MACQUARIE University
SYDNEY·AUSTRALIA

The Vietnam Antibiotic Resistance Resilience (VARR) Initiative

Date: 27 October 2024

[BUSA8030] Group 9, 9am Fridays

Word Count: 2640 words

Name	Student ID
Khuat Son Tra Nguyen	48144134
Ngoc Tram Tran	47753595
Do Minh Huu Nguyen	47772360
Quoc Trung Nguyen	48299405

Executive Summary

The Vietnam Antibiotic Resistance Resilience (VARR) Initiative is a comprehensive program addressing the critical issue of antibiotic resistance in Vietnam, aligned with Sustainable Development Goal 3.3 on communicable disease reduction. Vietnam faces a high prevalence of antimicrobial resistance (AMR), largely due to unregulated antibiotic sales, self-medication, and limited prescription tracking, making AMR a severe public health and socio-economic threat. While the National Strategy on AMR Control (2023-2030) aims to regulate antibiotic sales, the challenge requires innovative, data-driven solutions to enforce these policies effectively and sustainably.

Vietnam's Ministry of Health (MOH) faces key challenges in raising AMR awareness, enforcing regulations, and establishing a predictive model for AMR treatment. A cultural norm of self-medication and accessible antibiotics has compounded AMR rates, while limited healthcare infrastructure hinders effective prescription monitoring. This situation calls for a cross-sectoral approach that addresses AMR's biomedical and socio-structural drivers, from youth education to enhanced data integration and predictive analytics.

The VARR Initiative's strategy is built on three integrated pillars: Youth Education, Healthcare Data Integration, and Predictive Analytics. Educational efforts focus on ages 15-24, instilling responsible antibiotic practices early on. Nationwide data integration provides MOH with a centralised system for tracking prescriptions, supporting regulatory compliance across pharmacies and healthcare providers. Predictive analytics leverage machine learning to anticipate AMR trends and guide timely interventions, optimising healthcare resources.

VARR's effectiveness depends on collaboration across government bodies, educational institutions, healthcare providers, pharmacies, and strategic partners like the UN. This multi-stakeholder network supports VARR's comprehensive data collection and compliance strategies. Through this initiative, Vietnam not only tackles its AMR challenges but also contributes significantly to global efforts against antibiotic resistance.

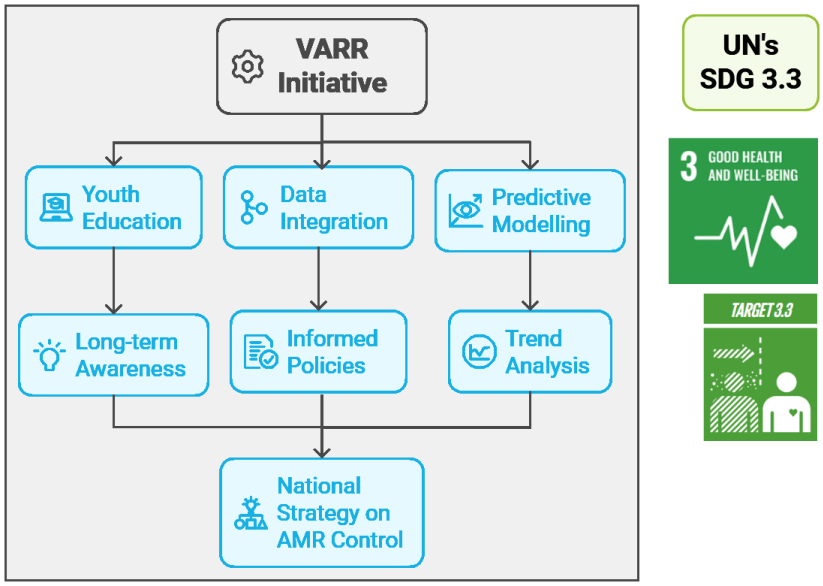
Table of Content

1. Introduction

a. Overview of the Initiative

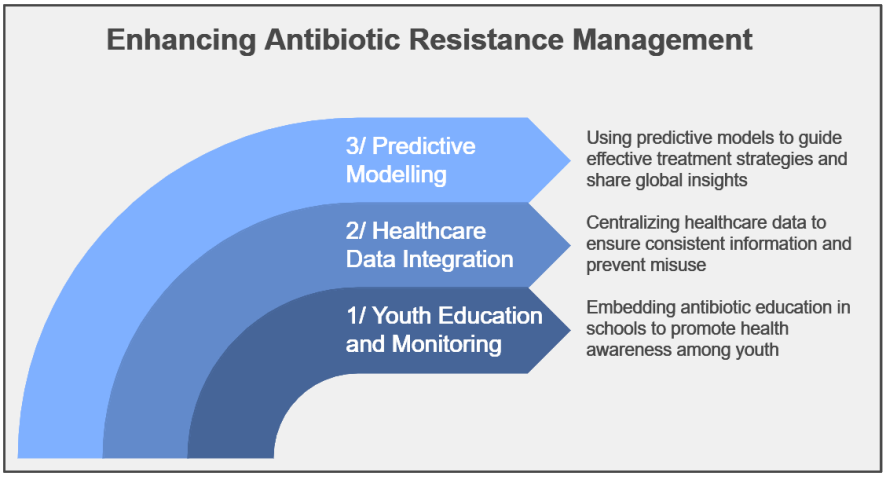
The Vietnam Antibiotic Resistance Resilience (VARR) Initiative (OpenAI, 2024), supporting SDG 3.3 "Communicable Diseases," assists Vietnam's Ministry of Health address antibiotic resistance through data-driven strategies. With Asia's highest antimicrobial resistance rates and limited resources (Vu et al., 2019), Vietnam faces urgent public health challenges. Overall, our initiative consists of:

1. Youth Education: Raising public's awareness, focusing on ages 15-24 by integrating health databases into School Health Programs.
2. Data Integration: Unifying healthcare infrastructure to enable data-informed policies and interventions.
3. Predictive Modelling: Ensuring sustainable impact through data-driven forecasting and AMR trend analysis.



This approach advances Vietnam's National Strategy on AMR Control (Decision 1121/QĐ-TTg, 2023-2030) by combining targeted education, healthcare system integration, and global collaboration to build antibiotic resistance resilience (Vietnamese Law, 2023).

b. Significance of Data-Driven Solutions



Our data-driven initiatives assists Vietnam's Ministry of Health (MOH) in enhancing its newly developed system to address citizens' antibiotic resistance through three strategic pillars:

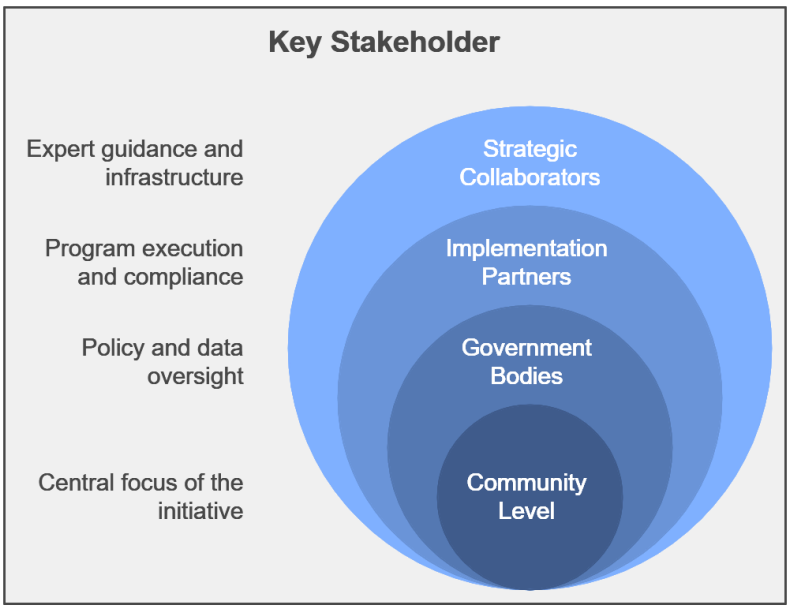
1. **Youth Antibiotic Education and Health Monitoring:** This approach fosters responsible health behaviours early by offering personalised feedback based on student health records, which will promote informed antibiotic use, reducing misuse risks and building sustainable, health-conscious habits (Ancillotti et al., 2018). Educated youth (ages 15-24) thus become a proactive population, contributing to long-term public health goals in combating antibiotic resistance.
2. **Nationwide Healthcare Data Integration:** Through an interconnected data network, the MOH can centralise information from hospitals, clinics, and pharmacies. Ensuring data consistency enables data-informed regulatory enforcement and interventions, helping to prevent those with misconceptions about antibiotic use from obtaining antibiotics inappropriately.
3. **Predictive Analytics for Antibiotic Resistance Treatment:** Utilising an integrated data network, predictive models provide valuable insights into antimicrobial resistance (AMR) patterns, guiding timely and effective treatment strategies, especially in resource-limited settings like Vietnam. Additionally, by contributing Vietnam's predictive model outcomes as a representative benchmark for comparable countries through UN collaborations, the MOH reinforces Vietnam's collaborative role in the global fight against antibiotic resistance.

c. Objectives of the Management Plan

VARR aims to address biomedical and socio-structural drivers of antibiotic misuse in Vietnam (McKinn et al., 2021) through three objectives:

1. Deploy data-informed youth education
    a. Deliver targeted antibiotic stewardship content
    b. Demographic monitoring through resource optimisation
    c. Track Enable data-based program adjustments
2. Build unified healthcare data infrastructure
    a. Connect hospitals, clinics, and pharmacies
    b. Comprehensive tracking of antibiotic prescriptions
    c. Provide evidence-based policies
3. Build predictive models
    a. Models for AMR diagnosis and treatment
    b. Share best practices in antibiotic stewardship
    c. Contribute to UN-led predictive modelling for mutual benefits

d. Key Stakeholders



- Community Level: Students and families
- Government Bodies: Ministry of Health (healthcare data/policy) and Ministry of Education (learning deployment)

- Implementation Partners: Educational institutions (program execution) and healthcare facilities/pharmacies (data network compliance)
- Strategic Collaborators: UN (predictive modelling), technology partners (infrastructure), and healthcare professionals (expert guidance)

This stakeholder network enables comprehensive data collection and sustainable interventions (Dat et al., 2020).

2. Problem statement

a. Problem Identification

Antibiotic resistance in Vietnam represents a critical challenge within SDG 3.3's global health agenda. Studies reveal concerning patterns: 67.4% of hospital inpatients receive antibiotics, with one-third being inappropriate prescriptions (Thu et al., 2012). This misuse stems from over-the-counter availability and self-medication practices (Van Duong et al., 1997), causing significant consequences - antibiotics constitute 28.6% of hospital medication costs (Dat et al., 2020) and drive high resistance rates (Nguyen et al., 2013).

The Vietnamese government responded with Decision 1121/QĐ-TTg (2023), launching the National Strategy on Antimicrobial Resistance Control (2023-2030) to regulate pharmacy antibiotic sales. However, implementing this initiative faces challenges in effectively raising awareness, timely policy enhancement and intervention, and establishing a sustained predictive modelling. As antibiotic resistance is projected to increase 200% by 2030 under current practices (Klein et al., 2018), it emphasises the urgency of addressing resistance within SDG 3's framework.

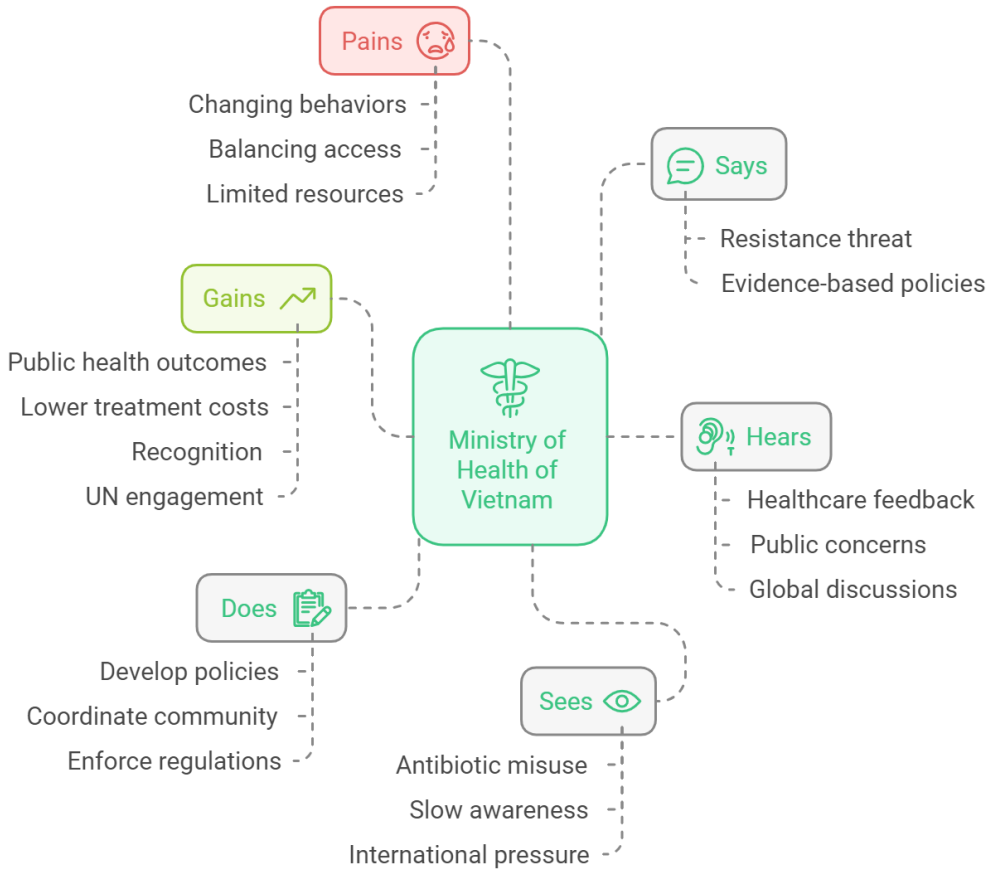
b. Empathy Maps

Primary Stakeholder: Vietnam's Ministry of Health (MOH)

- *Role:* Healthcare system oversight and public health protection
- *Challenge:* Rising antibiotic resistance
- *Required Actions:*
    - Implement targeted regulations

- Build comprehensive data analytics system
- Track antibiotic use and predict risks

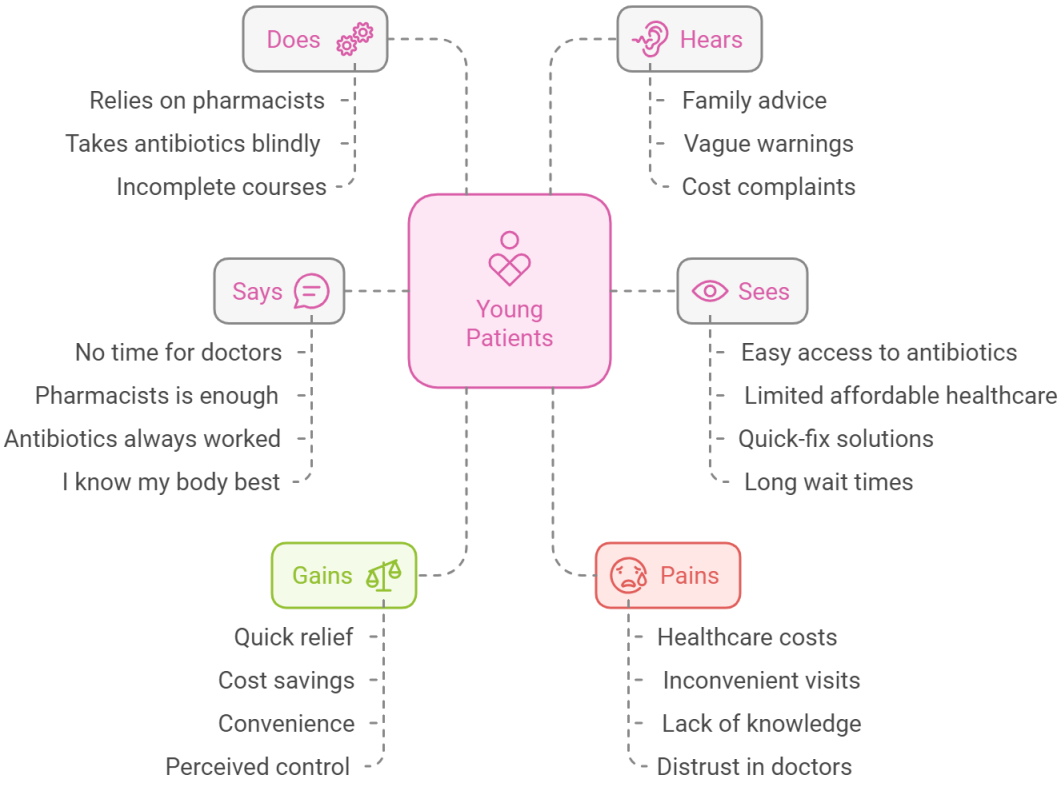
- *Success Metrics:* Reduced resistance rates, improved prescription compliance, functional data warehouse



Target Beneficiaries: Youth (Ages 15-24)

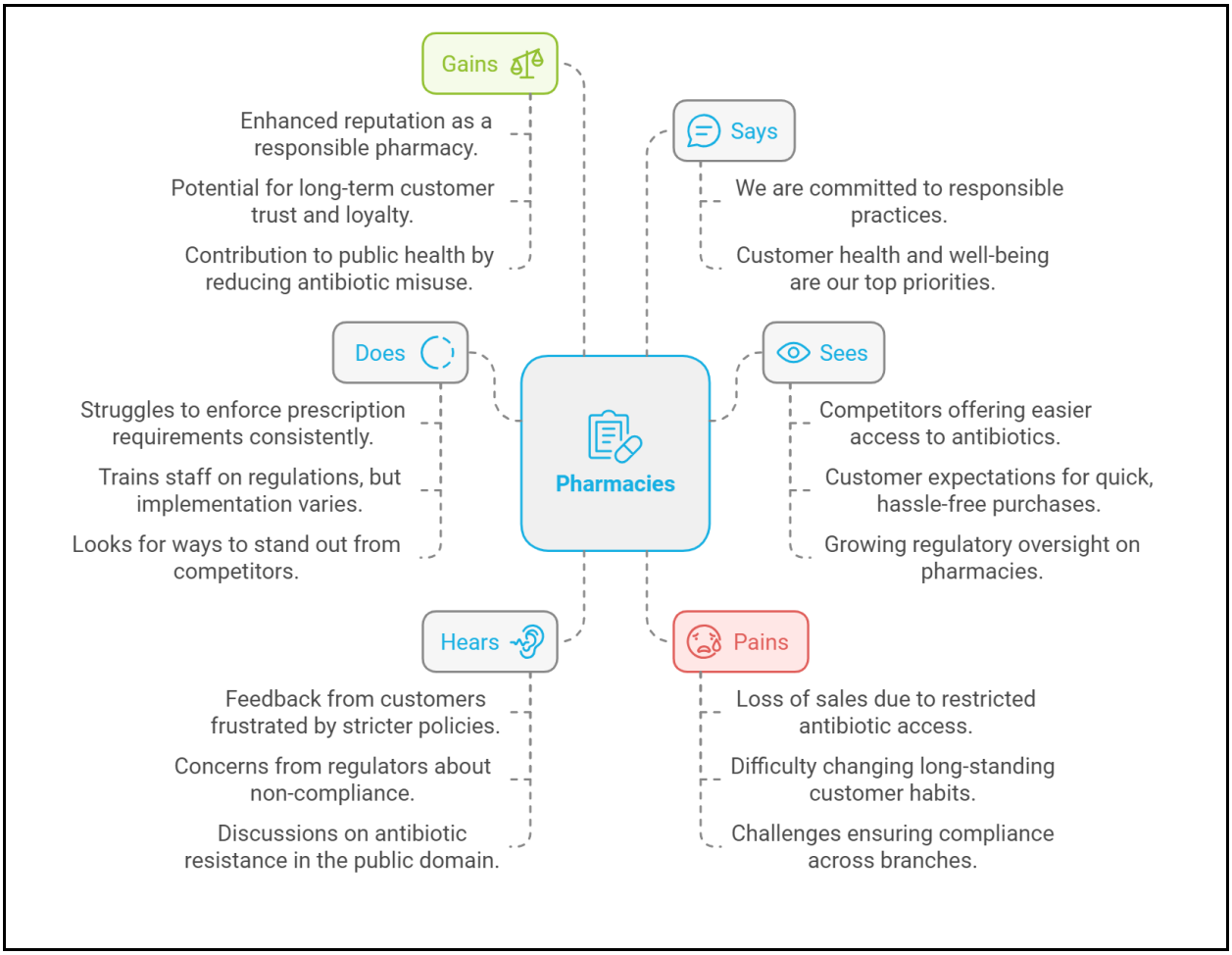
- *Role:* Future workforce
- *Challenge:* Vulnerable to antibiotic misuse and resistance
- *Required Actions:*
  - Have proper antibiotic use awareness
  - Have a health tracking record

- *Success Metrics:* Decreased unnecessary use, increased health literacy, reduced resistant infections



Key Partners: Pharmacies

- *Role:* Medicine providers
- *Challenge:* Balancing compliance with profitability
- *Required Actions:* Adapt to digital monitoring and new regulations
- *Success Metrics:* Improved compliance, digital system adoption



c. Potential Impacts of the Problem

Long-term Health due to Resistance Risks. Antibiotic resistance poses significant health threats to Vietnam's development. Antibiotic misuse through overuse, irregular use, and self-medication substantially contributes to resistance development in South Asia (Hussain et al., 2023), leading to prolonged illnesses, increased healthcare costs, and higher mortality rates (Hussain et al., 2023; Otia, 2024).

Socioeconomic Consequences. These health impacts compound Vietnam's demographic challenges, as the elderly population is projected to triple from 7% to 21% by 2050 (Maheshwari & Maheshwari, 2024). This rapid ageing, occurring faster than in comparable economies (Hung, 2022), threatens socio-economic development through reduced labour supply and productivity (Bui & Tran, 2023), creating an urgent need to protect the future workforce's health to sustain national development.

3. Lotus Blossom

(see Appendix A)

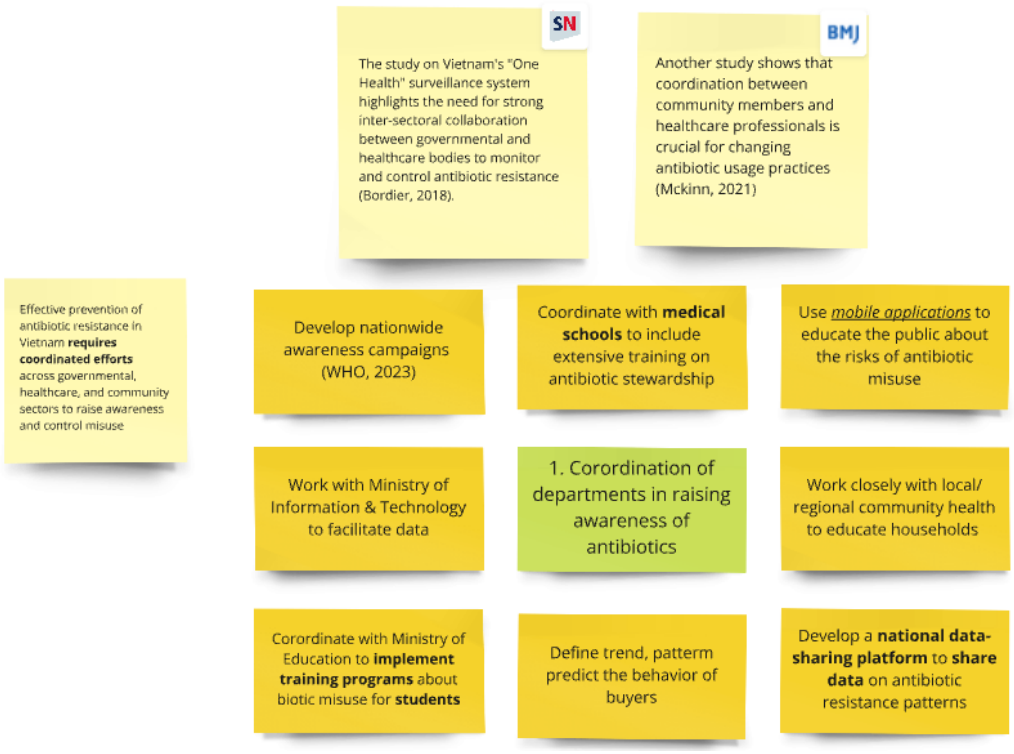
a. Potential Solutions

The proposed solutions for MOH address antibiotic resistance through **data-driven and conventional approaches**. The first potential approach emphasises enhancing AMR surveillance by current systems, leveraging data analytics and developing predictive capabilities. These efforts are combined with **conventional methods** strengthening awareness for young adults (15–24), interdepartmental coordination. Overall, these solutions align with both **Vietnam's national AMR framework** (Decision 1121/QĐ-TTg, 2023) and UN SDG 3.3 (Vietnamese Law, 2023).

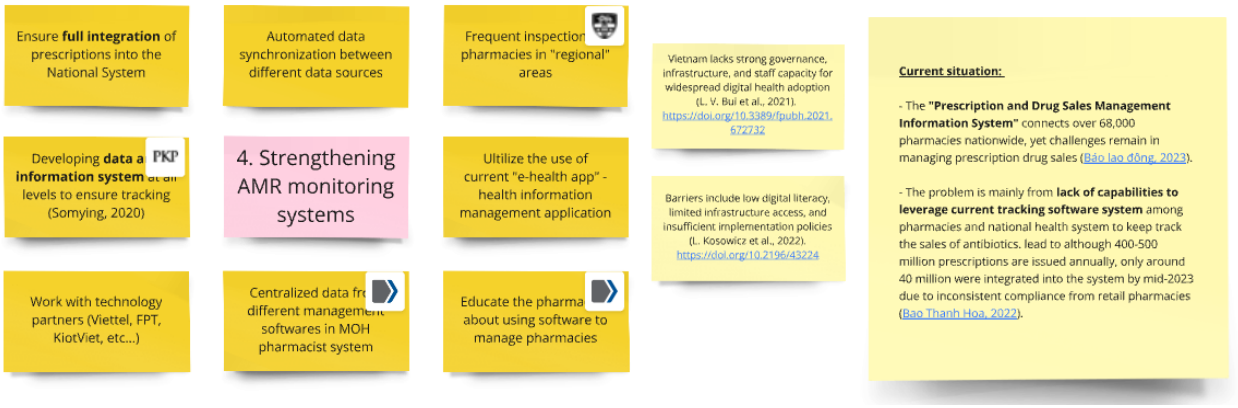
b. Rationale & interconnections between solutions

To begin, cross-sector collaboration between key stakeholders (our first potential solution, *see Appendix B*) is crucial for transforming antibiotic practices nationwide (McKinn et al., 2021). A

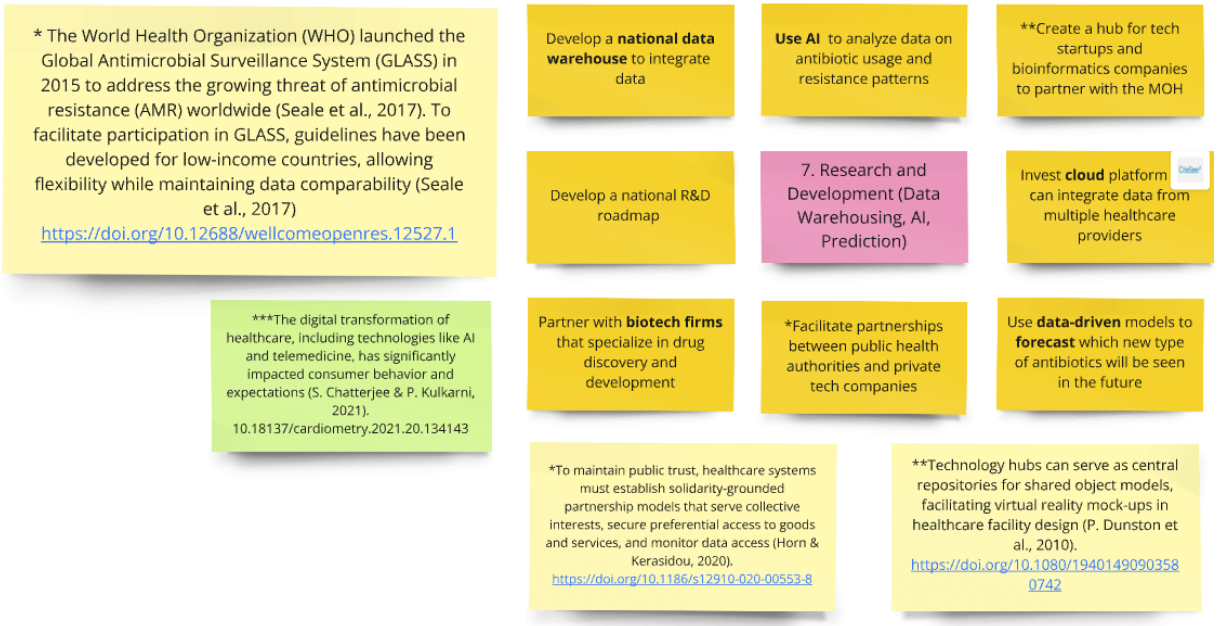
partnership with the Ministry of Education would enhance antibiotic awareness in school curriculum, helping students develop proper usage early in life (Lee et al., 2015). This educational foundation, combined with **public awareness campaigns** about antibiotic misuse dangers, helps sustain behavioural change across the nation (Ashiru & Hopkins, 2015). With this approach, MOH can set a foundation for a well-educated generation in antibiotic usage and sustain its AMR management system.



Although MOH has initiated digitization efforts, the newly built system witnesses low efficiency for antibiotic monitoring (To Hoa, 2022). Thus, our next potential solution focuses on **strengthening the current system** *(see Appendix C)* through a data-driven approach. To specify, the e-health system tracking antibiotic prescriptions and relevant patterns should be centralised to enhance MOH's decision-making capabilities (Carvalho et al., 2020). Moreover, current antibiotic sales regulations remain weak enforcement regarding over-the-counter sales (Nguyen et al., 2013). This strategy addresses the challenge through a bottom-up approach, including monitoring and enforcing different healthcare institutions using a seamless centralised national system, ensuring **regulatory compliance** (Domeyer et al., 2021).



Our third potential solution - **research and development** *(see Appendix D)* focuses on building a national data warehouse with AI-driven analytics to enable effective tracking of antibiotic usage and resistance patterns. This approach strengthens national surveillance and **contributes to global AMR efforts**. Through collaboration with the World Health Organization (WHO), MOH can align with international best practices and share critical resistance data (Morehead & Scarbrough, 2018). Hence, this initiates a robust guideline for tackling antibiotic resistance at **both national and international levels.**



Lastly, successful AMR control relies on **robust human resource management**, where healthcare professionals and community leaders help address the cultural misconceptions and knowledge gaps about antibiotic use (McKinn et al., 2021). Sustainable financial strategies are

essential to support these human resources in AMR. This also enables the operation of surveillance systems, awareness campaigns, and research initiatives. Hence, it enables MOH to ensure consistent program funding and effective execution of AMR action plans (Kmietowicz, 2015).

4. Solution Development

4.1 Youth Antibiotic Education and Health Monitoring

a. The Significance

According to Ancillotti et al. (2018), knowledge about antibiotic consumption and resistance, as well as good health communication from authorities has significant influence on public perceptions, contributing to solving the problem of misuse of antibiotics.

From a data-driven perspective, Vietnam's MOH can enhance public awareness of antibiotic consumption and resistance by integrating health databases into School Health Programs. Through existing health information systems and EMRs, such as VHIS and VAMRN, data on antibiotic use and resistance trends can be collected and analysed. Notably, a study by Nguyen (2010) demonstrated the successful implementation of such a system in Ho Chi Minh City, resulting in a central database containing treatment histories for every child.

Building on this, the MOH could collaborate with the Ministry of Education and Training to utilise this information to provide personalised health feedback to students during check-ups, fostering informed health behaviours and reducing self-medication. Furthermore, schools could periodically generate and disseminate educational health reports based on the latest database findings. These reports would provide students with relevant insights into how their behaviours align with or deviate from national trends, making the information both engaging and meaningful as well as guiding them to have a correct cognition and behaviour using antibiotics.

b. Alignment with Stakeholder Needs and Socio-Economic Issues

This initiative aligns closely with stakeholder needs and addresses critical socio-economic issues, particularly in Vietnam. By embedding health information systems in schools, it supports the Ministry of Health's mission to control antibiotic resistance through data-driven insights that monitor antibiotic use among key demographics, notably young people aged 14-25. For schools,

integrating health data during routine check-ups educates students about antibiotic misuse, supporting national efforts to instil long-term, responsible behaviour toward antibiotic consumption (Lee et al., 2013). This approach bridges the needs of educational institutions, healthcare stakeholders, and socio-economic priorities, fostering a future workforce equipped with essential health knowledge and promoting sustainable antibiotic practices across generations.

c. People and Management Aspects

To implement the strategy effectively, the MOH must coordinate with hospitals, clinics, and educational institutions to integrate EMRs and national databases. Training healthcare professionals and educators is essential for accurate data collection and communication. Collaboration with the Ministry of Education enables personalised health feedback in schools, fostering responsible antibiotic use among students. Effective communication and monitoring systems ensure accurate tracking and continuous improvement of the program, aligning with national health priorities to reduce antibiotic resistance.

4.2 Nationwide Healthcare Data Integration

a. The Significance

Next, **centralising real-time patient data** from hospitals and pharmacies into the national system enables MOH to develop **evidence-based interventions and policies** that effectively combat AMR. However, the current "Prescription and Drug Sales Management" system captures **only 10%** of annual prescriptions, which provides **insufficient data** for informed decision-making and policy design (Anh, 2019). By **integrating data** from all hospitals and pharmacies from their management systems and databases, this approach would ensure **comprehensive data** for tracking of antibiotic prescriptions (Vietnam Social Insurance, 2019; Smith et al., 2022). Successful international implementations demonstrate that this centralised framework both strengthens AMR regulatory enforcement and antibiotic usage guidelines (WHO, 2023; Domeyer et al., 2021).

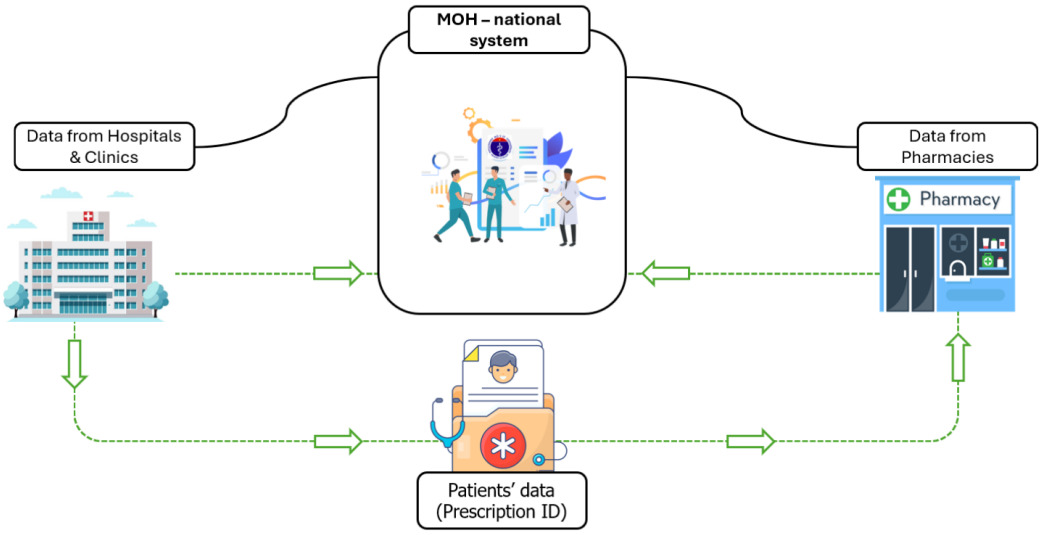


Figure 1. Recommended data journey to MOH's system

b. Alignment with Stakeholder Needs and Socio-Economic Issues

To assist the Ministry of Health (MOH) in achieving its aim of reducing the national antibiotic resistance rate, the solution suggests a centralised monitoring system to support data-informed policies and interventions. (Ministry of Health, 2023). E-prescriptions serve as the key link between hospitals, clinics, and pharmacies by connecting their different databases through MOH's national platform, regardless of the software used by individual institutions. By standardising and linking this data into the national system, every antibiotic prescription can be tracked (Robillard et al., 2024). Hence, MOH can analyse antibiotic usage patterns effectively, providing crucial evidence for developing regulation (Thakral, Sahay, & Mukherjee, 2023).

Young patients have faced misperception about antibiotic usage, leading to misuse. This data-driven approach provides data-informed and centralised regulations that outline proper antibiotic consumption practices. This helps young patients transition from blind antibiotic use to prescription-based consumption, contributing to MOH's antimicrobial resistance reduction goals.

Although restricting antibiotic sales without prescriptions may **reduce revenues for local pharmacies**, pharmacies complying with these regulations will gain official certification from MOH, demonstrating their commitment to public health standards. This recognition will **enhance their reputation**, ultimately building stronger trust among customers.

c. People and Management Aspects

People management is crucial in executing this solution, focusing on two essential workforce groups. First, the management of doctors and pharmacists emphasises their role, ensuring antibiotics are dispensed only with verified e-prescriptions to combat over-the-counter sales (Mitchell et al., 2020). Second, the management of technical personnel focuses on maintaining system integrity, ensuring security and scalability across healthcare facilities for effective AMR control (Joseph et al, 2017). This approach ensures the successful implementation of MOH's healthcare ecosystem.

4.3 Predictive Analytics for Antibiotic Resistance Treatment

a. The Significance

Beyond strategies aimed at reducing antibiotic misuse, MOH can leverage data-driven approaches to enhance antibiotic resistance treatment through predictive analytics. By utilising patient data such as demographic profiles, medical histories, health statuses, and infection sources and integrating this with microbiological and laboratory data on multi-drug resistant infections, the MOH can develop more refined guidelines for antibiotic use and resistance-targeted treatments.

Predictive models, in particular, can reveal insights into antibiotic susceptibility, assessing how effectively specific antibiotics can counteract certain bacteria or fungi. This predictive capability allows for early warnings of potential outbreaks, helping healthcare professionals make well-informed, timely treatment decisions (Behling et al., 2023).

Research by Elyan et al. (2022) highlights that even standard machine learning algorithms, applied to smaller datasets, can be instrumental in guiding antibiotic prescriptions. These models offer significant benefits in resource-constrained settings like Vietnam, where they help mitigate healthcare costs. Additionally, Pérez de la Lastra et al. (2024) suggest that integrating such models with AI systems can automate diagnosis with high accuracy, enabling the development of personalised treatment plans and improving overall care effectiveness.

b. Alignment with Stakeholder Needs and Socio-Economic Issues

This initiative aligns closely with the MOH goals by supporting effective treatments for antibiotic-resistant infections among antibiotic users. Especially for the individuals aged 15-24, predictive

analytics offer a proactive framework to address antibiotic resistance early, helping to prevent infections from worsening. This approach is particularly relevant within the context of Vietnam, where limited resources demand efficient, cost-effective strategies.

From the user perspective, given the reliance on pharmacists and family advice for health decisions, this approach contributes to shifting trust toward healthcare professionals by emphasising data-driven insights and underscoring the potential risks of antibiotic misuse. Overall, being able to establish this trust is crucial for fostering user compliance, thereby strengthening the impact of interventions and policies aimed at tackling antibiotic misuse.

c. People and Management Aspects

Effective implementation of these solutions necessitates collaboration among all stakeholders involved in addressing antibiotic misuse and reducing resistance rates. While off-the-shelf models may provide cost-effective solutions, the continuous improvement of data quality and availability is paramount. This requires a coordinated effort from the managing teams, pharmacies, and patients to ensure a robust and stable data pipeline, facilitating the use of data effectively, as highlighted by Elyan et al. (2022). Moreover, by contributing the predictive models to the UN, MOH could be able to improve the models and their efficacy in diagnosis and treatment thanks to the collaborative effort with other countries against antibiotic resistance.

5. Conclusion and Recommendations

The VARR initiative addresses Vietnam's high antimicrobial resistance rates through three data-driven strategies. First, it targets youth (ages 15-24) through school-integrated health programs to build early antibiotic awareness and foster responsible medication behaviours. Second, it implements nationwide healthcare data integration to track usage patterns, enforce regulations against inappropriate prescriptions, and prevent over-counter sales through real-time monitoring. Finally, it employs predictive analytics to refine treatment protocols, identify resistance trends in vulnerable communities, and optimise resource allocation.

These integrated efforts strengthen Vietnam's AMR control while contributing to global resistance prevention through UN collaboration. By sharing insights and predictive models with other resource-limited countries, the initiative enables evidence-based interventions without extensive local research requirements. This comprehensive approach aligns with SDG 3.3 goals while establishing Vietnam as a key contributor to international AMR prevention efforts.

References

1. Ancillotti, M., Eriksson, S., Veldwijk, J., Nihlén Fahlquist, J., Andersson, D. I., & Godskesen, T. (2018). Public awareness and individual responsibility needed for judicious use of antibiotics: A qualitative study of public beliefs and perceptions. *BMC Public Health*, *18*(1). https://doi.org/10.1186/s12889-018-6047-8
2. Anh, T. (2019, April 2). *Drug stores failing to connect to prescription data system to have licenses revoked.* Lao Dong News. https://laodong.vn/y-te/thu-hoi-giay-phep-cua-nha-thuoc-khong-ket-noi-lien-thong-du-lieu-666230.ldo
3. Ashiru, O., & Hopkins, S. (2015). Antimicrobial resistance: moving from professional engagement to public action. *Journal of Antimicrobial Chemotherapy*, *70*(11), 2927–2930. https://doi.org/10.1093/jac/dkv297
4. Behling, A. H., Wilson, B. C., Ho, D., Virta, M., O'Sullivan, J. M., & Vatanen, T. (2023). Addressing antibiotic resistance: computational answers to a biological problem?. *Current opinion in microbiology*, *74*, 102305.
5. Bui, T. N., & Tran, T. M. (2023). The Impact of Population Aging on Economic Development in Vietnam. *Journal of Multidisciplinary Science: MIKAILALSYS*, *1*(3), 319–331. https://doi.org/10.58578/mikailalsys.v1i3.2125
6. Carvalho, É., Estrela, M., Zapata-Cachafeiro, M., Figueiras, A., Roque, F., & Herdeiro, M. T. (2020). E-Health Tools to Improve Antibiotic Use and Resistances: A Systematic Review. *Antibiotics*, *9*(8), 505. https://doi.org/10.3390/antibiotics9080505
7. Chindelevitch, L., Jauneikaite, E., Wheeler, N., Allel, K., Grant, G., & Schmider, A. (2022). *Applying data technologies to combat AMR: current status, challenges, and opportunities on the way forward*. https://www.amr-insights.eu/wp-content/uploads/2022/08/Applying-data-technologies-to-combat-AMR.pdf

8. Dat, V. Q., Toan, P. K., van Doorn, H. R., Thwaites, C. L., & Nadjm, B. (2020). Purchase and use of antimicrobials in the hospital sector of Vietnam, a lower middle-income country with an emerging pharmaceuticals market. *PLOS ONE*, *15*(10), e0240830. https://doi.org/10.1371/journal.pone.0240830
9. Domeyer, A. D., Hieronimus, S., Klier , J., & Weber, T. (2021, September). *Government data management for the digital age | McKinsey*. Www.mckinsey.com. https://www.mckinsey.com/industries/public-sector/our-insights/government-data-management-for-the-digital-age
10. Elyan, E., Hussain, A., Sheikh, A., Elmanama, A. A., Vuttipittayamongkol, P., & Hijazi, K. (2022). Antimicrobial resistance and machine learning: challenges and opportunities. *IEEE Access*, *10*, 31561-31577.
11. Hung, L. D. (2022). The Aging Population in Vietnam: Trend and Policy. *VNU JOURNAL of ECONOMICS and BUSINESS*, *2*(1). https://js.vnu.edu.vn/EAB/article/view/4501
12. Hussain, S. A. S., Hussain, S. A. S., Qasid, S. H. A., Saleem, M., Darubra, S., & Majid, U. (2023). Antibiotic Misuse in South Asia: A Short Communication Report. *Asia Pacific Journal of Public Health*, *35*(1), 82–84. https://doi.org/10.1177/10105395221149252
13. Joseph, T., Hale, G. M., Eltaki, S. M., Prados, Y., Jones, R., Seamon, M. J., Moreau, C., & Gernant, S. A. (2017). Integration Strategies of Pharmacists in Primary Care-Based Accountable Care Organizations: A Report from the Accountable Care Organization Research Network, Services, and Education. *Journal of Managed Care & Specialty Pharmacy*, *23*(5), 541–548. https://doi.org/10.18553/jmcp.2017.23.5.541
14. Klein, E. Y., Van Boeckel, T. P., Martinez, E. M., Pant, S., Gandra, S., Levin, S. A., Goossens, H., & Laxminarayan, R. (2018). Global increase and geographic convergence in antibiotic consumption between 2000 and 2015. *Proceedings of the National Academy of Sciences*, *115*(15), E3463–E3470. https://doi.org/10.1073/pnas.1717295115

15. Kmietowicz, Z. (2015). Antibiotic research needs funding to make it more attractive and viable, says report. *BMJ*, *350*(feb05 30), h700–h700. https://doi.org/10.1136/bmj.h700
16. Lee, C.-R., Cho, I., Jeong, B., & Lee, S. (2013). Strategies to minimize antibiotic resistance. *International Journal of Environmental Research and Public Health*, *10*(9), 4274–4305. https://doi.org/10.3390/ijerph10094274
17. Lee, C.-R., Lee, J. H., Kang, L.-W., Jeong, B. C., & Lee, S. H. (2015). Educational Effectiveness, Target, and Content for Prudent Antibiotic Use. *BioMed Research International*, *2015*, 1–13. https://doi.org/10.1155/2015/214021
18. Maheshwari, A., & Maheshwari, G. (2024). Aging Population in Vietnam: Challenges, Implications, and Policy Recommendations. *International Journal of Aging*, *2*, e1–e1. https://doi.org/10.34172/ija.2024.e1
19. McKinn, S., Trinh, D. H., Drabarek, D., Trieu, T. T., Nguyen, P. T. L., Cao, T. H., Dang, A. D., Nguyen, T. A., Fox, G. J., & Bernays, S. (2021). Drivers of antibiotic use in Vietnam: implications for designing community interventions. *BMJ Global Health*, *6*(7), e005875. https://doi.org/10.1136/bmjgh-2021-005875
20. Ministry of Health Vietnam. (2023). *The necessity of developing unified and centralized healthcare data management regulations*. MOH Vietnam. https://moh.gov.vn/tin-tong-hop/-/asset_publisher/k206Q9qkZOqn/content/can-thiet-xay-dung-quy-inh-quan-ly-du-lieu-y-te-thong-nhat-ong-bo-va-tap-trung
21. Mitchell, M. E. V., Alders, R., Unger, F., Nguyen-Viet, H., Le, T. T. H., & Toribio, J.-A. (2020). The challenges of investigating antimicrobial resistance in Vietnam - what benefits does a One Health approach offer the animal and human health sectors? *BMC Public Health*, *20*(1). https://doi.org/10.1186/s12889-020-8319-3

22. Morehead, M. S., & Scarbrough, C. (2018). Emergence of Global Antibiotic Resistance. *Primary Care: Clinics in Office Practice*, *45*(3), 467–484. https://doi.org/10.1016/j.pop.2018.05.006
23. Nguyen, K. V., Thi Do, N. T., Chandna, A., Nguyen, T. V., Pham, C. V., Doan, P. M., Nguyen, A. Q., Thi Nguyen, C. K., Larsson, M., Escalante, S., Olowokure, B., Laxminarayan, R., Gelband, H., Horby, P., Thi Ngo, H. B., Hoang, M. T., Farrar, J., Hien, T. T., & Wertheim, H. F. (2013). Antibiotic use and resistance in emerging economies: a situation analysis for Viet Nam. *BMC Public Health*, *13*(1). https://doi.org/10.1186/1471-2458-13-1158
24. Nguyen, T. N. (2010). Institutional perspectives on implementing health information systems in developing countries: the case of electronic medical records (EMR) for children health in Vietnam.
25. Otia, M. (2024). Antibiotics over usage: a vital contributor of antibiotic resistance. *International Journal of Therapeutic Innovation*, *2*(2), 130–137. https://doi.org/10.55522/ijti.v2i2.0030
26. OpenAI. (2024). ChatGPT (4.0 version) [Large language model].https://chatgpt.com/share/671e353c-7460-8002-80b6-a6a0a8aba1e3
27. Pérez de la Lastra, J. M., Wardell, S. J. T., Pal, T., de la Fuente-Nunez, C., & Pletzer, D. (2024). From Data to Decisions: Leveraging Artificial Intelligence and Machine Learning in Combating Antimicrobial Resistance – a Comprehensive Review. *Journal of Medical Systems*, *48*(1), 71-. https://doi.org/10.1007/s10916-024-02089-5
28. Robillard, D. W., Sundermann, A. J., Raux, B. R., & Prinzi, A. M. (2024). Navigating the network: a narrative overview of AMR surveillance and data flow in the United States. *Antimicrobial Stewardship & Healthcare Epidemiology*, *4*(1). https://doi.org/10.1017/ash.2024.64

29. Smith, R. W., Jarvis, T., Sandhu, H. S., Pinto, A. D., O'Neill, M., Di Ruggiero, E., Pawa, J., Rosella, L., & Allin, S. (2022). Centralization and integration of public health systems: Perspectives of public health leaders on factors facilitating and impeding COVID-19 responses in three Canadian provinces. *Health Policy*, *127*, 19–28. https://doi.org/10.1016/j.healthpol.2022.11.011
30. Thakral, Y., Sahay, S., & Mukherjee, A. (2023). Microfoundations of Data-Driven Antimicrobial Stewardship Policy (ASP). *Antibiotics*, *13*(1), 24.
31. Thu, T. A., Rahman, M., Coffin, S., Harun-Or-Rashid, Md., Sakamoto, J., & Hung, N. V. (2012). Antibiotic use in Vietnamese hospitals: A multicenter point-prevalence study. *American Journal of Infection Control*, *40*(9), 840–844. https://doi.org/10.1016/j.ajic.2011.10.020
32. To Hoa. (2020, November 24). *Prescription drug sales remain uncontrolled*. Thanh Hoa Newspaper; Baothanhhoa.vn. https://baothanhhoa.vn/van-chua-kiem-soat-duoc-thuoc-ban-theo-don-127692.htm
33. Van Duong, D., Binns, C. W., & Van Le, T. (1997). Availability of antibiotics as over-the-counter drugs in pharmacies: a threat to public health in Vietnam. *Tropical Medicine and International Health*, *2*(12), 1133–1139. https://doi.org/10.1046/j.1365-3156.1997.d01-213.x
34. Vietnam Social Insurance. (2019). *National e-prescription software: Centralizing prescription data management*. Vietnam Social Insurance. https://baohiemxahoi.gov.vn/chidaodieuhanh/Pages/thong-tin-bao-chi.aspx?CateID=0&ItemID=14074
35. Vietnamese Law. (2024, October 21). Decision 1121/QD-TTg of 2023 approving the National Strategy on Prevention and Control of Drug Resistance in Vietnam for the period 2023-2030, with a vision to 2045. THU VIEN PHAP LUAT; thuvienphapluat.vn. https://thuvienphapluat.vn/van-ban/The-thao-Y-te/Quyet-dinh-1121-QD-TTg-2023-Chien-

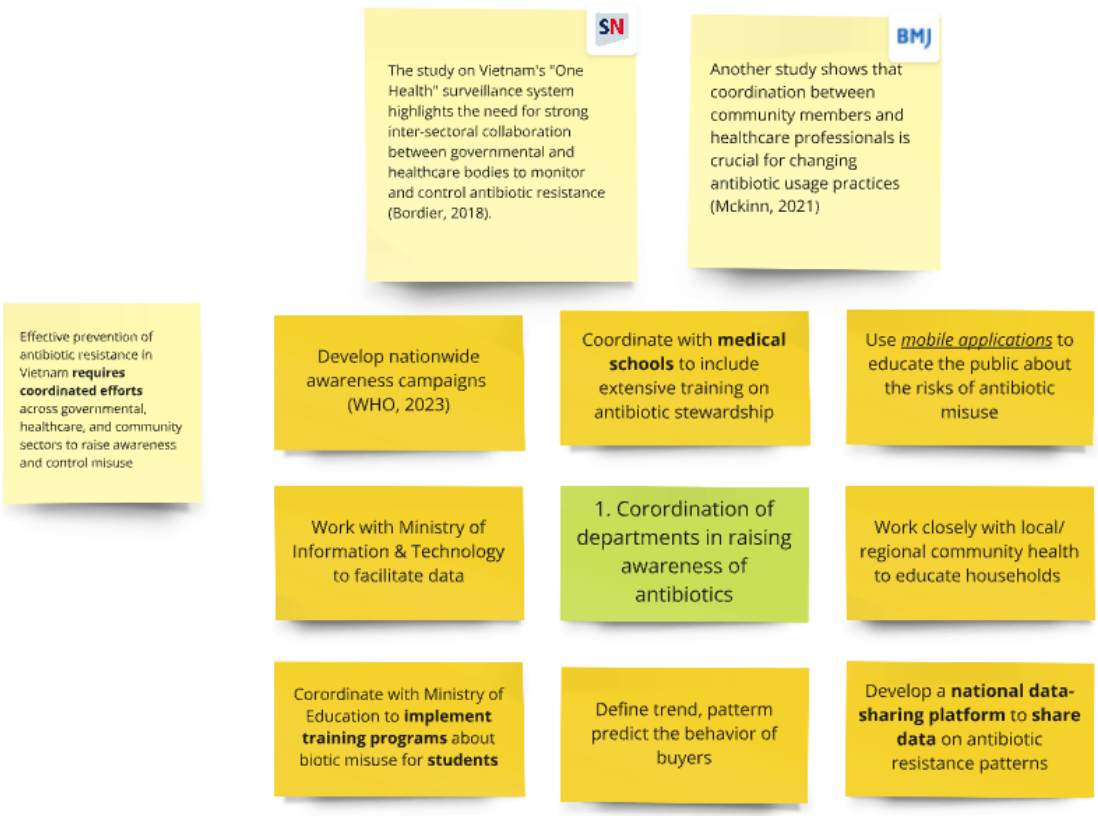
luoc-quoc-gia-phong-chong-khang-thuoc-tai-Viet-Nam-580479.aspx?fbclid=IwZXh0bgNhZW0CMTEAAR3xA2IE0uIdKx6pit2zQ1uyeWINC8TeuqLy6AUguySWa5ezqLQluR30dPo_aem_ito71pvIJ3QIGFN2OvcImw

36. Vu, T. V. D., Do, T. T. N., Rydell, U., Nilsson, L. E., Olson, L., Larsson, M., Hanberger, H., Choisy, M., Dao, T. T., van Doorn, H. R., Nguyen, V. K., Nguyen, V. T., & Wertheim, H. F. L. (2019). Antimicrobial susceptibility testing and antibiotic consumption results from 16 hospitals in Viet Nam: The VINARES project 2012–2013. *Journal of Global Antimicrobial Resistance*, *18*, 269–278. https://doi.org/10.1016/j.jgar.2019.06.00
37. WHO. (2023). *Global Antimicrobial Resistance and Use Surveillance System (GLASS)*. Www.who.int. https://www.who.int/initiatives/glass

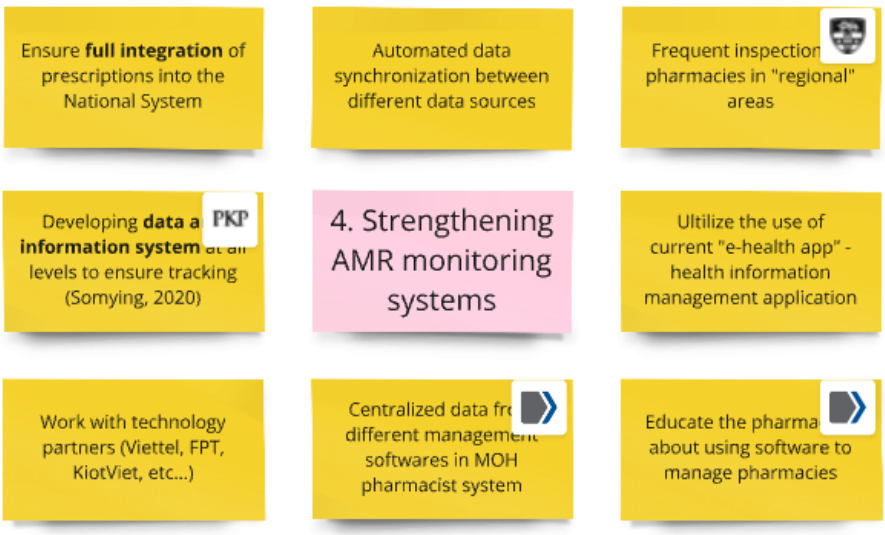
Appendix A

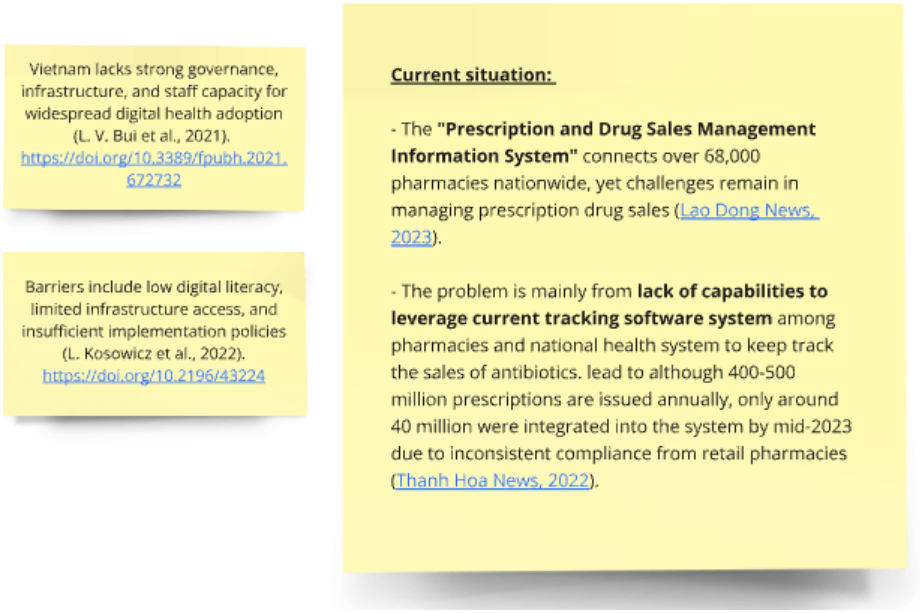
[Link to the full version of the Lotus Blossom]

Appendix B



Appendix C




Vietnam lacks strong governance, infrastructure, and staff capacity for widespread digital health adoption (L. V. Bui et al., 2021). https://doi.org/10.3389/fpubh.2021.672732
Barriers include low digital literacy, limited infrastructure access, and insufficient implementation policies (L. Kosowicz et al., 2022). https://doi.org/10.2196/43224
Current situation:
- The "Prescription and Drug Sales Management Information System" connects over 68,000 pharmacies nationwide, yet challenges remain in managing prescription drug sales (Lao Dong News, 2023).
- The problem is mainly from lack of capabilities to leverage current tracking software system among pharmacies and national health system to keep track the sales of antibiotics. lead to although 400-500 million prescriptions are issued annually, only around 40 million were integrated into the system by mid-2023 due to inconsistent compliance from retail pharmacies (Thanh Hoa News, 2022).

Appendix D


Develop a national data warehouse to integrate data
Use AI to analyze data on antibiotic usage and resistance patterns
**Create a hub for tech startups and bioinformatics companies to partner with the MOH
Develop a national R&D roadmap
7. Research and Development (Data Warehousing, AI, Prediction)
Invest cloud platform can integrate data from multiple healthcare providers
Partner with biotech firms that specialize in drug discovery and development
*Facilitate partnerships between public health authorities and private tech companies
Use data-driven models to forecast which new type of antibiotics will be seen in the future
*To maintain public trust, healthcare systems must establish solidarity-grounded partnership models that serve collective interests, secure preferential access to goods and services, and monitor data access (Horn & Kerasidou, 2020). https://doi.org/10.1186/s12910-020-00553-8
**Technology hubs can serve as central repositories for shared object models, facilitating virtual reality mock-ups in healthcare facility design (P. Dunston et al., 2010). https://doi.org/10.1080/19401490903580742

Appendix E

[Lotus Blossom] References

1. B. Hemo, Shamir-Shtein, N. H., Silverman, B. G., Tsamir, J., Heymann, A., S. Tsehori, & Friedman, N. (2018). *Can a nationwide media campaign affect antibiotic use?* American Journal of Managed Care. https://www.semanticscholar.org/paper/Can-a-nationwide-media-campaign-affect-antibiotic-Hemo-Shamir-Shtein/3475905c67265064b011ee2804e42b4d189f975b
2. Bordier, M., Binot, A., Pauchard, Q., Nguyen, D. T., Trung, T. N., Fortané, N., & Goutard, F. L. (2018). Antibiotic resistance in Vietnam: moving towards a One Health surveillance system. *BMC Public Health*, *18*(1). https://doi.org/10.1186/s12889-018-6022-4
3. Bui, L. V., Ha, S. T., Nguyen, H. N., Nguyen, T. T., Nguyen, T. P., Tran, K., Tran, T. V., Nguyen, T. H., Tran, T. H., Pham, N. D., & Bui, H. M. (2021). The Contribution of Digital Health in the Response to Covid-19 in Vietnam. *Frontiers in Public Health*, *9*. https://doi.org/10.3389/fpubh.2021.672732

4. Carvalho, É., Estrela, M., Zapata-Cachafeiro, M., Figueiras, A., Roque, F., & Herdeiro, M. T. (2020). E-Health Tools to Improve Antibiotic Use and Resistances: A Systematic Review. *Antibiotics*, *9*(8), 505. https://doi.org/10.3390/antibiotics9080505
5. Chatterjee, S., & Kulkarni, P. (2021). Healthcare consumer behaviour: the impact of digital transformation of healthcare on consumer. *CARDIOMETRY*, *20*, 135–144. https://doi.org/10.18137/cardiometry.2021.20.134143
6. Chokshi, A., Sifri, Z., Cennimo, D., & Horng, H. (2019). Global contributors to antibiotic resistance. Journal of global infectious diseases, 11(1), 36-42.
7. Cisneros, J. M., Cobo, J., Juan, R. S., Montejo, M., & Fariñas, M. C. (2013). Education on antibiotic use. Education systems and activities that work. Enfermedades Infecciosas Y Microbiología Clínica, 31, 31–37. https://doi.org/10.1016/s0213-005x(13)70130-7
8. Dự, P. (2024, June 27). Đề xuất tái lập điều kiện nhà thuốc phải cách nhau tối thiểu 200 m. vnexpress.net. https://vnexpress.net/de-xuat-tai-lap-dieu-kien-nha-thuoc-phai-cach-nhau-toi-thieu-200-m-4762975.html
9. Dunston, P. S., Arns, L. L., & McGlothlin, J. D. (2010). Virtual reality mock-ups for healthcare facility design and a model for technology hub collaboration. *Journal of Building Performance Simulation*, *3*(3), 185–195. https://doi.org/10.1080/19401490903580742
10. Ellen, M. E., Shach, R., & Balicer, R. D. (2018a). Helping patients help themselves: Supporting the healthcare journey. *Patient Education and Counseling*, *101*(9), 1708–1711. https://doi.org/10.1016/j.pec.2018.04.005
11. Ellen, M. E., Shach, R., & Balicer, R. D. (2018b). Helping patients help themselves: Supporting the healthcare journey. *Patient Education and Counseling*, *101*(9), 1708–1711. https://doi.org/10.1016/j.pec.2018.04.005
12. Fonseca, M. J., Santos, C. L., Costa, P., Lencastre, L., & Tavares, F. (2012). Increasing Awareness about Antibiotic Use and Resistance: A Hands-On Project for High School Students. *PLoS ONE*, *7*(9), e44699. https://doi.org/10.1371/journal.pone.0044699
13. Horn, R., & Kerasidou, A. (2020). Sharing whilst caring: solidarity and public trust in a data-driven healthcare system. *BMC Medical Ethics*, *21*(1). https://doi.org/10.1186/s12910-020-00553-8
14. Kmietowicz, Z. (2015). Antibiotic research needs funding to make it more attractive and viable, says report. *BMJ*, *350*(feb05 30), h700–h700. https://doi.org/10.1136/bmj.h700
15. Kosowicz, L., Tran, K., Khanh, T. T., Dang, T. H., Pham, V. A., Kim, H. T. T., Duong, H. T. B., Nguyen, T. D., Phuong, A. T., Le, T. H., Ta, V. A., Wickramasinghe, N., Schofield, P., Zelcer, J., Le, T. P., & Nguyen, T. A. (2023). Lessons for Vietnam on the Use of Digital

Technologies to Support Patient-Centered Care in Low- and Middle-Income Countries in the Asia-Pacific Region: Scoping Review. *Journal of Medical Internet Research*, *25*(1), e43224. https://doi.org/10.2196/43224

16. Masud, A. A., Walpola, R. L., Sarker, M., & Kabir, A. (2024). Understanding antibiotic purchasing practices in community pharmacies: A potential driver of emerging antimicrobial resistance. Exploratory Research in Clinical and Social Pharmacy. Elsevier. https://www.sciencedirect.com/science/article/pii/S2667276624000829
17. McKinn, S., Trinh, D. H., Drabarek, D., & Trieu, T. T. (2021). Drivers of antibiotic use in Vietnam: Implications for designing community interventions. BMJ Global Health. BMJ. https://gh.bmj.com/content/6/7/e005875.abstract
18. McKinn, S., Trinh, D. H., Drabarek, D., Trieu, T. T., Nguyen, P. T. L., Cao, T. H., Dang, A. D., Nguyen, T. A., Fox, G. J., & Bernays, S. (2021). Drivers of antibiotic use in Vietnam: implications for designing community interventions. *BMJ Global Health*, *6*(7), e005875. https://doi.org/10.1136/bmjgh-2021-005875
19. Minh, P. (2024, July 30). Bộ Y tế đưa ra cảnh báo về thuốc kháng sinh giả xuất hiện trên thị trường. Nhịp Sống Kinh Tế Việt Nam & Thế Giới. https://vneconomy.vn/bo-y-te-dua-ra-canh-bao-ve-thuoc-khang-sinh-gia-xuat-hien-tren-thi-truong.htm
20. Mitchell, M. E. V., Alders, R., Unger, F., Nguyen-Viet, H., Le, T. T. H., & Toribio, J.-A. (2020). The challenges of investigating antimicrobial resistance in Vietnam - what benefits does a One Health approach offer the animal and human health sectors? *BMC Public Health*, *20*(1). https://doi.org/10.1186/s12889-020-8319-3
21. Mitema, E. S. (2010). The role of unregulated sale and dispensing of antimicrobial agents on the development of antimicrobial resistance in developing countries. In Antimicrobial Resistance in Developing Countries (pp. 383-402). Springer. https://link.springer.com/chapter/10.1007/978-0-387-89370-9_23
22. Nguyen, K. V., Thi Do, N. T., Chandna, A., Nguyen, T. V., Pham, C. V., Doan, P. M., Nguyen, A. Q., Thi Nguyen, C. K., Larsson, M., Escalante, S., Olowokure, B., Laxminarayan, R., Gelband, H., Horby, P., Thi Ngo, H. B., Hoang, M. T., Farrar, J., Hien, T. T., & Wertheim, H. F. (2013). Antibiotic use and resistance in emerging economies: a situation analysis for Viet Nam. *BMC Public Health*, *13*(1). https://doi.org/10.1186/1471-2458-13-1158
23. P. Dhaka, Bedi, J. S., Sharan, M., Iqbal, S., & Gill, J. P. S. (2023). Development and Assessment of Awareness Module on “Antimicrobial Resistance and its Prevention” for

School Students in Punjab, India. *Journal of Veterinary and Animal Sciences*, *54*(4). https://doi.org/10.51966/jvas.2023.54.4.1088-1096

24. Porter, G., Kotwani, A., Bhullar, L., & Joshi, J. (2021). Over-the-counter sales of antibiotics for human use in India: The challenges and opportunities for regulation. Medical Law International, 21(2), 147–173. https://doi.org/10.1177/09685332211020786
25. Qidwai, W., Krishanani, M. K., & Hashmi, S. (2006). Private drug sellers education in improving prescribing practices. Journal of the College of Physicians and Surgeons Pakistan. eCommons. https://ecommons.aku.edu/pakistan_fhs_mc_fam_med/126/
26. Seale, A. C., Gordon, N. C., Islam, J., Peacock, S. J., & Scott, J. A. G. (2017). AMR Surveillance in low and middle-income settings - A roadmap for participation in the Global Antimicrobial Surveillance System (GLASS). *Wellcome Open Research*, *2*. https://doi.org/10.12688/wellcomeopenres.12527.1
27. Somying Pumtong, Puckwipa Suwannaprom, Siritree Suttajit, Napaporn Puripunyawanich, & Niyada Kiatying-Angsulee. (2020). Irrational Antibiotic Use and Distribution in the Thai Community: a Complex Situation in Need of Integrative Solution. *Journal of Health Science of Thailand*, S72–S81. https://thaidj.org/index.php/JHS/article/view/8414
28. Tamhankar, A. J., Nachimuthu, R., Singh, R., Harindran, J., Meghwanshi, G. K., Kannan, R., Senthil Kumar, N., Negi, V., Jacob, L., Bhattacharyya, S., Sahoo, K. C., Mahadik, V. K., Diwan, V., Sharma, M., Pathak, A., Khedkar, S. U., Avhad, D., Saxena, S., Nerkar, S., & Venu, V. (2019). Characteristics of a Nationwide Voluntary Antibiotic Resistance Awareness Campaign in India; Future Paths and Pointers for Resource Limited Settings/Low and Middle Income Countries. *International Journal of Environmental Research and Public Health*, *16*(24), 5141. https://doi.org/10.3390/ijerph16245141
29. Towse, A., Hoyle, C. K., Goodall, J., Hirsch, M., Mestre-Ferrandiz, J., & Rex, J. H. (2017). Time for a change in how new antibiotics are reimbursed: Development of an insurance framework for funding new antibiotics based on a policy of risk mitigation. *Health Policy*, *121*(10), 1025–1030. https://doi.org/10.1016/j.healthpol.2017.07.011
30. University of Sydney. (2022). *Tracking inappropriate antibiotic supply*. The University of Sydney. https://www.sydney.edu.au/sydney-southeast-asia-centre/news/2022/05/05/tracking-inappropriate-antibiotic-supply.html
31. Yamey, G., Schäferhoff, M., Montagu, D., Mathewos, B., & Mulligan, J. A. (2021). Funding global health: A comparison of the performance of public and private channels. Journal of Public Health Policy, 42(1), 24-36. https://doi.org/10.1057/s41271-020-00238-5

32. Zhang, T., Lambert, H., Zhao, L., Liu, R., Shen, X., Wang, D., & Cabral, C. (2022). Antibiotic Stewardship in Retail Pharmacies and the Access-Excess Challenge in China: A Policy Review. *Antibiotics*, *11*(2), 141. https://doi.org/10.3390/antibiotics11020141