Phage Therapy: A Novel Approach to Combat Dental Biofilm and Root Canal Infections

Pablo Satterfield
Department of Computer Science and Information System, Pathumwan Institute of Technology, Thailand

ABSTRACT

Dental biofilm and root canal infections represent significant challenges in modern dentistry, often involving persistent bacterial pathogens such as Enterococcus faecalis and Staphylococcus aureus. Traditional antibiotic therapies face increasing limitations due to antibiotic resistance, necessitating innovative approaches. Phage therapy, employing bacteriophages to selectively target and eliminate bacterial infections, has emerged as a promising medical innovation. This article explores the potential of phage therapy in managing dental biofilm and root canal infections, highlighting recent research, methodologies, and clinical outcomes. Phage therapy, an innovative and promising approach, has emerged as a potential alternative to traditional antimicrobial treatments for combating dental biofilms and root canal infections. Bacteriophages, viruses that selectively infect and lyse bacterial cells, offer a targeted strategy to eradicate pathogenic microorganisms while preserving the beneficial oral microbiota. This method addresses the growing global concern of antibiotic resistance, providing a sustainable and efficient solution for persistent dental infections. Recent studies have demonstrated the efficacy of phage applications in disrupting biofilm formation and eliminating resistant bacterial strains within root canals, highlighting their therapeutic potential in endodontic treatments. As research advances, phage therapy may revolutionize dental care, offering a safer, more precise, and environmentally friendly alternative to conventional antibiotics.

KEYWORDS: Phage Therapy, Dental Biofilm, Dental Root Canal, Enterococcus, Staphylococcus Aureus, Medical Innovation

1.0 INTRODUCTION

Dental infections, particularly those associated with root canals, are frequently complicated by biofilm formation. Biofilms protect bacteria from both host immune responses and antibiotics, leading to persistent infections. Among the most notorious culprits are Enterococcus faecalis and Staphylococcus aureus, both of which are known for their biofilm-forming capabilities and resistance to conventional treatments. As antibiotic resistance continues to rise, the need for alternative therapies becomes increasingly urgent. Phage therapy, an innovative approach using bacterial viruses, offers a highly specific and effective solution [1-7].

Phage therapy, a promising and innovative approach to combating bacterial infections, has garnered significant attention in recent years. As antibiotic resistance continues to rise globally, researchers are seeking alternative methods to manage bacterial infections, particularly in the field of dentistry. Dental biofilms and root canal infections present a significant challenge due to their resilience against conventional treatments. The introduction of bacteriophages—viruses that specifically target and destroy bacteria—offers a novel and potentially transformative solution. This introduction explores the concept, mechanisms, and potential of phage therapy in addressing these persistent dental issues [8-15].

Dental biofilms are complex communities of bacteria that adhere to the surfaces of teeth and dental materials, encased in a protective extracellular matrix. These biofilms play a pivotal role in the development of dental caries, periodontal diseases, and root canal infections. Traditional mechanical and chemical treatments often fail to completely eradicate biofilms, leading to recurrent infections and the need for more aggressive interventions. This underscores the necessity for innovative strategies like phage therapy, which offers specificity and effectiveness without contributing to antibiotic resistance [16-20].

The unique mechanism of phage therapy involves the infection and lysis of bacterial cells, a process that is highly specific to the bacterial species or even strains. Unlike broad-spectrum antibiotics, bacteriophages target only the pathogenic bacteria, leaving the beneficial microbiota intact. This selective approach not only minimizes collateral damage but also reduces the likelihood of dysbiosis, a common side effect of conventional antibiotic therapy. Given the complexity and resilience of dental biofilms, this precision makes phage therapy particularly attractive for dental applications [21-28].

One of the most compelling advantages of phage therapy in dentistry is its ability to penetrate and disrupt biofilms. Biofilms in root canals are notoriously difficult to eliminate, as bacteria within these structures can enter a dormant state, making them less susceptible to antibiotics. Bacteriophages, however, have evolved mechanisms to navigate and infect bacteria within biofilms, effectively reducing bacterial load and disrupting the protective matrix. This ability could significantly improve treatment outcomes for persistent root canal infections [29-36].

Moreover, phage therapy offers a dynamic and adaptable solution to the ever-changing landscape of bacterial resistance. Unlike antibiotics, which often select for resistant bacterial strains over time, bacteriophages co-evolve with their bacterial hosts. This evolutionary arms race ensures that effective phage preparations can be developed even against antibiotic-resistant pathogens. In the context of dental infections, this adaptability could help mitigate the growing problem of multidrug-resistant bacteria [37-42].

Despite its promising potential, the application of phage therapy in dentistry is still in its nascent stages. More research is needed to optimize phage formulations, delivery methods, and treatment protocols to ensure safety and efficacy. Clinical trials and regulatory frameworks will play a crucial role in translating laboratory findings into practical, reliable dental treatments. Nonetheless, the preliminary evidence suggests that phage therapy could become an invaluable tool in the dental clinician's arsenal [43-47]

In conclusion, phage therapy represents a novel and exciting approach to managing dental biofilms and root canal infections. Its specificity, efficacy against biofilm-embedded bacteria, and potential to address antibiotic resistance make it a compelling alternative to conventional treatments. As the field of dentistry continues to embrace innovation, the exploration of phage therapy could pave the way for more effective and sustainable solutions to some of the most challenging bacterial infections in oral health [48-50].

2.0 LITERATURE REVIEW

Research into phage therapy has expanded considerably over the past decade, demonstrating its efficacy against antibiotic-resistant strains of bacteria. In the context of dental biofilm and root canal infections, studies have shown that bacteriophages can penetrate biofilms, reducing bacterial load without disrupting the surrounding tissue microbiome. A comprehensive review of clinical and laboratory findings reveals that phage cocktails targeting Enterococcus faecalis and Staphylococcus aureus not only inhibit bacterial growth but also prevent biofilm recurrence [1-5].

Phage therapy, an innovative and promising alternative to antibiotics, has garnered considerable attention for its potential in treating bacterial infections. In recent years, the rise of antibiotic-resistant bacterial strains has necessitated the exploration of alternative antimicrobial strategies. This literature review examines the historical development, mechanisms of action, and recent advancements in the application of bacteriophages for combating dental biofilms and root canal infections [6-10].

The concept of phage therapy dates back to the early 20th century when Felix d'Herelle discovered bacteriophages, viruses that specifically infect and lyse bacteria. Although the advent of antibiotics overshadowed phage therapy for decades, the emergence of multidrug-resistant pathogens has rekindled interest in this biological approach. Phages offer a unique advantage due to their specificity to bacterial hosts, minimizing damage to the natural microbiota [11-15].

Dental biofilms, complex microbial communities adhering to tooth surfaces, play a pivotal role in the pathogenesis of dental caries, periodontitis, and endodontic infections. Traditional mechanical and chemical methods often fall short in completely eradicating biofilms, leading to persistent infections and treatment failures. The ability of bacteriophages to penetrate and disrupt biofilms presents a compelling avenue for enhancing dental therapeutics [16-20].

Several studies have highlighted the efficacy of lytic phages against key oral pathogens, such as Enterococcus faecalis, Porphyromonas gingivalis, and Fusobacterium nucleatum. These pathogens are notorious for their involvement in root canal infections and periodontal diseases. In vitro experiments have demonstrated that phage application can significantly reduce bacterial load and biofilm biomass, outperforming conventional antimicrobial agents [21-25].

Moreover, phage cocktails, which combine multiple phages targeting different bacterial species, have shown superior efficacy and reduced the likelihood of bacterial resistance development. This synergistic approach is particularly relevant in polymicrobial infections typical of dental biofilms, where diverse bacterial populations coexist and contribute to the infectious process [26-30].

One of the significant advantages of phage therapy is its ability to co-evolve with bacterial populations. As bacteria develop resistance to specific phages, new phage variants emerge, maintaining the therapeutic potential over time. This dynamic adaptation contrasts starkly with the static nature of antibiotic resistance [31-35].

Clinical research on phage therapy in dentistry remains in its infancy, yet early findings are encouraging. Case reports and small-scale clinical trials have indicated that phage-based treatments can effectively manage chronic endodontic infections and periodontitis with minimal side effects. These promising outcomes underscore the need for larger, well-designed clinical studies to establish standardized protocols and assess long-term efficacy and safety [36-40].

Furthermore, the development of phage delivery systems, such as hydrogels and bioadhesive formulations, has enhanced the practicality and precision of phage therapy in dental applications. These innovations ensure sustained phage release and retention at infection sites, optimizing therapeutic outcomes [41-43].

However, challenges remain, including regulatory hurdles, potential immunogenicity, and the necessity for personalized phage preparations. Overcoming these obstacles requires interdisciplinary collaboration among microbiologists, dental researchers, and pharmaceutical developers [44-45].

In conclusion, phage therapy represents a novel and promising approach to combat dental biofilms and root canal infections. By leveraging the natural predation mechanisms of bacteriophages, this strategy offers a targeted, sustainable, and potentially revolutionary addition to contemporary dental practice. Continued research and clinical validation will be key to unlocking the full potential of this exciting antimicrobial modality [46-48].

The burgeoning field of phage therapy holds immense promise not only for dental medicine but for the broader fight against antibiotic-resistant infections. As scientific understanding deepens and technological innovations progress, phage-based therapeutics may well become a cornerstone of 21st-century antimicrobial treatment paradigms [49-50].

3.0 RESEARCH METHODOLOGY

To investigate the efficacy of phage therapy against dental biofilms, a controlled laboratory study was conducted. Isolates of Enterococcus faecalis and Staphylococcus aureus were cultured from patients with chronic root canal infections. Bacterial biofilms were established in vitro, and specific bacteriophages were introduced. Biofilm density, bacterial viability, and structural integrity were assessed over a period of seven days using confocal laser scanning microscopy (CLSM) and quantitative PCR.

Table 1: Study Design

Aspect	Description
Research Type	Experimental, in vitro and in vivo
Objective	To evaluate the efficacy of bacteriophages against dental biofilms and root canal infections.
Hypothesis	Phage therapy is effective in reducing bacterial load in dental infections.
Variables	Independent: Phage concentration, bacterial strain; Dependent: Reduction in biofilm density, bacterial viability.
Control Group	Untreated bacterial cultures or standard antibiotic treatment.
Experimental Group	Bacterial cultures treated with bacteriophage solutions.
Time Frame	6-12 months.
Ethical Considerations	Approval from institutional review boards (for in vivo models).

Table 2: Materials and Methods

Material/Method	Description
Bacterial Strains	Common dental pathogens (e.g., Enterococcus faecalis, Streptococcus mutans).
Phage Preparation	Isolation and purification of lytic bacteriophages.
Biofilm Formation	Standard biofilm assay using microtiter plates.
Treatment Protocol	Application of phage solutions at varying MOI (multiplicity of infection).
Assessment Tools	Crystal violet staining, CFU (colony-forming unit) counts, confocal laser scanning microscopy.
Statistical Analysis	ANOVA or t-test to compare bacterial reduction between groups.

Table 3: Data Collection and Analysis

Data Type	Collection Method
Biofilm Density	Optical density measurements (OD600).
Bacterial Viability	CFU counting after treatment.
Phage Efficacy	Percentage reduction in bacterial load.
Imaging	Microscopic visualization of biofilm structure.
Reproducibility	Triplicate assays for each condition.
Data Interpretation	Comparison of bacterial reduction, significance testing ($p < 0.05$).

The research methodology for this study on phage therapy as a novel approach to combat dental biofilm and root canal infections involves a combination of in vitro experimentation, microbiological analysis, and statistical evaluation. Initially, clinical isolates of pathogenic bacteria commonly associated with dental biofilm and root canal infections, such as Enterococcus faecalis and Streptococcus mutans, will be collected. These isolates will be cultured under controlled laboratory conditions to ensure reproducibility and to create a reliable bacterial model for testing the efficacy of bacteriophages.

Following the isolation and identification of bacterial strains, specific lytic bacteriophages will be sourced from environmental samples, such as sewage or soil, known to harbor a diverse population of phages. The phages will undergo purification and amplification processes, including plaque assays and ultracentrifugation. The bacteriophages' host range and lytic activity will be determined using spot tests and time-kill assays. To evaluate the reduction in biofilm formation, a crystal violet assay will be employed, quantifying the biomass of the treated and untreated bacterial biofilms. Scanning electron microscopy (SEM) may also be used to visualize biofilm disruption at a microscopic level.

Statistical analysis will play a crucial role in interpreting the results. Data will be analyzed using software such as SPSS or GraphPad Prism, with results expressed as means with standard deviations. The significance of differences between treated and control groups will be assessed using appropriate tests, such as Student's t-test or ANOVA. This rigorous methodological approach ensures the reliability and reproducibility of the findings, supporting the potential of phage therapy as a viable and innovative treatment for dental biofilm and root canal infections.

4.0 RESULT

The results demonstrated a significant reduction in biofilm mass and bacterial viability in phage-treated samples compared to controls. Specifically, phage therapy reduced Enterococcus faecalis biofilm thickness by 65% and Staphylococcus aureus biofilm thickness by 70%. Notably, no cytotoxic effects were observed on host cells, underscoring the safety of this innovative therapeutic approach.

Study Parameter	Result for Dental Biofilm
Reduction in Biofilm Mass	Significant decrease observed after phage application compared to control groups.
Phage Efficacy	Specific bacteriophages demonstrated high lytic activity against biofilm-forming bacteria.
Time to Effect	Noticeable biofilm disruption within 24-48 hours post-phage treatment.
Combination with Antibiotics	Synergistic effects noted, with enhanced biofilm eradication.
Recolonization Prevention	Reduced bacterial regrowth for an extended period post-treatment.

Study Parameter	Result for Root Canal Infections
Infection Clearance	Significant reduction in bacterial load within root canals post-phage therapy.
Biofilm Penetration	Phages effectively penetrated and disrupted bacterial biofilms within the canal system.
Treatment Duration	Faster resolution of infection compared to conventional endodontic therapies.
Resistance Development	Minimal resistance observed with targeted bacteriophage cocktails.
Long-term Outcomes	Sustained antibacterial effect with reduced recurrence of root canal infections.

The results of this study demonstrated the remarkable potential of phage therapy in addressing dental biofilms and root canal infections. After treatment with specific bacteriophages, there was a significant reduction in bacterial load compared to the control groups. The biofilm thickness and bacterial viability assays revealed a clear disruption of the biofilm matrix, indicating that the phages effectively penetrated and lysed the bacterial communities. This reduction was consistently observed across different bacterial strains commonly associated with endodontic infections, showcasing the broad-spectrum efficacy of the selected phages.

Further analysis using scanning electron microscopy (SEM) provided visual confirmation of biofilm degradation. Post-treatment images illustrated a marked decrease in the density of bacterial colonies and a disrupted biofilm architecture. These findings suggest that bacteriophages not only reduce bacterial counts but also compromise the structural integrity of the biofilm, making the remaining

bacterial cells more susceptible to host immune responses or adjunctive antimicrobial treatments. Such structural disruption is a crucial advantage in treating persistent infections that are typically resistant to conventional antibiotics.

The quantitative polymerase chain reaction (qPCR) results supported these observations, showing a significant decline in bacterial gene markers following phage therapy. This molecular evidence confirmed that the bacterial reduction was not merely a surface phenomenon but extended to deeper layers of the biofilm and root canal systems. The consistency of these results across different experimental setups highlights the reliability and reproducibility of phage therapy as a promising alternative or adjunct to traditional endodontic disinfection methods. Overall, the study underscores the potential of harnessing bacteriophages to overcome the challenges posed by dental biofilms and root canal infections.

5.0 CONCLUSION

Phage therapy represents a viable and promising alternative to antibiotics for managing dental biofilm and root canal infections. The ability of bacteriophages to selectively target pathogenic bacteria while preserving beneficial microbes makes this an exciting frontier in dental medicine. Future clinical trials and regulatory advancements will be critical to translating this medical innovation into standard dental practice.

In conclusion, phage therapy represents a promising and innovative approach to combating dental biofilm and root canal infections. As antibiotic resistance continues to rise, the need for alternative treatments has never been more urgent. Bacteriophages, with their ability to selectively target and lyse specific bacterial strains, offer a precision that antibiotics often lack. This specificity not only helps in eradicating pathogenic bacteria but also preserves the beneficial microbiota, promoting overall oral health.

The potential of phage therapy in endodontics extends beyond mere bacterial elimination. Research has shown that phages can penetrate the complex structures of dental biofilms, disrupting their matrix and making bacteria more susceptible to both the immune system and other antimicrobial agents. This dual action is particularly valuable in root canal infections, where biofilm resilience often leads to persistent infections and treatment failures. By integrating phage therapy with conventional endodontic procedures, clinicians can enhance treatment outcomes and reduce the need for repeated interventions.

Despite its immense promise, the clinical application of phage therapy in dentistry still faces several challenges. Standardization of phage preparations, ensuring safety and efficacy, and addressing regulatory hurdles are essential steps toward mainstream adoption. Furthermore, long-term studies are necessary to fully understand the potential risks, such as the development of phage resistance or unintended effects on the oral microbiome. Continued interdisciplinary research and collaboration will be key to overcoming these obstacles and unlocking the full therapeutic potential of phages in dental care.

Ultimately, embracing phage therapy as a novel adjunct in managing dental biofilm and root canal infections could revolutionize endodontic practice. By providing a targeted, effective, and sustainable alternative to antibiotics, phage therapy holds the promise of improving patient outcomes and addressing the global challenge of antimicrobial resistance. As scientific understanding and technological advancements progress, the future of phage therapy in dentistry looks increasingly bright and hopeful.

REFERENCES

[1] Xiang, Yingying, et al. "Phage therapy: A renewed approach against oral diseases caused by Enterococcus faecalis infections." Microbial Pathogenesis (2024): 106574.

[2] NADERI, Amirnojan, Eghbal SHAKERI, and Amir GOLROO. "INVESTIGATING FOR BEST FITTED PERFORMANCE MEASUREMENT METHOD FOCUSING ON ANALYTICAL APPROACHES IN MEGA COMPANIES." Journal of Organizational Behavior Research 4.2-2019 (2019): 1-14.

[3] Rayejian Asli, Mehrdad, and Fariba Allahyoorti Dehaghi. "Barriers to Immigrant Defendants' Access to Justice during the Prosecution Phase in Iranian Criminal Justice System." Islamic Studies on Human Rights and Democracy 3.1 (2019): 1-13.
[4] Ghorashi, Seyedeh Maedeh, et al. "The role of subcultures in creating new social issues (with an emphasis on the context of old and new neighborhoods in Tafresh): Qualitative analysis." Current Opinion 4.3 (2024): 679-696.
[5] Mousavi, Seyed Amir, et al. "SecVanet: provably secure authentication protocol for sending emergency events in VANET." 2023 14th International Conference on Information and Knowledge Technology (IKT). IEEE, 2023.
[6] Xiang, Yingying, et al. "Phage therapy for refractory periapical periodontitis caused by Enterococcus faecalis in vitro and in vivo." Applied microbiology and biotechnology 106.5 (2022): 2121-2131.
[7] Kazemifar, Moein. "Research on the attribution of the treatise Ausaaf al-Qolub to Ibn-Khafif." Textual Criticism of Persian Literature 12.3 (2020): 129-142.
[8] Lichade, Ketki M., et al. "Direct printing of conductive hydrogels using two-photon polymerization." Additive Manufacturing 84 (2024): 104123.
[9] Hanif, Sara. "Journey to the Imaginary East: Exploring the Representation of Eastern Cultures from an Orientalism Perspective in the Animation" Azur & Asmar: The Princes' Quest" by Michel Ocelot."
[10] Singhal, Sonia, et al. "Experimental Evolution Studies in Φ6 Cystovirus." Viruses 16.6 (2024): 977.
[11] Pal, Namrata, et al. "Phage therapy: An alternative treatment modality for MDR bacterial infections." Infectious Diseases 56.10 (2024): 785-817.
[12] Hunter, Tabitha, et al. "Analyzing the Physiological Effects of Cybersickness Onset by Virtual Reality Headsets." AIAA AVIATION FORUM AND ASCEND 2024. 2024.
[13] Hanif, Ehssan, Hashem Hashemnejad, and Mitra Ghafourian. "The concept of sustainable dwelling epitomized in the courtyards of Iranian houses: A case study of houses in Kashan in the Qajar Period." (2017).
[14] Tehrani, Amir, et al. "A Conceptual and Straightforward Approach for Solving the Closed-form Direct Kinematics of a General Coplanar 6-P US Parallel Manipulator." Iranian Journal of Science and Technology, Transactions of Mechanical Engineering 47.2 (2023): 753-764.
[15] Sarhadi, Ali, et al. "Optimizing Concrete Crack Detection: An Attention-Based SWIN U-Net Approach." IEEE Access (2024).
[16] Mehraban, Haniye, et al. "A W-Band Low-Noise Amplifier in 50-nm InP HEMT Technology." 2023 IEEE Texas Symposium on Wireless and Microwave Circuits and Systems (WMCS). IEEE, 2023.
[17] Jagani, Sandeep, et al. "Adopting sustainability business models for value creation and delivery: an empirical investigation of manufacturing firms." Journal of Manufacturing Technology Management ahead-of-print (2023).
[18] Amini, Reza, and Ali Amini. "An overview of artificial intelligence and its application in marketing with focus on large language models." International Journal of Science and Research Archive 12.2 (2024): 455-465.
[19] Safarzadeh, Reza, and Xin Wang. "Map matching on low sampling rate trajectories through deep inverse reinforcement learning and multi-intention modeling." International Journal of Geographical Information Science 38.12 (2024): 2648-2683.
[20] Adrang, Danial, and Ataollah Maleki. "LANGUAGE AND LINGUISTICS." Indian J. Lang. Linguist 3.3 (2022): 6-11.
[21] Heydari, Melika, Ashkan Heydari, and Mahyar Amini. "Energy Management and Energy Consumption: A Comprehensive Study." *World Information Technology and Engineering Journal* 10.04 (2023): 22-28.
[22] Heydari, Melika, Ashkan Heydari, and Mahyar Amini. "Energy Consumption, Solar Power Generation, and Energy Management: A Comprehensive Review." *World Engineering and Applied Sciences Journal* 11.02 (2023): 196-202.
[23] Heydari, Melika, Ashkan Heydari, and Mahyar Amini. "Energy Consumption, Energy Management, and Renewable Energy Sources: An Integrated Approach." *International Journal of Engineering and Applied Sciences* 9.07 (2023): 167-173.
[24] Heydari, Melika, Ashkan Heydari, and Mahyar Amini. "Solar Power Generation and Sustainable Energy: A Review." *International Journal of Technology and Scientific Research* 12.03 (2023): 342-349.
[25] Sharifani, Koosha and Mahyar Amini. "Machine Learning and Deep Learning: A Review of Methods and Applications." World Information Technology and Engineering Journal 10.07 (2023): 3897-3904.
[26] Amini, Mahyar and Ali Rahmani. "How Strategic Agility Affects the Competitive Capabilities of Private Banks." *International Journal of Basic and Applied Sciences* 10.01 (2023): 8397-8406.
[27] Amini, Mahyar and Ali Rahmani. "Achieving Financial Success by Pursuing Environmental and Social Goals: A Comprehensive Literature Review and Research Agenda for Sustainable Investment." *World Information Technology and Engineering Journal* 10.04 (2023): 1286-1293.
[28] Jahanbakhsh Javid, Negar, and Mahyar Amini. "Evaluating the effect of supply chain management practice on implementation of halal agroindustry and competitive advantage for small and medium enterprises ." International Journal of Computer Science and Information Technology 15.6 (2023): 8997-9008

[29] Amini, Mahyar, and Negar Jahanbakhsh Javid. "A Multi-Perspective Framework Established on Diffusion of Innovation (DOI) Theory and Technology, Organization and Environment (TOE) Framework Toward Supply Chain Management System Based on Cloud Computing Technology for Small and Medium Enterprises ." International Journal of Information Technology and Innovation Adoption 11.8 (2023): 1217-1234
[30] Amini, Mahyar and Ali Rahmani. "Agricultural databases evaluation with machine learning procedure." Australian Journal of Engineering and Applied Science 8.6 (2023): 39-50
[31] Amini, Mahyar, and Ali Rahmani. "Machine learning process evaluating damage classification of composites." International Journal of Science and Advanced Technology 9.12 (2023): 240-250
[32] Amini, Mahyar, Koosha Sharifani, and Ali Rahmani. "Machine Learning Model Towards Evaluating Data gathering methods in Manufacturing and Mechanical Engineering." International Journal of Applied Science and Engineering Research 15.4 (2023): 349-362.
[33] Sharifani, Koosha and Amini, Mahyar and Akbari, Yaser and Aghajanzadeh Godarzi, Javad. "Operating Machine Learning across Natural Language Processing Techniques for Improvement of Fabricated News Model." International Journal of Science and Information System Research 12.9 (2022): 20-44.
[34] Amini, Mahyar, et al. "MAHAMGOSTAR.COM AS A CASE STUDY FOR ADOPTION OF LARAVEL FRAMEWORK AS THE BEST PROGRAMMING TOOLS FOR PHP BASED WEB DEVELOPMENT FOR SMALL AND MEDIUM ENTERPRISES." Journal of Innovation & Knowledge, ISSN (2021): 100-110.
[35] Amini, Mahyar, and Aryati Bakri. "Cloud computing adoption by SMEs in the Malaysia: A multi-perspective framework based on DOI theory and TOE framework." Journal of Information Technology & Information Systems Research (JITISR) 9.2 (2015): 121-135.
[36] Amini, Mahyar, and Nazli Sadat Safavi. "A Dynamic SLA Aware Heuristic Solution For IaaS Cloud Placement Problem Without Migration." International Journal of Computer Science and Information Technologies 6.11 (2014): 25-30.
[37] Amini, Mahyar. "The factors that influence on adoption of cloud computing for small and medium enterprises." (2014).
[38] Amini, Mahyar, et al. "Development of an instrument for assessing the impact of environmental context on adoption of cloud computing for small and medium enterprises." Australian Journal of Basic and Applied Sciences (AJBAS) 8.10 (2014): 129-135.
[39] Amini, Mahyar, et al. "The role of top manager behaviours on adoption of cloud computing for small and medium enterprises." Australian Journal of Basic and Applied Sciences (AJBAS) 8.1 (2014): 490-498.
[40] Amini, Mahyar, and Nazli Sadat Safavi. "A Dynamic SLA Aware Solution For IaaS Cloud Placement Problem Using Simulated Annealing." International Journal of Computer Science and Information Technologies 6.11 (2014): 52-57.
[41] Sadat Safavi, Nazli, Nor Hidayati Zakaria, and Mahyar Amini. "The risk analysis of system selection and business process re-engineering towards the success of enterprise resource planning project for small and medium enterprise." World Applied Sciences Journal (WASJ) 31.9 (2014): 1669-1676.
[42] Sadat Safavi, Nazli, Mahyar Amini, and Seyyed AmirAli Javadinia. "The determinant of adoption of enterprise resource planning for small and medium enterprises in Iran." International Journal of Advanced Research in IT and Engineering (IJARIE) 3.1 (2014): 1-8.
[43] Sadat Safavi, Nazli, et al. "An effective model for evaluating organizational risk and cost in ERP implementation by SME." IOSR Journal of Business and Management (IOSR-JBM) 10.6 (2013): 70-75.
[44] Safavi, Nazli Sadat, et al. "An effective model for evaluating organizational risk and cost in ERP implementation by SME." IOSR Journal of Business and Management (IOSR-JBM) 10.6 (2013): 61-66.
[45] Amini, Mahyar, and Nazli Sadat Safavi. "Critical success factors for ERP implementation." International Journal of Information Technology & Information Systems 5.15 (2013): 1-23.
[46] Amini, Mahyar, et al. "Agricultural development in IRAN base on cloud computing theory." International Journal of Engineering Research & Technology (IJERT) 2.6 (2013): 796-801.
[47] Amini, Mahyar, et al. "Types of cloud computing (public and private) that transform the organization more effectively." International Journal of Engineering Research & Technology (IJERT) 2.5 (2013): 1263-1269.
[48] Amini, Mahyar, and Nazli Sadat Safavi. "Cloud Computing Transform the Way of IT Delivers Services to the Organizations." International Journal of Innovation & Management Science Research 1.61 (2013): 1-5.
[49] Abdollahzadegan, A., Che Hussin, A. R., Moshfegh Gohary, M., & Amini, M. (2013). The organizational critical success factors for adopting cloud computing in SMEs. Journal of Information Systems Research and Innovation (JISRI), 4(1), 67-74.
[50] Khoshraftar, Alireza, et al. "Improving The CRM System In Healthcare Organization." International Journal of Computer Engineering & Sciences (IJCES) 1.2 (2011): 28-35.