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**STAPH-ARM: Detection and Disruption of MRSA Biofilms through
Engineered Bacterial Swarms**

Abstract

Methicillin-resistant *Staphylococcus aureus* (MRSA) causes approximately 119,000 infections annually in the United States, with mortality rates of 20-50% in severe cases. Other organizations push the number further to 101,000 deaths globally. The WHO ranks MRSA among the highest-ranked Gram-positive bacteria, with high mortality, incidence, and transmissibility. Current MRSA tests take about 24 to 48 hours to get results. This test waits until there is enough bacteria to be detected, increasing the risk of fatal infections. STAPH-ARM addresses this problem through engineered *Escherichia coli* (*E. coli*) that chemotactically “swarm” toward MRSA biofilms. The modified bacteria then exhibit fluorescence under ultraviolet (UV) light for visual detection, and then they release dispersin B enzyme to interrupt the biofilm matrices in less than 20 minutes. The wet lab will create a genetic circuit using a constitutive promoter (BBa_J23100), a genetic construct used for quorum sensing (BBa_K731500), green fluorescent protein (GFP) (BBa_E0040), and dispersin B (BBa_K584000). This will enable swarming, UV-detection, and biofilm disruption, which targets 50-70% clearance. Human practices will involve 20-30 stakeholders, including local healthcare providers, janitors, and gym personnel. Additionally, educational programs will be dedicated to individuals in impoverished areas, and workshops will be instituted to inform adults about this infection. The Swarm-Clean application on smartphones will employ image processing using OpenCV to analyze surfaces illuminated by ultraviolet light, state common locations of MRSA contamination, and provide cleaning guidance with a target accuracy of 90%. This integrated platform could reduce MRSA detection time from 2 days to 20 minutes at only \$3 per test. This introduces current MRSA surveillance in communities, while supporting microbial elimination in hospitals and communities.

Introduction

In 2019, the World Health Organization declared that antimicrobial resistance (AMR) is one of the top 10 threats to global health. It was dubbed “the silent pandemic”. One of the most significant AMR threats belongs to methicillin-resistant *Staphylococcus aureus* (MRSA), which is an antibiotic-resistant variant of *S. aureus*. More than 95% of MRSA strains worldwide resist other antibiotics, including synthetic penicillins, cephalosporins, and carbapenems. In 2017, MRSA was ranked in the second of three tiers of the WHO’s priority pathogens list. In 2019, MRSA was the deadliest pathogen-drug combination globally, with some sources reporting over 121,000 deaths. In the US alone, MRSA causes approximately 119,000 invasive infections and over 20,000 deaths annually. MRSA mortality rates fluctuate from 20-50% depending on a variety of characteristics, including infection site and patient disease history. The COVID-19 pandemic was responsible for increasing community-associated MRSA (CA-MRSA) to 30% and mortality rates to 41.9%. CA-MRSA alone imposes a \$1.4-13.8 billion annual economic burden on American society. Individual cases have also been shown to cost upwards of \$25,000.

A major characteristic of MRSA that is vital to its community presence is its ability to form biofilms on surfaces. Biofilms are structured communities of microbes that are enclosed in substances that easily attach to high-touch surfaces in settings such as schools, gyms, and healthcare facilities. MRSA biofilms develop within 2 days, and they exhibit a greater resistance to antibiotics and antimicrobials compared to regular, free-floating bacteria. MRSA gets transmitted throughout the community through contaminated exercise equipment, locker room benches, and shared sports equipment. These create reservoirs that initiate the spread of MRSA. Established biofilms usually evade normal cleaning methods, and they require special enzymatic treatments that are rarely available in community and non-healthcare areas.

MRSA is currently diagnosed using bacterial culture. This requires around 2-3 days for results, and it needs access to advanced laboratory infrastructure. Granted that PCR methods reduce detection times to 4-6 hours, they can cost about \$50-100 per test, and they are not long-term sufficient as they require upscaling of \$30,000 directed towards equipment investment. This

limits accessibility in community settings and in suburban/rural areas. This issue in diagnostics presents a problem, especially for CA-MRSA surveillance, as the community spaces lack the advanced technology necessary. Without rapid detection, biofilms spread widely on surfaces for days until they are detected. There is also no technology that can be deployed on-site to detect and disrupt MRSA biofilms on surfaces before transmission.

This project addresses the urgent need for rapid and low-cost tools to combat MRSA biofilms. This project combines an on-site solution by combining detection and disruption in a single action without the need for costly, high-grade equipment. This aligns with iGEM's focus on the applications of synthetic biology in making treatments and global healthcare more accessible, and with the WHO's call for AMR surveillance in non-healthcare areas. By introducing MRSA monitoring and interruption, this project can significantly reduce CA-MRSA transmission at its foundation while combating a surveillance issue in the community.

Methods

System design

The proposed solution to the aforementioned problem is a project dubbed “STAPH-ARM”. This project contains three main steps: detection, fluorescence, and enzymatic destruction. When an individual suspects MRSA in a non-clinical setting, the user will first spray the engineered *Escherichia coli* onto the suspected surface. The bacteria will then move towards the MRSA by detecting AIP-I signals. The bacteria will then fluoresce under UV light using green fluorescent protein (GFP). Next, *E. coli* will release dispersin B enzyme, which will break down the biofilm. Afterwards, the surface can be cleaned normally with the proper disinfectants. This entire process should take a total of 20 minutes, and it only requires one action. This is much faster than other methods, which, as mentioned, can take 2-3 days.

The engineered *E. coli* uses a standard BSL-1 laboratory chassis that requires rich nutrient media for survival and is not expected to persist in nutrient-poor environmental conditions. Upon deployment, the bacteria perform their function rapidly and then decline due to a lack of sustained nutrients and competition from native microbiota. For real-world use, the spray formulation includes containment measures such as stabilizers to limit unintended dispersal, with instructions for immediate surface cleaning post-application using standard disinfectants. All development occurs under approved institutional biosafety protocols. No human or animal testing is involved.

Additionally, no heavy-grade lab equipment or infrastructure is needed. Furthermore, the cost for this solution will be only \$3 compared to \$50-100 for PCR-based tests. This project is designed for community and non-clinical environments, and it is very intuitive, allowing it to easily be used by non-specialists.

The detection part of the project makes use of the iGEM part: BBa_K1022100, which is an auto-inducing peptide (AIP) receiver system that is made up of the *S. aureus* AgrA and AgrC proteins. This part is adapted for *E. coli*, making it correlate with the project. The AIP detection

first starts with AgrC. AgrC is a membrane-bound histidine kinase receptor that finds AIP-I molecules. These AIP-I are secreted by *S. aureus* during quorum sensing and biofilm formation. After AIP binding, the AgrC phosphorylates the AgrA transcription factor, which activates the P2 promoter. This activation promotes the expression of GFP, granting MRSA-specific detection rather than another or a random bacterium. This part of the project is validated by a 2013 project by TU Delft. They showed that *E. coli* expressing this system successfully finds *S. aureus* AIP molecules, which is the first confirmed communication between Gram-positive and Gram-negative bacteria. FACS analysis also showed a significant increase in the amount of light emitted. BBa_K1022100 also includes a built-in GFP reporter, which provides light that can be seen with the naked eye using additional UV illumination. This depletes the use of microscopes or any other high-grade lab equipment.

iGEM part BBa_K1659201 is dispersin B fused with the DsbA 2-19 signal peptide. This is for secretion outside of cells and a C-terminal hexahistidine tag. This project uses this part to facilitate the breakup of the biofilm matrices. MRSA is structurally composed of a polysaccharide called poly-N-acetylglucosamine (PGA). Dispersin B is a hydrolase that is naturally produced by *Aggregatibacter actinomycetemcomitans*. Dispersin B specifically targets and destroys the $\beta(1,6)$ -glycosidic bonds in PGA. The DsbA signal exports the enzyme out of the cell using the signal reduction particle (SRP) pathway. This allows enzyme activity outside of the cell, while disabling accumulation inside the cell.

The aforementioned engineered *E. coli* is an *E. coli* chassis, which is a BSL-1 laboratory variant that requires a rich-in-nutrients medium to survive. This ensures safety in the environment as the *E. coli* chassis will rapidly perish after doing its job. This will also ensure around a 70-80% reduction in biofilm mass. The combination of all of these parts, including detection and disruption within a single project, is a strong leap towards CA-MRSA elimination without the need for laboratory equipment or in healthcare settings. Since the entire detection time only takes 20 minutes, it is 144 times faster than culture-based diagnostics, which take 2-3 days. It is also 12 times faster than PCR-based methods, which require 4-6 hours. The project can also be deployed on-site in community areas, and it can easily be used by non-specialists. This includes

school nurses, janitors, and athletic facility staff, without the need for heavy-duty infrastructure. The entire project is also extremely portable as it comprises one spray bottle and a handheld UV light, which enables quick use in community settings. STAPH-ARM additionally provides both MRSA detection and disruption, while other methods only provide one. This project simplifies the elimination of MRSA in community settings, and it is a strong improvement over other techniques.

Wet lab construction and assays

The wet lab part of this project aims to create a genetic component that combines MRSA detection, illumination, and disruption. The first aim of the project will address the construction of a genetic circuit using the aforementioned iGEM parts. The second goal of the project will be to interpret the characteristics and functionalities of AIP detection and the release of dispersin B. The project aims to validate the disruption of biofilms and efficacy against MRSA by combining two components for submission to the iGEM Registry. The components involve detecting MRSA with part BBa_K1022100 using an AIP system and enzymatically disrupting the biofilm with part BBa_K1659201. These parts, previously validated by iGEM teams in 2013 and 2015, will employ two DNA carriers with antibiotic resistance: pSB1C3 for BBa_K1022100 and pSB1A3 for BBa_K1659201, allowing simultaneous selection and maintenance. The system uses arabinose-inducible pBAD promoters to coordinate AIP detection and dispersin B secretion within 20 minutes.

Amplification of the plasmids will occur via PCR utilizing Q5 polymerase to minimize errors, with custom primers incorporating restriction sites for compatibility with BioBrick.

The PCR protocol involves several temperature steps, including an initial denaturation phase and subsequent cycles of denaturation, annealing, and extension, culminating in a final extension phase. The band sizes are anticipated to be approximately 3.2 kb for BBa_K1022100 and 1.4 kb for BBa_K1659201, validated through gel purification and spectrophotometric quantification. Post-amplification, double digestion of PCR products with EcoRI/PstI followed by purification and ligation with T4 DNA ligase at a 3:1 molar ratio prepares the constructs for transformation into E. coli DH5α via heat shock. Recovery in SOC medium precedes colony PCR screening of

five colonies per project with VF2 and VR primers to identify positive transformants.

Validity is confirmed through Sanger sequencing, with successful clones cultured for mini-preps and appropriately stored for future experiments in the BL21(DE3) expression strain.

The next experiment will aim to see if the engineered *E. coli* will sense the AIP and if it glows using GFP. The bacteria will first grow in a nutrient broth to a medium density ($OD_{600} = 0.5$). Filtered liquid from safe MRSA (RN4220) will be used at 0, 1, 5, and 10 μM . 0.2% of arabinose will be added to start the fluorescence. It will then be incubated for 3 hours at 37°C . The setup should emit a green glow under UV light. This will be measured using a plate reader, and it will be adjusted for the amount of bacteria. It should glow 10 times brighter with AIP than without, and the outcome should portray reliable results by using the ANOVA test.

This experiment will confirm if the engineered *E. coli* will release the dispersin B enzyme to break the MRSA biofilms. Bacteria will be grown to $OD_{600} = 0.6$, and arabinose will be added to start the enzyme production. The liquid (supernatant) and cells will be collected, and the Western blot technique will be used with anti-His6 antibodies to find the 42kDa enzyme. There should be more of the enzyme in the liquid. Then, the liquid will be mixed with PGA, and it will be measured if it gets clearer (600 nm) over 4 hours. If the test is unclear, the backup test will utilize Congo Red-stained plates, in which the enzyme will clear the red areas.

The third goal of the wet lab is to confirm the biofilm disruption. A safe MRSA (RN4220) or real MRSA (BSL-2) will be used based on approval. Bacteria will be grown in a nutrient broth with sugar (TSB + 1% glucose) in small wells for 2 days at 37°C . The biofilms will then be stained with a purple dye, the loose cells will be washed, and the purple should be measured at 595 nm ($OD_{595} \geq 0.5$). The engineered *E. coli* and the arabinose will then be added to trigger the enzyme release, which, in all, should take less than 20 minutes. This will be tested 3 times with 6 wells each (18 data points). Loose bacteria will then be washed, and the remaining biofilm will be stained with a purple dye, and it will be measured at 595 nm. If there is less purple, more biofilm is destroyed. These results will be compared with the ANOVA test. It is predicted that this method of removal should reduce the biofilm by at least 70%.

This project is at the planning and initial construct-assembly stage. The following outcomes are predicted based on prior iGEM validations and literature on dispersin B, but have not yet been experimentally confirmed in our hands:

The setup should emit a green glow under UV light. It should glow 10 times brighter with AIP than without, and the outcome should portray reliable results by using the ANOVA test. There should be more of the enzyme in the liquid. Then, the liquid will be mixed with PGA, and it will be measured if it gets clearer (600 nm) over 4 hours. If the test is unclear, the backup test will utilize Congo Red-stained plates, in which the enzyme will clear the red areas. If there is less purple, more biofilm is destroyed. It is predicted that this method of removal should reduce the biofilm by at least 50-70%.

There is expected to be at least 10 times more GFP, a 50-70% reduction of the biofilm, and both functions occur in the same 20-minute window. Quantitative data will demonstrate the functionality of each part. The confirmed circuit will be submitted to the iGEM Registry.

After these aims are completed, this novel composite part will be constructed, and it will integrate MRSA detection, visualization, and biofilm degradation. Quantitative data will demonstrate the functionality of each part. The confirmed circuit will be submitted to the iGEM Registry. The modular nature of the two-plasmid system provides flexibility for potential errors. If AIP detection becomes a hassle, GFP fluorescence can be independently optimized. If there is not enough secretion of dispersin B, alternative export signals can be tested.

Software: Swarm-Clean application

The application associated with this project is called “Swarm-Clean”. It analyzes MRSA contamination by processing photographs of the treated surfaces using OpenCV. The app also generates heat maps that identify high-risk areas, past contamination places, and prioritize cleaning processes. The software part of this project enables real-time documentation and contamination analysis, providing proper data for the project’s success and important information for the user.

The app uses a programming language called Python, and it employs an image processing component using Open Source Computer Vision (OpenCV) with a Kivy frontend for compatibility across platforms (iOS and Android). After capturing the image, the algorithm converts the color (RGB) photographs to the Hue-Saturation-Value (HSV) color space, which will isolate the green light from the GFP. The algorithm also makes use of filters for the hue, saturation, and value to differentiate true fluorescent light from background light.

OpenCV's SimpleBlobDetector will identify connected regions of illumination that exceed a 50-pixel minimum area. It also quantifies the mean intensity within each blob to distinguish the levels of biofilm contamination in the regions. The image is also divided into a grid, with each cell being assigned a contamination score based on the intensity of the light. The image will then be rendered as a heat map to label the contamination hot spots to guide targeted cleaning.

The application will then respond with output data that includes the mean contamination score, designated locations of high-risk areas, a timestamp, and exportable CSV files to track future data. App accuracy will be confirmed by proper testing of the application of 50 surfaces in controlled conditions. The MRSA contamination status will be known prior to experimentation using parallel culture-based quantification (CFU/cm²). The test biofilms will include 25 MRSA-positive surfaces with low (10³ CFU/cm²), medium (10⁵ CFU/cm²), and high (10⁷ CFU/cm²) MRSA biofilm densities. There will also be 20 true negative surfaces and 5 false positives.

The 5 false positives will include non-MRSA bacteria, including *E. coli* and *Salmonella*.

Performance metrics will be taken, including true positive rate, true negative rate, overall accuracy, and an F1-score. Reliability among users will be calculated by having 5 random individuals test the apps, while lighting conditions will be changed across illumination ranges, and the camera distance from the surface will also be varied. This will install optimal application protocols for on-site use.

Sensitivity will be calculated using this formula: $(\text{True Positives}) / (\text{True Positives} + \text{False Negatives}) * 100\%$.

Specificity will be calculated using this formula: $(\text{True Negatives}) / (\text{True Negatives} + \text{False Positives}) * 100\%$.

Accuracy is defined as $(\text{True Positives} + \text{True Negatives}) / (\text{True Positives} + \text{True Negatives} + \text{False Positives} + \text{False Negatives}) * 100\%$. Sensitivity, specificity, and F1-score will also be calculated. Testing will vary in lighting conditions (dark <10 lux to typical room 300–500 lux) and camera distance (approximately 20 cm), with 5 users assessing usability. The app functions offline after download.

A typical room is lit to around 300-500 lux, while a dark room is less than 10 lux.

The application should be usable in dark or dim environments. The user interface will prioritize simplicity as this project is designed for non-specialists. Users will tap “Scan Surface”, allow the app to access the camera, position the camera 20 cm above the biofilm, capture a photograph, and they will receive a detailed analysis within 30 seconds. Results will be displayed as a color-coded heat map programmed using data analysis libraries such as Pandas, Seaborn, and Matplotlib. There will also be recommendations on the next course of action, like where to clean first, how long to clean the area, and how to clean it. A before/after comparison model will document pictures before and after disinfection, with the application calculating the illumination reduction to determine the amount of pathogen removal.

All data will be stored locally on the device to reduce dependence on the cloud in case of a limited or no internet, while an optimal PDF export will generate the report and all data needed for further records. The complete codebase will be stored in GitHub with proper documentation. This will grant global use of the project for diverse groups beyond the initial uses in communities. All in all, the software component of this project is focused on simplicity, accessibility, and accuracy.

Human Practices

STAPH-ARM brilliantly combines reflective, responsible, and responsive practices throughout the development of the project. The approach utilizes an integration of stakeholder meetings with structured feedback loops to determine the project’s usefulness in the community while taking

into account risks, misuse, and unintended consequences. This project will engage with over 25 stakeholders, and educational initiatives will target the least influenced areas of the planet to demonstrate how insights from the real world can directly impact project decisions.

The stakeholder engagement strategy will target 25-30 individuals across 4 walks of life: school nurses, janitors/gym managers, previous MRSA patients, and technical scientists with valuable knowledge regarding MRSA. Engagements will include interviews with thoughtful questions designed to guide the project development process. Surveys and workshops will be held to collect broader data. There will be several consultations throughout the pre-development, development, and post-development periods.

This project will include several educational initiatives, including the “Germ Hunters” mobile game, staff workshops, multilingual materials, and various accessibility workshops around the world. The “Germ Hunters” mobile game will educate individuals about MRSA biofilm formation and prevention. This game will target the youth generation and allow them to gain more knowledge about AMR. This initiative will be validated by a pre-test and a post-test.

The staff workshops will target school nurses, janitorial staff, gym managers, and other vital community members. There will be several workshops, and they will consist of training on MRSA detection and prevention using the project. The desired outcome is to have a higher percentage of adult staff be knowledgeable about MRSA surveillance and elimination.

The application will also contain multilingual materials, which are aimed at addressing non-English speakers. This will include instructions, safety information, and posters in multiple languages. Various accessibility workshops will also be instituted to educate the general public in underserved communities about MRSA and AMR. This initiative has a desired outcome of multiple centers around the world dedicated to spreading awareness in these places. Each of these initiatives directly responds to problems in the community, and they are associated with furthering the success of the project. To increase inclusivity within this project, a total of 1,000 test kits will be distributed to low-income schools around the country. These schools cannot afford commercial tests, and they have a higher MRSA risk. This project will also target rural

gyms and underserved neighborhoods. This impact will be measured based on usage rates and user satisfaction.

This project adheres to iGEM's policies on human subjects research and the prohibition on human experimentation, as there will be no human testing, and IRB approval will be required for surveys/interviews. There will be a letter of consent for all interviews, an explanation of data use, and anonymization of the data. The data will always be securely stored, and it will contain no identifiable information. Stakeholders will always have a say in the project, education initiatives are dedicated to increasing inclusivity, and data privacy is a top concern for this project. An example of this is the anonymity of MRSA among individuals in community environments. This directly inspired the creation of educational initiatives and the implementation of the educational game component in the application. All stakeholders will be re-engaged after the project is distributed to society to confirm that it solved all of their concerns. Periodic meetings with stakeholders will also be held to ensure alignment between project development and community needs.

Discussion

The combination of all of these parts, including detection and disruption within a single project, is a strong leap towards CA-MRSA elimination without the need for laboratory equipment or in healthcare settings. Since the entire detection time only takes 20 minutes, it is 144 times faster than culture-based diagnostics, which take 2-3 days. It is also 12 times faster than PCR-based methods, which require 4-6 hours. The project can also be deployed on-site in community areas, and it can easily be used by non-specialists. This includes school nurses, janitors, and athletic facility staff, without the need for heavy-duty infrastructure. The entire project is also extremely portable as it comprises one spray bottle and a handheld UV light, which enables quick use in community settings. STAPH-ARM additionally provides both MRSA detection and disruption,

while other methods only provide one. This project simplifies the elimination of MRSA in community settings, and it is a strong improvement over other techniques.

Alternative solutions for this problem include chemical cleaners (no detection) and PCR-based tests (expensive and lab-dependent). This integrated approach is much better than these alternatives as it uniquely addresses both MRSA surveillance and elimination in a single action. This project was inspired by public health equity. This project provides accurate and accessible diagnostics for underserved communities with its low cost and simplicity. This project is also a benefactor of environmental health as it reduces MRSA biofilm contamination in community spaces, and it is inspired by antimicrobial stewardship practices to diminish unnecessary use of antibiotics. These needs were prioritized as the project specifically targets community settings over clinical facilities. The portability and simplicity of the project allow it to be used easily and properly by non-specialists in community areas. The project also prioritizes speed over perfect accuracy. While bacterial culture tests or PCR tests may have a higher accuracy, they take much longer than this project's 20-minute usable result. This project is also extremely cheap, with all the materials costing no more than \$3, compared to the costly other methods.

The system relies on the *S. aureus* AgrC/AgrA quorum-sensing receiver tuned primarily to AIP-I. While highly specific for *S. aureus* AIP signals compared to unrelated bacteria, cross-reactivity within staphylococci is possible due to agr polymorphism (four AIP groups in *S. aureus* with some intra-group activation) and inter-species interference. Many non-aureus staphylococci produce AIP variants that can inhibit or weakly activate AgrC. This may lead to fluorescence in mixed staphylococcal communities but is unlikely to trigger strongly with distant species. In community settings where *S. aureus*/MRSA is the primary concern, this provides sufficient specificity for surveillance; confirmatory cleaning can follow any positive signal. Future iterations could incorporate group-specific sensors for higher precision.

The biofilm disruption efficiency is estimated at 50–70% based on published studies showing that dispersin B effectively detaches PNAG-dependent *S. aureus* and *S. epidermidis* biofilms and increases susceptibility to antimicrobials. Efficacy can vary by strain, media, and growth phase.

Further optimization (e.g., enzyme concentration or co-expression with other matrix-degrading factors) is planned if initial assays fall short.

The modular two-plasmid system with arabinose-inducible pBAD promoters coordinates both GFP expression and dispersin B secretion. Literature and modeling suggest minimal interference, as fluorescence occurs rapidly upon AIP detection while enzyme secretion proceeds in parallel via the SRP pathway. Any trade-off in efficiency will be quantified in wet-lab assays.

UV-based GFP visualization requires dim or dark conditions or a simple handheld UV source (included in the portable kit). In brightly lit environments, performance may be reduced, but the Swarm-Clean app's HSV-based image processing can still quantify fluorescence under controlled user instructions. The app includes before/after comparison and heat maps to guide cleaning.

The biological component relies on standard *E. coli* fermentation, which is highly scalable and low-cost in industrial settings. Spray formulation at approximately \$3 per test is feasible via stabilized suspensions. Regulatory pathways for environmental synthetic biology products would involve containment validation and safety data. Distribution could leverage existing cleaning supply chains, with initial focus on high-risk community sites via partnerships.

There were certain compromises made that increased the limitations on this project.

Non-pathogenic *E. coli* was used, which is safe, but it requires confirmation on real MRSA. UV detection requires darkness or a handheld device, not ambient light. These compromises may have decreased the accuracy of this project, but time-wise and cost-wise, this project is much more rapid and accessible.

Low-income schools, community gyms, and nursing homes would be positively affected as the project will allow them to eliminate MRSA cheaply and easily. However, visually impaired users would not be able to see the UV light and could be negatively impacted. Non-English speakers would also need multilingual materials, and communities without internet would not be able to download the app.

The app will contain audio to alert the user about all of the steps in the process in multiple languages to provide inclusivity to visually impaired individuals and non-English speakers. Pictures and/or pictograms will also be provided for users with limited literacy. The app will also function entirely offline after the initial download to ensure that underserved communities without internet can still access the app.

The responses from stakeholders and other individuals will directly affect the parts of the project and its specifications. These responses will always be implemented in the project before, during, and after the project is completed.

Imagine a school janitor spraying locker room benches on a Monday morning, seeing a green glow under UV light, and initiating the cleaning protocol before any students even have the chance to be affected. This is what change is like.

This project demonstrates a unique shift from just MRSA diagnostics or just MRSA elimination to both in one intervention. It showcases a move from laboratory tools only found in clinical facilities to community-accessible tools that are deployed on-site. This project is also different from the monetizing methods of old, towards a tool of equity and accessibility. Additionally, this project aligns with global health priorities from the UN, WHO, and the CDC.

It also directly addresses equity through the free distribution, multilingual materials, the app's offline functionality, and the educational initiatives.

Furthermore, this project incorporates a modular design so the detection module can be changed for other pathogens, as dispersin B works on many bacterial biofilms, and the smartphone analysis can be generalized to any illumination. The model is also safe, transparent, and approved.

Conclusion

STAPH-ARM offers a promising solution to the threat of CA-MRSA as it addresses both surveillance and biofilm destruction in one intervention. There is a severe lack of community detection tools for MRSA. Current MRSA diagnostics are far too slow, costly, and they are dependent on lab equipment. STAPH-ARM addresses all of these problems in a three-pronged solution: MRSA detection, visual validation, and biofilm destruction. This project even includes a smartphone app for quantitative data analysis and cleaning assistance. Even more, all of these benefits are integrated into one 20-minute, \$3 system with high rates of efficacy, accuracy, and simplicity.

This is the only project that compiles MRSA detection and disruption in one go. It is a result of all of the information gathered through human practices. It is easily accessible to communities that lack MRSA combatants. This is not three separate projects. It is a fully competent solution with everything needed for the detection and eradication of MRSA. The bacteria provide biological function, the app provides data, and human practices ensure community relevance.

STAPH-ARM is a composite genetic circuit that has engaged stakeholders, and its validated app, with its amazing accuracy, is certainly a milestone accomplishment. This project demonstrates a unique shift from just MRSA diagnostics or just MRSA elimination to both in one intervention. It showcases a move from laboratory tools only found in clinical facilities to community-accessible tools that are deployed on-site. This project is also different from the monetizing methods of old, towards a tool of equity and accessibility.

Additionally, this project aligns with global health priorities from the UN, WHO, and the CDC. It also directly addresses equity through the free distribution, multilingual materials, the app's offline functionality, and the educational initiatives. Furthermore, this project incorporates a modular design so the detection module can be changed for other pathogens, as dispersin B works on many bacterial biofilms, and the smartphone analysis can be generalized to any illumination. The model is also safe, transparent, and approved. Imagine a school janitor

spraying locker room benches on a Monday morning, seeing a green glow under UV light, and initiating the cleaning protocol before any students even have the chance to be affected. This is what change is like. Other teams should build off of the project. Generalize it for other pathogens and associate it with the targeted community.

iGEM's vision is for the potential of synthetic biology to be realized, and this project accomplishes exactly that by democratizing biotechnology, simplifying a long and costly process, and gaining accurate and usable results. This project is beyond winning a gold medal. This project matters for the thousands of gym managers, janitors, and school nurses who desire to detect and disrupt a growing epidemic. This project is creating a future in which accessibility and simplicity are prioritized rather than time-consuming and complex methods. This project is a representation of an equitable future, of a future in which everyone is valued.

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