

ARBOGuard

BUSINESS PLAN

uOttawa IGEM 2025-2026 Entrepreneurship Division

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1. Executive Summary

1.1 Our Mission

The University of Ottawa iGEM team is a student-led synthetic biology research group dedicated to advancing innovative, sustainable solutions to urgent global challenges. Each fall, we recruit new members from across several disciplines and faculties, offering students the opportunity to gain hands-on experience in synthetic biology through work study positions, volunteer roles, and diverse team divisions. Our members contribute not only to the wet lab and dry lab, but also to entrepreneurship, outreach, branding, and clinical applications, ensuring a holistic and collaborative approach to research and development.

Beyond our year-long project work, we also host the Great Canadian iGEM Meet-Up (GCM) each August, a national conference that fosters collaboration, knowledge-sharing, and community building among iGEM teams across Canada. This event reflects our commitment to empowering the next generation of scientists and innovators while strengthening Canada's synthetic biology network.

At the core of our mission is the drive to harness biotechnology to create impactful products that bridge the gap between science and society. Through our current project, ARBOGuard, we aim to reduce the global burden of mosquito-borne diseases by developing a sustainable, microbiome-based repellent that empowers individuals and communities with long-lasting protection.

1.2 Sustainability

Sustainability is at the core of our mission. We are committed to advancing scientific innovation in a way that upholds long-term environmental and social responsibility. ARBOGuard, our microbiome-based mosquito repellent, contributes directly to several United Nations Sustainable Development Goals (SDGs).

By addressing mosquito-borne diseases such as malaria, dengue, and Zika, ARBOGuard supports SDG 3: Good Health and Well-Being by reducing preventable illness and improving community health outcomes.¹

¹ World Health Organization. (2023). *Vector-borne diseases*. <https://www.who.int/news-room/fact-sheets/detail/vector-borne-diseases>



As a biotechnology platform that introduces a new approach to mosquito control, ARBOGuard advances SDG 9: Industry, Innovation, and Infrastructure by fostering sustainable solutions that bridge scientific research, entrepreneurship, and public health.²

Our emphasis on affordability and accessibility ensures that vulnerable and under-resourced populations remain a priority, contributing to SDG 10: Reduced Inequalities and promoting equitable access to protection against vector-borne diseases.³

By responding to the climate-driven expansion of mosquito habitats and related health risks, ARBOGuard contributes to SDG 13: Climate Action and builds resilience against shifting global challenges.⁴

Finally, by reducing dependence on chemical repellents that harm ecosystems, ARBOGuard helps preserve biodiversity in support of SDG 15: Life on Land.⁵

These commitments demonstrate that ARBOGuard is more than a public health tool. It represents a sustainable and equitable model of innovation that delivers value to people, communities, and the environment.

1.3 Overview of Report

This report provides a comprehensive overview of the uOttawa iGEM team's work, highlighting both our scientific innovation and our entrepreneurial strategy. It begins with an introduction to our mission and commitment to sustainability in science, followed by a detailed explanation of ARBOGuard as a marketable product. We then explore the market opportunity and target audience, examining the global health challenges associated with mosquito-borne diseases and identifying the populations who would most benefit from our solution. The commercialization strategy outlines how ARBOGuard will be positioned as a safe, effective, and sustainable alternative to current repellents, supported by preliminary results and a clear value proposition. The report also presents our business model and financial forecasts, demonstrating how ARBOGuard can achieve both scalability and long-term impact. Finally, we discuss regulatory considerations and key milestones that will

² United Nations. (2015). *Transforming our world: the 2030 Agenda for Sustainable Development*. <https://sdgs.un.org/2030agenda>

³ United Nations Development Programme (UNDP). (2023). *Inequality and health*. <https://www.undp.org>

⁴ Intergovernmental Panel on Climate Change (IPCC). (2022). *Climate Change 2022: Impacts, Adaptation, and Vulnerability*. <https://www.ipcc.ch>

⁵ United Nations Environment Programme (UNEP). (2022). *Chemicals and waste: Environmental impact of pesticides*. <https://www.unep.org>



guide our path toward successful implementation. Together, these sections provide a clear picture of how ARBOGuard can transition from an innovative iGEM project to a transformative product in the fight against mosquito-borne diseases.

1.4 ARBOGuard Introduction

ARBOGuard is a microbiome-based mosquito repellent that uses engineered *Staphylococcus epidermidis*, a natural skin bacterium, to provide long-lasting protection against mosquito bites. Delivered with a topical cream, ARBOGuard represents a new category of control: biologically integrated and sustainable.

Mosquito-borne diseases such as malaria, dengue, and Zika virus continue to pose a major global health threat, particularly in vulnerable and under-resourced regions. These diseases are responsible for over 700,000 deaths annually and are expanding in reach due to climate change, urbanization, and increased global travel. While some vaccines exist, they are limited by availability and population eligibility. For most people, repellents remain the first and only line of defence.

These more conventional repellents, such as DEET and picaridin, offer temporary protection, but suffer from limitations: they require frequent reapplication, are often washed off with sweat or water exposure, and may cause irritation or environmental concerns. Natural alternatives, like citronella or eucalyptus oils, are generally safer but wear off quickly and offer inconsistent protection. ARBOGuard addresses this gap by reprogramming the skin microbiome to disrupt the mosquito's host-seeking behaviour. Using engineered phages delivered through a topical application, we knock out the *ldh* gene in *S. epidermidis*, halting lactic acid production - a major attractant for mosquitoes. Simultaneously, we introduce a biosynthetic pathway for geraniol, a well-studied plant-derived terpene that actively repels mosquitoes.

In preliminary research, *ldh* knockout strains alone reduced mosquito landing rates by 80% for up to 12 days.⁶ The addition of geraniol further enhances efficiency and longevity. The cream is safe, easy to use, and requires reapplication only after exfoliation or approximately 12 days. This dramatically reduces user burden and improves accessibility for populations without consistent access to healthcare or supplies. It also opens up opportunities for longer-term protection in disaster zones, refugee camps, and other high-risk settings.

⁶ Liu, F., Coutinho-Abreu, I. V., Raban, R., Nguyen, T. T. D., Dimas, A. R., Merriman, J. A., & Akbari, O. S. (2024). Engineered skin microbiome reduces mosquito attraction to mice. *PNAS nexus*, 3(7), pgae267. <https://doi.org/10.1093/pnasnexus/pgae267>



2. Problem Statement

Vector-borne diseases, particularly those transmitted by mosquitoes, represent a significant and growing global health threat. According to the World Health Organization (WHO), these diseases account for more than 17% of all infectious diseases and are responsible for over 700,000 deaths annually.⁷ Illnesses such as malaria, dengue fever, Zika virus, and chikungunya not only cause fever, pain, and rashes, but in severe cases can lead to internal bleeding, long-term disability, chronic pain, and even death.⁸

The incidence of mosquito-borne illnesses is rising due to multiple interconnected factors, including climate change, increased global travel and trade, and urbanization. Warmer temperatures have expanded mosquito habitats and shortened their life cycles, enabling populations to thrive in regions previously considered low risk, including parts of North America. As a result, public health agencies are now reporting increasing cases even in temperate countries like Canada.

While vaccines exist for some diseases, such as dengue and malaria, they are not universally accessible, and many are limited by age restrictions or narrow pathogen coverage. For example, certain malaria vaccines only target *Plasmodium falciparum*, which may not be the most prevalent strain in a given region.⁹ As such, vector control and personal protection remain the most effective and widely applicable strategies for prevention.

Among these, insect repellents are the most common and accessible tool to prevent mosquito bites. Products containing DEET or picaridin disrupt the mosquito's ability to detect human skin cues, offering temporary protection. However, their effectiveness is concentration-dependent: a product with 15% DEET may protect for around 6 hours, while higher concentrations may last up to 8 hours.¹⁰ These products must be reapplied

⁷ World Health Organization. (2024, September 26). Vector-borne diseases. <https://www.who.int/news-room/fact-sheets/detail/vector-borne-diseases>

⁸ World Mosquito Program. (n.d.). Mosquito-borne diseases. <https://www.worldmosquitoprogram.org/en/learn/mosquito-borne-diseases>

⁹ Gladow, D. (2024, November 11). Mosquito-borne diseases on the rise. Tulane University Celia Scott Weatherhead School of Public Health and Tropical Medicine. <https://sph.tulane.edu/mosquito-borne-diseases-rise>

¹⁰ Peng, Z. Y., He, M. Z., Zhou, L. Y., Wu, X. Y., Wang, L. M., Li, N., & Deng, S. Q. (2022). Mosquito Repellents: Efficacy Tests of Commercial Skin-Applied Products in China. *Molecules* (Basel, Switzerland), 27(17), 5534. <https://doi.org/10.3390/molecules27175534>



frequently, especially after sweating, physical activity, or water exposure. Additionally, growing consumer concern over the use of synthetic chemicals on the skin has led many to seek out natural alternatives, such as essential oils, which tend to offer shorter protection windows and lower reliability.

With the continued spread of mosquito- and tick-borne illnesses, there is a pressing global need for a repellent that is longer-lasting, biologically integrated, and more widely accepted by consumers.

3. Solution Overview

We are developing a novel, biology-based mosquito repellent by engineering *Staphylococcus epidermidis*, a naturally occurring and abundant skin bacterium, to provide long-lasting protection against mosquito bites. Traditional repellents such as DEET can cause skin irritation, require frequent reapplication, and may have environmental drawbacks. In contrast, our approach targets the root cause of mosquito attraction: chemical signals produced by the skin microbiome.

Mosquitoes are primarily attracted to lactic acid, a key chemical cue produced on the skin by *S. epidermidis* via the enzyme lactate dehydrogenase (LDH). Our strategy involves reprogramming *S. epidermidis* to both eliminate the production of lactic acid and produce geraniol, a plant-derived terpene that is widely recognized as a safe and effective mosquito repellent.

To achieve this, we use engineered bacteriophages created via the PHEIGES TXTL platform. The engineered phage carries two functions, a CRISPR-Cas9 cassette to knock out the *ldh* gene, and a biosynthetic pathway for geraniol production. These genetic components are delivered simultaneously to *S. epidermidis* via phage infection, resulting in a dual-action strain that is both less attractive to mosquitoes and actively repels them.

Previous research demonstrated that knocking out *ldh* alone reduced mosquito landing rates by 80% for up to 12 days. By adding geraniol biosynthesis, our design enhances both the effectiveness and duration of protection.

Our solution will be delivered in the form of a topical spray or cream containing engineered bacteriophage, allowing for simple and familiar application by users. Once applied, the bacteria colonize the skin surface and continuously provide protection without the need for frequent reapplication.

This innovation is not only novel but potentially patentable due to its unique use of phage-mediated dual-function gene editing in skin commensals. It represents a sustainable, biologically integrated alternative to chemical repellents, offering scalability,



skin compatibility, and a lower environmental footprint. These features make our approach highly competitive in the mosquito repellent market, with significant potential to improve global health outcomes, particularly in regions affected by mosquito-borne diseases.

4. Target Market

Project ARBO recognizes that scaling an innovative mosquito-repellent solution requires a deliberate, phased approach to maximize impact, reduce risk, and build credibility with stakeholders. By structuring our target market into clearly defined phases, we establish a roadmap that begins with local validation and expands strategically toward global health adoption. This phased strategy reflects best practices in biotechnology and public health innovation, as it enables us to reduce risk by first testing safety, effectiveness, and market acceptance on a small scale.¹¹ Early pilots also generate proof of concept through sales and data collection, which are essential for attracting NGO and government interest. At the same time, phased expansion ensures that resources are optimized by targeting achievable markets first, then reinvesting in broader outreach. Importantly, this staged growth builds investor confidence by demonstrating measurable milestones and scalability, while allowing us to adapt continuously based on consumer feedback, epidemiological trends, and regulatory guidance.

4.1. Phase 0: Pilot Studies and Local Validation

Project ARBO's market entry strategy is designed in phases to ensure credibility, efficiency, and sustainable global impact. We begin with Phase 0: Pilot Studies and Local Validation, focusing on Ottawa and Ontario as controlled test environments. By engaging student volunteers, outdoor enthusiasts, and families in real-world trials at farmer's markets, community events, and universities, we will collect data on safety, effectiveness, and user preferences. Small-scale pilot studies are widely used in vector control product development and provide critical validation prior to NGO procurement or regulatory approval.¹²

4.2. Phase 1: Local Canadian consumer market

Following successful pilots, Phase 1 targets the local Canadian consumer market, particularly outdoor workers and recreationists who experience frequent mosquito

¹¹ World Health Organization. (2009). *Guidelines for efficacy testing of mosquito repellents for human skin*. World Health Organization. <https://www.who.int/publications/i/item/WHO-HTM-NTD-WHOPES-2009.4>

¹² Achee, N.L., Bangs, M.J., Farlow, R. et al. Spatial repellents: from discovery and development to evidence-based validation. *Malar J* 11, 164 (2012). <https://doi.org/10.1186/1475-2875-11-164>



exposure. ARBOGuard will be positioned as an eco-friendly and effective alternative to conventional DEET and picaridin products, distributed through retail, outdoor associations, and online platforms. Consumer demand for safer, non-toxic repellents is growing, and studies confirm that efficacy and user preference strongly influence adoption rates in these markets.¹³ By proving commercial viability locally, we will generate early revenue streams and refine our distribution strategies.

4.2. Phase 2: NGO and Humanitarian Partnerships

Once validated in Canada, Phase 2 expands to NGO and humanitarian partnerships in high-burden regions such as sub-Saharan Africa, Southeast Asia, and Latin America. This phase prioritizes at-risk groups including children under five, pregnant women, and outdoor laborers, who are disproportionately impacted by mosquito-borne diseases.¹⁴ NGOs like Médecins Sans Frontières and the Red Cross have historically facilitated distribution of novel prevention tools, making them essential partners for scaling equitable access. Collaborating with these organizations aligns ARBOGuard with existing health campaigns, such as mosquito net distribution and vaccine rollout, maximizing both reach and public health outcomes.¹⁵

4.3. Phase 3: Public health procurement and global expansion

Finally, Phase 3 targets public health procurement and global expansion through Ministries of Health, WHO, and UNICEF. At this stage, ARBOGuard would be incorporated into Integrated Vector Management (IVM) strategies,¹⁶ complementing nets, vaccines, and education programs. Embedding repellent innovation in national procurement frameworks ensures sustainability and scale, much like immunization-style campaigns that achieve rapid population coverage. Evidence from recent malaria and dengue resurgence studies demonstrates the need for layered prevention strategies at the national level.¹⁷ By

¹³ Peng, Z.-Y., He, M.-Z., Zhou, L.-Y., Wu, X.-Y., Wang, L.-M., Li, N., & Deng, S.-Q. (2022). Mosquito Repellents: Efficacy Tests of Commercial Skin-Applied Products in China. *Molecules*, 27(17), 5534. <https://doi.org/10.3390/molecules27175534>

¹⁴ Hassan I. N. (2025). Arboviral infections and pregnancy: An overlooked public health challenge. *New microbes and new infections*, 65, 101587. <https://doi.org/10.1016/j.nmni.2025.101587>

¹⁵ World Health Organization. (2020). *World Malaria Report 2020*. WHO. <https://www.who.int/publications/i/item/9789240015791>

¹⁶ World Health Organization. (n.d.). *Integrating vector management*. WHO Western Pacific. Retrieved September 27, 2025, from <https://www.who.int/westernpacific/activities/integrating-vector-management>

¹⁷ Ntoumi, F., Aklillu, E., Asogun, D., Ansumana, R., Mfinanga, S., Yeboah-Manu, D., Nachege, J. B., & Zumla, A. (2025). Malaria resurgence in Africa: Confronting the challenges. *The Lancet Infectious Diseases*, 25(10), 1066–1068. [https://doi.org/10.1016/S1473-3099\(25\)00499-2](https://doi.org/10.1016/S1473-3099(25)00499-2)



advancing in structured phases, Project ARBO moves from local validation to global adoption, balancing commercial growth with public health impact.

5. Customer Discovery

Our customer discovery process combined exploratory interviews with a structured public opinion survey designed to validate early assumptions about ARBOGuard and its market potential. Initial conversations with students, community members, and individuals in mosquito-endemic regions revealed common frustrations with conventional repellents, particularly around chemical exposure, short duration of effectiveness, and environmental concerns. These informal insights provided a foundation to test more systematically through a large-scale survey.

In the summer of 2025, our team launched a bilingual survey that was reviewed and approved by the University of Ottawa Research Ethics Board. The survey was distributed nationwide and targeted individuals aged eighteen and older. At the time of this report, we have collected 106 responses, providing a strong dataset for early-stage analysis. Nearly all respondents (98%) confirmed they were above the age of eighteen, validating eligibility. The age distribution skewed younger, with seventy-six participants (72%) between eighteen and twenty-four years old, eleven participants (10%) between twenty-five and thirty-nine, and seventeen participants (16%) between forty and fifty-nine. While the dominance of younger demographics reflects our distribution networks, the presence of older respondents demonstrates cross-generational interest in mosquito repellent solutions.

Patterns of current repellent use highlight a reliance on sprays and creams, which respondents described as both familiar and frustrating. A recurring theme was the need for frequent reapplication, a feature many respondents disliked. One participant summarized this frustration succinctly: “no re-application if possible – especially when I’m travelling and can’t carry it somewhere.” Others expressed dissatisfaction with the sensory qualities of conventional repellents, citing greasiness, odors, or irritation. Another respondent noted they would prefer a product with “AUCUNE odeur [no odor], pas gras [not greasy].”

When presented with the concept of ARBOGuard, a microbiome-based repellent, participants revealed both enthusiasm and caution. Several respondents explicitly tied their interest to safety and health, with statements such as “Safe & effective” and “Not toxic to humans and pets.” At the same time, the novelty of the approach prompted demands for evidence. One participant emphasized the need for validation, writing: “Number of success by different people” while another requested “Real world data showing that it works for multiple people.” This feedback indicates that transparency



around testing, regulation, and third-party validation will be indispensable for customer trust.

Sustainability and eco-friendliness emerged as consistent drivers of interest. Multiple respondents highlighted their preference for environmentally responsible products, including comments such as “Long lasting. Eco friendly.” and “Does the same as a ‘good’ repellent but eco-friendly.” In contrast to chemical repellents, ARBOGuard was viewed as a potential solution that could balance personal protection with environmental stewardship. This environmental positioning was reinforced by another respondent who stated they would be convinced by “Proof of low environmental and health effects.”

Affordability also played a critical role in consumer expectations. While participants were open to innovation, they repeatedly emphasized the need for competitive pricing, with one noting that adoption would depend on “Pricing comparable to sunscreen.” This suggests that while sustainability and innovation are differentiators, market success will also hinge on ensuring the product is positioned as accessible rather than exclusive.

From these responses, three primary user personas emerged. The first is the outdoor enthusiast, who seeks long-lasting, convenient protection and dislikes the hassle of constant reapplication. The second is the eco-conscious consumer, who is motivated by sustainability and prefers environmentally responsible products even at a premium. The third is the health-focused caregiver, who prioritizes safety for children, pets, and sensitive skin and who is particularly sensitive to regulatory credibility and transparent communication.

These findings point toward several strategic priorities for ARBOGuard. Trust and safety must be addressed directly through third-party validation, transparent communication of regulatory steps, and accessible education around microbiome engineering. Format preferences should remain flexible, with both cream and spray formulations under consideration to appeal to different consumer habits. Sustainability should remain central to brand positioning, as eco-friendliness was consistently identified as a compelling advantage over chemical repellents. Finally, pricing strategies must ensure that ARBOGuard is accessible to mainstream consumers, particularly if distributed through NGOs or public health campaigns in endemic regions. Ultimately, the customer discovery process has confirmed that there is strong demand for a repellent that is effective, safe, and sustainable. However, it has also highlighted the need for rigorous proof, transparent communication, and consumer education to ensure that a biotechnology-based innovation is embraced not just as novel, but as trustworthy and indispensable.

Fig 1. Public Opinion Survey flyers circulated around campus and social media



6. Competitive Analysis

6.1 Competitor Landscape

ARBOGuard enters a market that is already populated with a wide range of mosquito repellent solutions, which can be broadly categorized into chemical, natural, and physical repellents. Each of these categories has established consumer bases, but all face limitations that create opportunities for innovation.

6.2 Direct Competitors

Our closest competitors are commercial chemical repellents, such as OFF! and Ben's, which rely on synthetic active ingredients like DEET and picaridin. These products are widely available, affordable, and clinically validated to provide several hours of protection, typically between five and ten hours depending on formulation strength. However, despite their effectiveness, they are frequently associated with health and



environmental concerns. Consumers report issues such as skin irritation, unpleasant odors, and reluctance to use them on children or pets. Long-term reliance on synthetic repellents also raises ecological concerns, making them less appealing to eco-conscious consumers.

6.3 Indirect Competitors

Indirect alternatives take several forms. One emerging approach involves genetically modified (GM) mosquitoes designed to suppress mosquito populations at the source¹. While scientifically promising, these methods face steep hurdles in regulatory approval, ethical debate, and public acceptance, limiting their near-term feasibility as consumer solutions.

Another category of indirect competitors includes natural repellents, such as citronella, eucalyptus, or essential oil blends. While perceived as safer and environmentally friendly, these products typically provide less than two to three hours of protection and have inconsistent effectiveness. As such, they tend to appeal to eco-conscious consumers but fail to meet the performance expectations of high-risk populations or frequent outdoor users.

Lastly, physical repellents such as wristbands, stickers, or wearable nets offer convenience and novelty but often lack scientific validation. These solutions rely on weak active ingredients or passive barriers and are generally regarded as supplemental rather than primary forms of protection.

6.4 SWOT analysis

SWOT Analysis: ARBOGuard

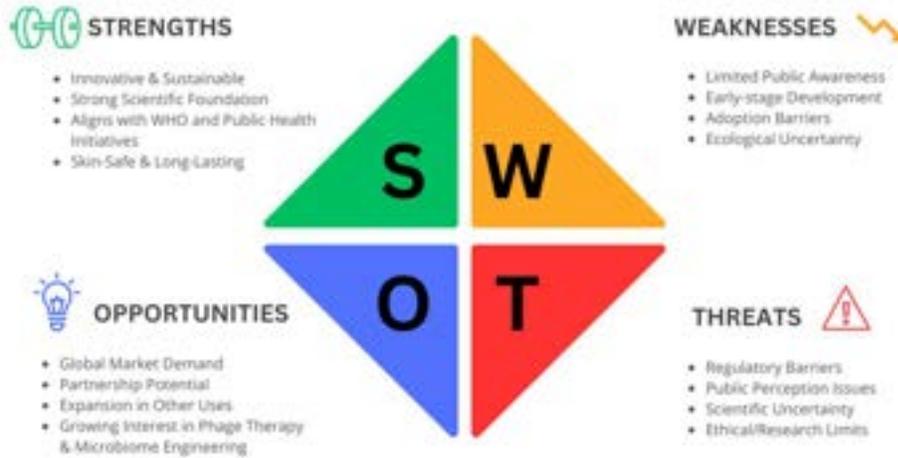


Fig. 2 SWOT Analysis

Our SWOT analysis highlights ARBOGuard’s positioning relative to existing competitors. ARBOGuard’s strengths lie in its innovative, biology-driven design, which delivers sustainable, long-lasting, and skin-safe protection. These qualities directly address consumer pain points around chemical irritation and environmental harm. Weaknesses include the early-stage nature of the technology and the need to overcome public unfamiliarity with microbiome-based solutions. The opportunities are significant, with rising global demand for mosquito repellents, the potential for partnerships with NGOs and public health organizations and growing scientific interest in microbiome engineering. Threats remain in the form of regulatory complexity, public perception challenges, and the inherent caution surrounding synthetic biology innovations.

6.5 Competitive Advantage

Unlike traditional repellents, ARBOGuard introduces a microbiome-based approach that leverages naturally occurring skin bacteria to produce mosquito-repelling compounds directly on the skin. This innovation addresses three major gaps left by current market leaders:

- **Long-lasting protection:** Unlike sprays that require frequent reapplication, ARBOGuard is designed to provide extended coverage by producing active compounds continuously.

- Eco-friendly and sustainable: By avoiding synthetic chemicals, ARBOGuard minimizes ecological harm and appeals to environmentally conscious consumers.
- Non-irritating and safe: Our solution prioritizes skin-friendliness and is suitable for sensitive populations, including children, making it more versatile than chemical-based competitors.

This unique positioning allows ARBOGuard to combine the effectiveness of synthetic products with the safety and sustainability of natural alternatives, filling a critical gap in the global mosquito repellent market.

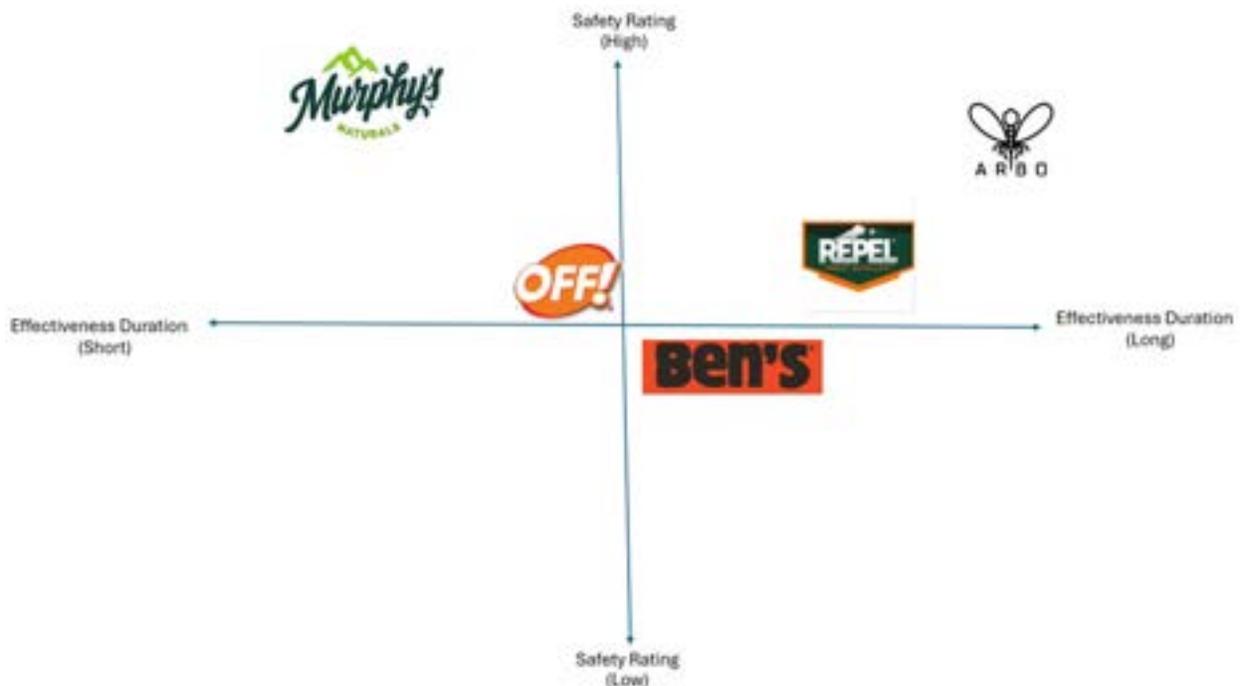


Fig 3. Competitive Analysis Chart

The competitive analysis chart further illustrates ARBOGuard's differentiation. Natural products such as Murphy's Naturals are highly safe but provide short-term protection of four to six hours. Repel combines synthetic and natural active ingredients, offering up to ten hours of protection but relying on DEET or IR3535. OFF!, one of the most recognized brands globally, provides six to eight hours of protection but is associated with chemical exposure concerns. Ben's represents the high-DEET market, offering up to ten hours of effectiveness but with the lowest consumer perception of safety.

ARBOGuard is positioned in the upper-right quadrant, a solution that offers both high safety and long duration of protection. This dual advantage underscores our product's ability to outcompete existing repellents by addressing consumer demand for both performance and sustainability



7. Business Model Canvas

Our key partners include suppliers of raw materials, manufacturing and distribution partners, NGOs, health organizations, and the University of Ottawa, which provides lab space, equipment, and mentorship.

Our key activities span research and development, product testing and validation, regulatory compliance, and marketing and outreach initiatives. We also engage in partnerships for awareness campaigns to drive adoption in high-risk regions.

ARBOGuard's value proposition is a safe, long-lasting mosquito repellent that provides up to 12 days of protection, with customizable, odorless, and skin-friendly formulations in multiple application formats. Clinically validated for non-toxicity and environmental safety, it reduces application frequency, minimizes irritation, and supports sustainable global health solutions. This innovative approach delivers effective disease prevention while enhancing comfort for outdoor activities.

Our key resources include advanced lab facilities, formulation expertise, and secure funding streams (USRO, NSERC, grants, sponsorships). Our intellectual property: patents, trademarks, and regulatory approvals, combined with strong partnerships and a reliable distribution network, enables scalable production. A trusted brand reputation reinforces credibility with stakeholders and end-users.

Cost structure includes R&D, manufacturing, and production expenses, alongside distribution, logistics, and regulatory compliance costs. Additional expenditures cover intellectual property management, marketing and branding, and influencer endorsements to boost awareness. Variable costs such as packaging, labeling, and transaction fees are balanced with fixed costs like quality assurance and advertising.

Our product builds fit-for-purpose stakeholder relationships in regard to customer relationships. With agencies, we offer service contracts, pilot design assistance, and uncomplicated impact reporting such that procurement groups can responsibly fund and scale up. With hospitals and clinics, troubleshooting and a lightweight monitoring tool kit that captures bite reduction and safety measures without creating workload burdens are provided. For retail, precise labelling and advice at point of purchase generate correct expectations and abuse reduction, with an uncomplicated path to replacement where justified batch problems are occurring. These relationships safeguard users, produce credible data, and guarantee take-up.

ARBOGuard has two prime target markets and one adjacent market in regard to customer segments. Bulk buying agencies in the public health sector and NGOs in vector



control are our prime payers. Our prime users are individuals who use the product and are benefited on a daily basis, such as homes where the mosquito is of medical significance, outdoor workers and recreators, shift or outreach healthcare workers, and internally displaced individuals in camps or temporary settlements. The secondary market consists of tourists who travel to endemic places and families who frequent and whose youngsters would like to reduce exposure from mosquitoes at home or on trips. Separating the payer from the user allows our design, evidence, and message to be focused on true needs and true decisions.

ARBOGuard spans three channels, each filling in the gaps of the others. Institutional procurement through the government and NGOs provides pilots that switch over to regional supply, topped up with training and reporting specific to program cycles. Healthcare provision through hospitals, clinics, school health days, mobile units, and work safety programs fills in distribution into regular visit intervals, also increasing right use, adherence monitoring, and follow-up. Commercial partnerships through outdoor and pharmacy retailers undergird putting the product where families and travellers are already purchasing, with refill access between campaigns and between seasons.

ARBOGuard's business model combines program volume and wide availability when considering revenue streams. Quantity B2B sales and procurement contracts to ministries, NGOs, and humanitarian purchasers offer volume stability for negotiated deliverables. Direct sales and web channels reach travelers and families, and in-store visibility in sporting goods retailers capture demand at the point of need. Collaboration with health organizations offers subsidized access in low-income environments, and outbreak emergency packs offer a speed-of-response solution with reduced deployment time within seasonal surges. Combined, channels offer ongoing validation, quality, and volume stability

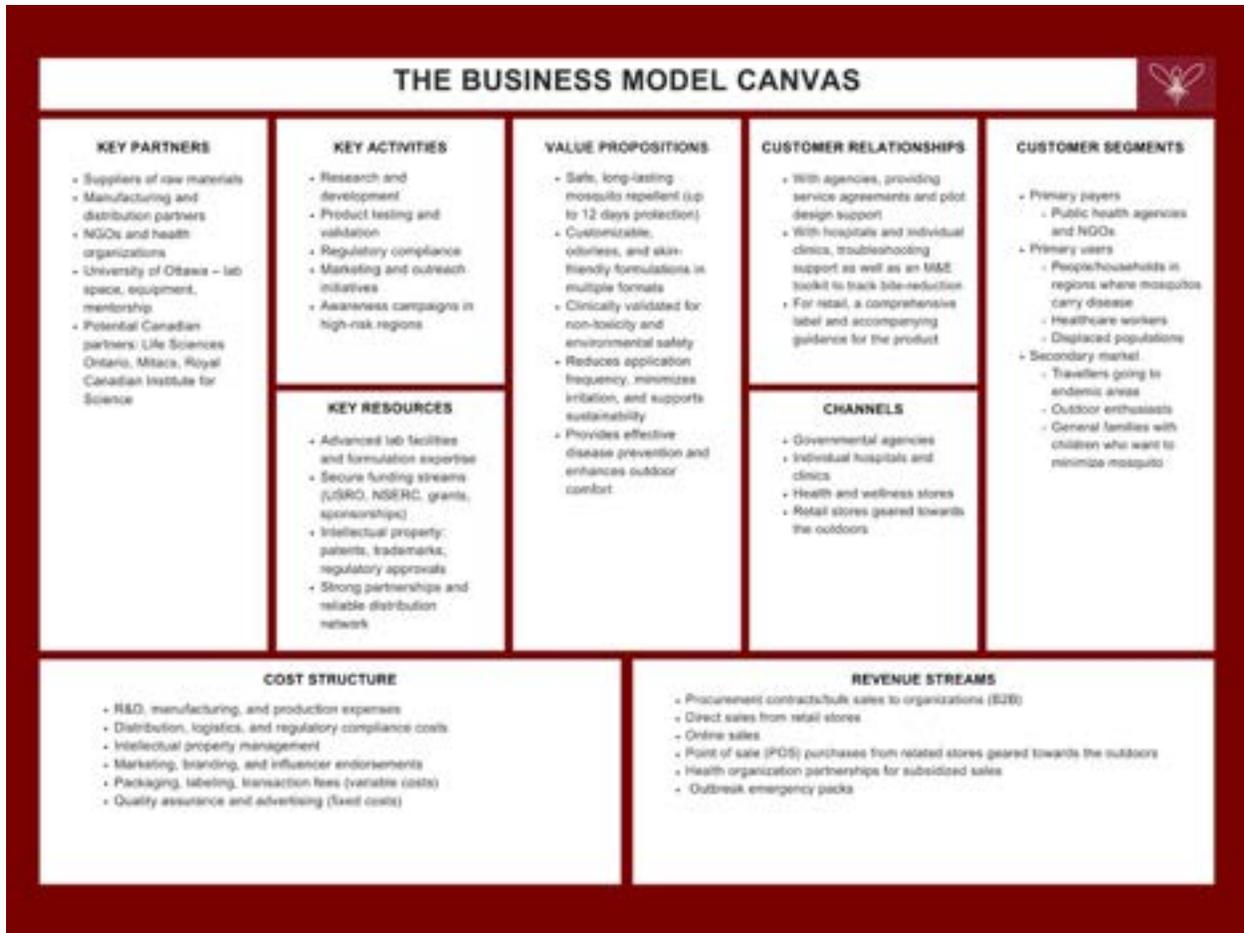


Fig 4. Business Model Canvas

8. Market Strategy

8.1 Market Entry Plan and Trust-Building Approach

While no recent survey reported an exact percentage of Canadian households participating in outdoor activities, early reports stated that around 70-80% participate in activities involving the use of mosquito repellents. A recent article from CBC News highlights a surge in mosquito activity due to higher temperatures recorded and increased precipitations in some provinces¹⁸. Additionally, Canada hosts around 80 different species of mosquitoes, now adapting to drought like conditions, making them more resilient¹⁹.

¹⁸ Singh, I. (2025, May 17). Beware: Mosquito season will soon be upon us. Here's what you need to know. CBC. <https://www.cbc.ca/news/science/mosquitoes-this-year-2025-1.7537748>

¹⁹ National Collaborating Centre for Environmental Health. (2025, January 22). Mosquitoes in a changing climate. <https://nceh.ca/resources/subject-guides/mosquitoes-changing-climate>



Overall, it is expected to have a growing consumer need for safer and more effective mosquito repellents that allow outdoor enthusiasts to enjoy their activities. In that context, early commercialization should focus on recreational and lifestyle enthusiasts (outdoor activities, traveling), and after building trust within the community, we can target parents seeking better and safer protection for children and elderly. Our message clearly highlights the differences between our solution and chemical-based repellents, and how it is skin-compatible, environmentally sustainable, and offers long-lasting protection.

As stated above, the geographical focus would start in Canada, U.S and high-income areas in Europe. After gaining traction and regulatory approval, we will expand into high need global health areas with high prevalence of mosquito borne diseases (e.g. tropical and subtropical regions). The expansion plan will be put in place through key partnerships with NGOs, health organizations, regulatory bodies, and government authorities.

To introduce our phage-based product and build consumer trust, we will pair the launch plan with targeted education campaigns and endorsements from trusted health professionals including dermatologists and pharmacists. These initiatives aim to reduce the hesitation associated with phage technology and make customers more comfortable with the use of ARBOGuard.

The launch plan is structured into three distinct phases designed to scale awareness and adoption:

Phase 1: Pilot (April – June)

- Small-scale launch in 1-2 key provinces at the start of the hiking/ camping season. Distribution channels will include:
 - Retail stores and park kiosks
 - Partnerships with known hikers/campers for authentic customer reviews
 - Online platforms

Phase 2: Medium-scale expansion – National market

- National retail channels (Canadian Tire, Sport check, pharmacy chains)
- Digital advertising campaigns
- Sponsorships and participation in outdoor events

Phase 3: Large-scale expansion – Preparation for global market

- This phase focuses on strengthening the market influence and preparing for the next season:



- Nationwide availability in major retailers (Walmart, Costco, Metro, and other grocery stores)
- Promotional offers such as bundles/ discounts for repeat buyers
- Collaboration with national parks and tourism organizations to increase visibility
- Laying the ground for international partnerships to prepare for global expansion

8.2 Marketing Channels and Communication Strategy

Given the novel nature of ARBOGuard, our marketing strategy will prioritize trust, safety, and efficacy. Our approach will focus on education, ensuring credibility, and building a connection with consumers while meeting regulatory and compliance standards.

1. Brand Identity Development

- **Visual identity:** Leverage the already-designed logo to create a creative branding across packages, digital platforms, and social media materials
- **Educational materials:** Create a comprehensive document that outlines how to use ARBOGuard, and an overview of the unique additional value compared to other repellents (e.g., how-to-use flyer)
- **Brand narrative:** Generate a compelling brand story to emphasize ARBOGuard's mission that focuses on the health of our consumers and environmental responsibility

2. Web Design

- Share with consumers the journey of the product, key information about regulatory approvals, the science behind the phage technology of ARBOGuard, and future milestones to build trust based on transparency
- Implement a public FAQ page, verified testimonials (including IHP endorsements), and a public reviews section

3. Public Relations and Awareness

A structured PR approach is key to building a strong image, establishing credibility, and attracting interest of both consumers and potential partners (national and international):

- **Social media advertising:** Content creation campaigns in line with healthcare advertising regulations



- **Partnerships with retail stores:** Collaborate for website promotion, placements in key sections of pharmacies and outdoor recreational stores
- **User persona development:** Create buyer profiles of ideal customers to connect and resonate with the audience on a more personal level (interests, concerns, and motivations to choose an alternative mosquito repellent to what's on the market)

4. Scientific Credibility

- **Peer reviews and engagement:** Pursue opportunities for peer-reviewed publications and healthcare professional endorsement. Present at relevant conferences and pitch opportunities to reach scientific communities
- **Science communication:** Develop creative and easy-to-understand infographics that translate the complex scientific information on the product into accessible content for different audiences

8.3 Customer Education Strategy

Due to the unfamiliar nature of phage-based mosquito repellents, it is critical to educate consumers in an engaging, relatable, and accessible. We aim to build content focusing on simplifying the science and better understand what the consumers would look for before buying the product:

- Use a variety of content formats and channels to bridge the knowledge gap and make complex information more digestible through podcasts, videos, graphics, newsletter, and social media campaigns
 - ➔ Content can be adaptable based on the user (simple overview vs deeper scientific explanations)
- Animations and interactive experiences can make learning more engaging for the general audience as well as children
- Building a community of outdoor enthusiasts who share a common interest and passion or concerns regarding repellents like DEET that are already on the market
 - ➔ By encouraging customers to interact with each other, share their personal experience with the product, we can gather feedback and adapt our commercialization approach accordingly
- Share safety data, laboratory results, statistics, and regulatory approvals to ensure complete transparency and an opportunity to emphasize our message (e.g.: harnessing the naturally occurring skin bacteria, avoiding harsh chemicals, reduced environmental impact...)
- Leverage key partnerships (e.g.: dermatologists, microbiologists, public health organizations, professors) to validate safety claims and help educate customers.

9. Market Research

9.1 Epidemiological Insights and Disease Burden

9.1.1 Malaria

An estimated 263 million malaria cases reported in 2023, and 597 000 malaria related deaths across 83 different countries. The African region bore the highest burden accounting for 94% of cases and 95% of deaths²⁰.

A combination of factors results in Africa being the most affected region²¹:

- The presence of resistant mosquito species with high rates of transmission,
- The dominance of the main parasite species most likely to cause severe malaria and death (*Plasmodium falciparum*)
- Year-round climate conditions favorizing transmission
- Socio-economic instability, which limits access to prevention and treatment

Based on the WHO 2023 data, over half of the deaths occurred in four main countries: Nigeria, Democratic Republic of Congo, Niger, and the United Republic of Tanzania. Children under 5 and pregnant women are the most affected due to their more vulnerable immune systems.

➔ To address this global health challenge, WHO has established a global technical strategy to reduce the case and mortality rate by at least 90% by 2030²²

9.1.2 Dengue

Based on CDC reports, more than 13 million cases were reported in 2024, primarily across North, Central and South America, as well as the Caribbean, with outbreaks declared in several areas²³

²⁰ World Health Organization: WHO & World Health Organization: WHO. (2024, December 11). *Malaria*. <https://www.who.int/news-room/fact-sheets/detail/malaria>

²¹ *Malaria's impact worldwide*. (2024, April 1). Malaria. <https://www.cdc.gov/malaria/php/impact/index.html>

²² Patouillard, E., Griffin, J., Bhatt, S., Ghani, A., & Cibulskis, R. (2017). Global investment targets for malaria control and elimination between 2016 and 2030. *BMJ Global Health*, 2(2), e000176. <https://doi.org/10.1136/bmjgh-2016-000176>

²³ *Current Dengue outbreak*. (2025, July 29). Dengue. <https://www.cdc.gov/dengue/outbreaks/2024/index.html>

The latest situation updates as of July 2025 highlighted data reports of 3.6 million cases and more than 1900 deaths from 94 different countries since the beginning of 2025²⁴. Regions affected include EURO, PAHO, Southeast Asia and West Pacific, EMRO and Africa.

A recent WHO article published on August 21st, 2025, highlights that half of the world's population is now at risk of contracting dengue, with an estimated 100 to 400 million cases occurring annually. In 2024, a historic record break of over 14.6 million cases was reported and affecting over 100 countries worldwide. Young children and older population are more vulnerable and at higher risk for severe complications or death²⁵.

9.1.3 Zika Virus

Major outbreaks and a significant spike in cases were observed during 2015-2016. Although case numbers started declining after 2017, Zika virus transmission remains at low levels across the Americas and other endemic regions, with a total of 89 recorded countries that reported evidence of mosquito Zika transmission²⁶.

- Pregnant women and developing fetuses are the most vulnerable populations, as the virus can cause birth defects. Other impacted groups include travelers to regions with Zika transmission mosquitoes and their sexual partners, as well as patients receiving blood, cells, or organs²⁷.

²⁴ *Dengue worldwide overview*. (2025, September 16). European Centre for Disease Prevention and Control. <https://www.ecdc.europa.eu/en/dengue-monthly>

²⁵ World Health Organization: WHO & World Health Organization: WHO. (2025, August 21). *Dengue*. <https://www.who.int/news-room/fact-sheets/detail/dengue-and-severe-dengue>

²⁶ World Health Organization: WHO. (2019, November 1). *Zika virus disease*. https://www.who.int/health-topics/zika-virus-disease#tab=tab_1

²⁷ Public Health Agency of Canada. (2019, December 24). *Zika virus: Prevention and risks*. Canada.ca. <https://www.canada.ca/en/public-health/services/diseases/zika-virus/prevention-risks.html>

- *Aedes aegypti* mosquitoes mostly known for transmission of Zika are present in some countries even in the absence of reported cases. Refer to the geographical risk map below for an overview of transmission zones²⁸:

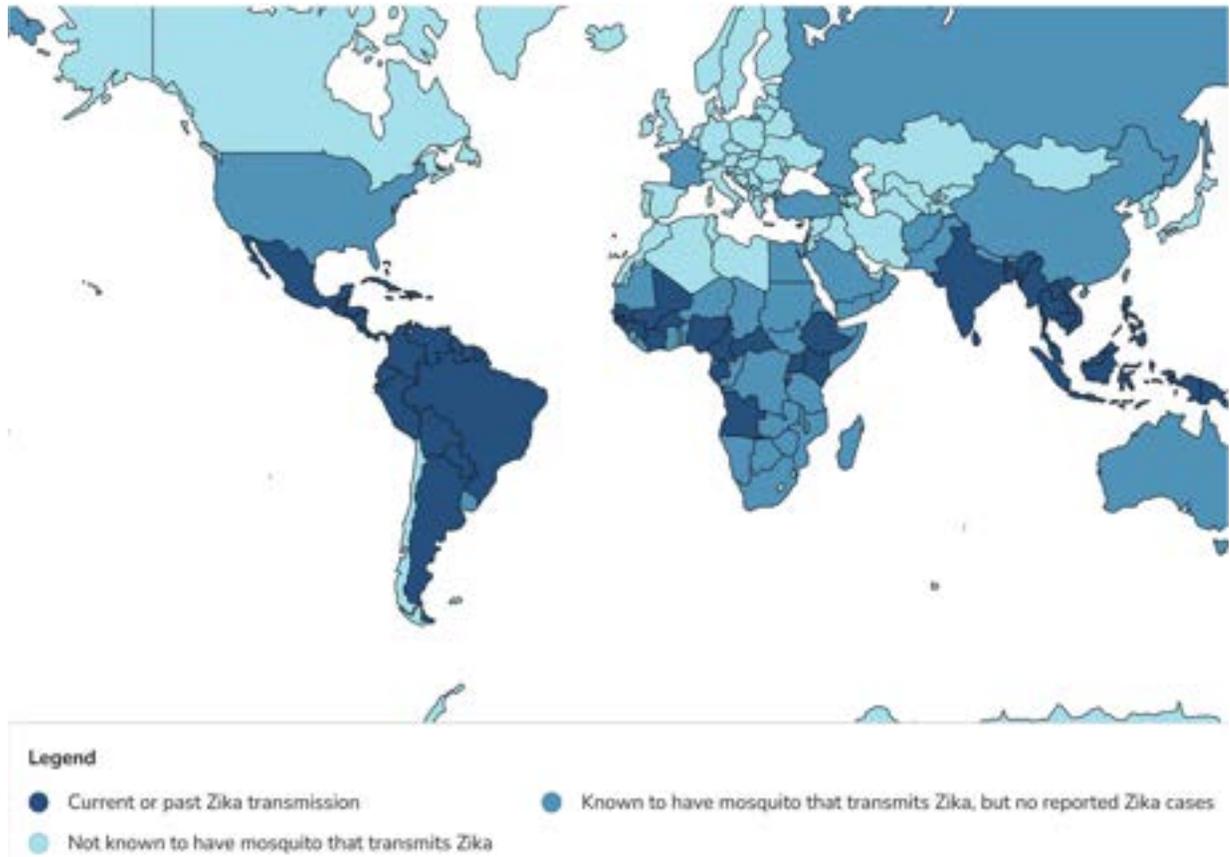


Figure 5. Geographical distribution of risk zones for Zika transmission as of June 2025.

9.2 Market and Assumptions

Phage therapy and synthetic biology are moving from research and niche applications into broader markets. Several industries are already commercializing phage-based products, which demonstrates both technical credibility and market demand.

9.2.1. Medical Market

Phage therapy is gaining traction not only as an alternative to antibiotics, but also as a complementary treatment. Clinical evidence supports its efficacy in treating conditions like cystic fibrosis infections, diabetic foot osteomyelitis, and refractory urinary tract

²⁸ *Countries & territories at risk for Zika.* (2025, June 24). Zika Virus. <https://www.cdc.gov/zika/geo/index.html>



infections². Belgium has already established a national phage bank, while UC San Diego's Innovative Phage Applications and Therapeutics (IPATH) is leading U.S. clinical efforts. Investment is accelerating: BiomX absorbed Adaptive Phage Therapeutics in 2024, adding \$50M in capital and two Phase 2 assets, while BARDA awarded \$23.9M to Locus Biosciences for its CRISPR-engineered phage therapeutic³. As of 2024, there are over 90 active interventional clinical studies involving phages. This indicates strong investor confidence and a rapidly growing pipeline.

Market prospects are promising given the growing interest in bacteriophage applications for human health, particularly in the field of infectious diseases. Our project leverages phage delivery of CRISPR-Cas9 as an innovative approach to reduce mosquito landings, targeting mosquito-borne disease prevention. Below, we present the TAM, SAM, and SOM framework relevant to our sector.

- **TAM (Total Addressable Market):**

This represents the global bacteriophage therapy market across all applications. In 2025, the market was valued at **USD 1.24 billion** and is projected to reach USD 1.51 billion by 2030, growing at a CAGR of 3.99%⁸.

- **SAM (Serviceable Available Market):**

This refers to the portion of the phage market specific to infectious diseases, which account for 52.48% of revenue. This corresponds to approximately USD 650 million.

- **SOM (Serviceable Obtainable Market):**

This reflects the realistic segment of the SAM that can be captured. Based on preliminary survey data administered to Canadian adults (primarily in Ottawa and the University of Ottawa student population), and applying a conservative capture of 2%, the SOM is estimated at USD 13 million.



Figure 6. TAM–SAM–SOM analysis showing the global bacteriophage therapy market

9.2.2 Food Industry Market

Phages are used to control foodborne pathogens such as *Listeria monocytogenes*, *E. coli*, and *Salmonella*⁴. Companies like Intralytix, Microcos Food Safety, KINK TEC GmbH, Passport Food Safety Solutions, and Phagelyx have already entered this space. Applications focus on reducing spoilage and contamination, improving food safety without introducing chemicals. Regulatory approvals exist in the U.S. for phages in pesticide (EPA) and food applications (FDA/USDA), which gives this sector a clearer commercialization path.

9.2.3. Skincare Market

Phages are being positioned as a natural and precise alternative to traditional skincare antimicrobials. For example, Phyla’s Acne Phage Serum retails at \$56 and targets acne-causing bacteria without disrupting the skin microbiome⁵. Research also shows phage-based cosmetic applications can reduce skin infections caused by pathogenic *Staphylococcus*⁶. These products fit within the growing consumer interest in microbiome-friendly and sustainable skincare.

9.2.4 Regulatory Landscape

The main challenge for phage commercialization remains the absence of standardization⁷. Even with identical protocols, labs can observe different host ranges for the same phage, which complicates quality control and approval processes. Regulatory

approvals for medical phages are still limited, though food and agricultural applications are further ahead.

9.3 Market Dynamics and Revenue Distribution

9.3.1 Local Market – Canada²⁹

- The Canadian insect repellent market generated approximately USD 101.9 million in 2024 and is projected to reach USD 151 million by 2030
- Growth is driven by multiple factors, notably climate change, contributing to increased public health concern
- Based on historical data from 2018-2023, with 2024 as the base year, and forecast period from 2025-2030, mosquito repellents are identified as the largest and fastest growing segment

9.3.2 Global Market³⁰

- As of 2025, the global mosquito repellent market is valued at USD 7.49 billion, with projections indicating it will reach USD 11.07 billion by 2032
- Driven by climate change, urbanization and increased awareness of mosquito-borne diseases, there was an observed market share growth across countries. Regional and country-level highlights include:
 - Asia Pacific led the market in 2024, driven by large population and climate conditions
 - India and China demonstrate strong demand due to rapid urban growth and humid climates that support mosquito breeding cycles
 - United States market growth primarily influenced by periodic outbreaks of West Nile virus
 - Brazil and Argentina have experienced increased demand due to rising cases of dengue and housing development
 - In the UAE region, government initiatives and international collaboration to combat vector-borne diseases have stimulated the market demand

²⁹ *Canada Insect Repellent Market Size & Outlook, 2030*. (2025, September 17). <https://www.grandviewresearch.com/horizon/outlook/insect-repellent-market/canada>

³⁰ *Mosquito Repellent Market Size, Share | Growth Report [2032]*. (n.d.). <https://www.fortunebusinessinsights.com/mosquito-repellent-market-104417>



9.4 Canadian Market Size and Consumer Segments

9.4.1 Market size

- Based on the 2024 Canadian insect repellent market valuation of approximately USD 101.9 million, the largest segment is mosquito repellents, accounted for 46.91% (~47% = ~ USD 47.8 millions) of the market³¹.
- Using average retail prices, we can estimate the approximate number of mosquito repellent users in Canada:

Standard sprays

- Average price ~ CAD 14 = ~ USD 10
- Estimated users ~ 4.78 million

Electronic or area-based

- Average price ~ CAD 50 = ~ USD 36
- Estimated users ~1.33 million

9.4.2 User segmentation

Outdoor enthusiasts:

- While there is no recent statistical report for 2025 average Canadians that engage in outdoor activities, the latest report from Statistic Canada for 2021 reports an estimate of 78% of household families that enjoyed outdoor activities³²
- Globally, participation in outdoor and recreational activities is increasing, but in countries with limited access to natural spaces, mosquito repellents are often purchased for domestic or indoor protection

Travellers:

- Mosquito-borne diseases are less prevalent in Canada as in other countries or tropical regions, but Lyme and West Nile virus are an increasing concern driven by climate change³³

³¹ *Canada Insect Repellent Market Size & Outlook, 2030*. (2025b, September 17). <https://www.grandviewresearch.com/horizon/outlook/insect-repellent-market/canada>

³² Government of Canada, Statistics Canada. (2023, August 17). *More Canadians getting active outside*. Statistics Canada. <https://www.statcan.gc.ca/o1/en/plus/4316-more-canadians-getting-active-outside>

³³ Pelley, L. (2023, September 9). Why insect-transmitted illnesses are emerging threats in Canada and beyond. *CBC*. <https://www.cbc.ca/news/health/why-insect-transmitted-illnesses-are-emerging-threats-in-canada-and-beyond-1.6959492>

- In Canada and the US, domestic travel to specific regions with higher risk of mosquitoes is typically seasonal
- International travels face exposure to higher-risk zones for mosquito transmission of diseases such as Malaria, Dengue, and Zika virus, typically in tropical and subtropical regions

Families and health-conscious buyers:

- Parents are more cautious regarding the type of mosquito repellent use and seek natural or child-safe repellents, avoiding harsh chemicals
- In Asia and Pacific regions, where the risk Dengue and Malaria is high, consumers show a stronger preference for highly effective repellents, regardless of the chemical composition



Figure 7. TAM–SAM–SOM analysis showing the global mosquito repellent market

10. Revenue Model

10.1 Revenue Model & Phased Implementation



ARBOGuard's revenue model follows a hybrid B2C (Business-to-Consumer) and B2B (Business-to-Business) framework designed for both accessibility and long-term scalability. The model evolves through three structured phases, aligning commercial growth with regulatory milestones and geographic expansion.

Phase 0–1: Pilot Launch and Local Validation (Years 1–2)

Objective: Establish ARBOGuard's credibility, validate user safety and efficacy, and collect early sales and performance data within regulated North American markets.

During the initial phase, ARBOGuard will focus on direct-to-consumer distribution via e-commerce platforms, pharmacies, and outdoor retailers in Canada and the U.S. A monthly or seasonal subscription model will complement single-unit sales, delivering refills during peak mosquito months (May–September).

Pricing and Rationale:

- Retail unit: \$15–\$20 CAD, benchmarked against premium repellents such as OFF!® Botanicals (\$12–\$18) and Natrapel® (\$14–\$22), while emphasizing ARBOGuard's longer duration of protection and eco-friendly formulation.³⁴
- Subscription plan: \$12/month, modeled after recurring skincare and wellness products (e.g., Native deodorant and Function of Beauty) that maintain strong customer retention rates (20–30%).³⁵³⁶

Projected Sales Volume:

- Year 1: ~10,000 units, reflecting a modest 0.005% penetration of Canada's ~\$300M annual mosquito-repellent market.³⁷
- This projection is based on achievable direct-to-consumer reach through social media campaigns, early partnerships with outdoor retailers, and pilot feedback studies.

Expected Revenue:

³⁴ Amazon Canada & Walmart Canada (2024). Retail pricing listings for OFF!® Botanicals and Natrapel® insect repellents.

³⁵ McKinsey & Company (2021). The State of the Consumer Subscription Economy. <https://www.mckinsey.com>

³⁶ Shopify (2023). Consumer Trends Report: The Rise of Subscription Commerce. <https://www.shopify.com>

³⁷ IBISWorld (2023). Insect Repellent Manufacturing in Canada – Market Size and Growth Statistics.



- \$150,000 CAD in Year 1, derived from retail and subscription mix (~60% retail, 40% subscription).

Validation Goals:

- Collect user data on skin compatibility, perceived protection, and application frequency.
- Generate performance and safety documentation for regulatory submissions (PMRA and Health Canada).

Phase 2: Regional Expansion and Institutional Partnerships (Years 3–5)

Objective: Expand access and impact by partnering with NGOs, governments, and healthcare agencies operating in mosquito-endemic regions, while increasing B2C distribution through international e-commerce.

Following successful pilot validation, ARBOGuard will transition into high-demand markets in South America, Sub-Saharan Africa, and South Asia, where vector-borne diseases such as dengue, Zika, and malaria pose significant health and economic challenges.

Revenue Channels:

- Bulk institutional contracts with organizations such as PATH, Médecins Sans Frontières, and WHO regional offices.
- Corporate co-branding with travel, outdoor, and wellness companies.

Pricing:

- Institutional bulk price: \$10 per unit for orders over 1,000, reflecting typical 30–40 % cost reductions at scale in life-science manufacturing.³⁸
- Tiered humanitarian discounts (5–15 %) to enhance accessibility.

Market Context:

- The global mosquito-repellent market was valued at \$4.1 billion USD in 2021 and is projected to reach \$7.2 billion USD by 2030 at a 5.5 % CAGR.^{39,40}

³⁸ IBISWorld (2023). Insect Repellent Manufacturing in Canada – Market Size and Growth Statistics.

³⁹ Deloitte (2022). Life Sciences Manufacturing Cost Benchmark Report. <https://www.deloitte.com>

⁴⁰ Allied Market Research (2023). Mosquito Repellent Market by Type and Distribution Channel – Global Opportunity Analysis and Industry Forecast, 2021–2030. <https://www.alliedmarketresearch.com>



- Capturing 0.02 % of this market equates to approximately 100,000 units by Year 3.

Financial Projection:

- Estimated revenue: \$1.2 million CAD in Year 3, increasing to \$2–3 million CAD by Year 5 through recurring institutional contracts and expanded retail sales.

Strategic Outcomes:

- Establish credibility with global health partners.
- Strengthen alignment with WHO and EPA regulatory frameworks.

Phase 3: Global Licensing and Mass Distribution (>5 Years)

Objective: Achieve global reach through licensing and integration into public health programs, ensuring ARBOGuard becomes a cornerstone of sustainable vector control.

By Phase 3, ARBOGuard will license its intellectual property and production rights to established biotech, skincare, and pharmaceutical companies with existing distribution networks in target regions. These partnerships enable rapid scale-up and compliance with varying international regulatory frameworks.

Revenue Streams:

- Licensing Agreements: Multi-year contracts for production and regional distribution, with royalties estimated at 8–10% of gross sales.⁴¹
- Public Health Campaign Integration: Bulk sales for mass-distribution programs (e.g., UNICEF, Global Fund, Ministries of Health).
- Corporate Collaborations: White-label or co-branded formulations (e.g., “Powered by ARBOGuard”).

Projected Financial Growth:

- Target sales exceeding 500,000 units annually by Year 5+, generating \$6–8 million CAD in revenue.
- Licensing royalties projected to contribute an additional \$500,000–\$1M annually once global contracts mature.

Market Rationale:

⁴¹ PwC (2022). Pharmaceutical and Biotech Licensing Outlook. <https://www.pwc.com>



- Assuming <0.1% capture of global mosquito-repellent demand (~\$7B market), the projections are conservative yet scalable given ARBOGuard's differentiation in sustainability and microbiome-based longevity.
- Global NGOs and governments collectively spend over \$500M annually on vector control (WHO, 2022), offering a large institutional customer base.⁴²

11. Forecast & Cost

Our financial forecast draws on a combination of laboratory budgeting data, market benchmarking, and industry-standard assumptions for early-stage biotech products. Costs are divided into categories that reflect the trajectory from research and development to market entry, ensuring that each stage is both scientifically rigorous and commercially viable.

11.1 Research and Development (R&D):

Initial R&D costs in 2026 are estimated at approximately \$12,965. These values are derived directly from the iGEM budget and experimental expense breakdowns, which include essential reagents, consumables, and small-scale lab testing. We assume that R&D will remain relatively constant year-over-year, since much of the early development is front-loaded and subsequent years focus on optimization rather than fundamental redesign.

11.2 Regulatory and Legal Compliance:

We project \$10,000 in 2026 to cover licensing, contracting fees, permits, and consultations with regulatory experts. This reflects early-stage uncertainty and the need for extensive expert input during classification and approval processes. After the initial investment, annual regulatory maintenance is modeled at \$1,000, covering renewals and minor legal updates. This assumption is based on consultations with professionals in regulatory affairs who indicated that ongoing costs decrease significantly after the initial submission phase.

11.3 Materials and Ingredients:

Our forecast for raw materials begins at \$6,756 in 2026, directly calculated from laboratory ingredient and reagent requirements. We assume a 10% annual increase in line with inflation, supply chain variability, and the shift from lab-scale to small-batch

⁴² World Health Organization (2022). Global Vector Control Response (GVCR) Annual Report. <https://www.who.int>



production. This incremental growth ensures the projection accounts for scaling without overestimating costs.

11.4 Manufacturing Fees:

Manufacturing is one of the largest cost drivers, starting at \$30,000 in 2026. This estimate is based on average industry pricing for small-scale biotech manufacturing (contract development and manufacturing organizations). We assume a 10% annual increase as production scales and additional batches are required to support pilot trials and early market entry. The growth trajectory reflects the transition from proof-of-concept runs to limited commercial batches.

11.5 Packaging:

Packaging costs are forecasted at \$5,000 in 2026, increasing by 10% annually. This estimate is grounded in market research for consumer healthcare and personal care packaging, adjusted for moderate volumes. The increase accounts for scaling as distribution expands, while maintaining premium, eco-friendly packaging that aligns with ARBOGuard's sustainability mission.

11.6 Quality Assurance (QA):

QA is projected at \$25,000 in 2026, rising to \$33,275 by 2029. This category includes biosafety testing, third-party lab validation, and compliance audits. The assumption is that rigorous testing will be required in the early years to establish trust and meet regulatory standards. Incremental increases reflect ongoing testing as volumes scale, but at a controlled growth rate since much of the infrastructure is established early.

11.7 Warehouse, Distribution, and Retail Placement:

Storage and distribution begin modestly at \$2,000 and \$12,000 respectively in 2026, with retail placement estimated at \$8,000. These values are based on average industry costs for logistics in personal care products. We assume steady annual increases (10–12%) to reflect broader reach into new retail channels and expanded partnerships. Placement costs grow as shelf space and promotional agreements are secured with retailers and NGOs.

11.8 Marketing and Advertising:

Marketing begins conservatively at \$5,000 in 2026, focusing on digital campaigns, educational outreach, and partnerships with NGOs. Annual growth of 10% is assumed, scaling in proportion to distribution. This reflects a lean, targeted marketing approach



typical of early biotech consumer health products, while allowing for gradual brand building.

Overall, ARBOGuard's cost structure emphasizes high upfront investment in R&D and regulatory processes, followed by steady increases in manufacturing, logistics, and marketing as the product transitions into the market. This approach ensures biosafety, quality, and accessibility are maintained while establishing ARBOGuard as a trusted, innovative solution in the mosquito-repellent market.

12. Regulatory and Safety Considerations

Developing ARBOGuard as a microbiome-based mosquito repellent requires careful navigation of regulatory frameworks in Canada, the United States, and globally. In Canada, we have already taken proactive steps by reaching out to Health Canada and the Pest Management Regulatory Agency (PMRA). Specifically, we have submitted both a Subject to Registration inquiry and a Label Use Form to ensure our product aligns with national safety, labeling, and compliance requirements. We've also reached out to government evaluators at the PMRA and regulatory affairs professionals to understand the most probable classification pathway and data requirements. These actions mark the beginning of our dialogue with regulatory authorities to establish ARBOGuard's path to approval.

12.1 Pathway in Canada

In Canada, ARBOGuard falls under the Pest Management Regulatory Agency (PMRA) as a pest control product. Based on feedback from a scientific evaluator at PMRA, the product is likely to be considered a non-conventional pest control product. To begin the process, we have already submitted a Subject to Registration inquiry and Label Use Form, which were acknowledged, with a formal response expected in November 2025.

The PMRA evaluator explained that our submission could follow several possible routes:

- **Category B:** Applicable if our active ingredient has a precedent registration. This pathway requires primarily acute toxicity studies (oral, inhalation, eye/skin irritation, and sensitization), guided by OECD protocols.
- **Category L:** Possible if our formulation is similar to previously registered products, which could reduce the scope of data requirements.
- **Category A:** Necessary if our active ingredient is entirely novel. This would require a full toxicological dataset, including long-term studies on carcinogenicity, neurotoxicity, reproductive toxicity, and genotoxicity.

The evaluator emphasized that beyond toxicology, other PMRA review teams (e.g., chemistry, environmental safety) will assess factors such as manufacturing processes,



impurities, and ecological impact. This feedback is already shaping our testing roadmap and experimental design.

12.2 International and U.S. Pathways

In the United States, the Environmental Protection Agency (EPA) would oversee ARBOGuard under its Biopesticides and Pollution Prevention Division. The U.S. framework is sometimes more flexible than Canada's, and some startups launch there first. However, for ARBOGuard, our strategy prioritizes the Canadian pathway first due to its clearer and more structured approval process. This will also serve as a model to align with international standards established by the WHO and OECD, ensuring adaptability to global markets.

12.3 Biocontainment and Public Health Policies

As ARBOGuard relies on engineered *Staphylococcus epidermidis*, biocontainment and biosafety are central to its design. Our approach prioritizes strategies such as controlled gene expression, genetic safeguards, and post-market monitoring to minimize risks of unintended environmental spread. Public health policies also require us to demonstrate that engineered microbes will not adversely affect the natural skin microbiome, human health, or ecological systems. Continued engagement with regulators ensures these safety standards are met.

Our consultations with regulatory professionals reinforced several priority areas:

- **Toxicology:** Demonstrating product safety through dermal/eye irritation studies, sensitization testing, and acute exposure analysis.
- **Environmental fate:** Evaluating how engineered phages behave if released into non-target systems such as animals, aquatic environments, or the human gut microbiome.
- **Horizontal gene transfer:** Addressing the potential risk of antibiotic resistance transfer.
- **Stability:** Establishing product shelf life and formulation stability as prerequisites for regulatory approval.
- **Biocontainment:** Incorporating genetic safeguards such as controlled expression systems and kill switches to minimize risks of environmental spread.

These considerations will guide our toxicology and environmental testing plan, ensuring regulatory readiness and scientific rigor.

12.4 Ethical, Legal, and Communication Considerations

Introducing engineered microbes into consumer-facing products raises unique ethical and communication challenges that must be addressed proactively. Our approach emphasizes transparency and trust through clear labeling, public education, and accessible messaging to demystify the role of bacteriophages. We prioritize effective science communication, using approachable visuals and simplified language such as illustrated graphics to reduce consumer concerns about the misconceptions. To further build confidence, we draw on precedent awareness, highlighting successful examples such as Phyla Skincare, a U.S. phage-based cosmetic that demonstrates both regulatory acceptance and consumer trust in microbiome-based innovations. At the same time, we are committed to strong legal protections, ensuring robust intellectual property ownership (currently held by the uOttawa iGEM team, with additional filings planned as formulations mature), while also addressing liability concerns and complying with international GMO trade regulations. Together, these efforts form the foundation of our ethical, legal, and communication strategy, positioning ARBOGuard as a safe, responsible, and trustworthy innovation.

Table 1. Regulatory, Safety, and Ethical Framework for ARBOGuard

Regulatory Pathways	Safety Measures	Ethical & Legal Considerations
Submitted Subject to Registration inquiry and Label Use Form to Health Canada/PMRA	Biocontainment strategies (genetic safeguards, controlled expression, post-market monitoring)	Transparent labeling and communication with consumers
Preparing alignment with EPA (U.S.) and international standards (WHO, OECD)	Public health compliance to ensure no harm to skin microbiome or environment	Intellectual property, liability, and compliance with GMO trade regulations
Building roadmap adaptable for global approval and risk assessment frameworks	Risk evaluation of engineered microbes in human and environmental contexts	Ethical biotech practices to foster public trust and acceptance

12.4 Strategic Next Steps

To advance ARBOGuard toward regulatory approval, we plan to prepare for a pre-consultation meeting with the PMRA once preliminary formulations and supporting data are ready. In parallel, we will gather decision summaries and approval packages for topical repellents previously registered under PMRA to strengthen our submission strategy and anticipate potential requirements. A comprehensive testing plan will be developed that covers toxicology, environmental safety, and efficacy studies, including mosquito landing reduction trials to demonstrate effectiveness. Recognizing the importance of audience-specific engagement, we will design tailored communication strategies for regulatory



bodies and for the general public to ensure clarity, transparency, and trust. Finally, as product specifications become more defined, we will advance intellectual property protections to secure ARBOGuard's innovative platform and safeguard long-term commercialization.

13. Sustainability and Impact

13.1 Environmental Sustainability

Sustainability is embedded in the design and vision of ARBOGuard. From an environmental perspective, ARBOGuard reduces reliance on synthetic chemical repellents such as DEET or pyrethroids, which often accumulate in water systems and harm non-target insect species. Instead, it leverages the skin microbiome and engineered phages to provide long-lasting protection with minimal reapplication, decreasing packaging turnover and waste. By avoiding widespread pesticide use, our product also contributes to biodiversity preservation, supporting pollinator health and ecosystem stability.

13.2 Social Sustainability

Socially, ARBOGuard is built around accessibility and equity. Mosquito-borne diseases disproportionately impact vulnerable groups such as children, pregnant women, outdoor workers, and displaced populations. By providing a safe, affordable, and long-lasting repellent, our repellent reduces disease burden in at-risk communities, improves school and work attendance, and alleviates strain on healthcare systems. Education campaigns and transparent regulatory engagement will further ensure that users understand and trust the technology, empowering communities to take ownership of their health.

13.3 Economic Sustainability

Economically, ARBOGuard emphasizes affordability and scalability. Its long duration of action reduces the need for frequent purchases, lowering costs for individuals and families. At the systemic level, stable procurement contracts with NGOs and Ministries of Health will provide predictable revenue streams while ensuring broad distribution in high-need regions. Over time, partnerships with local manufacturers will further reduce costs, create employment opportunities, and stimulate regional economies, reinforcing both sustainability and resilience.

13.4 Alignment with UN Sustainable Development Goals (SDGs)

ARBOGuard's impact aligns strongly with the United Nations Sustainable Development Goals (SDGs). It supports SDG 3 (Good Health and Well-Being) by reducing mosquito-borne disease transmission, SDG 9 (Industry, Innovation, and Infrastructure) by



pioneering a new category of microbiome-based biotechnology, SDG 10 (Reduced Inequalities) through affordable access for underserved populations, SDG 13 (Climate Action) by responding to the shifting distribution of mosquito populations caused by climate change, and SDG 15 (Life on Land) by reducing pesticide reliance and supporting biodiversity.

13.5 Measures of Success

To measure success, ARBOGuard will track health outcomes such as bite reduction and disease incidence, environmental impact via life-cycle analysis of packaging and chemical use, accessibility metrics such as the proportion of low-income and at-risk populations reached, and economic performance through cost savings for users and procurement revenue. Finally, user acceptance, public trust, and repeat adoption will serve as key indicators of long-term social sustainability and impact.

ARBOGuard's Sustainability Framework

Table 2. Environmental, Social, and Economic Sustainability Outcomes

Environmental Sustainability	Social Sustainability	Economic Sustainability
Reduces reliance on synthetic chemicals (DEET, pyrethroids) that pollute waterways and harm biodiversity	Provides affordable, long-lasting protection for vulnerable populations (children, pregnant women, outdoor workers, displaced communities)	Reduces reapplication frequency, lowering annual household costs
Decreases packaging waste through fewer applications	Improves health equity by reducing disease burden and healthcare strain	Stable procurement contracts with NGOs & Ministries of Health
Protects pollinators and ecosystems by avoiding indiscriminate pesticide use	Builds trust via education campaigns, transparent regulation, and healthcare endorsements	Local manufacturing partnerships create jobs and stimulate regional economies

Sustainability is central to the mission of ARBOGuard. Beyond providing a safe and effective solution to mosquito-borne diseases, the project was intentionally designed with the triple bottom line in mind: protecting the environment, advancing social well-being, and fostering economic resilience. The table above outlines how ARBOGuard's development and deployment strategy addresses each of these dimensions, ensuring that the solution is not only scientifically innovative but also ethically responsible, socially equitable, and economically viable



14. Milestones and Roadmap

14.1 What Has Been Achieved

Since the start of our project ARBOGuard, our team has moved beyond concept to achieve significant early milestones in both research and stakeholder engagement. We successfully completed the foundational design and proof-of-concept for our microbiome-based mosquito repellent by developing a genetic engineering strategy for *Staphylococcus epidermidis* in combination with bacteriophage delivery. To strengthen the robustness of our approach, we engaged external advisors in biosafety and regulatory affairs, validating our preliminary safety strategy and incorporating their recommendations into our design. In addition, we reached out to several key stakeholders, including scientific evaluators at the Pest Management Regulatory Agency (PMRA), professionals in regulatory affairs, public health experts, and industry advisors, to clarify classification pathways, regulatory expectations, and safety considerations. Complementing this, we initiated early community-facing efforts through ethics-approved public opinion surveys to better understand consumer perceptions of microbiome-based solutions.

Parallel to our technical and regulatory progress, we have built strong organizational capacity and visibility. We established sponsorship partnerships with national and international organizations, hosted major synthetic biology events such as the Great Canadian iGEM Meet-Up, and cultivated collaborations with experts in biotechnology, pest management, and health. On the regulatory side, we filed initial inquiries with Health Canada and the PMRA, including a Subject to Registration form and Label Use inquiry, marking the beginning of a formalized approval process. Together, these efforts demonstrate ARBOGuard's momentum as both a scientific innovation and a venture with a clear pathway toward regulatory compliance, stakeholder alignment, and eventual market entry.

14.2 Key Goals: Short-Term (Next 12 Months)

- Finalize laboratory prototypes and validate effectiveness through controlled wet-lab trials.
- Expand partnerships with biotech companies, regulatory consultants, and academic collaborators.
- Secure additional funding and sponsorships to support scale-up and field trial planning.
- Publish results from public surveys and incorporate community feedback into product design.
- Develop a clear regulatory strategy and refine product safety documentation.



14.3 Key Goals: Long-Term (2–5 Years)

- Scale prototype production for larger laboratory and semi-field trials.
- Establish formal collaborations with global health organizations for testing in mosquito-endemic regions.
- Advance regulatory submissions with Health Canada, the U.S. EPA, and international equivalents.
- Position ARBOGuard as a market-ready solution aligned with sustainable development goals (SDGs).
- Explore diversification of the platform to additional microbiome-based applications beyond mosquito repellency.

15. Prototype Scaling, Partnerships, and Trials

The successful development of ARBOGuard requires a carefully phased approach to prototype scaling, supported by strong partnerships and evidence-based testing. Our roadmap emphasizes gradual advancement to ensure that biosafety, efficacy, and regulatory compliance remain central at every stage.

15.1 Prototype Scaling

Our immediate priority is the optimization of the engineered *Staphylococcus epidermidis* strains and phage delivery system under controlled laboratory conditions. Once safety and efficacy benchmarks are validated *in vitro*, we will expand to pilot-scale production using established biomanufacturing pipelines. Partnerships with academic labs and contract development and manufacturing organizations (CDMOs) will allow us to refine our genetic constructs, optimize yields, and develop standardized quality control processes. Scaling will also require robust formulation development across our proposed formats (spray, cream, and stick), coupled with stability and shelf-life testing to ensure feasibility in real-world markets.

15.2 Strategic Partnerships

Collaboration is central to ARBOGuard's success. Our team has already engaged with regulatory experts at PMRA and Health Canada, and we will continue building these relationships to guide product classification and approval requirements. In parallel, partnerships with academic institutions will provide access to advanced laboratory facilities and biosafety expertise, while collaborations with biotech companies will support process development and eventual large-scale manufacturing. Engagement with public health organizations, NGOs, and outdoor health product distributors will further ensure that ARBOGuard is aligned with both global health priorities and market demand.



15.3 Field Trials and Validation

Following laboratory validation, we plan to initiate small-scale controlled field trials in partnership with entomology and public health researchers. These trials will focus on measuring mosquito landing reduction rates in real-world environments while monitoring impacts on the skin microbiome, user safety, and ecological stability. Data from these trials will be used to strengthen regulatory submissions, refine labeling claims, and build market confidence. Once efficacy and safety are confirmed, larger trials will be pursued in high-incidence regions for mosquito-borne diseases in collaboration with NGOs and health authorities.

15.4 Path to Adoption

By following this staged approach, laboratory optimization, pilot-scale production, controlled field testing, and expanded global trials, ARBOGuard will be positioned for responsible, scalable adoption. Each stage not only validates the technology but also builds credibility with regulators, investors, and end-users. This roadmap ensures that by the time ARBOGuard reaches the market, it will have undergone rigorous testing, transparent stakeholder engagement, and alignment with international biosafety and efficacy standards.