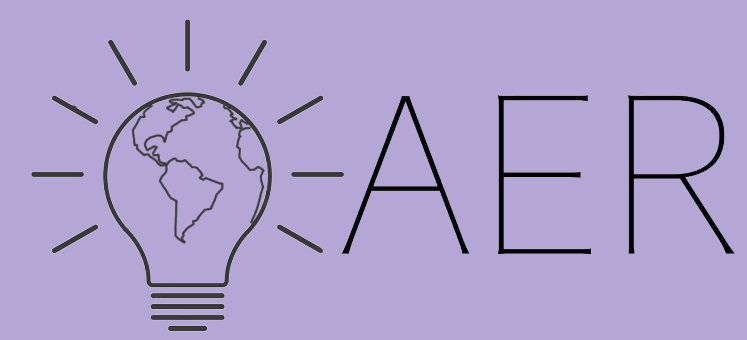




Scaling Dengue Diagnostic Technologies In SEA Island Nations

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INTRODUCTION

Dengue fever, which thrives in tropical and subtropical environments such as those in the Southeast Asian region, faces challenges largely due to the economic and cultural barriers posed within endemic regions. One of the most significant challenges in managing the virus in the region is the lack of widespread, accurate, and accessible diagnostic tools with the capability to be used and distributed from dense urban areas to remote rural populations. In much of maritime Southeast Asia, where access and affordability are just as important as accuracy, it is essential to consider the requirements these technologies must meet to be widely produced and utilized across the region. This research will evaluate which dengue diagnostic technologies, most notably antigen rapid diagnostic tests (RDTs), reverse transcription loop-mediated isothermal amplification (RT-LAMP), and reverse transcription polymerase chain reaction (RT-PCR), show the most promise for wide-scale use throughout the region.

RESEARCH METHODOLOGIES

Diagnostic devices were evaluated on accuracy, efficiency, cost, infrastructure, and training self-sufficiency. Accuracy was measured as the average of sensitivity and specificity. Efficiency combined turnaround time (70%) and workflow complexity (30%) with workflows scored from simple (100) to complex (20). Training-self sufficiency was scored based on expertise, from none (100) to advanced (20). Affordability compared costs relative to the lowest-cost option. Infrastructure independence was rated from largely independent (100) to having advanced lab requirements (20).

Quantitative data scored each case across six standardized metrics: health seeking behavior, trust in medicine, public health infrastructure, urban-rural equality, government effectiveness, and geographic access, using ordinal scales for comparison. Health-seeking behavior uses a three-point scale, while all other metrics used five-point scales, with higher scores indicating better conditions (e.g., greater trust, stronger infrastructure, more equity, more effective governance, and fewer geographic barriers).

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***QR CODE TO FULL PAPER:



DISCUSSION, ANALYSIS, AND EVALUATION

Health Metrics By Country

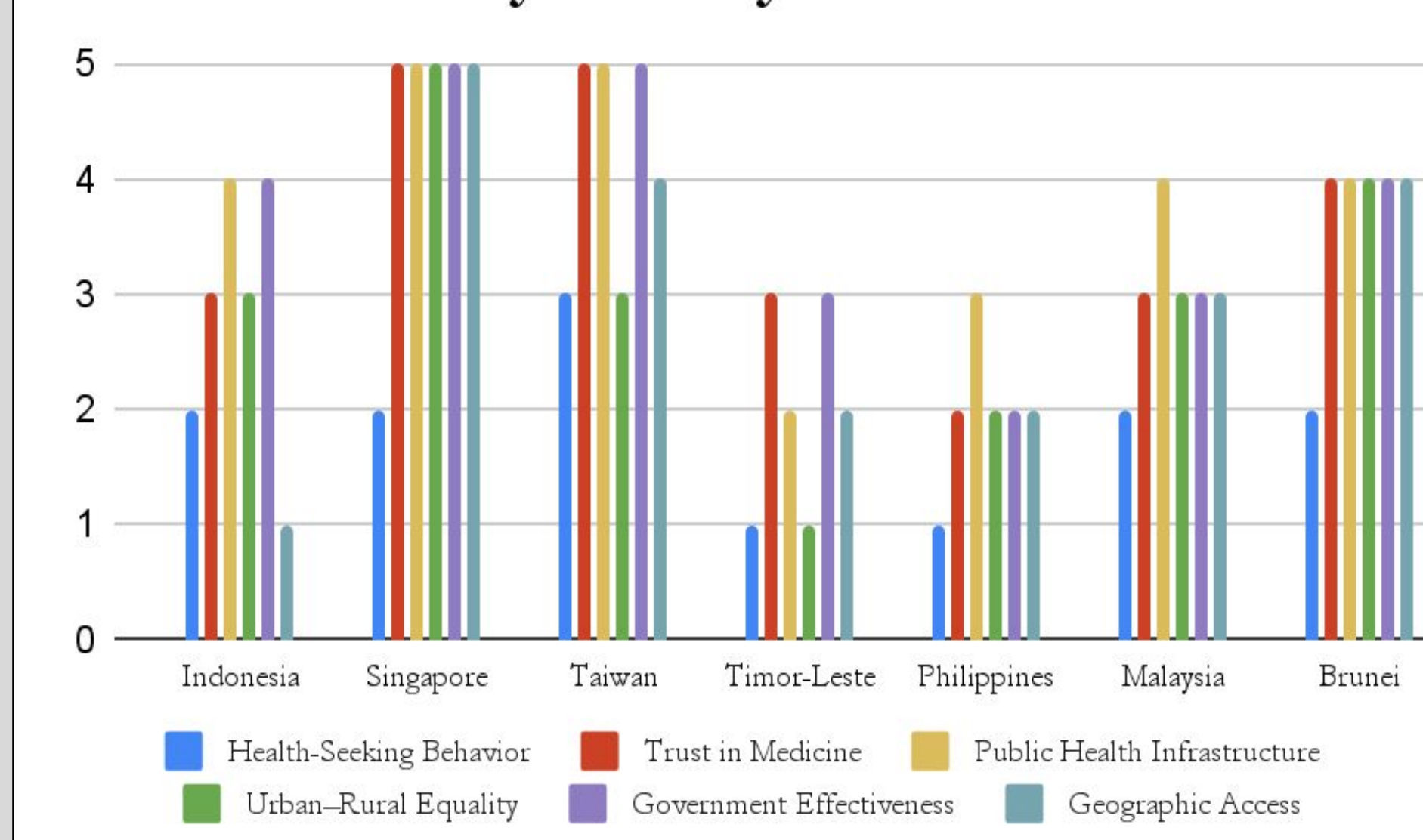


Figure 1: This clustered column chart displays country-specific metrics of qualitative data, capturing a myriad of factors that influence scalability and feasibility.

Rapid Diagnostic Tests (RDTs) have the highest accuracy (99.55), efficiency (100), and infrastructure independence (100), making them suitable in Indonesia and Malaysia, both with mixed practices (score = 2) as environments where rapid, low-barrier diagnostics can bridge the gap between traditional and formal care. In contrast, the Philippines and Timor-Leste, where traditional practices dominate (score = 1), require technologies that minimize training and infrastructure demands.

RT-qPCR, despite being the most affordable (score = 100), has lower efficiency (~17.7) and higher infrastructure requirements, making it unsuitable for geographically fragmented regions such as Indonesia and the Philippines (geographic access score = 1 and 2). RT-LAMP, with a diagnostic accuracy of 99.5 offers a compromise, with moderate efficiency (~55) and improved portability, making it a viable solution in countries with moderately developed infrastructure, such as Malaysia and Brunei.

High-performing systems such as Singapore and Taiwan, both of which are home to government effectiveness (score = 5) and high trust in medicine (score = 5), are capable of supporting a broader range of diagnostic tools, including RT-qPCR and RT-LAMP, due to robust infrastructure and compliance. However, these represent exceptions rather than the norm.

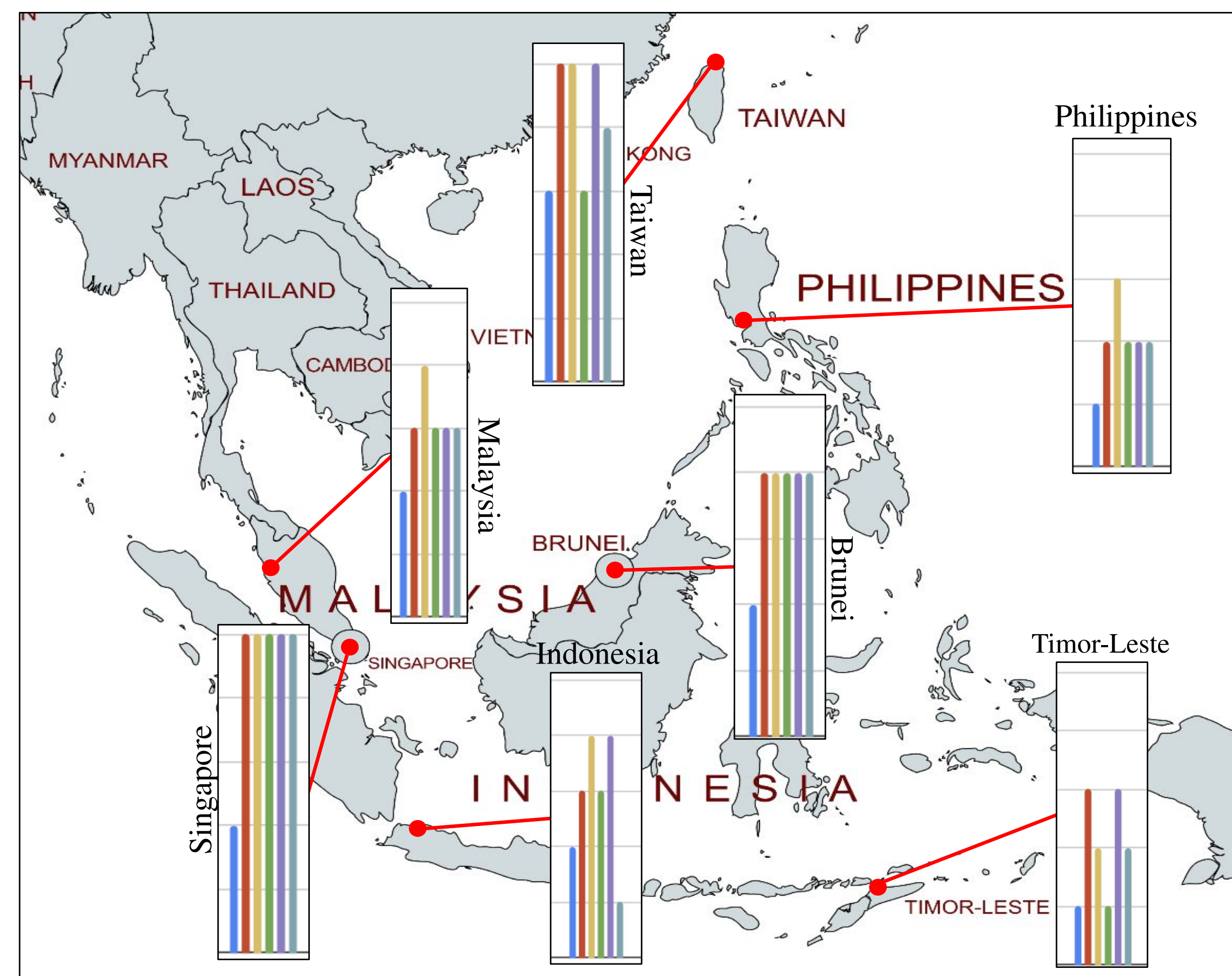
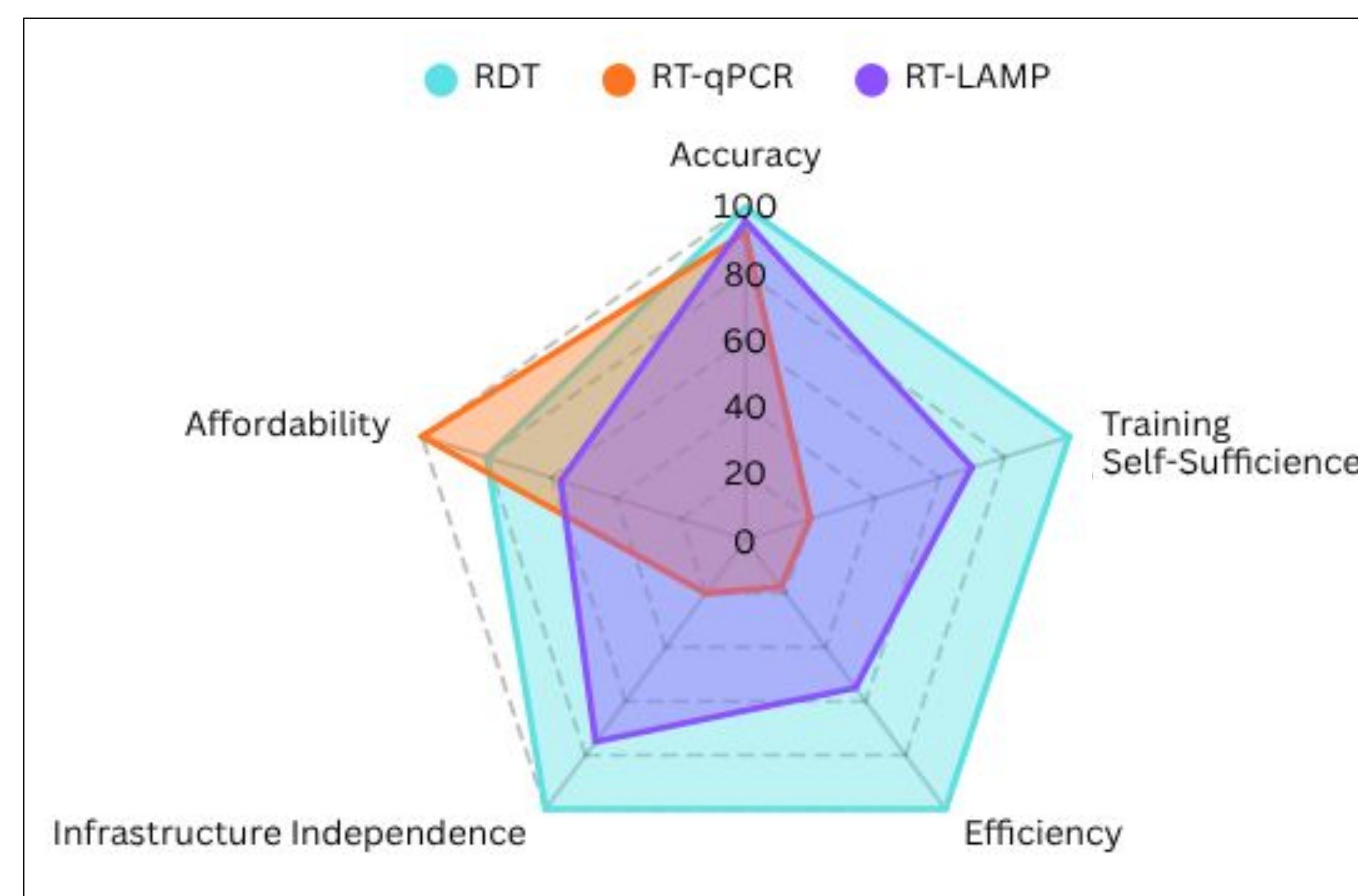


Figure 2: This map shows the health metrics of all nations evaluated in this study. The key is found under figure one—including health seeking behavior, trust in medicine, public health infrastructure, urban-rural equality, government effectiveness, and geographic access.

Figure 3: This radar chart displays the strengths and weaknesses of each diagnostic device evaluated in this study, including the calculated score of affordability, infrastructure, training, accuracy, and efficiency of each device.



CONCLUSIONS, IMPLICATIONS, AND NEXT STEPS

The findings indicate that Rapid Diagnostic Tests (RDTs) are the most scalable dengue diagnostic technology across Southeast Asian island nations due to their efficiency, minimal training requirements, and alignment with the constraints of regional health systems. While RT-qPCR and RT-LAMP offer high accuracy, their dependence on infrastructure, trained personnel, and stable healthcare systems limits their applicability in resource-limited settings. RT-qPCR and RT-LAMP would be best suited in countries with more optimal environments for operation, such as Singapore, Taiwan, and Brunei.

The implications of this research are significant for public health policy and investments, as governments and international health organizations should prioritize the distribution of RDTs in rural and underserved regions, especially in countries with high geographic barriers and low trust in formal healthcare systems, such as the Philippines, Indonesia, Timor-Leste, and Malaysia. Simultaneously, hybrid diagnostic frameworks could be implemented, where RDTs serve as frontline screening tools, with RT-LAMP or RT-qPCR being secondary in centralized or urban facilities.

Future steps should focus on strengthening the integration of scalable diagnostics within national health systems. This includes investing in community health workers and infrastructure, and improving public trust through transparent health communication. Additionally, further research should explore the long-term effectiveness and impact of these more decentralized diagnostic methods.