existing systems and training requirements were other notable organizational barriers, highlighting the challenges in integrating AR with current inventory management systems and the need for extensive training to ensure employees are proficient in using the technology. Resistance to change and lack of top management support further contributed to the organizational challenges, reflecting the importance of organizational culture and leadership in facilitating AR adoption.

Environmental barriers, with a weight of 0.05571, were identified as the fifth most significant category. Within this category, resource efficiency was the most critical barrier, ranking nineteenth overall with a global weight of 0.017637. This finding highlights the challenges in optimizing resource use and reducing waste through AR implementation. Carbon footprint, energy consumption, and e-waste generation were other notable environmental barriers, emphasizing the need for sustainable practices in deploying AR technology.

Legal barriers were the sixth most significant category, with a weight of 0.04728. Regulatory compliance was the most critical legal barrier, ranking twentieth overall with a global weight of 0.015605. This barrier reflects the complexities and costs associated with navigating the regulatory landscape for AR technology. Liability concerns, data privacy regulations, and

intellectual property issues were other notable legal barriers, highlighting the legal risks and challenges in deploying AR.

Social barriers, with a weight of 0.03001, were the least significant category. User acceptance was the most critical social barrier, ranking twenty-ninth overall with a global weight of 0.007804. This barrier underscores the challenges in achieving widespread acceptance and comfort with AR technology among users. Cultural barriers, ethical concerns, and the impact on employment were other notable social barriers, reflecting the social and ethical considerations in AR adoption.

Table 4: Weights and Rankings of Barrier Categories and Sub-Categories

Category	Weight	Sub-Category	Local Weight	Global Weights	Global Rank
Technological	0.25084	High Implementation Costs	0.23081	0.057896	6
		Lack of Technical Expertise	0.16926	0.042457	10
		Data Security Concerns	0.11826	0.029664	16
		Compatibility Issues	0.15849	0.039756	11
		Reliability and Performance	0.12283	0.030811	15
		Rapid Technological Changes	0.20035	0.050256	8
		Resistance to Change	0.14745	0.019039	18
Organizational	0.12912	Lack of Top Management Support	0.12045	0.015553	21
		Integration with Existing Systems	0.25817	0.033335	14
		Training Requirements	0.20001	0.025825	17
		Workforce Adaptability	0.27392	0.035369	12
		High Maintenance Costs	0.22784	0.065005	4
Financial	0.28531	Uncertain ROI	0.26046	0.074312	2
		Cost of Training	0.21806	0.062215	5
		Initial Capital Expenditure	0.29364	0.083778	1
		Energy Consumption	0.22549	0.012562	24
Environmental	0.05571	E-Waste Generation	0.19792	0.011026	25
		Carbon Footprint	0.26	0.014485	22
		Resource Efficiency	0.31659	0.017637	19
		Regulatory Compliance	0.33006	0.015605	20
Legal	0.04728	Intellectual Property Issues	0.18008	0.008514	27
		Data Privacy Regulations	0.20831	0.009849	26
		Liability Concerns	0.28155	0.013312	23
		User Acceptance	0.26004	0.007804	29
Social	0.03001	Cultural Barriers	0.23074	0.006925	30
		Ethical Concerns	0.22959	0.00689	31
		Impact on Employment	0.27963	0.008392	28
		Complexity of Operations	0.3224	0.065038	3
Operational	0.20173	Supply Chain Disruptions	0.17458	0.035218	13
		Maintenance and Support	0.27594	0.055665	7
		Scalability Issues	0.22708	0.045809	9

The comprehensive analysis using the BWM approach provided a detailed understanding of the barriers to AR adoption in inventory management. The findings highlight the need for targeted strategies to address the most significant barriers, particularly financial and operational challenges. Addressing high implementation costs and uncertain ROI through cost-sharing models, phased implementation approaches, and detailed cost-benefit analyses can help mitigate financial risks. Enhancing technical expertise through specialized training programs and collaborations with technology providers can address technological barriers. Organizational resistance can be overcome through change management initiatives and strong leadership support.

Furthermore, integrating AR solutions with sustainable practices, such as energy-efficient technologies and e-waste recycling programs, can address environmental barriers. Staying informed about regulatory developments and seeking legal counsel can help navigate legal challenges. User-centered design, cultural sensitivity, and ethical considerations can address social barriers, ensuring widespread acceptance and comfort with AR technology.

MANAGERIAL IMPLICATIONS

The findings of this study have significant implications for managers aiming to adopt AR in inventory management. By addressing identified barriers, managers can facilitate smoother implementation and integration of AR technology, enhancing operational efficiency and sustainability.

Financial barriers are the most critical, with substantial initial capital expenditure being a major concern. Managers can explore cost-sharing models or phased implementation approaches to spread out expenses. Conducting thorough cost-benefit analyses can justify investments by highlighting long-term savings and efficiency gains. To address uncertain ROI, clear metrics and performance indicators should be developed to measure AR's impact, helping secure stakeholder support. Managing high maintenance costs and training expenses through comprehensive training programs and maintenance schedules ensures workforce proficiency and system reliability.

Operational challenges, particularly the complexity of integrating AR into diverse environments, require careful planning. Pilot studies can provide valuable feedback and identify potential issues before a full-scale rollout. Detailed implementation roadmaps help manage complexity and ensure structured integration. Robust support systems, including dedicated teams or partnerships with AR providers, can minimize downtime and ensure continuous functionality. Addressing scalability issues from the planning stages ensures effective expansion across different locations. Technological barriers such as high implementation costs, rapid technological changes, compatibility issues, lack of technical expertise, and data security concerns need strategic solutions. Prioritizing investments in scalable AR technology and staying updated on advancements can mitigate technological challenges. Close collaboration with IT departments ensures seamless integration with existing

systems. Continuous learning programs enhance technical expertise, while stringent data security protocols protect sensitive information.

Organizational barriers like resistance to change, lack of top management support, integration challenges, training requirements, and workforce adaptability require effective change management. Fostering a culture of innovation and clearly communicating AR benefits can alleviate resistance. Securing top management support through compelling business cases aligns AR technology with organizational goals. Detailed integration plans and comprehensive training programs ensure smooth adoption. Supporting workforce adaptability through continuous development programs is crucial.

Environmental barriers such as energy consumption, e-waste generation, carbon footprint, and resource efficiency must be addressed with sustainable practices. Prioritizing energy-efficient AR solutions and implementing e-waste recycling programs minimize environmental impact. Optimizing resource use through accurate inventory tracking enhances sustainability. Legal barriers including regulatory compliance, intellectual property issues, data privacy regulations, and liability concerns require careful navigation. Staying informed about regulations and consulting legal experts help address these challenges. Ensuring compliance and protecting the organization against legal risks are essential. Social barriers like user acceptance, cultural differences, ethical concerns, and the impact on employment require thoughtful management. Engaging employees and stakeholders to understand and address their concerns enhances acceptance. Cultural sensitivity and ethical considerations ensure responsible AR use. Managing employment impact through upskilling and reskilling opportunities helps employees transition to new roles.

Addressing these barriers strategically enables successful AR implementation in inventory management, driving efficiency and sustainability. The insights from this study provide a roadmap for overcoming AR adoption challenges, allowing organizations to leverage the full potential of this transformative technology.

CONCLUSIONS

This study identified and ranked the barriers to adopting AR in inventory management using the BWM. Financial barriers, particularly initial capital expenditure and uncertain return on investment, were the most significant, followed by operational and technological barriers. Addressing these barriers through strategic financial planning, detailed implementation roadmaps, continuous learning programs, and robust data security protocols can facilitate smoother AR integration. The findings provide a roadmap for overcoming these challenges, enabling organizations to leverage AR for improved efficiency and sustainability in inventory management. In future research can be done focusing on longitudinal studies to track AR adoption over time and detailed case studies of successful implementations. Assessing the long-term impact of AR on efficiency and sustainability, exploring new technological advancements, and understanding user experiences are crucial. Additionally, examining regulatory and ethical considerations, scalability, cost-effectiveness, and integration with sustainable practices will

provide deeper insights and practical solutions to facilitate broader AR adoption in inventory management.

REFERENCES

- Akbari, M., Ha, N., & Kok, S. (2022). A systematic review of AR/VR in operations and supply chain management: maturity, current trends and future directions. *Journal of Global Operations and Strategic Sourcing*, 15(4), 534-565.
- Alqahtani, E. S., & AlNajdi, S. M. (2023). Potential obstacles to adopting augmented reality (AR) technologies as pedagogical tools to support students learning in higher education. *Interactive Learning Environments*, 1-10.
- An, J., Yeom, S., Hong, T., Jeong, K., Lee, J., Eardley, S., & Choi, J. (2024). Analysis of the impact of energy consumption data visualization using augmented reality on energy consumption and indoor environment quality. *Building and Environment*, 250, 111177.
- Attaran, M. (2020). Digital technology enablers and their implications for supply chain management. In *Supply Chain Forum: An International Journal*, 21(3), 158-172.
- Bekaroo, G., Sungkur, R., Ramsamy, P., Okolo, A., & Moedeen, W. (2018). Enhancing awareness on green consumption of electronic devices: The application of Augmented Reality. *Sustainable Energy Technologies and Assessments*, 30, 279-291.
- Berkemeier, L., Zobel, B., Werning, S., Ickerott, I., & Thomas, O. (2019). Engineering of augmented reality-based information systems: design and implementation for intralogistics services. *Business & Information Systems Engineering*, 61, 67-89.
- Berman, B., & Pollack, D. (2021). Strategies for the successful implementation of augmented reality. *Business Horizons*, 64(5), 621-630.
- Billinghamurst, M. (2021). Grand challenges for augmented reality. *Frontiers in Virtual Reality*, 2, 578080.
- Chuah, S. H. W. (2018). Why and who will adopt extended reality technology? Literature review, synthesis, and future research agenda. *Literature Review, Synthesis, and Future Research Agenda* (December 13, 2018).
- Conroy, D. T. (2017). Property rights in augmented reality. *Mich. Telecomm. & Tech. L. Rev.*, 24, 17.
- de Macêdo Brito, E., de Arruda, Â. M., de Sá Brandim, A., Sebaio, A. G., Pereira, B. A., da Silva Santos, E. I., ... & Pereira, M. V. (2024). Innovations in virtual and augmented reality: Transforming organizational culture management for the 21st century. *Seven Editora*, 758-773.
- Gromova, E. A., Koneva, N. S., & Titova, E. V. (2022). Legal barriers to the implementation of digital industry (Industry 4.0) components and ways to overcome them. *The Journal of World Intellectual Property*, 25(1), 186-205.
- Hall, N., Lowe, C., & Hirsch, R. (2015). Human factors considerations for the application of augmented reality in an operational railway environment. *Procedia Manufacturing*, 3, 799-806.

- Hallevy, G. (2018). Criminal liability for intellectual property offenses of artificially intelligent entities in virtual and augmented reality environments. In *Research handbook on the law of virtual and augmented reality* (pp. 389-419). Edward Elgar Publishing.
- Isley, S. C., Ketcham, R., & Arent, D. J. (2017). Using augmented reality to inform consumer choice and lower carbon footprints. *Environmental Research Letters*, 12(6), 064002.
- Konopka, B., Hönemann, K., & Wiesche, M. (2024). Investigation of Key Barriers Regarding Adoption and Implementation of Augmented Reality in Industrial Organizations—A Delphi Study. 57th Hawaii International Conference on System Sciences, Hawaii.
- Kumari, S., & Polke, N. (2019). Implementation issues of augmented reality and virtual reality: A survey. In *International Conference on Intelligent Data Communication Technologies and Internet of Things (ICICI) 2018* (pp. 853-861). Springer International Publishing.
- Martínez, H., Skourmetou, D., Hyppölä, J., Laukkanen, S., & Heikkilä, A. (2014). Drivers and bottlenecks in the adoption of augmented reality applications. *J. Multimed. Theory Appl*, 2.
- Masood, T., & Egger, J. (2019). Augmented reality in support of Industry 4.0—Implementation challenges and success factors. *Robotics and Computer-Integrated Manufacturing*, 58, 181-195.
- Masood, T., & Egger, J. (2020). Adopting augmented reality in the age of industrial digitalisation. *Computers in Industry*, 115, 103112.
- Mendoza-Ramírez, C. E., Tudon-Martinez, J. C., Félix-Herrán, L. C., Lozoya-Santos, J. D. J., & Vargas-Martínez, A. (2023). Augmented reality: survey. *Applied Sciences*, 13(18), 10491.
- Mostert, F. (2020). Digital tools of intellectual property enforcement: their intended and unintended norm setting consequences. In *Research Handbook on Intellectual Property and Digital Technologies* (pp. 553-576). Edward Elgar Publishing.
- Nassereddine, H., Hanna, A. S., Veeramani, D., & Lotfallah, W. (2022). Augmented reality in the construction industry: use-cases, benefits, obstacles, and future trends. *Frontiers in Built Environment*, 8, 730094.
- Oesterreich, T., & Teuteberg, F. (2017). Evaluating augmented reality applications in construction—a cost-benefit assessment framework based on VoFI. 25th European Conference on Information Systems (ECIS), Guimarães, Portugal.
- Oke, A. E., & Arowoia, V. A. (2022). Critical barriers to augmented reality technology adoption in developing countries: a case study of Nigeria. *Journal of Engineering, Design and Technology*, 20(5), 1320-1333.
- Osuna, J. B., Gutiérrez-Castillo, J., Llorente-Cejudo, M., & Ortiz, R. V. (2019). Difficulties in the incorporation of augmented reality in university education: Visions from the experts. *Journal of New Approaches in Educational Research (NAER Journal)*, 8(2), 126-141.
- Palmarini, R., Erkoyuncu, J. A., Roy, R., & Torabmostaedi, H. (2018). A systematic review of augmented reality applications in maintenance. *Robotics and Computer-Integrated Manufacturing*, 49, 215-228.
- Rampolla, J., & Kipper, G. (2012). *Augmented reality: An emerging technologies guide to AR*. Elsevier.
- Rejeb, A., Keogh, J. G., Wamba, S. F., & Treiblmaier, H. (2020). The potentials of augmented reality in supply chain management: A state-of-the-art review. *Management review quarterly*, 1-38.
- Rezaei, J. (2015). Best-worst multi-criteria decision-making method. *Omega*, 53, 49-57.

- Rezaei, J. (2016). Best-worst multi-criteria decision-making method: Some properties and a linear model. *Omega*, 64, 126-130.
- Rohani, V. A., Peerally, J. A., Moghavvemi, S., Guerreiro, F., & Pinho, T. (2022). Illustrating scholar-practitioner collaboration for data-driven decision-making in the optimization of logistics facility location and implications for increasing the adoption of AR and VR practices. *The TQM Journal*, 34(2), 280-302.
- Schein, K. E., & Rauschnabel, P. A. (2021). Augmented reality in manufacturing: Exploring workers' perceptions of barriers. *IEEE Transactions on Engineering Management*, 70(10), 3344-3357.
- Sharma, Y. (2011). Cost-Effective Inventory Management Using Augmented Reality. *Asian Journal of Multidisciplinary Research & Review*, 5(1), 34-46.
- Shevchenko, T., Saidani, M., Danko, Y., Golysheva, I., Chovancová, J., & Vavrek, R. (2021). Towards a smart E-waste system utilizing supply chain participants and interactive online maps. *Recycling*, 6(1), 8.
- Sidani, A., Dinis, F. M., Duarte, J., Sanhudo, L., Calvetti, D., Baptista, J. S., ... & Soeiro, A. (2021). Recent tools and techniques of BIM-Based Augmented Reality: A systematic review. *Journal of Building Engineering*, 42, 102500.
- Stoltz, M. H., Giannikas, V., McFarlane, D., Strachan, J., Um, J., & Srinivasan, R. (2017). Augmented reality in warehouse operations: opportunities and barriers. *IFAC-PapersOnLine*, 50(1), 12979-12984.
- Sureshkumar, S., Rani, P. K., Agash, C. P., Kumar, B. A., & Kaviyaraj, R. (2023, March). Augmented Reality and Waste Reduction: Enhancing the Recycling Process for Mobile E-Waste in Automotive Manufacturing. In *2023 9th International Conference on Advanced Computing and Communication Systems (ICACCS)* (Vol. 1, pp. 549-553). IEEE.
- Syed, T. A., Siddiqui, M. S., Abdullah, H. B., Jan, S., Namoun, A., Alzahrani, A., ... & Alkhodre, A. B. (2022). In-depth review of augmented reality: Tracking technologies, development tools, AR displays, collaborative AR, and security concerns. *Sensors*, 23(1), 146.
- Thiede, S., Damgrave, R., & Lutters, E. (2022). Mixed reality towards environmentally sustainable manufacturing—overview, barriers and design recommendations. *Procedia CIRP*, 105, 308-313.
- Tikwayo, L. N., & Mathaba, T. N. (2023). Applications of Industry 4.0 Technologies in Warehouse Management: A Systematic Literature Review. *Logistics*, 7(2), 24.
- Viljakainen, T. (2020). Adoption of Augmented reality solutions in field engineering and maintenance: Drivers and barriers for organizations.
- Volkov, V. E. (2023). Public legal regulation of technologies of virtual (augmented) reality. *Juridical Journal of Samara University*, 9(3), 56-62.
- Wassom, B. (2014). *Augmented reality law, privacy, and ethics: Law, society, and emerging AR technologies*. Syngress.
- Wintersberger, P., Frison, A. K., Riener, A., & Sawitzky, T. V. (2018). Fostering user acceptance and trust in fully automated vehicles: Evaluating the potential of augmented reality. *PRESENCE: Virtual and Augmented Reality*, 27(1), 46-62.

- Zaman, S. I., Khan, S., Zaman, S. A. A., & Khan, S. A. (2023). A grey decision-making trial and evaluation laboratory model for digital warehouse management in supply chain networks. *Decision Analytics Journal*, 100293.
- Zhmud, V., Liapidevskiy, A., & Avrmachuk, V. (2021). Characteristic barriers to the implementation of the roadmap for augmented reality technology development program. In *IOP Conference Series: Materials Science and Engineering* (Vol. 1019, No. 1, p. 012089). IOP Publishing.
- Zhmud, V., Liapidevskiy, A., & Avrmachuk, V. (2021). Characteristic barriers to the implementation of the roadmap for augmented reality technology development program. In *IOP Conference Series: Materials Science and Engineering* (Vol. 1019, No. 1, p. 012089). IOP Publishing.
- Singh, A. K., & Kumar, V. P. (2024). Analyzing the barriers for blockchain-enabled BIM adoption in facility management using best-worst method approach. *Built Environment Project and Asset Management*, 14(2), 164-183.

***CORRESPONDING AUTHOR**

Zainab Asim can be contacted at zainab_asim@tec.mx

CITATION

- Asim, Z., & Muneeb, S. M. (2025). A comprehensive analysis of barriers to augmented reality implementation in sustainable inventory management. *Sohar University Journal of Sustainable Business*, 1(1). 1-20.



مجلة جامعة صحر
للأعمال المستدامة
Sohar University Journal
of Sustainable Business



جامعة صحر
Sohar University

e-ISSN: 3007-5572 | Volume1, Issue1 Nov 2025