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Research Article

Strategic Plans to Reduce the Risk of Antimicrobial Resistance in Saudi Arabia

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ABSTRACT

Antimicrobial resistance (AMR) poses a serious threat to public health and national healthcare systems. Combating AMR requires a coordinated, multisectoral strategy and plans, aligned with the World Health Organization's Global Action Plan. This study aims to assess the awareness and practices of healthcare professionals in Saudi Arabia regarding AMR. In this study, we explored strategic plans to mitigate the risks of AMR in Saudi Arabia. A literature review focused on solutions to AMR, surveillance systems, and frameworks, as well as studies investigating the development of new treatments, was also reviewed. The study used a SWOT analysis to assess internal strengths and weaknesses, a PESTLE analysis to identify external macro-environmental factors, and a Balanced Scorecard (BSC) to evaluate performance across financial, customer service, internal operations, and learning and growth dimensions. A quantitative descriptive approach was adopted, utilizing a structured questionnaire as the primary data collection tool. The questionnaire was distributed to a sample of healthcare workers from hospitals across the Kingdom, researchers, patients, and the general public. It focused on key aspects such as knowledge of AMR diseases and attitudes towards medication dispensing practices. The results revealed varying levels of awareness, with a significant gap between knowledge and actual practice. Additionally, the findings highlighted the need for awareness and education programs and stricter policies to regulate antibiotic dispensing and use. The study recommends implementing national awareness campaigns and educating the general public about AMR in medical curricula to reduce the risks and impact of AMR.

Keywords: Antimicrobial Resistance, AMR, Strategic plans, PESTLE Analysis, SWOT Analysis, Balanced Scorecard analysis.

INTRODUCTION

(AMR) Antimicrobial resistance is the bacteria viruses, and fungi ability to resist the antibacterial drugs [1]. It is an emerging global public health threat, the World Health Organization's (WHO) research agenda for (AMR) has identified 40 research priorities to combat with AMR and be addressed by 2030 [2]. in 2017 Saudi has published its first AMR National Action Plan aligning with the World Health Organization's (WHO) Global Action Plan on Antimicrobial Resistance. The main objectives of the WHO action plan are first, to increase public awareness of antimicrobial resistance through clear communication, education, and training. Second, to improve knowledge and evidence by advancing both in research and surveillance efforts. Third, to minimize infections by better sanitation, hygiene, and preventive measures. Fourth, to improve the use of antimicrobial medicines in human and animal health [3]. This paper overviews the current state of AMR migration strategies in Saudi and recommends reformed strategies to better deal with the emerging aspect of AMR. The structure of the paper is as follows, Section 1 covers Introduction, Section 2 is a literature review, Section 3 explores the methodology of the paper, section 4 is results and recommendations, and last is Section 5 that concludes the paper with the Conclusion.

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LITERATURE REVIEW

(AMR) happens when microorganisms such as bacteria viruses, and fungi develop the ability to resist antibacterial drugs and treatments. It is a global emerging challenge as multi-drug resistant pathogens are widely spreading. Some of the cause of AMR are The overuse and misuse of antimicrobials, the lack of awareness, and the antimicrobial residues in the environment [4].

A. SURVEILLANCE AND FRAMEWORKS

In 2017, Saudi Arabia's Ministry of Health (MOH) published its first AMR National Action Plan, adopting GLASS [3]. In addition to the well-known WHO Global AMR Surveillance System the importance of implementing the one health approach which is unifying the three sectors concerned with AMR which are human, animal, and environment is highlighted in the following studies as follow: The Korean version of (GLASS) the global antimicrobial surveillance system (kor-GLASS) with quality control center (QCC) and implements the one health approach. With the addition of (QCC) has ensured the collaboration of 7 ministries which are ministry of science and information and communication technology, ministry of Food and Drug safety, ministry of oceans and fisheries, ministry of environment, Ministry of Agriculture, ministry of ruler development administration, and Korea Disease Control and prevention agency [8]. Moreover, in 2015 a surveillance system was established by the UAE Ministry of Health and Prevention adopting (GLASS). After that the focus was on making this surveillance system national which was done by the collaboration of the minister of health and the seven Emirates to make a network for 317 surveillance sites including hospitals clinics and health centers. Some of the challenges faced during the implementation are the lack of awareness, human capacity, lack of a national reference lab for antimicrobial resistance and lack of funding [10]. Finally, there are National Action Plans (NPAs) to combat antimicrobial resistance. The implementation can vary between different regions while all share the same goal [11], [12].

B. ADVANCED TREATMENT, ADVANCED GENOMIC ANALYSIS AND NATIONAL ACTION PLANS FOR AMR

There are studies that have looked into developing new treatments and analyzing genetic sequences to predict the extent of bacterial resistance to drugs: The study discusses the causes of antimicrobial resistance diseases and the importance of research and development into the possibility of phage-based therapies as an alternative treatment for antimicrobial resistance diseases in the Kingdom of Saudi Arabia [15]. The study explores need to use advanced technologies such as machine learning or whole genome sequencing for accurate diagnosis that predicts antimicrobial resistance [17]. The study focusses on studying the entire genome of a particular organism such as bacteria to understand genetic changes including whole genome sequencing (WGS) that are useful in monitoring and predicting antimicrobial resistance [18]. The study illustrates new technologies and treatments that provide more effective solutions to antimicrobial resistance such as CRISPR, as bacteriophage therapy and antimicrobial peptides (AMPs) [20]. The study explores the importance of antimicrobial susceptibility testing, which is used to determine whether bacteria are sensitive or resistant to certain antibiotics [21]. For the following study, the alignment of the WHO Global Action Plan on Antimicrobial Resistance with national action plans of countries around the world was assessed using a policy analysis approach [22].

C. SOLUTIONS TO REDUCE AMR

There are many solutions to reduce AMR, vaccines can prevent infections, and reduce antibiotic use, while monoclonal antibodies mAbs provide targeted treatment. In addition to the current vaccine technologies such as glycoconjugates, bioconjugates, and nanoparticle vaccines [28]. By using Vaccine Value Profiles for the analysis of 16 pathogens, the vaccine will succeed in controlling drug-resistant Salmonella [31]. The vaccines and monoclonal antibodies (mAbs) used to combat AMR in Escherichia coli and Pseudomonas aeruginosa. In addition, the potential of outer membrane vesicles (OMVs) to develop the vaccine and the need for targeted interventions against biofilm formation [32]. AMR is a major health threat, particularly in hospital-acquired infections, and advanced technologies can improve prevention, diagnosis, and management. In addition, alternative therapies such as vaccines, monoclonal antibodies, and nanotechnology [33]. By developing an action framework for increased vaccine coverage, recent vaccine development, and policy integration that combats AMR. vaccines such as pneumococcal, rotavirus, and typhoid conjugate significantly reduce antibiotic usage and AMR risk. In addition, expanding vaccine use allows for lowering the spread of resistant bacteria [34].

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METHODOLOGY

To gather information on AMR, as shown in Figure 1 the research was initiated with the recents literature review, and a survey that resulted in 82 responses. Thereafter, according to the data that was collected to conduct the PESTEL and SOWT analysis, which are inputs to the Balanced Scorecard. Following that, the monitoring and evaluation.

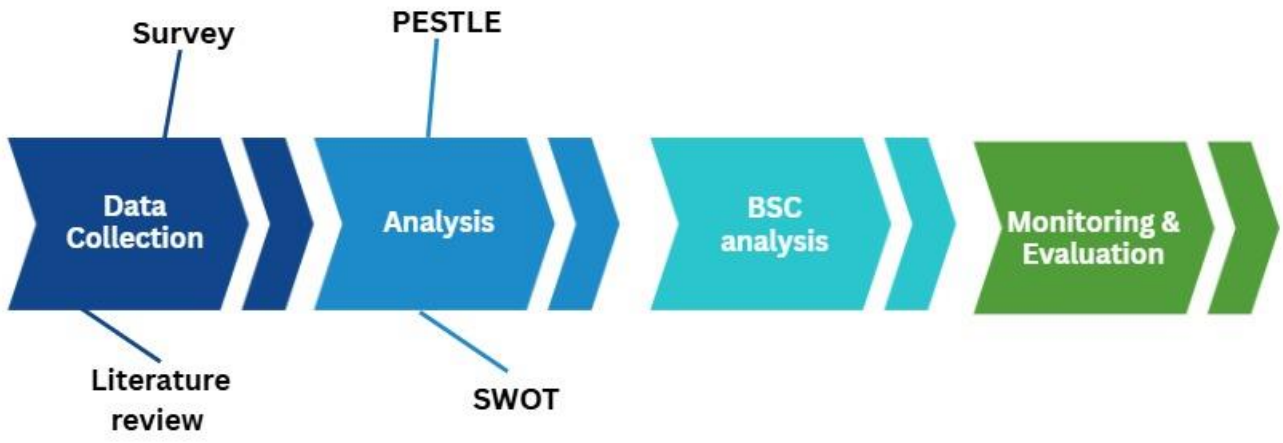

FIGURE 1. Methodology.

A. DATA COLLECTION

- Demographics:

The demographics results showed that most of the participants 80% were female participants, showing greater interest of Antimicrobial Resistance diseases among female participants. Moreover. 65% of the participants were between the ages of 18-24 showing higher participation by young participants. Around 70% of the participants were from Jeddah showing limitations in the geographically data representation. Moreover, roles of the participants which are researcher, healthcare provider, patient general public also varied but the majority were general public with 67.5% participation as showing in the following figure 2 and 3:

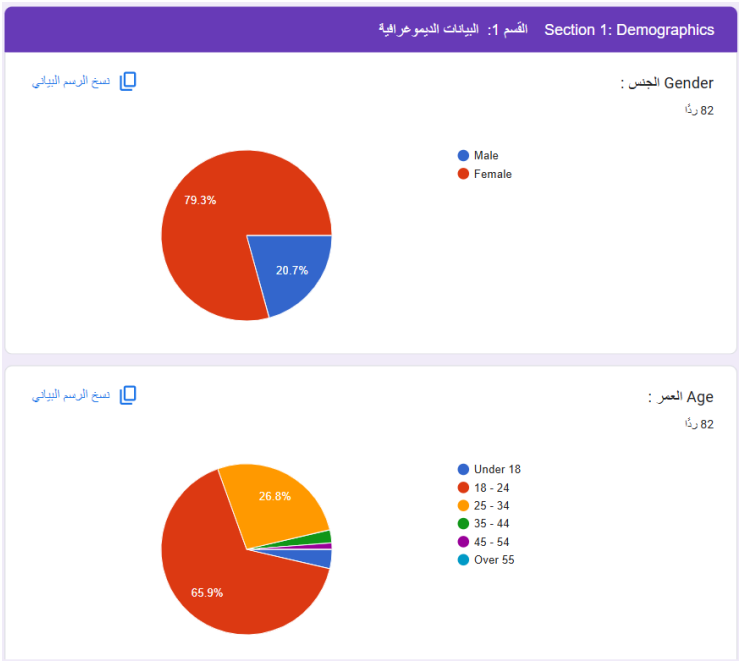

FIGURE 2. Demographics.

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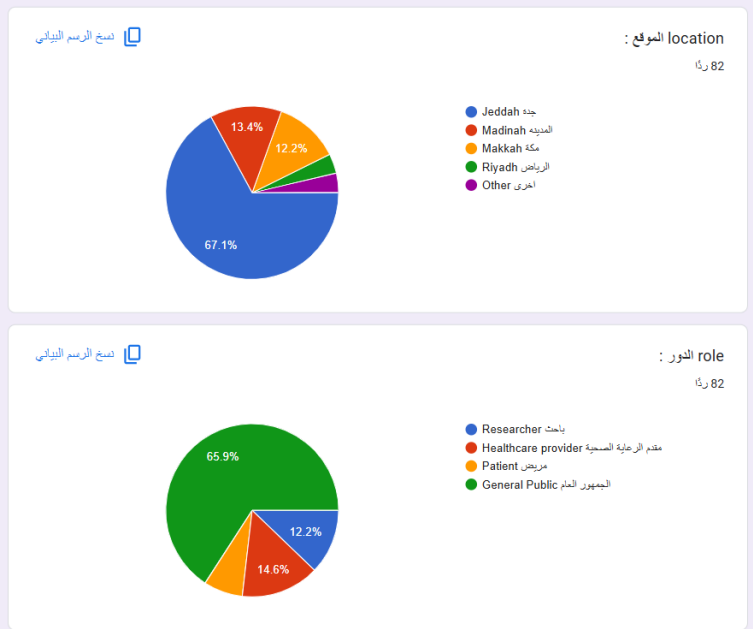

FIGURE 3. Demographics.

- Knowledge and awareness:

The results shown in figures 4 and 5 that more than 50% of the participants are unaware of what AMR diseases are, despite that the vast majority of participants think that AMR diseases are dangerous. Highlighting the need for more awareness campaigns to improve the general public knowledge and awareness.

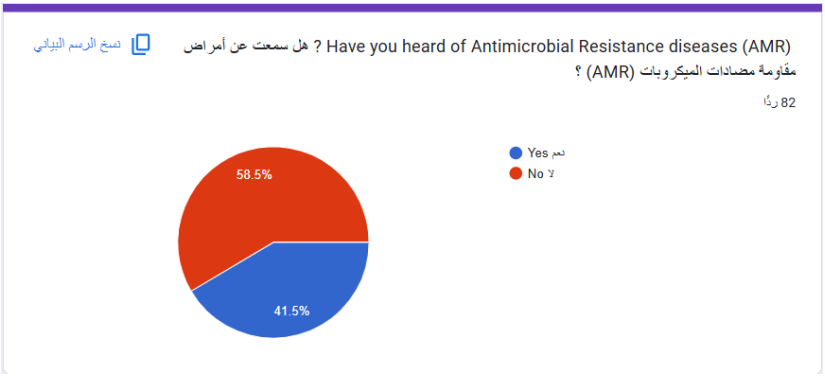

FIGURE 4. Knowledge and awareness

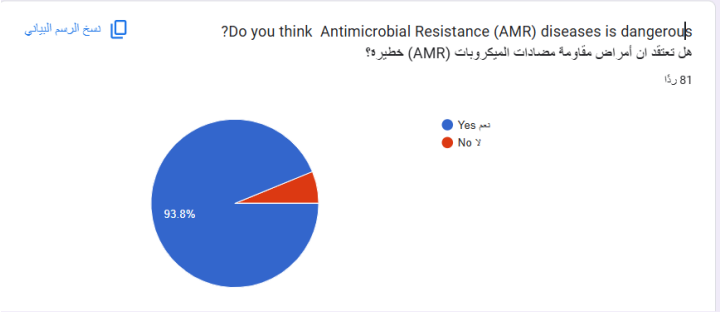

FIGURE 5. Knowledge and awareness

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- Attitude and perception:

In terms of the participants' perception of AMR diseases, the results show in figures 6, 7 and 8 that 40 out of 80 of the participants think that the effectiveness of implementing strategies to reduce AMR is between 3-5/5. Showing the participants awareness of the importance of implementing strategies to reduce Antimicrobial Resistance diseases. Moreover, the majority of the participances think that the environment effects the prevalence of AMR showing the awareness of the environmental element. Finally 70% of the participants think that the current research grants does not meet the needs for AMR research, highlighting the need for more investment in the AMR researches field.

FIGURE 6. Attitude and perception.

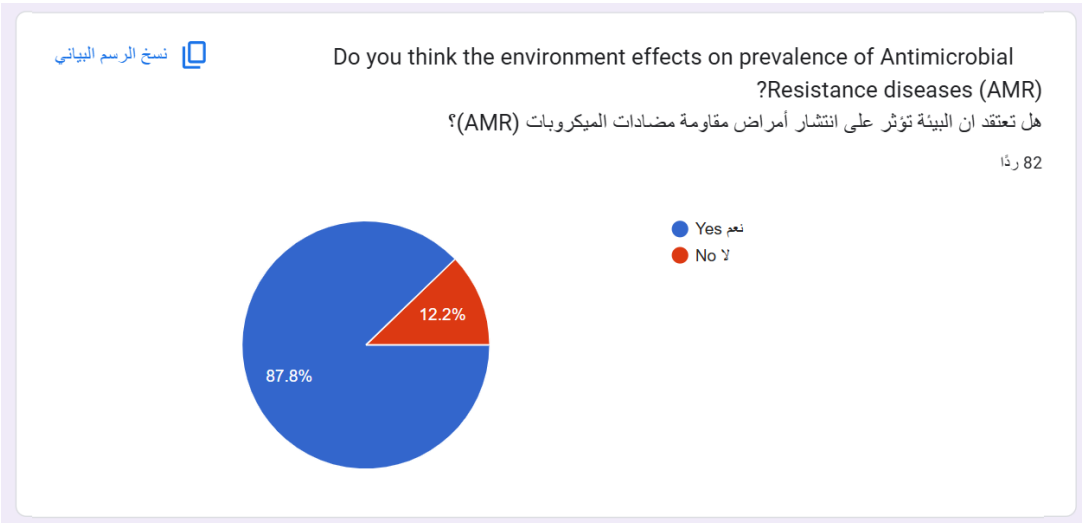

FIGURE 7. Attitude and perception.

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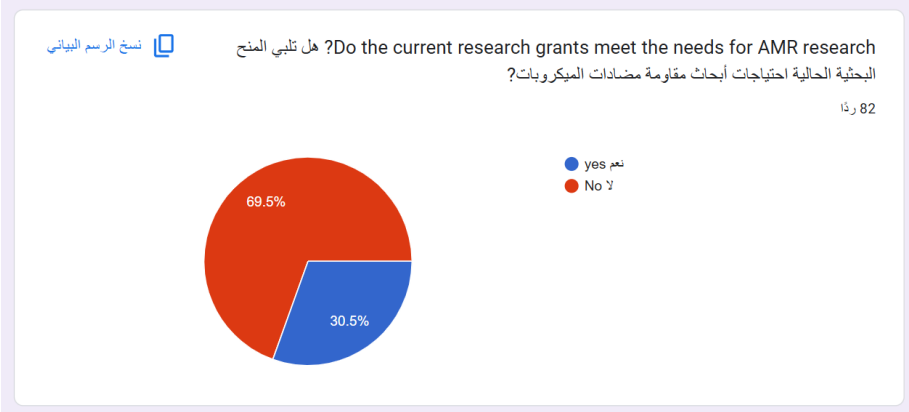

FIGURE 8. Attitude and perception.

- Behavioral data:

The results show that 56% of the participants rarely use antibiotics while around 29% of the participants use the antibiotics often, however, none of the participants us it always, as following figure 9.

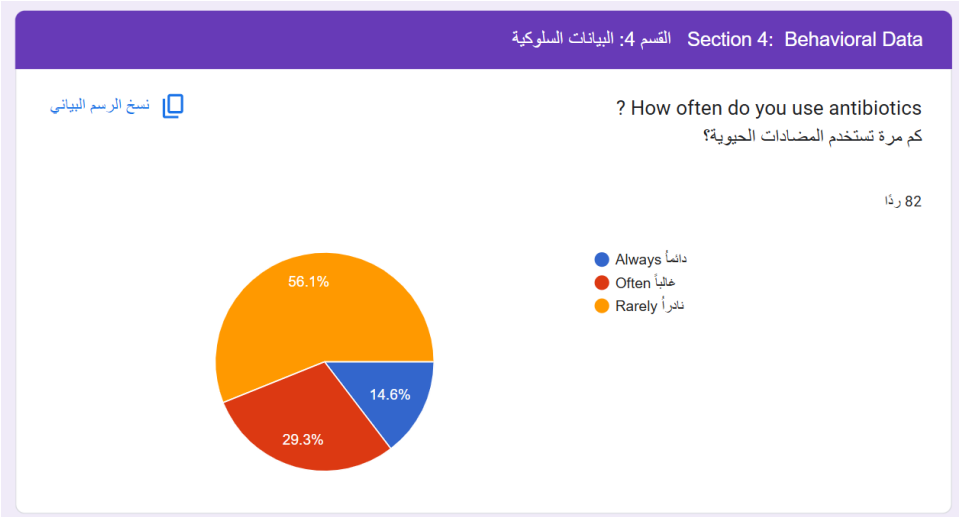

FIGURE 9. Behavioral data.

- Open ended questions:

The answers of the participants vary after filtering the open ended questions these are some of the insightful answers for the two questions:

Q1) What factors do you think increase the prevalence of Antimicrobial Resistance diseases (AMR) ?

- Surgical site infection.
- Increased antibiotic intake.
- Doctors careless prescribing.
- unawareness of the side effects of antibiotics.
- Not finishing antibiotics course.

Q2) what challenges do you see in implementing strategies to reduce Antimicrobial Resistance diseases (AMR)?

- Lack of awareness.
- Lack of research.
- Implications complexities.

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B. PESTEL Analysis

To clarify the external factors of AMR according to the collected data, we used PESTLE analysis as shown in Figure 10, which includes 6 main factors:

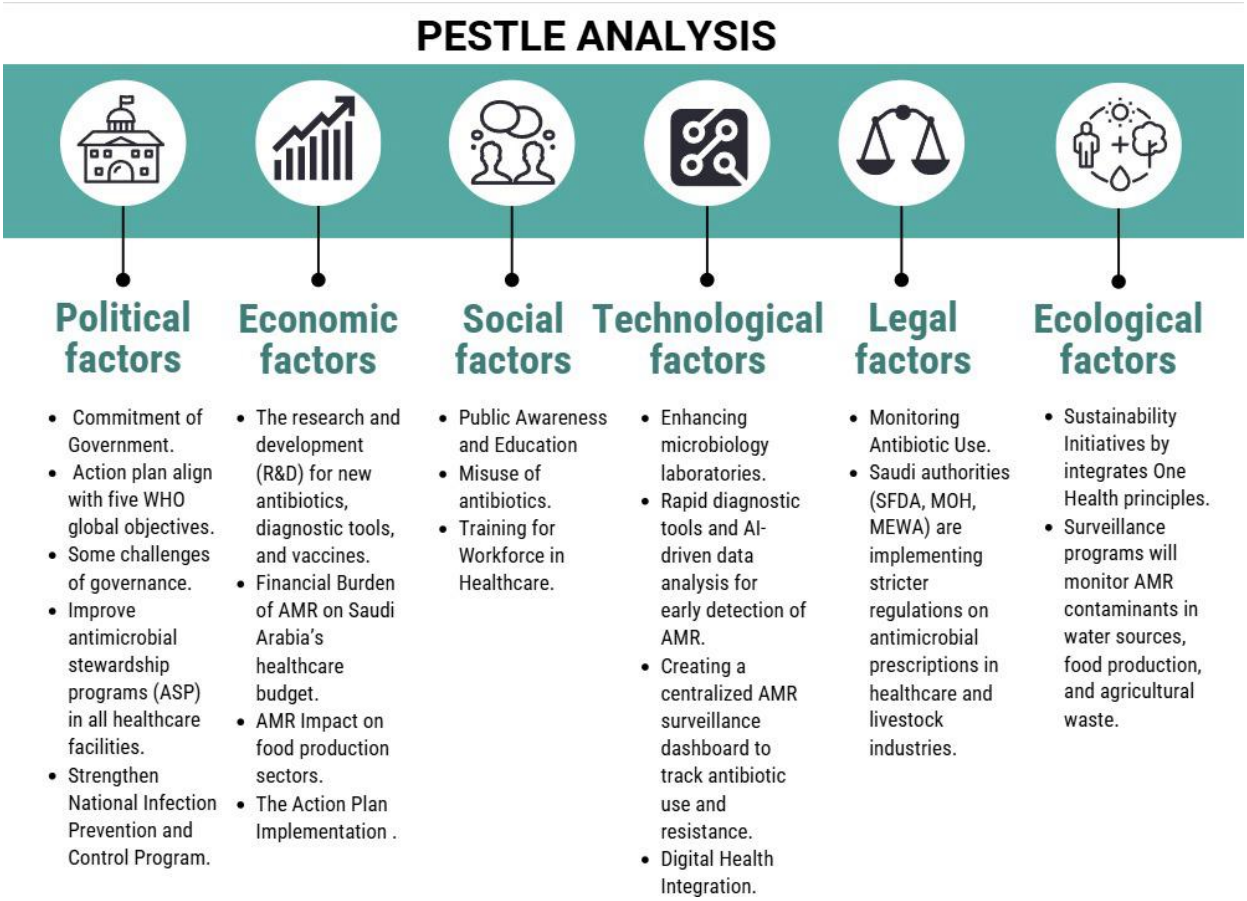

FIGURE 10. PESTLE Analysis.

- Political factors: The important factors that affect AMR are antimicrobial stewardship programs (ASP), as well as the national infection prevention and control program. However, these factors need to be improved and strengthened. In addition, the action plan of Saudi Arabia should align with the five WHO global objectives. [30].
- Economic factors: According to the survey responses, there is a lack of research and development for new antibiotics, diagnostic tools, and vaccines for AMR in Saudi Arabia.
- Social factors: According to the survey responses, there is a lack of public awareness and education regarding AMR disease. As well as misuse of medication, unawareness of the side effects of antibiotics. In addition, not finishing the antibiotics course.
- Technological factors: According to the survey responses, the digital health integration needs improvement. Hence, the small hospitals provide unnecessary prescriptions for patients, such as antibiotics. In addition to the wrong prescriptions, which contribute to increasing the prevalence of AMR.
- Legal factors: According to the survey responses, there is a lack of regulation that monitors the use of antibiotics and the prevention of unnecessary prescriptions.
- Ecological factors: the environment plays a critical role in affecting AMR, according to the survey responses, there is an issue of not following the instructions about AMR of cleanliness and precautions related to the

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environment.

C. SWOT Analysis

The swot analysis of antimicrobial resistance (AMR) in Saudi Arabia highlights different factors influencing the efforts to combat with this global health challenge. Strengths include existing efforts such as the 2017 national action plan, collaboration with national and international experts, and the establishment of a dedicated AMR committee, which provided a framework for combating (AMR). However, weaknesses such as limited public awareness and insufficient research funding are still affecting the progress. On the other hand, opportunities to strengthen AMR management involve investing in awareness campaigns, investing in research, enhancing surveillance systems like WEQAYA, improving hospital reporting systems, and enhancing data collection processes. However, there are threats such as the life-threatening health impacts, rapid spread of multidrug-resistant pathogens, and significant economic consequences. Finally, this analysis highlights the need for organized efforts to utilize strengths, mitigate weaknesses, seize opportunities, and prevent threats to ensure effective strategy for combating AMR in Saudi Arabia.

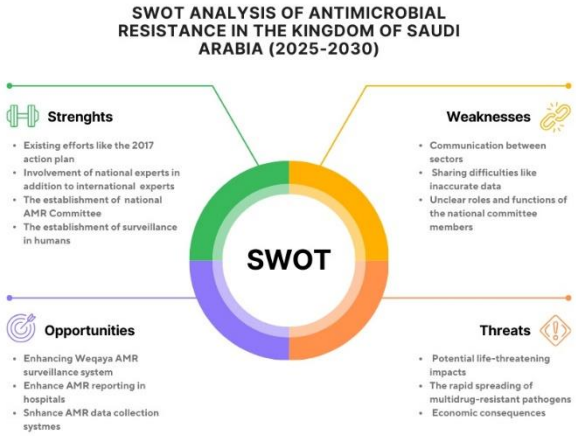

FIGURE 11. PESTLE Analysis

D. Balanced Scorecard analysis

It is an organizational planning and management tool that makes sure business activities are in line with the company's vision and strategy, boosts communication inside and outside the company, and keeps a check on how well the company is doing in meeting its strategic goals.

The Balanced Scorecard analyzes performance from four key perspectives:

- Financial Perspective :

The financial perspective focuses on an organization's ability to generate financial returns, such as revenue growth, cost management, return on investment, and profitability. These metrics help improve and increase a company's financial profits.

- Customer Perspective :

The customer perspective addresses an organization's service to its customers, such as customer satisfaction, loyalty, retention, and their overall experience. To build a strong reputation and gain a competitive advantage, we must understand customer needs, as this will lead to customer loyalty and increased sales.

- Internal Business Processes Perspective :

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The Internal Business Processes Perspective focuses on the internal processes that drive and contribute to an organization's success, such as production efficiency, process cycle time, and innovation rates. Improving internal processes helps an organization deliver better products and services.

- Learning and Growth Perspective (Organization Capacity):

The Organization Capacity perspective focuses on the organization's success and continuous improvement through employee training, structure, and the use of advanced technologies to support its long-term success. It also focuses on the organization's ability to adapt and evolve.

Vision:	**Be Saudi Arabia a global leader in combating AMR**			
Mission:	reduce AMR diseases through collaborative One Health approach and enhanced surveillance			
Strategic Themes:	innovation & Research	Healthcare Approach Enhancing	Public Awareness and Education	
Strategic Results:	Invest in research and innovation to develop alternative treatments and rapid diagnostics	Establish a national collaborative platform to facilitate the exchange of AMR data	Create public and professional community awareness about AMR risks	
Strategic Objective		**Measures**	**Targets**	**Initiatives**
Financial Stewardship	• Promote Financing for the AMR Program • Reduce Healthcare Costs Due to AMR	• Improve allocate budget for AMR programs • AMR-related treatment costs	• ↑20% for for AMR programs • ↓50% AMR-related treatment costs	• Implement cost-effective AMR prevention programs
Constituent / Stakeholder	• Improve Public Awareness of AMR Risks • Enhance Healthcare Providers Compliance	• % of awareness campaigns • % reduction in unnecessary antibiotic prescriptions	• 80% awareness on AMR by 2030 • 90% compliance by 2030	• Implementing national awareness campaigns on AMR
Internal Business	• Enhance Monitoring and Reporting Mechanisms • Improve Measures for Infection Prevention and Control	• % of hospitals using AMR surveillance • % reduction in infections due to AMR	• 95% hospital implementing AMR surveillance by 2030 • 50% reduction in AMR by 2030	• Develop national AMR database • Implement infection control protocols
organizational Capacity	• Enhance Research and Innovation on AMR Solutions • Developing skills for healthcare workers	• Number of research in AMR • % of Training effectiveness	• Double AMR research publications by 2030 • 95% of healthcare workers	• Create national grants for AMR research • Create training plans for workers
Core Values:	**Awareness**	**Innovation**	**Accountability**	**Collaboration**

FIGURE 12. Balanced Scorecard.

E. Monitoring and Evaluation

The important KPIs to reduce AMR include medication monitoring, awareness of the risk of AMR, and regulations regarding wrong and unnecessary prescriptions. In addition to improvements in the surveillance system, and the number of research and development projects on AMR.

RESULTS AND RECOMMENDATIONS

The analysis of the current strategies contributes to reducing the risk of AMR in Saudi Arabia, showing that many issues need to be considered, including awareness of AMR for the public, monitoring medication use, lack of research and development, and integration of health facilities. However, the recommendations to improve the present strategies include improving the national surveillance system of AMR to be centralized, including all the facilities in Saudi Arabia. As well as raising awareness of AMR for the public by implementing campaigns in schools, universities, and public facilities. In addition to providing training to the workers in hospitals to deal with AMR professionally. Additionally, the a need to intensify work on the research and development of medication and vaccines.

CONCLUSION

In conclusion, this study highlights the need to address antimicrobial resistance in Saudi Arabia through a strategic approach. Survey results revealed a lack of awareness regarding antibiotic use, underscoring the importance of ongoing education and awareness. Strategic analyses using SWOT, PESTLE, and balanced scorecard analyses

provided valuable insights into the internal capabilities and external challenges impacting antimicrobial resistance management. The study emphasizes the need for national policies and strategic plans that encourage the proper use of antibiotics, promote antimicrobial resistance control practices, and ensure long-term public health sustainability. Also, all authors declare that they have no potential bias or conflicts of interest.

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TABLE1. ***Appendix***

Ref.	Gaps	Findings
[5]	the lack of resources, expertise and capacity in LMICs	the Idea of transitioning from isolate- or sample-based approach to a case-based approach
[6]	Lack of Environmental AMR Surveillance Integration	investigate the implementation of EIS, the characteristics and effectiveness.
[7]	Limited Stakeholder Perspectives	he usage of DHIS2 is very encouraged to be used as a AMR surveillance platform. However, the current knowledge of how to use DHIS2 is not very promising.
[8]	Lack of diverse represent the diverse.	Evaluation of (Kor-GLASS)s organizational structure .
[9]	lack of collaboration between agencies, disjointed policies.	Evaluation of India's AMR guidelines and policies.
[10]	the lack of awareness and technical and human capacity, lack of a national reference lab for antimicrobial resistance	Overview of the national AMR surveillance UAE.
[11]	The lack of policy frameworks and the fragmented efforts.	assess the NAP by the GAP.
[12]	The lack of financial support, and human resources across countries.	strategic opportunities global NPAs.
[13]	the lack resource allocation across human health, animal health, and environmental sectors.	current status in Eastern Mediterranean Region (EMR) in face of AMR.
[14]	The missing One Health approach.	Showcase the Latin American NAPs in the context of AMR governance.

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[15]	The application of therapeutic phages in clinical settings is limited by regulatory and logistical challenges.	The possibility of phage therapy as an alternative treatment for AMR diseases.
[16]	Physicians' opinions and reasons for prescribing antibiotics were not analysed.	The survey found that pharmacists have good awareness of antibiotic resistance.
[17]	complexity of antimicrobial resistance and need for standardization.	the role of machine learning in accurate diagnosis.
[18]	Financial constraints and need for large datasets in genome sequencing for antimicrobial resistance research.	The role of genomic and metagenomic methods in identifying antibiotic resistance genes and predicting resistance mechanisms .
[19]	lack of funding and inadequate legislation on the use of antibiotics.	The effectiveness of mitigation strategies such as the One Health Approach and global monitoring initiatives such as SMART and GLASS.
[20]	high costs, resistance development, and accessibility issues in low-income settings.	The effectiveness of integrating genomics, CRISPR, and novel therapeutics in combating antimicrobial resistance (AMR).
[21]	Emerging methods are still in the research and clinical practice stages.	Discuss different antimicrobial susceptibility testing methods, their uses, comparison, benefits, limitations and time taken to obtain results.
[22]	Many NAPs did not assess a SWOT analysis and comparisons were difficult due to lack of standardization.	Surveillance systems lacking in many nations, especially in low-income.
[23]	No numerical objectives.	They conclude that there were no areas not covered by the national action plan.
[24]	Limited of specialized staff such as clinical pharmacists and microbiologists.	Six key themes were identified that influence implementation NAP.
[25]	Lacks experimental data and economic feasibility discussions.	Vaccines can prevent infections, and reduce antibiotic use, while mAbs provide targeted treatment.
[26]	Limited quantitative data on AMR reduction through vaccines.	sing Vaccine Value Profiles to analyze 16 pathogens, the vaccine will succeed in controlling drug-resistant Salmonella.
[27]	Lacked clinical trial data and focused more on theoretical approaches than current implementations.	Potential of outer membrane vesicles (OMVs) to develop the vaccine and the need for targeted

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		interventions. against biofilm formation.
[28]	Lacked clinical trial data for proposed technologies.	AMR is a major health threat, particularly in hospital-acquired infections, and advanced technologies can improve prevention, diagnosis, and management.
[29]	Limited quantitative data on vaccine efficacy in different populations.	Vaccines such as pneumococcal, rotavirus, and typhoid conjugate significantly reduce antibiotic usage and AMR risk.
[30]	Depending on existing literature, without collecting new data.	Emphasized the need for a national surveillance program, improved antimicrobial stewardship, and infection control measures to combat AMR, aligning with Saudi Vision 2030 to enhance healthcare, economy, and public awareness.
[31]	Lack of new experimental data and limited focus on real-world implementation.	AMR is rising globally, and more developed than new antibiotics.
[32]	High costs and limitations in diagnostic accessibility, especially in low-income regions.	High prevalence of resistance genes in environmental samples, stressing the need for enhanced surveillance and policy intervention.
[33]	Lack of detailed intervention strategies and experimental validation.	Suggested enhanced global surveillance, antibiotic stewardship policies, and stricter regulations as solutions.
[34]	Lack of case studies and a regional focus on Europe.	Suggested strategies include promoting responsible antibiotic use, improving surveillance, and encouraging research into new antibiotics and diagnostics.