Impact of Global Health Research Training on Scholarly Productivity: The Fogarty International Clinical Research Scholars and Fellows Program

Douglas C. Heimburger,* Catherine Lem Carothers, Meridith Blevins, Tokesha L. Warner, and Sten H. Vermund

Vanderbilt Institute for Global Health, Vanderbilt University, Nashville, Tennessee; Department of Medicine, Vanderbilt University School of Medicine, Nashville, Tennessee; Department of Biostatistics, Vanderbilt University School of Medicine, Nashville, Tennessee; Department of Pediatrics, Vanderbilt University School of Medicine, Nashville, Tennessee; Fogarty International Clinical Research Scholars and Fellows Support Center at Vanderbilt, Vanderbilt University, Nashville, Tennessee; Office of the Vice President for Research, University of Georgia, Athens, Georgia; Vaccine and Infectious Disease Division, Global Oncology, Fred Hutchinson Cancer Research Center, Seattle, Washington

Abstract. In the Fogarty International Clinical Research Scholars and Fellows (FICRS-F) Program, 536 U.S. and international doctoral and postdoctoral health profession students and trainees completed 1-year research training at research centers in low- and middle-income countries. To evaluate the Program's impact, we analyzed data gathered prospectively during the Program, from PubMed, and from a representative survey of alumni. Of 100 randomly selected respondents, 94 returned the survey. Reflecting the sources of funding, human immunodeficiency virus/acquired immunodeficiency syndrome was the focus of 47% of the projects, but research in noncommunicable diseases (NCDs) and dual infection/NCD-related topics increased over time. Among the first 1,617 alumni publications, output was associated positively with being an international versus U.S. trainee, a postdoctoral Fellow versus predoctoral Scholar, and accumulation of more years post-training (all $P < 0.001$). Fellows were first author on a higher proportion of their articles than were Scholars ($P < 0.001$), and U.S. trainees were more often first author than international trainees ($P = 0.04$). Survey respondents had submitted 117 grant applications, and 79 (67.5%) had been funded. The FICRS-F Program yielded substantial research productivity in the early post-training years. Research outputs and impact will increase over time as alumni careers mature and they gain research independence and assume leadership positions.

INTRODUCTION

Interest in experiences and training in global health has increased substantially in recent years among students of medical, public health, and other health professions schools in the United States.¹ Structured training experiences in research, clinical care, and public health in resource-limited settings launched during this period have now matured.^{2–5} From 2004 to 2012, the Fogarty International Clinical Research Scholars and Fellows Program (FICRS-F, www.fogartyscholars.org) provided 1-year research training opportunities for U.S. and international doctoral and postdoctoral health professions students and trainees at research centers in low- and middle-income countries (LMICs). The Program was funded by the Fogarty International Center (FIC) and 15 other institutes, centers, and offices of the U.S. National Institutes of Health (NIH). From 2007 to 2012, the Program was administered by the FICRS Support Center at the Vanderbilt Institute for Global Health through an R24 grant from the FIC. U.S. predoctoral Scholars and U.S. and international postdoctoral Fellows were selected through competitive centralized processes managed by the Support Center, and international Scholars (“twins”) were selected by the international research sites to work alongside the selected U.S. Scholars.^{6,7} From 2004 to 2007, the Program was limited to predoctoral Scholars from the United States and their international counterparts; beginning in 2008, the Program was expanded to include postdoctoral Fellows from the United States and LMICs.

The FICRS-F Program's goals were to foster the next generation of global health-focused clinical investigators and to help build global health research partnerships between United States and international investigators and institutions. Trainees gained hands-on experience at research centers funded by the

NIH in LMICs in Africa, Asia, Central and South America, the Caribbean, and eastern Europe.¹ To support local institutions in their efforts to mentor research trainees entirely in the international sites, the Program provided both training and capacity building for research in the foreign sites. In 2012, FIC decentralized the Program among 20 institutions in five consortia (Global Health Program for Fellows and Scholars).⁸ In prior publications, we have documented the FICRS-F Program's structure, participating NIH institutes and centers, research training sites, countries, and affiliated U.S. institutions, and the trainees' demographics and regions and countries of origin¹; the Program's methods of recruitment and selection of doctoral Scholars⁶ and postdoctoral Fellows,⁷ including factors associated with success in enrolling in the Program; lessons learned from management and administration of the Program⁹; narrative reflections of Program alumni¹⁰; and impacts of the Program on the career trajectories of alumni.¹¹

To evaluate and document the Program's global research impact, we analyzed multiple variables of interest from data gathered prospectively during the Program. A survey of alumni conducted after the Program's completion provided additional data and trainee experiences.

METHODS

Throughout the Support Center's administration of the FICRS-F Program, Support Center staff prospectively collected extensive data of interest on all trainees and Program alumni, and entered them into FIC's online CareerTrac database. CareerTrac data included sex, race (American trainees only), region of origin, trainee category (U.S. versus international and Scholar versus Fellow), year of training initiation, duration of FICRS-F-supported training, and region and country of training. We divided the trainees' research areas into three major disease categories (infectious diseases, noncommunicable diseases [NCD], and dual infectious/NCDs); 23 additional disease subcategories; and five special populations categories

*Address correspondence to Douglas C. Heimburger, Vanderbilt Institute for Global Health, Vanderbilt University, Nashville, TN 37203. E-mail: douglas.heimburger@vanderbilt.edu

(women, children, adolescents, aging, and animals). Within infectious diseases, we designated human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS) and non-HIV sexually transmitted infections (STIs) as major subcategories. We searched PubMed for Scholar and Fellow publications, and categorized and analyzed in depth publications indexed through October 15, 2013.

To supplement the CareerTrac and PubMed data with impact-relevant variables that these sources did not capture, we surveyed 100 Program alumni between May 7 and October 23, 2013, using Vanderbilt's web-based survey and database tool, REDCap™ (<http://projectredcap.org/>). The selection of survey participants was random, but selection probability was weighted such that the combination of program (U.S. and international, Scholar and Fellow) and year of training should have a distribution similar to that of the entire program. The evaluation included questions on accomplishments, ongoing collaborations, career influences, continuing research, evolution of the trainees' interest in global health, return visits to the training sites, and trainees they had mentored. We reported results from these survey questions previously.¹¹ The survey also asked alumni for numbers of publications, posters presented, and grant applications submitted and obtained, which we report here.

U.S. and LMIC trainees were classified as having completed the Scholar program, Fellow program, or both. The latter denotes persons who first were Scholars and were then supported as Fellows in subsequent years. Descriptive statistics were used to summarize trainee characteristics, research areas, and publication outputs by type of trainee. We used

counts and percentages for categorical data and medians with interquartile ranges for continuous data. To estimate the association between trainee characteristics and publication output, we used multivariable linear regression with number of publications or first-author publications as the outcome. Specifically, program type, start year, number of years in program, sex, country of origin, major research area, and research on special populations were included in the model as covariates of interest. Too few of them had PhD degrees alone, so we elected not to enter degree into our regression models. An interaction term was included between training program and start year to fit the hypothesis that trainee publication output would differ by number of years elapsed since training. R-software 3.1.2 (www.r-project.org) was used for all data analyses, including a word cloud.

RESULTS

The FICRS-F Program deployed 436 Scholars (often doctoral trainees in medicine or other health sciences) and 122 Fellows (postdoctoral health professionals)—totaling 558—in mentored clinical research training experiences at 61 NIH-funded sites in 27 countries. These comprised 540 individuals, as 18 persons were supported first as Scholars and subsequently reapplied and were supported as Fellows. Here we report outcomes for the 536 (99.3%) individuals who completed a year of supported research training in either or both capacities.

CareerTrac results. Table 1 shows FICRS-F trainee characteristics by type of trainee and year of enrollment. Trainees

TABLE 1
Fogarty International Clinical Research Scholar and Fellow Characteristics by type of trainee

	U.S. Scholar	International Scholar	U.S. Fellow	International Fellow	U.S. both*	International both*	Combined
<i>N</i>	210	203	63	42	6	12	536
Doctoral level	Predoctoral	Pre- and postdoctoral	Postdoctoral	Postdoctoral	—	—	—
Means of selection	Competitive, centralized	Managed by international sites	Competitive, centralized	Competitive, centralized	—	—	—
Start year, <i>n</i> (%)							
2004	17 (8%)	14 (7%)	0 (0%)	0 (0%)	3 (50%)	1 (8%)	35 (7%)
2005	23 (11%)	28 (14%)	0 (0%)	0 (0%)	2 (33%)	0 (0%)	53 (10%)
2006	21 (10%)	24 (12%)	0 (0%)	0 (0%)	1 (17%)	2 (17%)	48 (9%)
2007	26 (12%)	19 (9%)	0 (0%)	0 (0%)	0 (0%)	1 (8%)	46 (9%)
2008	32 (15%)	31 (15%)	15 (24%)	15 (36%)	0 (0%)	3 (25%)	96 (18%)
2009	31 (15%)	29 (14%)	10 (16%)	9 (21%)	0 (0%)	4 (33%)	83 (15%)
2010	37 (18%)	36 (18%)	18 (29%)	10 (24%)	0 (0%)	1 (8%)	102 (19%)
2011	23 (11%)	22 (11%)	20 (32%)	8 (19%)	0 (0%)	0 (0%)	73 (14%)
Years of deployment, <i>n</i> (%)							
1 year	209 (100%)	202 (100%)	41 (65%)	35 (83%)	N/A	N/A	487 (91%)
> 1 year	1 (< 1%)	1 (< 1%)	22 (35%)	7 (17%)	6 (100%)	12 (100%)	49 (9%)
Sex, <i>n</i> (%)							
Female	122 (58%)	94 (46%)	38 (60%)	26 (62%)	0 (0%)	6 (50%)	286 (53%)
Male	88 (42%)	109 (54%)	25 (40%)	16 (38%)	6 (100%)	6 (50%)	250 (47%)
Region of origin, <i>n</i> (%)							
East Asia and Pacific	3 (1%)	31 (15%)	0 (0%)	6 (14%)	0 (0%)	0 (0%)	40 (7%)
Europe and Central Asia	3 (1%)	2 (1%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	5 (1%)
Latin America and Caribbean	3 (1%)	59 (29%)	0 (0%)	8 (19%)	0 (0%)	7 (58%)	77 (14%)
North America	193 (92%)	1 (< 1%)	60 (95%)	0 (0%)	6 (100%)	0 (0%)	260 (49%)
South Asia	2 (1%)	31 (15%)	0 (0%)	1 (2%)	0 (0%)	0 (0%)	34 (6%)
Sub-Saharan Africa	6 (3%)	79 (39%)	3 (5%)	27 (64%)	0 (0%)	5 (42%)	120 (22%)
Race (U.S. trainees only), <i>n</i> (%)							
American Indian or Alaskan	1 (1%)	—	0 (0%)	—	0 (0%)	—	—
Asian	41 (21%)	—	12 (21%)	—	1 (17%)	—	—
Black or African-American	7 (4%)	—	6 (11%)	—	0 (0%)	—	—
Chose not to specify	4 (2%)	—	2 (4%)	—	0 (0%)	—	—
White	143 (73%)	—	37 (65%)	—	5 (83%)	—	—

*"Both" denotes trainees supported first as a Scholar and in a subsequent year as a Fellow. For these individuals, the first year of enrollment is used as the index date for analyses.

FIGURE 1. Fogarty International Clinical Research Scholars and Fellows research areas by start year.

were nearly evenly divided between women (53%) and men (47%); 49 (9%) of them were extended with support for a second year within their Scholar or Fellow role. Reflecting the Program's design, 52% were of U.S. origin and 48% were international, and the international trainees' regions of origin were diverse. Regionally, sub-Saharan Africa contributed the most international trainees (120). Peru, China, South Africa, India, and Kenya contributed more international trainees (at least 20 each) than did other countries, but no country other than the United States contributed more than 8% of the total. Among U.S. trainees, 71% reported their race as white, 21% as Asian, 5% as African-American, and 3% as other or chose not to specify.

Figure 1 shows trends in the major research categories (infectious diseases, NCDs, and combined infectious/NCD) pursued by trainees over the years of FICRS-F. In addition to an increase in total research projects in 2008 when the Fellows Program was instituted, the graph shows an increase in NCD and infectious/NCD research in the Program's last 4 years. Comparing 2004–2007 with 2008–2011, the proportion of infectious disease-only projects declined from 84% to 60% (52% in the final year, 2011), whereas projects focused on NCDs or infectious/NCDs increased from 16% to 40% (52% in the final year, 2011). Table 2 shows subcategories of

TABLE 2
Fogarty International Clinical Research Scholar and Fellow Research Areas by type of trainee

	U.S. Scholar	International Scholar	U.S. Fellow	International Fellow	U.S. both	International both	Combined
<i>N</i>	210	203	63	42	6	12	536
Major research area, <i>n</i> (%)							
Infectious	150 (72%)	132 (73%)	30 (48%)	25 (61%)	3 (50%)	6 (50%)	346 (68%)
Noncommunicable	25 (12%)	31 (17%)	22 (35%)	10 (24%)	0 (0%)	2 (17%)	90 (18%)
Noncommunicable and infectious	33 (16%)	17 (9%)	11 (17%)	6 (15%)	3 (50%)	4 (33%)	74 (15%)
HIV/AIDS and/or STIs							
HIV/AIDS	112 (53%)	84 (41%)	27 (43%)	19 (45%)	5 (83%)	7 (58%)	254 (47%)
STIs (non-HIV)	37 (18%)	17 (8%)	8 (13%)	6 (14%)	0 (0%)	2 (17%)	70 (13%)
Specific topic							
Allergy or immunology	20 (10%)	19 (9%)	3 (5%)	4 (10%)	0 (0%)	1 (8%)	47 (9%)
Basic science (genetics, molecular biology, pathology)	33 (16%)	45 (22%)	10 (16%)	8 (19%)	1 (17%)	1 (8%)	98 (18%)
Health behavior	55 (26%)	17 (8%)	10 (16%)	7 (17%)	2 (33%)	7 (58%)	98 (18%)
Cancer	25 (12%)	14 (7%)	7 (11%)	6 (14%)	0 (0%)	1 (8%)	53 (10%)
Cardiology	17 (8%)	13 (6%)	10 (16%)	8 (19%)	0 (0%)	2 (17%)	50 (9%)
Dermatology	6 (3%)	3 (1%)	2 (3%)	1 (2%)	1 (17%)	0 (0%)	13 (2%)
Diabetes/kidney/metabolic	9 (4%)	8 (4%)	2 (3%)	3 (7%)	1 (17%)	1 (8%)	24 (4%)
Diarrheal diseases	21 (10%)	19 (9%)	1 (2%)	1 (2%)	0 (0%)	1 (8%)	43 (8%)
Eye diseases	3 (1%)	1 (< 1%)	3 (5%)	2 (5%)	0 (0%)	1 (8%)	10 (2%)
Environmental health	15 (7%)	14 (7%)	0 (0%)	1 (2%)	1 (17%)	2 (17%)	33 (6%)
Health care systems	43 (20%)	14 (7%)	13 (21%)	4 (10%)	1 (17%)	3 (25%)	78 (15%)
Maternal and child health	30 (14%)	16 (8%)	8 (13%)	5 (12%)	1 (17%)	3 (25%)	63 (12%)
Mental health	6 (3%)	3 (1%)	6 (10%)	3 (7%)	1 (17%)	1 (8%)	20 (4%)
Neurological disease and stroke	13 (6%)	15 (7%)	6 (10%)	3 (7%)	1 (17%)	1 (8%)	39 (7%)
Nutrition	15 (7%)	19 (9%)	3 (5%)	5 (12%)	2 (33%)	0 (0%)	44 (8%)
Parasitology	35 (17%)	27 (13%)	7 (11%)	4 (10%)	2 (33%)	1 (8%)	76 (14%)
Pulmonary	43 (20%)	21 (10%)	7 (11%)	7 (17%)	3 (50%)	3 (25%)	84 (16%)
Substance abuse	10 (5%)	4 (2%)	1 (2%)	1 (2%)	0 (0%)	0 (0%)	16 (3%)
Surgery/trauma	4 (2%)	0 (0%)	5 (8%)	1 (2%)	1 (17%)	1 (8%)	12 (2%)
Tobacco	1 (< 1%)	1 (< 1%)	0 (0%)	1 (2%)	0 (0%)	0 (0%)	3 (1%)
Tuberculosis	35 (17%)	19 (9%)	4 (6%)	5 (12%)	3 (50%)	3 (25%)	69 (13%)
Oral	5 (2%)	2 (1%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	7 (1%)
Other	10 (5%)	2 (1%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	12 (2%)
Special populations							
Aging	1 (< 1%)	2 (1%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	3 (1%)
Women	49 (23%)	28 (14%)	12 (19%)	6 (14%)	1 (17%)	5 (42%)	101 (19%)
Children	46 (22%)	29 (14%)	14 (22%)	11 (26%)	1 (17%)	2 (17%)	103 (19%)
Adolescents	11 (5%)	2 (1%)	1 (2%)	1 (2%)	0 (0%)	1 (8%)	16 (3%)
Animals	7 (3%)	4 (2%)	0 (0%)	2 (5%)	0 (0%)	1 (8%)	14 (3%)

AIDS = acquired immunodeficiency syndrome; HIV = human immunodeficiency virus; STI = sexually transmitted infection.

TABLE 4
Most cited global health articles with Fogarty International Clinical Research Scholar and Fellow Alumni as first author and as coauthor

First author		Coauthor	
Journal, year	Title	Journal, year	Title
<i>Acad Med</i> , 2007	Global health in medical education: a call for more training and opportunities	<i>Science</i> , 2010	Effectiveness and safety of tenofovir gel, an antiretroviral microbicide, for the prevention of HIV infection in women
<i>Acad Med</i> , 2009	Global health training and international clinical rotations during residency: current status, needs, and opportunities	<i>Lancet</i> , 2012	DALYs for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010
<i>J Am Coll Cardiol</i> , 2011	Incidence of cardiovascular risk factors in an Indian urban cohort results from the New Delhi birth cohort	<i>Lancet</i> , 2012	YLDs for 1,160 sequelae of 289 diseases and injuries 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010
<i>J Am Coll Cardiol</i> , 2013	HIV and cardiovascular disease in Sub-Saharan Africa: The Sutton Law as applied to global health	<i>N Engl J Med</i> , 2010	Timing of initiation of antiretroviral drugs during tuberculosis therapy
<i>BMC Infect Dis</i> , 2006	Male circumcision, religion, and infectious diseases: an ecologic analysis of 118 developing countries	<i>N Engl J Med</i> , 2010	Pediatric hospitalizations associated with 2009 pandemic influenza A (H1N1) in Argentina
<i>Nature Rev. Microbiol</i> , 2009	Cholera transmission: the host, pathogen, and bacteriophage dynamic	<i>Lancet</i> , 2007	Syphilis in China: results of a national surveillance program
<i>PLoS One</i> , 2009	Within-subject variability of interferon- γ assay results for tuberculosis and boosting effect of tuberculin skin testing: a systematic review	<i>JAMA</i> , 2007	Clinical outcomes and CD4 cell response in children receiving antiretroviral therapy at primary health care facilities in Zambia
<i>Am J Resp Crit Care Med</i> , 2009	Within-subject variability and boosting of T-cell interferon- γ responses after tuberculin skin testing	<i>N Engl J Med</i> , 2010	Maternal or infant antiretroviral drugs to reduce HIV-1 transmission
<i>Sex Transm Dis</i> , 2006	China's syphilis epidemic: a systematic review of seroprevalence studies	<i>Acad Med</i> , 2007	Global health in medical education: a call for more training and opportunities
<i>N Engl J Med</i> , 2010	Syphilis and social upheaval in China	<i>Acad Med</i> , 2009	Global health training and international clinical rotations during residency: current status, needs, and opportunities

DALY = disability-adjusted life year; HIV = human immunodeficiency virus; YLD = year lived with disability. Citations were analyzed as of October 2013.

Linear regression on correlates of first-author publication output yielded similar results, with Fellow (versus Scholar, $P < 0.001$), training in earlier Program years (versus later, $P < 0.001$), and the interaction of these terms ($P = 0.001$) associated with significantly higher first-author publication

output (Table 5). After controlling for these variables in the same regression model as above, however, LMIC trainees had lower first-author output ($P = 0.04$). Other significant factors were 2 or more years in the program (higher output, $P = 0.006$) and pursuit of research involving children (lower

TABLE 5
Factors associated with Fogarty International Clinical Research Scholar and Fellow publication output in multivariable linear regression

	Total publications		First-author publications	
	Effect (95% CI)	P value	Effect (95% CI)	P value
Program type and start year interaction		0.001*		0.001*
Scholars (per 1 year passed)	0.42 (0.23, 0.61)	—	0.12 (0.04, 0.19)	—
Fellows (per 1 year passed)	1.59 (0.90, 2.3)	—	0.59 (0.31, 0.87)	—
Number of years in program		0.01		0.006
1 year only (referent group)	0	—	0	—
2 or more years	1.63 (0.33, 2.92)	—	0.73 (0.21, 1.25)	—
Female	−0.53 (−1.27, 0.20)	0.16	−0.15 (−0.44, 0.15)	0.323
Country of origin		< 0.001		0.043
United States (referent group)	0	—	0	—
LMIC	1.33 (0.60, 2.05)	—	−0.30 (−0.59, −0.01)	—
Major research area		0.93		0.729
Infectious (referent group)	0	—	0	—
Noncommunicable	−0.04 (−1.05, 0.96)	—	0.16 (−0.25, 0.56)	—
Noncommunicable and infectious	0.19 (−0.86, 1.25)	—	0.08 (−0.34, 0.51)	—
Research experience involved women	0.27 (−0.66, 1.19)	0.57	−0.09 (−0.46, 0.29)	0.652
Research experience involved children	−1.16 (−2.06, −0.26)	0.012	−0.47 (−0.83, −0.10)	0.012
Research experience involved animals	−1.66 (−3.87, 0.55)	0.14	−0.72 (−1.60, 0.17)	0.112

CI = confidence interval; LMIC = low- and middle-income countries.

This model includes 510 scholars and fellows (26 individuals were missing data on major research area). Participants who completed both programs were included in this model as Scholars.

*There is evidence of association for program type ($P < 0.001$), start year ($P < 0.001$), and their interaction ($P = 0.001$).

output, $P = 0.012$). We did not detect a difference by trainee sex, major research area, research involving women, and research involving animals.

Survey results. Among the 100 alumni randomly selected for the intensive survey in 2013, we achieved a response rate of 94% (38 U.S. and 34 international doctoral Scholars and 15 U.S. and seven international postdoctoral Fellows).¹¹

Accomplishments derived directly from work done by the survey respondents during their training period included 207 primary research papers (2.2 per trainee), 14 book chapters, 52 review articles, 32 other publications (e.g., letters, editorials, commentaries, book reviews), and 215 poster presentations. U.S. Fellows had published four (median; IQR: 2–7) papers; international Fellows two (1–4); U.S. Scholars one (0–2); and international Scholars one (1–2) papers. Most participants had presented two or more posters at scientific meetings. Respondents reported submission of 117 grant proposals derived directly from work done during training by U.S. Fellows ($N = 37$), U.S. Scholars ($N = 22$), international Fellows ($N = 17$), and international Scholars ($N = 41$). These 94 alumni received 30 U.S. government-funded grants and 49 non-U.S. government-funded grants (total 79 funded, estimated success rate = 67.5%).

DISCUSSION

During its 8 years of operation, the NIH FICRS-F Program supported a large number of pre- and postdoctoral trainees from the United States and LMICs in yearlong LMIC-based research training experiences. Our analysis shows that FICRS-F alumni were productive in terms of research publications and grant applications, and they had been relatively successful in obtaining grant awards. Accomplishments that may be directly linked to the FICRS-F experience are numerous, and there is evidence that productivity increases over time. Although predoctoral Scholars were less productive within the first several years of their training, this is to be expected as they were mostly students (versus postdoctoral Fellows). The output of former Scholars may become more evident in future years as they complete formal training and play more active roles in determining the directions of their careers. Postdoctoral Fellows were productive in these output metrics and were also moving toward independence in global health research, as judged by first-author publications, grant applications submitted, and grants awarded.

Scholarly output, both publications and grant applications, was higher from trainees supported in the Program's earlier years, who had thus accumulated more post-training years. Of interest, LMIC alumni coauthored more total publications than did U.S. alumni, but U.S. alumni were first author on a larger proportion than were LMIC alumni. The higher age of international Scholars versus U.S. Scholars (median 32 versus 27 years, and indistinguishable from the ages of U.S. and international Fellows) and/or the higher proportion of biomedical scientists among international Scholars¹ may have given LMIC alumni an advantage in total publication output, but the greater output of Fellows versus Scholars mitigates against this speculation (Table 5). Similarly, there was a higher proportion of men among international Scholars, but sex was not correlated with publication output. The higher first-author publication output of U.S. alumni could indicate that U.S. postdoctoral trainees moved more quickly into

research independence than did LMIC alumni, who might have faced greater competing demands, such as for teaching or patient care, after their FICRS-F fellowships. LMIC alumni may also have worked within larger collaborative groups, and thus had to compete in larger author pools for first authorship. They might also have been subject to institutional guidelines or expectations favoring supervisors or senior colleagues as first authors, or publication circumstances (e.g., facility with English language writing) that favored U.S. authors. PubMed's show of greater total output from international Scholars (Table 3) suggests that our survey, although designed to be randomly representative of the overall alumni pool, may not have captured this group adequately.

Research conducted by FICRS-F trainees evolved from primarily infectious diseases in the Program's early years to a substantial proportion of research on NCDs and infection-related NCDs. This reflected a trend in global health research investments and priorities of the NIH institutes, centers, and offices that invested into the program, toward more global NCD research that is likely to continue into the future.^{12,13}

Our productivity impact evaluation has strengths and limitations. Our findings benefit from prospective collection of much of the data and from PubMed, which does not depend on responses from or perceptions of Program alumni. The high response to our representative survey of alumni yielded additional results about grant submissions and awards, as well as information of a more reflective nature, but its variance from PubMed's findings may indicate that it underrepresented publication output from international Scholars. Our findings would have been strengthened by inclusion of a comparison group, but no such group was followed in the Program.

The investment of NIH institutes and centers into the FICRS-F Program yielded substantial research productivity in the early years following the trainees' completion of support. Research outputs and impact will increase over time as alumni careers mature and they gain research independence and assume leadership positions. Impacts on LMIC institutions will be harder to measure, but many alumni, both U.S. and (especially) LMIC alumni remain engaged at the LMIC training sites,¹¹ and will contribute for years to come. We believe, but cannot prove, that formal research training, with U.S. institutional linkages, will incentivize LMIC clinical scientists to remain in their home countries, and represent a concrete effort to build expertise and opportunities that may curtail the long-standing "brain drain" to high-income nations.^{14–16} In this manner, the successor Fogarty Global Health Fellows and Scholars Program continues to equip U.S. and LMIC Fellows and Scholars⁸ for effectiveness in global health research, and they are likely to contribute similarly to global health research productivity and institutional capacity.

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Authors' addresses: Douglas C. Heimbarger and Sten H. Vermund, Vanderbilt Institute for Global Health, Vanderbilt University, Nashville, TN, E-mails: douglas.heimbarger@vanderbilt.edu and sten.vermund@vanderbilt.edu. Catherine Lem Carothers, Vaccine and Infectious Disease Division, Global Oncology, Fred Hutchinson Cancer Research Center, Seattle, WA, E-mail: ccarothe@fredhutch.org. Meridith Blevins, Department of Biostatistics, Vanderbilt University, Nashville, TN, and Institute for Global Health, Vanderbilt University, Nashville, TN, E-mail: meridith.blevins@vanderbilt.edu. Tokesha L. Warner, Office of the Vice President for Research, University of Georgia, Athens, GA, E-mail: tlwarner@uga.edu.

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