The Next Generation: Mentoring and Diversity in the Antibacterial Resistance Leadership Group

Anthony D. Harris,[1] Maria Souli,[2] and Melinda M. Pettigrew;[3] for the Antibacterial Resistance Leadership Group

[1]Department of Epidemiology and Public Health, University of Maryland School of Medicine, Baltimore, Maryland, USA; [2]Duke Clinical Research Institute, Duke University School of Medicine, Durham, North Carolina, USA; and [3]Yale School of Public Health, New Haven, Connecticut, USA

The Antibacterial Resistance Leadership Group (ARLG) Mentoring Program was established to develop and prepare the next generation of clinician-scientists for a career in antibacterial resistance research. The ARLG Diversity, Equity, and Inclusion Working Group partners with the Mentoring Committee to help ensure diversity and excellence in the clinician-scientist workforce of the future. To advance the field of antibacterial research while fostering inclusion and diversity, the Mentoring Program has developed a number of fellowships, awards, and programs, which are described in detail in this article.

Keywords. equity; clinician-scientists; mentorship; antibacterial resistance; underrepresentation.

"If you want one year of prosperity, grow grain,

If you want ten years of prosperity, grow trees,

If you want one hundred years of prosperity, grow people."

—Chinese proverb

MISSION OF THE ANTIBACTERIAL RESISTANCE LEADERSHIP GROUP MENTORING PROGRAM

The mission of the Antibacterial Resistance Leadership Group (ARLG) is to prioritize, design, and execute clinical research that will impact the prevention, diagnosis, and treatment of infections caused by antibiotic-resistant bacteria. The ARLG is composed of over 120 experts working to combat the antibacterial resistance (AR) crisis, improve patient care, and conserve antibiotics for future generations. Achieving these objectives requires a sustained program that simultaneously addresses complex issues from a variety of sectors and perspectives. The ARLG Mentoring Program was established to develop and prepare the next generation of clinician-scientists for a career in AR research.

The Mentoring Program focuses on 3 key elements that are critical to success in clinical and translational research as it pertains to AR:

1. Mentorship by established investigators
2. Mentor-mentee–driven research projects focused on AR
3. Skills in research core competencies

Across the ARLG Mentoring Program, each of these 3 elements are tailored to the career level and specific interests of the mentee. Mentees gain practical experience in research management and team science by being integrated into the ARLG for the years of their mentee tenure.

During the initial grant cycle, "ARLG 1.0," and the first renewal, "ARLG 2.0," a number of individual awards and programs were launched to accomplish this goal. A summary of these key awards is outlined in Table 1. A number of key publications from these awards are the following references [1–10].

DIVERSITY, EQUITY, AND INCLUSION IN THE ARLG

Diversity, equity, and inclusion (DEI) are critical components and core values of the ARLG. Diversity has been shown to increase creativity and innovation, and enhance decision making and problem solving [11]. The ARLG DEI Working Group was created to develop a framework to ensure implementation and full integration of DEI principles throughout the ARLG. This working group is part of the ARLG Scientific Leadership Center. We seek to accomplish this goal by the following:

1. Accessing, monitoring, and evaluating ARLG's DEI success in the current AR landscape
2. Sharing educational and learning opportunities
3. Developing and maintaining an inclusive environment
4. Promoting, mentoring, and developing investigator career advancement opportunities within infectious disease (ID) and AR in particular

Table 1. Awards Available as Part of the Antibacterial Resistance Leadership Group (ARLG) Mentoring Program

Award Name	Eligibility/Targeted Applicant	Award Details	Number Awarded Thus Far by the ARLG	Number of Publications From ARLG Studies
The Dr. John G Bartlett ARLG Fellowship Award	MD, ID fellows	Salary support for up to 2 y, tuition for epidemiology or statistics	11	58
The Early-Stage Investigator Award	Junior faculty: MD, PhD	Up to $50 000 for 1 y	10	33
Early Faculty Seedling Award	Junior faculty: MD, PhD	Up to 50% salary support and up to $25 000 research for up to 2 y	1	0
Early-Stage Investigator Program Promoting Diversity in Antibacterial Resistance Research (EVERYONE)	Junior faculty: MD, PhD, from underrepresented minorities in medicine (URiM)	Up to $50 000 for 1 y	≥2[a]	0

Abbreviation: ID, infectious disease.

[a]Indicates decision pending.

Reductions in the number of clinician-scientists in the workforce have been noted over the past few decades [12], which has implications for biomedical research overall and for AR research in particular. The DEI Working Group partners with the ARLG Mentoring Committee to develop the next generation of diverse and excellent clinician-scientists to advance the AR field and meet workforce needs. The diversity of medical school graduates, trainees, and clinicians does not reflect the demographics of the US population [13, 14]. Mentored K awards (eg, K01/K08/K23), career development awards, are an important step to becoming a federally funded independent investigator [15]. Black, Hispanic, and Native American trainees are underrepresented as K award applicants and K awardees compared with their proportional representation among doctoral and medical degree recipients. Women and Black principal investigators are underrepresented among researchers with multiple National Institutes of Health (NIH) research project grants (eg, R01, UO1) [16]. It is a national priority to increase the diversity of the clinician-scientist workforce. Recommendations to increase the pipeline and address attrition include active assistance and mentoring for early- and midcareer women and members of historically marginalized groups, programs that provide protected time for research training during residency, and a special focus on the time between residency and receipt of a career development award [12]. Research on optimal mentor models highlights the need for networks of mentors with variable areas of expertise, rank, and gender [17]. Factors associated with strong mentorship include advocacy, sponsorship, help with writing grants, and opportunities for networking, which the ARLG provides. There is a need and opportunity to identify new ways to approach the systemic problem of underrepresentation at every level of research.

THE DR. JOHN G. BARTLETT ARLG FELLOWSHIP AWARD (ARLG FELLOWSHIP)

The ARLG Fellowship award was re-named in honor of Dr. John G. Bartlett in 2021. Among Dr. Bartlett's many accomplishments and contributions to the field was his passion for mentoring. He chaired the original ARLG Mentoring Program and led many of its initial efforts. Dr. Anthony Harris became Chair in November 2014. The Dr. John G. Bartlett ARLG Fellowship aims to provide support for ID fellows interested in AR, offering an opportunity to acquire expertise in AR clinical research. The ARLG Fellowship is designed for ID fellows interested in pursuing research, training, and a subsequent career in the patient-oriented study of AR. Recipients are integrated into the ARLG mission and programs and receive salary for up to 2 years with formal training in epidemiology and statistics, the costs of which are covered by the ARLG.

Thus far in ARLG 1.0 and 2.0, the Mentoring Program has had 11 ARLG fellows. Overall, 5 of the 7 ARLG fellows who completed their fellowship are still in academic medicine. These ARLG fellows have had more than 200 publications since they were awarded the ARLG fellowship and 58 publications directly related to ARLG studies. Most notable areas of interest include multidrug-resistant gram-negative infections [9, 18–20], *Staphylococcus aureus* infections [20, 21], febrile illness in India [4, 22], infections in immunocompromised hosts [5, 8, 23], the epidemiology of *Clostridioides difficile* infections [7, 24], exploration of desirability of outcome ranking (DOOR) as an endpoint for registrational trials [25, 26] and other trial design innovations [27], and fecal microbiota transplantation (FMT) [6, 28–30]. The results of a randomized clinical trial by 1 of the ARLG fellows showed that FMT promotes reduction of AR by strain replacement; these data were recently accepted for publication in *Science Translational Medicine*.

THE ARLG EARLY-STAGE INVESTIGATOR AWARD

The purpose of Early-Stage Investigator (ESI) awards is to allow trainees to generate preliminary data leading to additional external funding. The ESI awards provide up to $50 000 in direct costs for 1 year. In ARLG 1.0 and 2.0, the ARLG Mentoring

Program has had 10 ESI awards granted; 9 ESI awardees are still in academic medicine. These ESI awardees have had more than 500 publications since they received their award and 33 publications directly related to ARLG studies.

THE ARLG TRIALIST IN TRAINING PROGRAM

The Trialist in Training Program arose from the need for an additional training track to support junior faculty interested in becoming clinical trialists. These individuals are able to commit to projects for longer than 2 years and are able to integrate into ARLG clinical trials from beginning to completion. This program is an effective mechanism to develop highly skilled investigators focused on AR. Candidates are "embedded" in day-to-day operations of an approved ARLG clinical trial. The trainee receives salary support to develop protocols, identify and train sites, optimize data-management strategies, establish halting rules, define endpoints, and ultimately write and typically be first author on the publication arising from the project.

Thus far, the Mentoring Program has had 8 trialists in training in ARLG 1.0 and 2.0. They have led 12 trials, including Rapid Identification and Susceptibility Testing for Gram Negative Bacteremia, Fast Antibiotic Susceptibility Testing for Gram Negative Bacteremia, the Rapid Diagnostics in Categorizing Acute Lung Infections series, Master Protocol-Gonorrhoeae and Chlamydia Testing of Extragenital Specimens, Dalbavancin as an Option for Treatment of *S. aureus* Bacteremia, Study of the Safety and Microbiological Activity of Bacteriophage in Persons with Cystic Fibrosis Colonized with *Pseudomonas aeruginosa*, Screening for Colonization with Resistant Enterobacterales in Neutropenic Patients with Hematologic Malignancies, Genomics, Sequencing-based Typing, Epidemiology, Linkage, and Antimicrobial Resistance Tool, and others. All trialists in training are still in academic medicine and have had more than 400 publications since they entered the Trialist in Training Program, with 59 publications directly related to ARLG studies.

THE ARLG EARLY FACULTY SEEDLING AWARD

The Early Faculty Seedling Award is a new award created as part of ARLG 2.0 to fill a missing gap in the existing portfolio. It is specifically aimed at junior faculty who need more support and protected time than the ESI award could provide. For example, this award may provide salary support for a junior faculty member who has not yet successfully obtained a career development grant and needs protected time and mentoring to strengthen their portfolio to meet that goal.

This award provides 1 individual with 50% of current salary support annually for protected research for up to 2 years and up to $25 000 in direct costs for research over the 2 years. Thus far, the Mentoring Program has had 1 Early Faculty Seedling

awarded and received a number of additional applications for consideration for future awards.

EARLY-STAGE INVESTIGATOR PROGRAM PROMOTING DIVERSITY IN ANTIBACTERIAL RESISTANCE RESEARCH

The Early-Stage Investigator Program Promoting Diversity in AR Research (EVERYONE) is a new award created as part of ARLG 2.0. The EVERYONE award aims to (1) foster diversity in the field of AR; (2) identify, develop, and support promising investigators in AR research; and (3) allow researchers to generate preliminary data leading to additional external funding. The award provides up to $50 000 in direct costs for 1 year for research in areas related to AR. Individuals should be from underrepresented populations in the extramural scientific workforce, as defined by the NIH. Thus far, the Mentoring Program has received and reviewed 10 applications and intends to fund at least 2 of the 3 most recent applications received, which were of high quality and demonstrated great potential.

ADDITIONAL MENTORING WITHIN THE ARLG

As outlined throughout this article, training the critical generation of mentees may be ARLG's most important role. Thus, many mentees are enrolled in different aspects of the ARLG outside of the awards listed in Table 1.

The ARLG mentees on many different scientific career paths receive mentorship from ARLG investigators and contribute to ARLG publications. Several mentees who are undergraduate students, graduate students, postdoctoral fellows, or junior faculty have been supervised by mentors involved in funded ARLG projects. In ARLG 1.0, 24 such "other mentees" were involved in ARLG projects, and in ARLG 2.0, 25 "other mentees" have been included thus far. In addition, statistical and trial design mentees have been involved in the ARLG Statistical and Data Management Center based at George Washington University. Laboratory mentees work under the supervision of the ARLG Laboratory Center at the Mayo Clinic, and operational mentees participate in the ARLG Clinical Operations Center (COC) at Duke University. In addition, the COC trains clinical trial sites and staff to develop new investigators and research teams that are able to conduct federally funded research in AR, which is especially key to future ARLG efforts to expand diversity in all aspects of AR clinical research. In essence, the ARLG is a comprehensive training ground with many training and mentoring activities in addition to the mentoring awards.

REVIEW PROCESS AND THE ARLG MENTORING COMMITTEE

The ARLG Mentoring Committee currently consists of 16 members who have diverse skill sets and diverse expertise in AR. The review process for the awards is modeled after the

NIH review study sections, which allows applicants (both successful and unsuccessful) to learn from their submission by receiving comments from the committee after review. ARLG applications require a diversity and inclusion plan, and reviewers are asked to evaluate whether the plan is acceptable and makes a significant contribution to the overall proposal. The Mentoring Committee meets on a monthly basis to review applications and to discuss items relevant to the overall mission of the ARLG Mentoring Program.

Across all of the ARLG Mentoring Program awards, mentees are taught about appropriate research methodology; a particular emphasis is placed on teaching methodology for ID studies dealing with AR. As part of the ARLG Fellowship Award specifically, funds are provided for coursework to obtain a Master of Public Health (MPH) or a Master of Science (MSc) in epidemiology. For those award recipients who already have an additional degree in epidemiology, coursework is covered for additional skills that will enhance the mentee's career development.

Antibacterial resistance studies span the spectrum of study designs, including case-control, cohort, quasi-experimental interventional, and randomized controlled studies. Mentees obtain expertise in these study design principles at various leading universities and gain mentoring from ARLG members who have publications on specific study design issues pertaining to AR [31–35]. In addition, the ARLG Statistical and Data Management Center is involved in many aspects of the study design and analyses for ARLG mentee studies. The ARLG Mentoring Committee strives to have mentees obtain epidemiological and statistical research skills that will help them throughout their careers.

FUTURE GOALS OF THE ARLG MENTORING PROGRAM

The ARLG Mentoring Program has been a success. Overall, across all of the awards listed in Table 1, 68% of awardees are still in academic medicine and 100% of those are still studying AR. The program has expanded the types of awards over ARLG 1.0 and 2.0 to fill missing gaps based on feedback from mentees, mentors, and leaders of the ARLG. The Mentoring Program is optimistic about the success of the newly created EVERYONE award and optimistic about the continued success of the recent Early Seedling Award.

The program continues to revise and improve current awards, the review process for applications, and the award process. One specific future direction under consideration is to update the review process to ensure that the accomplishments of the applicant are evaluated in the context of their opportunities. The NIH is recommending changes to the review process for National Research Service Award fellowship applications with the intent of making the process more equitable and effective in identifying the next generation of outstanding scientists. The planned changes are meant to (1) empower peer reviewers to better evaluate the applicant's potential and the quality of the scientific training plan without unwarranted influence of the reputation of the sponsor or institution and (2) ensure that the information provided in the application is aligned with the revised criteria and focused on the specific training needs of the fellowship applicant.

"Tell me and I forget, teach me and I may remember, involve me and I learn."

—Benjamin Franklin, Founding Father of the United States

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